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THE RAT MITE ATTACKING MAN.

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The blood-sucking mite of the rat, *Liponyssus bacoti* Hirst, has recently attracted attention in the South as an annoyer of man. So far as the writer is aware there are no published references to the occurrence of this pest in the United States, although its habit of attacking man has been reported by Hirst.[1] The species is known to occur in New South Wales and Western Australia, Egypt, Abyssinia, and Argentina.

The first occurrence of these mites in the United States to be reported to the writer was during the spring of 1920, when a department store in Dallas, Tex., called for aid. Early in 1921, reports of similar trouble began coming in from various establishments in Dallas and Fort Worth, Tex. The trouble in some instances was acute, causing the expenditure of much time and money in efforts to combat it and, in certain cases, compelling the abandonment of parts of buildings, as in the case of the dead letter division of the post office in the basement of the Federal building in Fort Worth.

Dr. A. H. Flickwir, health officer of Houston, Tex., has reported the occurrence of a mite attacking man in a building in that city. Although the species was not determined, it is almost certainly *Liponyssus bacoti.*

A similar occurrence of these mites has been reported by D. L. Van Dine. In this instance the trouble, which occurred in a railway station in a small town in Mississippi, was traced by Mr. Van Dine to the presence of many rats.

OBSERVATIONS ON THE SITUATION IN TEXAS.

The initial outbreak of this mite as a pest to man was coincident with a tremendous increase in the number of rats in the city of Dallas. These rodents began to appear in unusual numbers in 1920 and seemed to reach their maximum abundance in the early summer of 1921. Buildings which were newly constructed of steel and concrete were overrun, and residences in which a rat had never been seen before were frequently invaded.

[1] Hirst, S. 1914. Bul. Ent. Research, London. Vol. 5, part 3, pp. 225–229, December.

driven out the mite trouble soon subsides. As is well known, complete control of rats is extremely difficult. This is especially true where only sporadic and individual efforts are put forth against them. In the case of the infestations in north Texas a continuous and energetic warfare against the rats has been recommended, and along with this the cleaning out of all débris and nests and thorough spraying with kerosene. On floors a mixture of anthracene oil, 1 part, and kerosene, 2 parts, has been advised and used with success. This apparently destroys and repels the mites for several days. For the spraying of cabinets, desks, and shelves, a fine mist spray of gasoline appears to give temporary relief.

Undoubtedly fumigation with hydrocyanic-acid gas is one of the most effective methods of procedure, especially if rats can be excluded following the treatment. This was tried in a motion-picture house in May, 1922. Up to September 1 of that year there was no recurrence of the mite trouble, although the rats had reappeared in moderate numbers. In this case the standard proportions of the chemicals were employed, using 10 ounces of sodium cyanid (96–98 per cent) for each 1,000 cubic feet of contained space. As hydrocyanic-acid gas is extremely poisonous, fumigation should be conducted only by those who are thoroughly informed regarding the process and who use the greatest care.

Pyrethrum when fresh gives relief if used very frequently, but in all cases it seems essential to get at the nesting places of the rats to secure satisfactory control.

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THE CATTLE TICK: ITS BIOLOGY AND CONTROL

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The cattle tick, *Boophilus annulatus* Say, is one of the most important ectoparasites in the United States. This tick is important not only on account of its irritating and blood-consuming habits, but particularly because of the part it plays as a transmitter of the deadly malady of cattle known as Texas fever, caused by the protozoan, *Piroplasma bigeminum*.

The total monetary loss from this parasite is stupendous. Not even rough estimates of the loss caused by the different varieties of the cattle tick in Africa, Australia, and South America are available, but in the United States the more tangible losses have been rather carefully weighed by different investigators. The total tax put on southern agriculture by this pest has been variously estimated at from $40,000,000 to $200,000,000 annually.

The losses are of various types, some of which are: death of cattle from Texas fever; stunted development of southern cattle as a result of this disease; reduction in milk flow, lowered condition, and death loss from gross tick infestation; damage to hides and skins (No. 3 in grade), as a result of scars from tick attachment; inability to introduce pure blood cattle, to improve the cattle below the quarantine line; restriction on marketing; and cost of combating the ticks and maintaining the quarantine.

Boophilus annulatus proper is restricted in its normal distribution to the Southern States, south of about the thirty-seventh degree latitude, to Southern California, and to certain parts of northeastern and northwestern Mexico. The varieties of this species extend the distribution to practically all parts of the tropics and subtropics. The variety *australis* is most widespread. In the United States, it occurs in Florida and extreme southern Texas. It is assumed by some writers that the cattle tick is not indigenous to this country, but that it was introduced by Spanish cattle. The species was described by Say in 1801 from Florida. It cannot be doubted that the tick was present in this country long before that. In fact, the evidence favors the assumption that the species is indigenous.

Cattle are the preferred host, but horses, asses, mules, and deer are often attacked. The cattle tick has been found in the adult stage on sheep, goats, dogs, hogs, and peccaries. There is evidence that the bison is a congenial host. Man is seldom attacked. Experiments indicate that this tick will not develop successfully on cats, rabbits, nor guinea pigs. The rate of development is practically the same on any congenial host. The cattle tick may be differentiated from other species of ticks in all stages but the egg. The larvae are not so easily distinguished as the later stages. The capitulum, palpi, hypostome, scutum, and coxae give the best diagnostic characters.

The life cycle of the cattle tick is briefly as follows. Upon hatching the larvae crawl up grass or weed stems and await an opportunity to attach to a passing animal. When such an opportunity comes they attach and in 5 to 14 days molt to nymphs without leaving the host. The nymphs become engorged and molt to adults from 8 to 18 days later. The females may become engorged in four days, but usually require from 6 to 8 days and they may take as long as 14 days. Mating takes place on the host. When engorged the females release their hold and fall to the ground where they seek protected places, lay a large number of eggs, and die.

The preoviposition period is influenced by temperature and to a slight extent by the state of engorgement of the ticks. This period is usually from 2 to 5 days when the mean temperature is above 70°F. When the mean temperature falls much below 70°F. the preoviposition period is distinctly longer. In a few cases females have begun to oviposit the day after dropping from a host. During the winter it is usual to find preoviposition periods ranging from 15 to 40 days. The longest preoviposition period recorded was 66 days, under the following temperatures: maximum 80°F., minimum 14°F., mean 48.6°F.

The average number of eggs deposited by a female each day was fifty-nine during the cooler part of the year as compared with 233 during the warmer months. The maximum number of eggs deposited during one day was 857 and the average number was 148. The duration of oviposition is in inverse ratio to the rate. The shortest periods of oviposition occur in hot weather when they range from 11 to 16 days. The number of eggs deposited is influenced by the size and degree of engorgment of the female. It appears that cool weather not only prolongs oviposition, but reduces to some extent the number of eggs laid. For instance, the average number laid by 26 females collected in midsummer was 3,176 and the average number deposited by 27 females collected during the colder months was 2,767. The average number of eggs deposited by 53 well-engorged females collected or dropped at different times of the year was 2,967 and the maximum 4,547.

The incubation period is closely correlated with temperature, the index of correlation being .956 and the index of determination 92 per cent; that is, 92 per cent of the variation is due to temperature. The shortest incubation period observed under natural conditions was 18 days, and the longest 202 days. The eggs of females collected in September gave some of the shortest and some of the longest periods. This is explained by the frequent occurrence of warm weather during September and a marked drop in temperature in October. The records made during several years indicate that incubation is retarded to some extent by moisture being applied to the soil beneath them.

The larvae upon hatching remain on the egg mass for a day or two and then begin to cluster on adjacent objects. The individuals making up these masses move more or less and the entire mass usually progresses from a few inches up to six or eight feet during the long period while awaiting a host. Accessibility of suitable hosts is doubtless an influencing factor in fixing this habit. In cold periods of the spring and fall and during extremely hot weather the larvae move downward and search for protection. The longevity of the larvae ranges from a few days under extremely unfavorable conditions to many months, the maximum longevity recorded being 246 days. Temperature is a dominant influence on larval longevity, the index of determination being 79 per cent.

Fully engorged larvae and nymphs removed from a host will molt even when kept at out-of-door temperatures. The longevity of nymphs which molt from engorged larvae removed from a host, is relatively short. It ranges from a few hours to 12 days. Nymphs that are removed from a host when partially engorged live slightly longer, the maximum longevity recorded being 18 days. Adults that molt from nymphs removed from a host lived from 1 to 24 days.

The engorged females are strongly negatively phototropic, and when obstacles are not present they make rather rapid progress away from the strongest source of light. The maximum distance a female has been observed to crawl under average pasture conditions was thirty inches. Under such conditions the engorged ticks usually show a tendency to crawl beneath a clump of grass, under manure, or into a crack.

The total non-parasitic period, that is, the period from the dropping from the host of the engorged female until the last of her progeny (larvae), which have not found a host are dead, has an important economic bearing. Data on the length of this period, among other things, answer the question, as to how long a pasture will remain infested after all hosts have been removed. The data accumulated during the several years in which records were made of the non-parasitic periods of many ticks, has such a wide application that these data are summarized in the accompanying table. It will be noted that in general the shortest non-parasitic periods occur in the case of ticks which become engorged during May, June, and July, and the longest periods during

September, October, and November. This emphasizes the desirability of conducting eradication campaigns against the cattle tick during the spring and summer.

The data presented in the table are based on weekly collections of engorged female ticks exposed under three sets of conditions. Each week four females were put individually on soil in glass cylinders and exposed to approximately

TABLE I

BOOPHILUS ANNULATUS: SUMMARY OF PREOVIPOSITION, INCUBATION, AND LARVAL LONGEVITY, BASED ON GROUPS OF TICKS COLLECTED AT WEEKLY INTERVALS (Dallas, Texas)

Month and Yr. females collected	Period	Preoviposition		Incubation		Drop to hatch		Larval longevity		Non-parasitic period	
		Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F
1906 July	Shortest	13	80.2	24	79.5	37	79.9	175	58.3	202	62.6
	Longest	13	80.2	27	79.4	40	79.8	185	59.1	209	63.3
	Mean	13	80.2	25.5	79.5	38.5	79.8	180	58.7	205.5	62.9
Aug.	Shortest	12	79.5	22	78.4	35	79.4	160	54.7	200	48.8
	Longest	13	78.2	36	71.1	47	74.7	204	56.5	246	61.5
	Mean	12.9	79.1	25.9	77.4	38.7	78.3	184.5	56.6	223.9	59.8
Sept.	Shortest	13	80.5	42	69.6	55	71.9	64	64.6	181	57.3
	Longest	20	63.0	182	56.4	202	57.3	168	56.1	284	61.1
	Mean	18	70.0	131.2	55.5	148.6	56.8	97.6	62.8	248.3	58.8
Oct.	Shortest	20	59.5	169	56.2	191	56.4	73	72.7	264	60.9
	Longest	22	58.7	169	56.2	191	56.4	73	72.7	264	60.9
	Mean	21	59.2	169	56.2	191	56.4	73	72.7	264	60.9
Nov.	Shortest	1*	....	98	52.2	100	....	84	65.7	184	....
	Longest	2*	....	100	51.4	101	....	125	69.4	226	....
	Mean	1.6	....	98.7	51.9	100.3	....	104.6	66.5	205	....
Dec.	Shortest	2*	....	86	51.7	88	....	115	69.5	203	....
	Longest	2*	....	86	51.7	88	....	115	69.5	203	....
	Mean	2	....	86	51.7	88	.. ..	115	69.5	203	....
1907 Mar.	Shortest	3	68	67	64.9	71	65.5	32	79.3	110	68.6
	Longest	11	64.2	76	66	83	65.7	68	83	147	75.9
	Mean	6.9	66.9	71.8	66.3	79	66.2	50.6	81	129.6	72.1
April	Shortest	5	65.3	45	71.8	53	54.2	49	82	102	67.6
	Longest	16	60.5	63	68.2	62	69.8	68	83.2	130	76.8
	Mean	9.9	61.3	50.9	69.5	58.8	69.6	57.4	82.5	117.5	75.1
May	Shortest	4	69.4	25	81.4	33	78.9	35	82	80	77.1
	Longest	12	65.6	42	74.3	54	72.3	64	82.9	112	78.0
	Mean	8.2	67.1	35 4	76.5	43.3	74.6	51.1	83.2	94.4	79.2
June	Shortest	3	82.3	22	80.5	26	80.5	35	83.2	65	82.1
	Longest	6	80.6	27	81.4	33	81.2	62	82.5	96	82.9
	Mean	4	81.3	24.4	81.2	28.4	81.3	51.4	83.6	79.9	82.8
July	Shortest	3	79.2	20	84.8	24	84	44	82.3	89	81.0
	Longest	5	79.7	25	85.2	28	84.9	160	58.3	188	62.2
	Mean	3.8	82.5	22.1	84.4	25.9	84.2	77.9	74.0	104.0	76.5

* These are records on ticks kept in a heated room until oviposition.

TABLE I *Continued*

Month and Yr. females collected	Period	Preovi-position Days	Preovi-position Mean temp. °F	Incubation Days	Incubation Mean temp. °F	Drop to hatch Days	Drop to hatch Mean temp. °F	Larval longevity Days	Larval longevity Mean temp. °F	Non-parasitic period Days	Non-parasitic period Mean temp. °F
Aug.	Shortest	2	83.6	21	84.6	26	84.8	88	64.7	114	69.3
	Longest	6	85.1	32	78.7	36	79.1	244	58.1	264	59.9
	Mean	4.2	84.4	25.8	81.0	30.0	81.0	189.2	57.0	220.2	60.4
Sept.	Shortest	3	81.0	30	77.1	33	77.7	53	65.2	191	56.4
	Longest	7	76.9	191	54.9	195	55.3	224	65.5	245	61.9
	Mean	4.5	78.8	104.5	57.9	106.4	58.9	139.1	51.2	248.2	57.5
Oct.	Shortest	4	75.1	180	54.2	189	54.7	12	81.9	231	59.4
	Longest	27	51.4	202	58.0	208	55.4	88	76.0	292	61.5
	Mean	10.0	62.1	190.9	56.2	208.4	57.0	53.0	75.4	261.5	59.8
Nov.	Shortest	46	50.0	...	....	...	....	...	....	...	....
	Longest	66	48.6	...	....	...	....	...	....	...	....
	Mean	56.0	49.3	...	....	...	....	...	....	...	....
Dec.	Shortest	30	48.7	...	....	170	60.1	45	80.4	215	64.4
	Longest	43	49.0	...	....	170	60.1	45	80.4	215	64.4
	Mean	36.5	48.8	...	....	170.0	60.1	45	80.4	215.0	64.4
1908 Feb.	Shortest	7	69.8	68	64.7	75	66.1	57	78.8	132	71.6
	Longest	20	54.4	69	64.7	98	62.2	65	79.1	140	72.1
	Mean	12.3	59.6	68.5	64.7	82.6	66.5	61.0	78.9	135.4	72.2
Mar.	Shortest	6	62.6	47.0	66.8	59	67.8	20	80.3	91	70.4
	Longest	13	62.1	65	66.2	77	65.9	78	80.4	155	73.2
	Mean	9.5	63.2	56.8	67.8	68.2	67.1	64.9	80.8	132.9	73.7
April	Shortest	4	72.1	26	77.9	37	74.5	43	80.8	93	78.3
	Longest	13	68.8	48	69.4	56	68.5	85	81.8	136	75.7
	Mean	7.2	67.2	39.0	72.4	47.0	71.5	67.8	81.0	115.0	77.1
May	Shortest	2	74.8	22	81.0	26	80.4	45	81.2	83	79.5
	Longest	8	74.4	32	77.6	36	77.6	95	80.3	126	80.1
	Mean	4.8	76.3	26.4	79.2	32.1	79.0	67.1	81.2	99.2	80.4
June	Shortest	2	83.8	21	80.1	25	80.6	54	81.6	83	81.0
	Longest	9	78.9	27	80.4	31	80.3	121	70.9	150	72.7
	Mean	4.0	80.6	24.6	80.2	28.9	80.4	71.6	79.4	99.7	79.8
July	Shortest	2	82.0	21	82.1	24	82.4	30	78.5	59	80.1
	Longest	6	77.9	24	81.5	30	81.7	22.5	59.5	253	62.0
	Mean	4.2	81.5	22.6	82.1	27.3	81.8	95.5	69.2	122.7	71.9
Aug.	Shortest	2	83.0	21	80.3	25	80.1	47	58.4	153	63.4
	Longest	5	79.3	34	73.1	38	76.0	246	58.3	275	60.7
	Mean	3.7	81.0	26.2	78.7	30.2	78.8	198.7	58.7	230.1	61.8
Sept.	Shortest	4	76.1	41	68.4	44	71.0	60	64.8	116	56.9
	Longest	8	66.3	171	54.4	176	55.0	197	69.8	265	59.9
	Mean	5.6	74.3	105.2	56.9	108.2	57.7	113.2	56.9	221.2	57.3
Oct.	Shortest	5	69.7	153	53.3	162	55.8	44	82.3	212	56.4
	Longest	22	54.1	171	51.5	181	55.5	104	72.3	277	62.1
	Mean	10.9	61.4	160.2	53.9	173.5	54.8	78.5	71.2	252.0	60.0
Nov.	Shortest	10	60.3	141	56.0	154	52.3	37	76.5	191	57.4
	Longest	39	51.3	143	56.5	183	54.8	47	76.3	248	61.3
	Mean	23.2	52.6	142	56.2	181.3	56.4	41.3	78.1	223.0	60.4
Dec.	Shortest	21	53.9	...	....	163	59.7	32	82.2	195	63.4
	Longest	27	52.0	...	....	163	59.7	32	82.2	195	63.4
	Mean	24.4	52.2	...	....	163.0	59.7	32.0	82.2	195.0	63.4

TABLE I *Continued*

Month and Yr. females collected	Period	Preovi-position		Incubation		Drop to hatch		Larval longevity		Non-parasitic period	
		Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F
1909 Jan.	Shortest	7	65.3	100	....	118	60.2	37	82.7	151	62.7
	Longest	18	57.6	100	....	118	62.2	49	81.7	179	64.0
	Mean	10.4	58.4	100	62.1	118.0	60.2	42.3	82.0	170.5	66.0
Feb.	Shortest	10	60.1	...	....	103	65.6	32	70.2	123	69.4
	Longest	18	57.6	...	....	117	61.5	40	81.9	157	66.6
	Mean	13.0	59.2	...	....	108.0	63.8	36.6	83.0	144.6	68.6
Mar.	Shortest	6	63.9	46	69.2	58	67.5	29	83.2	103	73.8
	Longest	25	58.0	61	69.1	67	68.6	83	84.0	148	76.4
	Mean	13.0	59.4	51.0	68.6	65.4	71.6	62.1	83.6	127.5	77.5
April	Shortest	6	65.8	34	74.4	41	73.2	37	88.5	84	78.9
	Longest	12	64.6	48	71.1	52	70.6	75	83.9	126	77.4
	Mean	9.0	64.0	39.0	72.8	47.8	71.2	55.0	84.4	102.8	76.7
May	Shortest	1	78.7	23	81.7	32	77.6	35	85.6	72	82.2
	Longest	7	74.8	41	75.3	44	75.6	53	85.3	96	82.2
	Mean	5.3	74.5	29.9	78.6	35.2	78.0	45.2	86.3	80.5	82.8
June	Shortest	2	83.3	19	86.8	23	85.8	30	86.8	58	86.2
	Longest	5	81.3	26	82.7	28	82.7	55	86.7	83	85.3
	Mean	3.5	83.2	21.9	85.0	24.4	84.5	43.8	86.6	68.2	86.0
July	Shortest	2	88.1	18	87.3	20	96.3	18	85.1	43	86.4
	Longest	5	88.6	23	86.2	26	86.7	85	75.6	108	77.9
	Mean	2.9	87.3	19.7	86.8	22.9	86.9	39.6	82.8	60.5	....
Aug.	Shortest	3	82.2	20	84.9	22	83.1	8	71.2	35	80.8
	Longest	6	83.8	41	74.2	45	75.2	225	57.2	251	59.7
	Mean	3.5	86.2	24.7	81.7	28.2	83.4	91.4	58.7	119.6	77.2
Sept.	Shortest	3	77.8	31	72.4	35	73.8	47	66.2	200	56.1
	Longest	8	69.5	173	53.1	180	53.8	205	55.6	259	58.6
	Mean	5.2	74.9	80.5	59.4	85.0	60.6	146.4	55.4	231.9	57.3
Oct.	Shortest	4	67.3	159	51.9	168	52.6	17	68.9	221	56.0
	Longest	12	65.2	197	54.4	204	54.9	97	71.3	269	59.4
	Mean	7.7	67.1	178.0	53.2	182.4	54.0	69.2	71.9	239.7	58.6
Nov.	Shortest	7	60.5	177	53.5	185	53.9	48	80.4	239	58.6
	Longest	14	59.5	186	54.5	198	73.2	61	77.6	255	60.6
	Mean	10.5	60.5	182.7	54.2	192.1	54.3	55.8	77.4	247.8	59.8
1910 Feb.	Shortest	9	65.9	78	66.9	93	66.5	38	83.4	139	71.5
	Longest	21	57.0	86	67.3	105	65.7	58	82.3	163	72.0
	Mean	14.2	60.3	82.5	68.7	100.9	67.1	48.9	86.2	148.0	73.4
Mar.	Shortest	7	70.9	60	70.1	73	68.9	38	81.2	114	78.9
	Longest	16	62.4	74	68.1	89	67.2	61	84.1	148	73.5
	Mean	11.1	64.3	68.1	68.8	78.8	68.2	48.8	82.7	127.5	73.8
April	Shortest	7	64.9	43	72.6	50	72.3	32	84.0	86	76.9
	Longest	13	64.5	60	70.1	70	69.7	64	85.0	127	76.4
	Mean	10.0	65.8	50.9	71.7	60.7	71.2	45.2	84.0	106.0	76.5
May	Shortest	3	82.5	27	80.0	31	80.2	27	84.4	60	82.6
	Longest	9	68.3	44	75.1	51	74.0	63	85.8	128	81.6
	Mean	6.6	71.4	34.3	78.2	40.4	77.1	41.1	85.4	81.4	81.3
June	Shortest	3	82.3	20	83.4	26	84.1	7	87.8	35	85.0
	Longest	11	76.2	29	80.0	33	80.8	80	85.8	95	84.9
	Mean	4.5	80.4	24.2	83.3	27.7	82.8	34.0	85.4	61.7	84.3

TABLE I *Continued*

Month and Yr. females collected	Period	Preovi-position		Incubation		Drop to hatch		Larval longevity		Non-para-sitic period	
		Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F	Days	Mean temp. °F
July	Shortest	3	81.9	18	88.2	22	87.9	6	88.4	29	87.6
	Longest	6	86.0	25	86.4	29	85.9	124	69.2	149	72.2
	Mean	4.0	84.5	21.0	87.4	25.8	85.5	29.1	81.6	54.8	83.5
Aug.	Shortest	2	86.2	18	87.2	21	87.1	10	85.8	32	87.5
	Longest	6	86.3	26	82.3	30	82.6	240	60.2	266	62.5
	Mean	3.3	88.0	21.5	85.6	25.5	85.7	151.4	60.1	176.8	65.8
Sept.	Shortest	3	78.6	18	74.8	22	75.5	56	59.5	127	60.1
	Longest	6	80.0	147	57.2	151	57.9	220	58.6	250	60.8
	Mean	3.8	81.1	43.2	67.8	53.4	67.1	170.0	58.1	223.5	60.3
Oct.	Shortest	4	79.7	19	67.5	25	67.8	27	79.3	198	57.5
	Longest	16	59.6	181	56.6	192	56.8	213	58.9	242	60.6
	Mean	8.7	63.4	144.2	56.7	152.1	56.6	74.8	66.1	227.0	60.2
Nov.	Shortest	14	56.3	170	57.3	186	57.3	11	76.4	204	59.0
	Longest	37	50.1	181	58.4	197	58.3	24	79.3	210	59.8
	Mean	20.9	53.5	175.0	57.8	195.2	57.3	16.8	79.2	207.8	59.0
Dec.	Shortest	36	....	.....	....	.....	....	.....	....	.....	....
	Longest	52	....	.....	....	.....	....	.....	....	.....	....
	Mean	41.7	49.9	.....	....	.....	....	.....	....	.....	....
1911 Jan.	Shortest	7	57.6	98	62.8	108	62.8	11	79.3	129	64.5
	Longest	21	58.4	109	61.3	130	62.2	59	84.3	183	69.3
	Mean	14.7	60.4	104.9	62.7	118.8	62.7	28.9	82.7	147.9	66.7
Feb.	Shortest	8	54.5	74	66.2	84	77.7	9	84.7	100	68.5
	Longest	30	58.7	91	65.5	110	63.6	85	84.6	169	75.2
	Mean	18.7	55.2	79.0	68.3	98.9	65.6	26.9	84.9	125.8	69.7
Mar.	Shortest	5	77.9	53	69.7	64	69.0	9	82.9	77	72.0
	Longest	19	61.3	76	65.8	83	67.5	75	84.7	155	75.6
	Mean	10.9	64.3	62.2	68.2	73.7	67.6	26.7	85.5	100.3	71.7
April	Shortest	7	67.9	31	76.8	41	73.9	4	85.6	49	76.2
	Longest	17	64.1	50	70.8	59	69.9	73	85.2	120	80.3
	Mean	9.7	65.3	38.9	74.1	48.5	72.4	23.8	86.0	71.9	76.9

normal conditions. Two females in similar containers were kept where the surrounding soil was moistened daily when rains did not occur. Thirty-five females were put on the soil in the center of a screened cage. Daily examinations were made of each of the lots. The total non-parasitic period was found to correlate closely with temperature. The index of determination was 93 per cent.

The parasitic period in the case of the cattle tick is continuous, *i.e.*, the ticks remain on the host from the time they attach as unengorged larvae until they drop off as engorged females or die as males. The total parasitic period must be known in order to determine the interval between dippings and also in connection with eradication by the feed-lot and certain pasture rotation methods.

Mating takes place on the host. The males usually molt before the females and attach beneath an engorged nymph which is to become a female.

As would be expected on a warm-blooded host, the parasitic period is not affected markedly by climatic conditions. The minimum period required for development from larvae to adults is lengthened by cold weather. The host species, if congenial, appears to affect the rate of development very little. Larval engorgement and molting require from 5 to 10 days, nymph engorgement and molting from 5 to 11 days with a possible maximum of 22 days; engorgement of the females takes from 6 to 12 days with a possible maximum of 37 days, and the total developmental period requires from 21 to 55 days. A minimum total developmental period of 20 days has been reported by Hooker, Bishopp, and Wood, and a maximum developmental period of 59 days has been recorded by Hunter and Hooker.

Since the development of the cattle tick proceeds more or less continually, especially in the extreme south, and also as larvae gain access to a host in nature at various times, there are no well-defined broods. Based on the length of time required for preoviposition and incubation during different seasons of the year, and the developmental period on suitable hosts, it is apparent that five generations are possible at the latitude of Dallas, Texas.

Field observations and checked experiments show that there is a direct relationship between the condition of cattle and the degree of tick infestation. The development of ticks on cattle on maintenance rations proceeds at about the same rate as on cattle on fattening rations, but the number of ticks reaching maturity is greater on the former. There is no consistent difference in the susceptibility to tick infestation of cattle of different breed, age, or color. There is, however, a pronounced tendency toward immunity to tick attack shown by the Zebu or Asiatic breeds. Individual resistance to tick infestation has often been observed, in the case of both cattle and horses. The reason for this resistance is unknown.

Since the cattle tick remains on its hosts for several weeks and since the engorged adults drop at any time or place, the importance of host movement is obvious. The major method of dissemination is through the shipment of live stock, hence the enforcement of the rigid quarantine. Engorged females have been found to lay eggs and the eggs to hatch when such ticks are put in hay as it is baled. This indicates the danger of transporting ticks through the shipment of such commodities. The fact that larvae, eggs, and unengorged females of the cattle tick can withstand considerable periods of submergence makes it possible for the species to be spread by streams, especially in flood. The movement of the ticks themselves is of little importance in the spread of the species.

By experiments under out-of-door conditions and in laboratory apparatus it has been found that engorged females can withstand temperatures as low as 9.5°F. Specimens which have begun to oviposit are slightly more susceptible to cold than those which have not. Larvae are decidedly more resistant to cold than are engorged females. The effect of low temperatures on larvae varied much in different experiments. In some cases from 20 to 40 per cent were killed by exposure during one night to a minimum temperature of 14°F., in others temperatures of 1.5°F. killed very few. In several instances eggs in different stages of incubation were killed by exposure out-of-doors to several nights of subfreezing temperatures, the minimum being 10.5°F. Exposure for six hours to temperatures of 7 to 10°F. reduced the hatch 5 to 10 per cent. In another test, however, exposure for six hours to temperatures ranging from one-half to 8°F. killed only 50 per cent of the eggs. Low winter temperatures are clearly a dominant factor in restricting the northern distribution of this species. Humidity also exerts an important influence on the cattle tick and doubtless is the principal factor limiting its normal occurrence in the southwest.

All stages of the tick are resistant to long periods of submergence in water. In one test 94 per cent of the eggs hatched after being submerged 32 days. Larvae have been reported to live 157 days submerged. Over 50 per cent of the females submerged forty-seven hours deposited eggs, but few of them hatched.

Domestic fowls are capable of consuming large numbers of engorged cattle ticks. In one case a hen devoured 68 replete females as rapidly as they were given to her. Various species of birds destroy ticks. A female Brewers' blackbird was found to have 30 cattle ticks in its stomach, and a jackdaw was found to have eaten 33 specimens. Predatory insects, particularly ants of the genus *Solenopsis*, destroy engorged females and their eggs.

The cattle tick may be eradicated by several methods involving the starvation of the ticks on infested areas and their elimination from their hosts by pasture rotation or dipping. The success of these methods is dependent upon the exact knowledge of the parasitic period and the periods from the dropping of engorged females to the hatching of their eggs and to the death of the last tick. The information regarding the various non-parasitic periods presented in the table furnishes a basis for eradication procedure.

Systematic dipping has been depended upon almost entirely in the eradication campaign. Arsenical dip is now used exclusively. In laboratory experiments with arsenical dips on ticks removed from the host, a study was made of the influence of the state of engorgement of the female ticks, the length of time submerged, the area of integument covered, and the part of the tick treated, on the effectiveness of the dip. It was found that females in different stages of engorgement were equally susceptible. Less than 1 per cent of the females completely submerged laid viable eggs, while the greater number died without ovipositing. The duration of submergence did not influence the percentage of kill. By applying the solution to different parts of the ticks it was found that the effect did not vary greatly. The area of the integument covered appeared to be the dominant factor.

Since it is possible for the cattle tick to complete its development and leave a host in 21 days, to accomplish eradication the interval between dippings must not exceed that period. In practice it has been found advisable to reduce the interval to 14 days. Theoretically it is possible to eradicate the cattle tick on a given area under the conditions prevailing at Dallas, Texas, in a period as short as 118 days. If all engorged ticks are prevented from dropping from hosts on such an area after May 1, it will be tick free by August 27. In practice, however, it has been found necessary to continue dipping for a period of seven or eights months.

Pasture burning is commonly practiced to destroy ticks. Tests made show that it cannot be relied upon to kill all ticks on a given area; this is also true of plowing. Burial of engorged females at depths of from one to three inches in different types of soil resulted in destruction of a high percentage of the ticks. Some larvae hatch from eggs buried in this way and reach the surface.

The great difference between the habits of other pestiferous ticks and those of the cattle tick, prevents the eradication of such species by the methods employed against the cattle tick.

Biting and sucking lice are controlled, but not necessarily eradicated, by the dipping schedule used against the cattle tick. Screw worm losses are reduced as a result of cattle tick eradication. When ticks are abundant, screw worm flies lay their eggs on the lesions produced by the ticks and are attracted to the blood resulting from the crushing of ticks.

Sulfur administration in feed or water is ineffective in protecting cattle from cattle ticks, although it is reputed to be of value for this purpose.

ARGAS PERSICUS COMME PARASITE DE L'HABITATION HUMAINE.

par M.M. **I. Ciurea** et **Théodore Stephanescou**

Bulletin de la Société Roumaine de Dermatologie et de Syphiligraphie (Section de Bucarest).

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BUCAREST

L'IMPRIMERIE CULTURA

1929

ARGAS PERSICUS COMME PARASITE DE L'HABITATION HUMAINE.

par M.M. **I. Ciurea** et **Théodore Stephanescou**

Le 18 Avril 1929 se présente au Laboratoire de parasitologie de la Faculté de Médecine Vétérinaire Mr. Z. W. de Bucarest, accompagné de sa femme et de sa fille (âgée de quatre aus), en nous disant que depuis le mois de Mars, ils sont piqués pendant la nuit, par des insectes qui ont infesté leur habitation; ils ajoutent, en outre, que les piqûres de ces parasites sont très désagréables par l'irritation locale et le prurit intense qu'elles provoquent. Sur les quelques exemplaires qu'ils nous apportent dans un petit flacon nous avons reconnu au premier coup d'oeil qu'il s'agissait d'une espèce d'Argas. Tous les moyens qu'ils ont employés pour désinfecter la maison ont été sans résultat, de sorte qu'ils se sont décidés à changer d'habitation. A l'enquête que nous avons faite au domicile, nous avons constaté que Mr. Z. W. loge dans un appartement situé au second étage d'une maison construite en béton, l'année dernière. Dans la chambre à coucher nous avons pu récolter, en plein midi, trois exemplaires d'Argas, qui se trouvaient sur le plafond. M-me Z. W. nous a dit qu'elle faisait chaque matin la chasse à ces acariens et que plusieurs fois elle avait inspecté les fissures des fenêtres, de la porte et des meubles en bois, sans pouvoir découvrir les endroits où ils se réfugiaient. Dans les autres pièces de l'appartement on n'observe pas d'Argas; on ne les trouve que dans les pièces qui servent de chambres à coucher. Suivant les informations recueillies, il n'y a pas de colombiers, ou de poulaillers dans la maison, la volaille qu'ils consomment étant achetée egorgée et déplumée. Nous n'avons pas de renseignements précis sur la présence de ces acariens dans les autres appartements de cette maison. C'est M-me Z. W. qui nous dit y avoir vu des exemplaires isolés, mais en tout cas les autres locataires ne se plaignent pas d'avoir été piqués par de semblables parasites.

Le résultat de cette enquête nous fait supposer que les Argas ont été introduits dans l'appartement avec des objets infestés, apportés par Mr. Z. W. lui-même, qui est commis-voyageur.

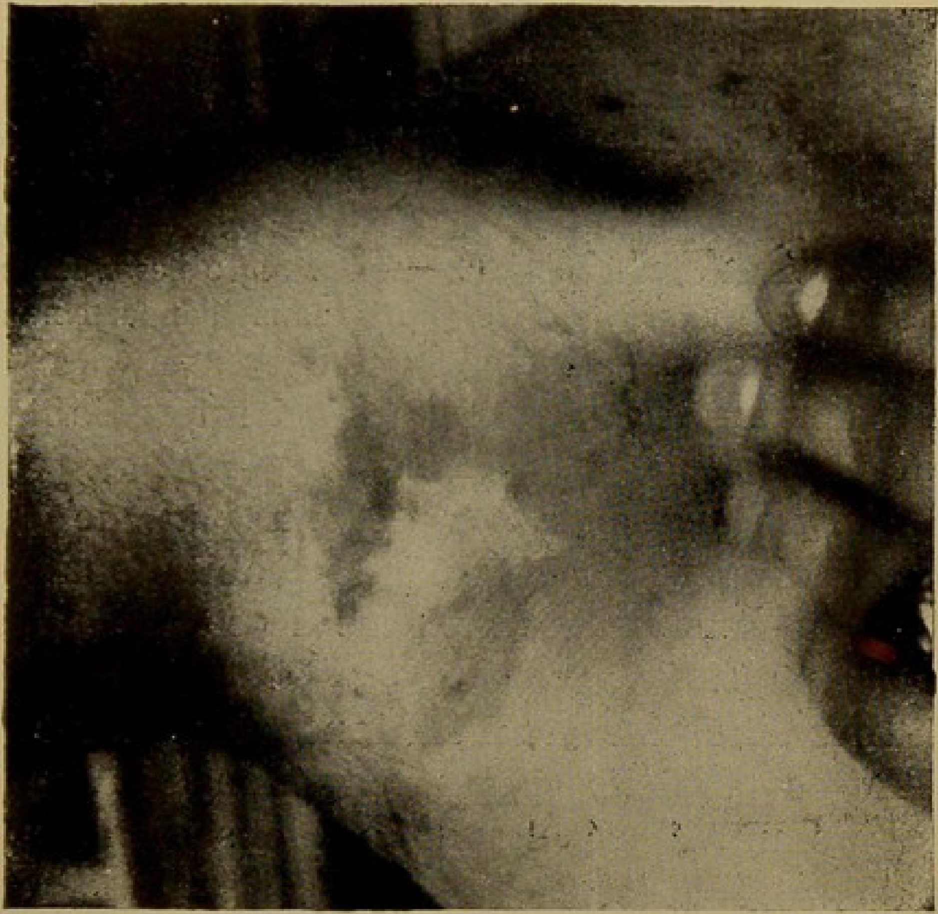
Nous avons recommandé la pratique des fumigations de soufre dans les chambres infestées.

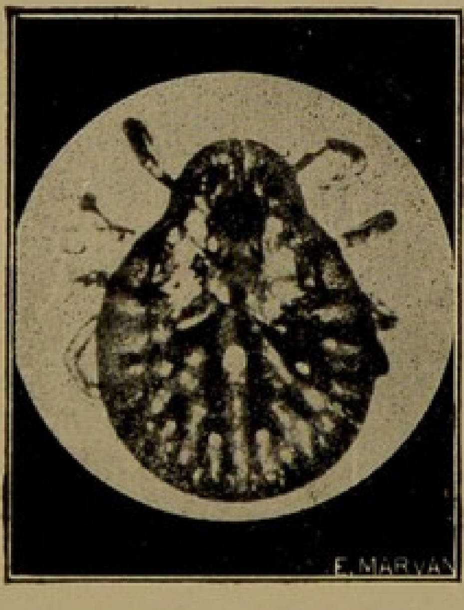
Tous les exemplaires *d'Argas* recoltés dans l'appartement mentionné appartiennent à l'espèce *Argas persicus Latreille;* nous avons reconnu parmi eux une femelle et huit nymphes octapodes.

Observation clinique. Les premières piqûres ont été observées sur le pied de la fillette; elles se présentaient d'abord comme des lésions insignifiantes qui peu après se transformaient en de petites plaques urticariennes; celles-ci en quelques heures augmentaient de volume pour atteindre les dimensions d'une pièce de deux francs. Ces plaques urticariennes produisaient un prurit très intense. La fillette a eu des lésions semblables sur les bras et sur les organes génitaux externes.

Chez Mr. Z. W., qui a été piqué sur plusieurs régions du corps (mains, bras, région pectorale, abdominale et pieds), les lésions avaient le même caractère initial, mais la réaction locale était plus violente; les plaques urticariennes atteignant parfois le volume d'un oeuf de poule, comme il arriva au pied gauche, la peau étant dans cet endroit fortement tumefiée tendue et luisante, de sorte que le patient ne pouvait plus se chausser.

Les placards urticariens atteignaient leur maximum six heures après la piqûre, ils restaient stationnaires pendant quelques heures, et la peau ne redevenait normale que deux jours environ après la piqûre; il ne persistait plus à l'endroit piqué qu'n petit point rouge brunâtre. Pendant ce temps l'état général du malade fut assez bon, il n'eut pas de fièvre, il ne fut troublé que par la tuméfaction et surtout le prurit très intense qui persista pendant près de huit jours. Par le grattage, quelques-uns des éléments s'irritèrent et s'infectèrent, donnant naissance à des érythèmes étendus et même à des lésions echymotiques et des ulcérations.





Argas persicus, nymphe octapode (grossie 14 fois).

Ainsi, sur le bord externe du pied gauche, on observe une ulcération de la dimension d'une pièce de cinquante centimes, très prurigineuse et douloureuse.

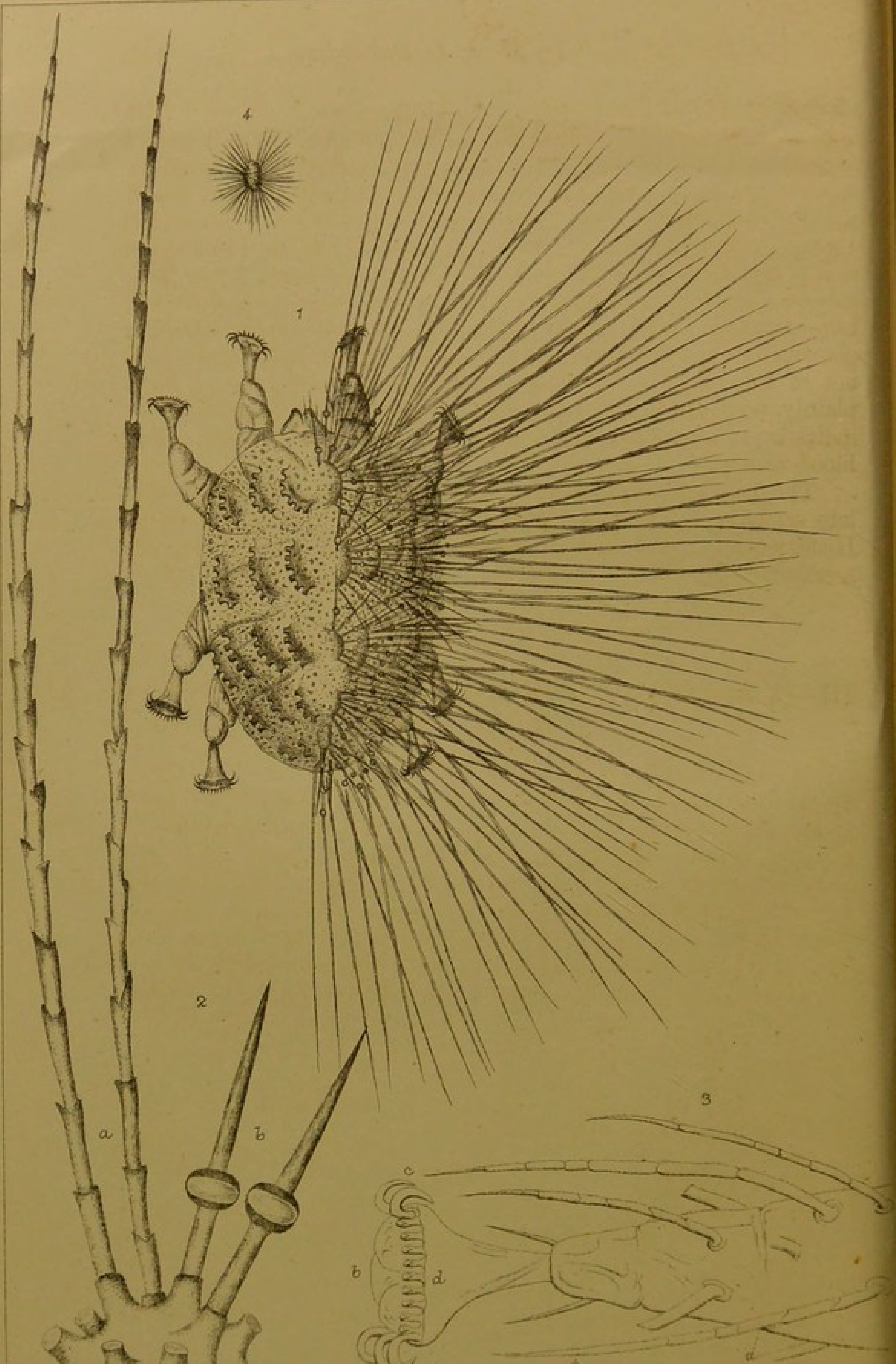
Autour de celle-ci on voit un érythème d'une coloration rouge foncé ayant une largeur d'environ trois à cinq centimètres. Au même pied nous avons observé de plus un autre placard rouge foncé, squameux, situé entre le premier et le deuxième orteil, au niveau de l'articulation métacarpo-phalangienne. Nous attirons l'attention sur le fait que chez M-me Z. W. les piqûres de ces acariens étaient suivies de réactions urticariennes moins intenses et moins prurigineuses que chez son mari et sa fille.

Un mois après (le 21 Mai) nous avons visité une seconde fois la famille Z. W. et la maison infestée. Malgré les fumigations de soufre, les *Argas* persistaient toujours dans l'appartement.

Cette communication nous paraît intéressante à deux points de vue:

1) *L'argas persicus,* qui est un parasite des habitations des oiseaux a infesté une habitations humaine. C'est, croyons-nous, le premier cas de ce genre mentionné dans notre pays.

2) Chez l'homme les réactions consecutives aux piqûres d'Argas persicus varient en intensité d'un individu à l'autre, comme il résulte de nos observations.



A. L. Donnadieu ad nat del. W. West & Co. lith.

Heterotrichus inæquarmatus, Donn.

affected by the old and still vexed question, as to whether the nucleus exists distinctly or at all in the corpuscle while it circulates within the living blood-vessels, or is formed only after its exposure to the atmosphere or chemical reagents. Many years ago De Blainville, Valentin, Henle, and others, and more recently Savory, supported the latter view; and the former was adopted by Mayer and Kölliker, to which Brunke has lately conformed. The subject cannot be entertained here; only it may be noted that I have satisfied myself of the substantial accuracy of Mr. Savory's observations on the blood-disks of some British Batrachians, but not of the validity of his conclusions therefrom, and that I have plainly seen in certain fishes the projections on the corpuscles, indicative of a nucleus, while they were flowing within the living blood-vessels."

The facts, described above, were shown in the living fish at a late scientific meeting, at Canterbury, of the East Kent Natural History Society, and were regarded with much interest by the members present.

III.—*A New Acarite.* By M. A. L. Donnadieu, D.Sc., Professor at the Lyceum of Lyons.

Plate CLXXXIII.

In the month of April, 1873, in emptying into a plate full of weak acetic acid * the contents of a collection from a sweeping net, I found an acarite which appeared to me to be quite new. It is difficult for me to give any exact idea as to its origin. The glass was full of acarites of all kinds, *Scirus, Trombidium, Gamasus*, &c., and with them a great many insects, among which the *Diptera* were most numerous, more especially those allied to the common fly.

With regard to the specimen which I found, which, in spite of

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EXPLANATION OF PLATE CLXXXIII.

Fig. 1.—*Heterotrichus inæquarmatus.* Entire animal seen from behind. The left half is represented without the numerous hairs which cover the body, in order to show the tubercles which support these hairs.

Fig. 2.—A tubercle very much enlarged, and showing the two kinds of hairs. *a.* Long and pointed hairs divided into segments. *b.* Short hairs with the peculiar spherical swelling.

Fig. 3.—Extremity of one of the feet. *a.* Tarsus. *b.* Edge of the cupuliform membrane deprived of hooklets. *c.* Two large internal hooklets. *d.* Nine small spatuliform hooklets. *f.* The three large external hooklets. *g.* hairs.

Fig. 4.—Acarite magnified twice.

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* See, for an explanation of this process of research, 'Recherches sur les Tétramiques,' par A. L. Donnadieu, 1875, p. 27.

all my search for others, was but that of a single individual, I believe that it is an undeveloped form (*hypopiale*) of *Gamasus*, which might very well have proceeded from one of the Diptera which I shall refer to. The mouth, too badly defined to have any significant value, the general form of the body, and, above all, the absence of reproductive organs, seem to me to confirm this idea.

I would observe that my description refers to the actual form of the individual, without in the slightest degree indicating what the ultimate appearances may be. I have called it *Heterotrichus inæquarmatus*, which name can be applied to the complete form when I am fortunate enough to obtain it.

The body, which is very transparent, is ovate; the *rostrum* makes a very slight bend forwards, through which one distinguishes only that which should be the *palpæ*. The inferior surface is flattened, the upper one is swelled out (*bombée*). The skin on the entire region of the body is granular, and presents grooves in the neighbourhood of the feet and rostrum.

On the dorsal face one sees a series of rounded elevations like little tubercles. At their level the skin is slightly brownish; they serve to support the hairs which by their nature justify the generic name that I have given the animal.

These hairs are, in fact, of two kinds. The one spiny at their ends seem formed of a series of joints, which fit one into the other. They are twice to three times the length of the body. They are comparatively slender, but are nevertheless rigid enough to give the animal the appearance of a body covered with sharp spines. The others are short, and terminate in a slender point; almost in the middle they present a very large vesicular swelling filled with a mucous-like fluid, which by its transparence contrasts vividly with the brownish tint which fills the rest of the hair.

The disposition and number of each of these hair-like processes on their little elevations of the surface are unimportant; but these latter are so abundant that the whole body disappears beneath the mass of hairs which cover it.

The feet, eight in number, are short and decidedly conoid. They differ very slightly in length, the anterior pair being slightly shorter than the others. Two pairs are directed in front, and two backwards. At the point of origin they sensibly approach each other.

Their mode of termination is the most remarkable point about them. The conical tarsus is terminated by a wide membrane capable of forming a cupuliform caruncula, on the lower border of which are placed hooklets. The latter are of two forms, and their appearance led me to give the specific qualification to the animal of *inæquarmatus*. The first are freely bent, as is the case in the majority of the species. They thin away from base to extremity, and their curvature forms a more or less marked semicircle. Two are directed to the front and the external border (*le bond externe*). Three others are seen in the outer border, but they are directed backwards. Between these two series are placed the hooklets of the second form (*les crochets de la deuxième forme*). The latter are placed regularly upon the inferior borders of the tarsal extremity, and are nine in number. They are short, and their initial part assumes up to the point of its insertion a more or less spatular form. Towards their summit they curve brusquely upwards, and terminate in a very short conical point. They are all equal in their length, which does not exceed a third of the preceding ones.

Finally, the feet are covered with hairs analogous to the long ones on the body, but much shorter and more transparent.

By all the characters that I have pointed out, this acarite appears to belong to the *Gamasidæ*, to which certainly belong the adult forms represented in the present state of our knowledge by the undeveloped stage of certain Gadflies.—*Journal de l'Anatomie*, December 1876.

IV.—*On the Action of Chlorophyll in the Vine.*

By Giovanni Briosi, Engineer and Director of the Agricultural Station in Palermo.*

One of the grandest conquests in the realm of modern botanical physiology, since it concerns the most fundamental phenomenon of life, is, without doubt, the discovery of the assimilating function of chlorophyll by which it forms starch out of the carbonic acid of the atmosphere and water, under the action of the light. As is known, it was the work of Mohl, Gris, Böhm, Sachs, Nägeli, Kramer, Kraus, &c., which led to this discovery, which has often since been confirmed. Consequently it is at present generally admitted that the starch is, at least amongst the vegetable substances which are known to us, the primary form of the organic material of plants, out of which the laboratory of nature derives by transformations partly understood, and partly unknown to the chemist, all other physiological allied substances, as sugar, dextrine, inulin, cellulose, fat, &c.

In another work,† I have pointed out that the product of the assimilation process of chlorophyll in some plants cannot be starch,

* Translated from the Italian by W. R.

† Briosi, "Ueber normale Bildung von fettartiger substanz im Chlorophyll" ('Botanische Zeitung,' 1873, No. 20 and following ones); also 'Nuovo Giornale Botanico,' April 1875.

and demonstrated in fact that in the chlorophyll of the *Strelitziæ* and *Muscæ*, instead of starch, oil or fat is constantly formed, and that in these plants afterwards, out of those substances, the cellulose, and the starch itself (which, too, is found in some of their organs), &c., originate.

And these *Musaceæ* and the *Allium cepa*, in whose chlorophyll-grains Sachs could never detect starch, and where it is suspected that glucose is formed, are the only plants in which (to my knowledge at least) it is certain that no hydrocarbon is formed.

Since 1872, whilst studying what substances are formed in the vine, and what transformations they undergo, I often had occasion to observe, that in the chlorophyll-grains of this plant no starch is found, but the knowledge that this well-known and important plant had already formed the subject of the researches of the most distinguished scientific men deterred me from prosecuting my labours; and since then I had no opportunity of taking them up again, as during the last few years I have almost been taken away entirely from my studies.

Having been called upon towards the end of last autumn, by His Excellency the Minister of Agriculture, to occupy myself with a new disease of which we were warned in some vineyards at Favara (which disease has shown itself at present in the neighbourhood of Palermo as well, in a vineyard of Count Tasca, and which seems to threaten serious disaster to our wild vine), I recommenced my researches on the vine, of which, for the moment, I will state the following facts:

Up to the present, I have never been able to detect even the slightest trace of starch in all the vine leaves I have examined, either young or old, in different vineyards and different varieties.

The chlorophyll-grains of the vine, when treated with alcohol, potash, acetic acid, or iodine (usual method), appear more or less with hollows, but there never is the slightest indication of a starch reaction.

Holes and little gutters are also formed in the chlorophyll-grains, either under treatment with alcohol, or even with distilled water. When dry, and without applying any reagent, the chlorophyll-grains appear (uniform) without any holes or cavities.

The chlorophyll-grains, which are for several days placed in a saturated solution of bichromate of potash, appear mostly without holes, but have lost their homogeneousness, and often show in their interior more or less dark spots. On the other hand, I never found starch in the *mesophyll* of the vine leaves hitherto examined by me, with exception of the enclosure-cells of the stomata, where it is never wanting. A small quantity of starch only is found in the *vasi crivellati* and in the *strati amilacei of* Sachs, and in the ordinary fibro-vascular bundles.

Tropical Rat Mites, Liponyssus Bacoti Hirst, Vectors of Endemic Typhus

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DALLAS, TEXAS

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TROPICAL RAT MITES, LIPONYSSUS BACOTI HIRST, VECTORS OF ENDEMIC TYPHUS *

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AND
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DALLAS, TEXAS

This report shows that in three instances a subclinical type of endemic typhus was transmitted from a guinea-pig to rats through bites of tropical rat mites, *Liponyssus bacoti* Hirst. It shows that in five instances the disease was transmitted from guinea-pig to guinea-pig by such mites. The evidence is based on temperatures of the animals after infected mites had fed on them and on studies of these infections in other guinea-pigs.

Studies on a human dermatitis caused by bites of tropical rat mites suggested a coincidental occurrence of cases of endemic typhus and tropical rat mites.[1] In the vicinities of Longview and Henderson, Texas, it seemed likely that these parasites were concerned in the transmission of this disease. Records were obtained of thirty-seven persons having symptoms of the disease, and in each instance their blood gave a positive Weil-Felix reaction. Twenty-three of these persons worked in establishments where foods and grains were handled. Such places were favorable for rats and tropical rat mites. At four of these locations, mites were collected and identified as *Liponyssus bacoti.* At Fort Worth and Dallas, Texas, also tropical rat mites were found in locations suspected as origins of three cases of endemic typhus fever.

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* Read before the Section on Practice of Medicine at the Eighty-Second Annual Session of the American Medical Association, Philadelphia, June 12, 1931.

* From the Division of Insects Affecting Man and Animals, U. S. Bureau of Entomology, and of the Department of Dermatology, Baylor University College of Medicine.

1. Shelmire, Bedford; and Dove, W. E.: The Tropical Rat Mite, Liponyssus Bacoti Hirst, J. A. M. A. **96:** 579-584 (Feb. 21) 1931.

Our strain of endemic typhus was obtained from a white man, J. H., aged 40, residing at Dallas, Texas. His past history was essentially negative. One month previous to his admittance into the hospital he took work as a waiter in a café at Henderson, Texas. During this period of service he experienced on the lower limbs bites which he attributed to chiggers or mosquitoes; he did not observe any mites. When the premises of this café were investigated by us, rats were obtained and found to be infested with tropical rat mites.

The patient was admitted to Baylor Hospital, Nov. 1, 1930. There was a typical prodromal period, fever, skin eruption, headaches, delirium, aches and pains over the body, and a Weil-Felix reaction in dilutions of 1:320. During the fourth to the eleventh day following the beginning of fever, the white blood cell count showed an increase from 6,000 to 17,300. On the twelfth day there was a white blood cell count of 14,900. On the eighth day following the beginning of fever, blood was drawn and 2.5 cc. was given intraperitoneally to each of two male guinea-pigs. After nine days, both pigs developed scrotal swellings. By the end of the thirteenth day following inoculation, the swelling subsided. At the autopsy of one of the animals, petechial hemorrhages were found on the surface of the testes. Also, adhesions of the parietal and visceral tunica were present. Whole blood of these animals was used in transferring the infection to other guinea-pigs. On the ninth day following the transfers, the latter animals exhibited similar symptoms. From them, scrapings were obtained of infected areas of the tunica vaginalis. When these were stained by Giemsa's or Castaneda's [2] methods, the presence of intracellular diplobodies was demonstrated. On the fourth or fifth day following inoculation, and when scrotal swelling first appeared, the organisms were easily found in the cytoplasm of endothelial cells. We are indebted to Dr. H. A. Kemp, Baylor University of Medicine, for assistance and confirmations of these observations.

BEHAVIOR OF STRAIN IN LABORATORY ANIMALS

Intraperitoneal inoculations of guinea-pigs were followed by febrile reactions and typical scrotal swellings.

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2. Castaneda, M. R.: A New Stain for Rickettsia Bodies, J. Infect. Dis. **47**: 416-417 (Nov.) 1930.

When inoculations were made some distance from the scrotum, as under the skin of the back, there was a febrile reaction but no scrotal swelling. Such pigs were later found to be immune to inoculations of our stock strain of typhus. When subcutaneous inoculations were made near the scrotum, as in the posterior portion of the abdominal wall, they resulted in fever and scrotal swellings. When injections were made subcutaneously 2 or more inches in front of the scrotum, there was apparently no localization of the infection in the tunica, and scrotal swellings were not present.

The guinea-pig receiving the initial inoculation of whole blood of man showed an incubation period of nine days. After the strain was carried through a few generations in guinea-pigs, the incubation period was reduced to four or five days.

Through the courtesy of Dr. R. R. Parker of the U. S. Public Health Service, Rocky Mountain spotted fever station at Hamilton, Mont., we obtained organs of guinea-pigs infected with Rocky Mountain spotted fever. Cross immunization tests with guinea-pigs demonstrated that the disease known to us as endemic typhus fever is not identical with Rocky Mountain spotted fever.

ENDEMIC TYPHUS PRODUCED EXPERIMENTALLY IN GUINEA-PIGS WITH INOCULATIONS OF CRUSHED MITES

From a cage containing a guinea-pig infected with endemic typhus and a supply of tropical rat mites, twenty-five adult female mites were obtained. They were crushed in physiologic solution of sodium chloride and injected intraperitoneally into a male guinea-pig. On the fourteenth day after inoculation, this pig developed febrile reactions and a scrotal swelling. *Rickettsia* was found in smears made from the tunica. Eight recipient pigs, receiving four inoculation generations of this strain, developed febrile reactions and scrotal swellings. The experiment demonstrated that in this instance organisms of endemic typhus were harbored by female mites. Other experiments were made to determine whether or not the infection could be transmitted through bites of tropical rat mites.

TRANSMISSION EXPERIMENTS

Mites, Guinea-Pigs and Methods Used.—From a residence located at Dallas, Texas, hundreds of tropical rat mites were collected and kept in dry tubes. Persons bitten by mites of this infestation could furnish no evidence of symptoms of endemic typhus fever. Also, tests with the mites indicated that they were free of the typhus virus.

Ten unengorged mites were emulsified in saline solution and injected intraperitoneally into two adult male guinea-pigs. During an observation period of two weeks these animals showed neither febrile reaction nor scrotal swelling. When reinoculated with tunica emulsion of our stock virus, both animals developed typical symptoms of endemic typhus fever. This experiment indicates that the mites were not infected with typhus fever.

Mites from this collection were also allowed to feed on eight fresh guinea-pigs. As none of these animals developed any evidence of endemic typhus fever, it seemed safe to consider our supply of mites noninfected.

The second time these mites were fed, they were placed on an infected guinea-pig. They took blood from a pig on the fifth day after it had been inoculated with our stock strain of the disease. At this time the guinea-pig had a scrotal swelling and a temperature of 105 F. Following this engorgement, the mites were transferred to a number of clean, dry test tubes and kept at air temperatures of approximately 70 F. The mites were now considered infected with endemic typhus. After intervals of four, seven and ten days, different mites of this lot were placed on different guinea-pigs and allowed to take meals of blood. The guinea-pigs used in these experiments had shown no fever after they had been bitten by uninfected mites. Following bites by the infected mites, the pigs were isolated and kept under observation. When their temperatures were suggestive of infection, they were killed. At autopsy, the tunica, brain or spleen was ground in a sterile mortar with physiologic solution of sodium chloride and used for inoculations of other animals. Some of the guinea-pigs receiving such inoculations were killed in order to obtain material for transferring the infections and for the demonstration of organisms. Other pigs were used in tests to determine whether or not there was a development of immunity to our stock strain.

Guinea-pigs used in our experiments were kept in separate cages and isolated with moats of water. The adult mites engorged within one to three hours and were collected as soon as they had taken a meal of blood. The guinea-pigs did not attempt to eat the mites. When albino rats were used in these experiments, it was necessary to fit their necks with metal collars in order to prevent them from eating the mites.

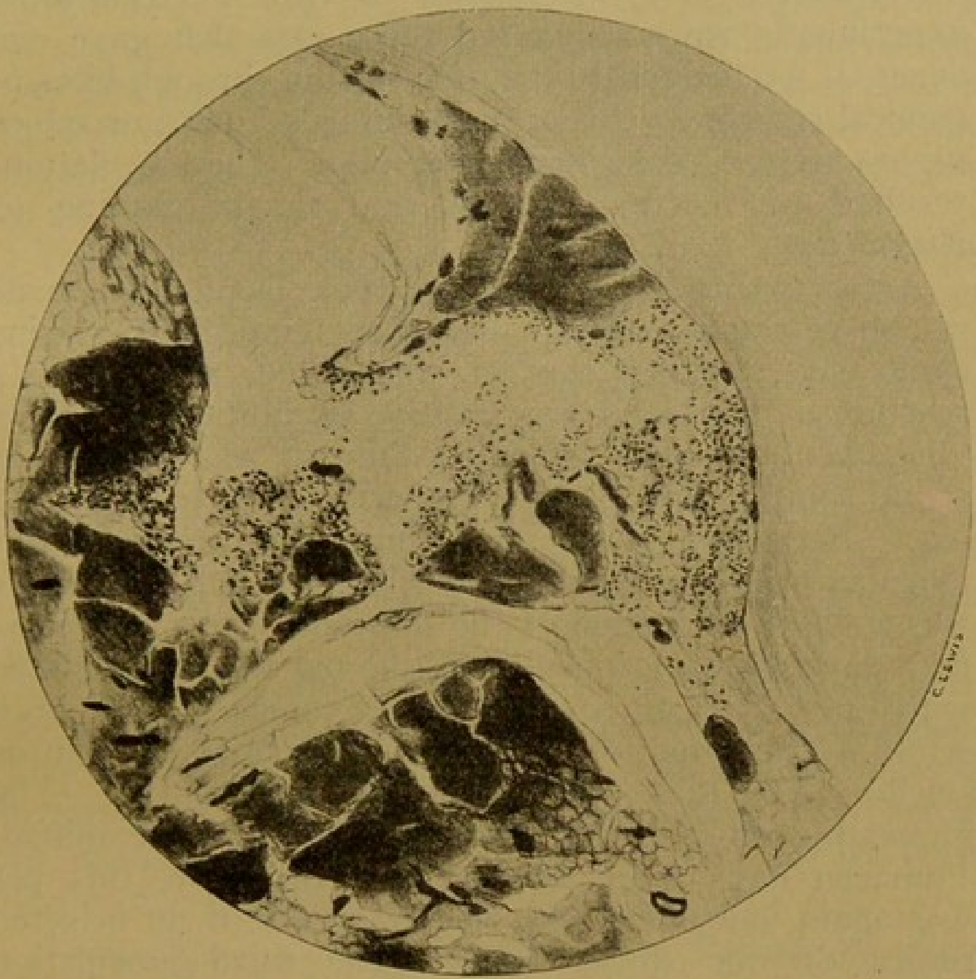

Fig. 1.—Microtome section of a female tropical rat mite showing an infection of a muscular attachment by Rickettsia. Four days before fixation the mite fed on blood of a guinea-pig infected with endemic typhus. Alcoholic sublimate and Giemsa.

Bites of Tropical Rat Mites That Did Not Furnish Evidence of Transmission of the Disease.—With both guinea-pigs and rats we encountered animals that did not receive infections of endemic typhus through bites of tropical rat mites, or such infections were not recognized. Since three of ten rats employed in our early experimentation were found infested with tropical rat mites when purchased from a dealer, and since two rats from this series were found immune to infection with our stock strain of virus, it is possible that our negative results were occasioned by our working with rats immune in nature. With serums of rats later obtained from this source, positive Weil-Felix reactions were obtained. Investigation revealed that these animals were reared in a district where typhus had recently been reported.

Bites of Tropical Rat Mites That Transmitted a Subclinical Type of the Disease to Rats.—During other experiments we encountered three rats that gave evidence of a subclinical type of infection through bites of tropical rat mites. From these animals, tunica or spleen tissues were used in inoculating pigs. The inoculations resulted in febrile reactions and in the finding of *Rickettsia.*

After twenty infected mites took blood of a male rat, there was no abnormality in its temperature during eight days. When the rat was killed, a Weil-Felix reaction of the blood was positive in dilutions of 1:40. One twentieth of a tunica of this rat was crushed in saline solution and given intraperitoneally to a guinea-pig. Six days after the guinea-pig received this inoculation, its temperature reached 104.6 F. and there was a slight congestion of the scrotum. On the twenty-fifth day following inoculation, the pig was reinoculated with one twentieth of an infected tunica of our stock strain. This was not followed by a febrile reaction or swelling like that observed in the control pig. The guinea-pig was therefore considered an immune animal. Fourteen days after the second inoculation, this pig was again inoculated with one twentieth of an infected tunica of our stock strain. The third inoculation resulted in a febrile reaction and swelling of the left side of the scrotum. This reaction is interpreted to mean that a temporary immunity was established in the pig. The experiment is interpreted to mean, also, that infected mites transmitted a subclinical type of endemic typhus to the rat.

Infected mites were allowed to feed on a male rat for a period of twenty-four hours. The temperature of the animal did not exceed 101.4 F., and there was no evidence of scrotal swelling during the following ten days. At autopsy, a Weil-Felix test of the blood was negative in all dilutions. A tunica was crushed in physiologic solution of sodium chloride and one twentieth of it was given intraperitoneally to a male guinea-pig. On the fifth day following inoculation, the pig developed a temperature of 106.8 F. and the scrotum showed characteristic swelling. At autopsy on the eighth day following inoculation, the tunica and surface of a testicle were markedly hemorrhagic. Scrapings made for endothelial cells of the tunica vaginalis demonstrated the presence of *Rickettsia*. One twentieth of an infected tunica of this pig was crushed in physiologic solution of sodium chloride and used successfully in inoculating two other guinea-pigs. This experiment shows that a rat bitten by infected tropical rat mites may harbor the organism for at least ten days and show no symptoms of the infection.

Infected mites were allowed to feed on another male rat for a period of twenty-four hours. During a period of twenty-one days the rat showed no abnormalities in temperature. At autopsy, organs were used in inoculating two guinea-pigs. Five days after these injections were made, each of the two guinea-pigs had moderate swellings of the scrotum, and temperatures between 104 and 105.6 F. were recorded. Endothelial cells of the tunica of one of them were found to be infected with *Rickettsia*.

After sixteen days the other pig was reinoculated with our stock strain of the disease and found to be immune. The test shows that a rat may obtain a subclinical infection of endemic typhus through bites of tropical rat mites and may harbor the organism for at least twenty-one days.

Transmissions of the Disease After Periods of Four and Ten Days.—Four days after mites were allowed to take blood of an infected guinea-pig, two lots of seven mites each were allowed to feed respectively on two guinea-pigs. One of these animals did not develop abnormal temperatures. Crushed tunica of this animal was injected into two guinea-pigs, but it did not produce in them fever or swelling. One of the latter pigs was subsequently found to be susceptible to our stock strain of the disease.

The other pig receiving bites of the mites four days after they had fed on an infected animal developed fever. Transfers of the supposed infection to another guinea-pig resulted in fever and subsequently in immunity to our stock strain of the disease. A microtome section of one of the mites (fig. 1) shows an invasion by *Rickettsia.*

Ten days after adult mites were fed on an infected guinea-pig, seven of the mites were allowed to engorge on a "clean" guinea-pig. During twenty-nine days there was no evidence of infection. A reinoculation of the animal with our stock strain resulted in a typical infection.

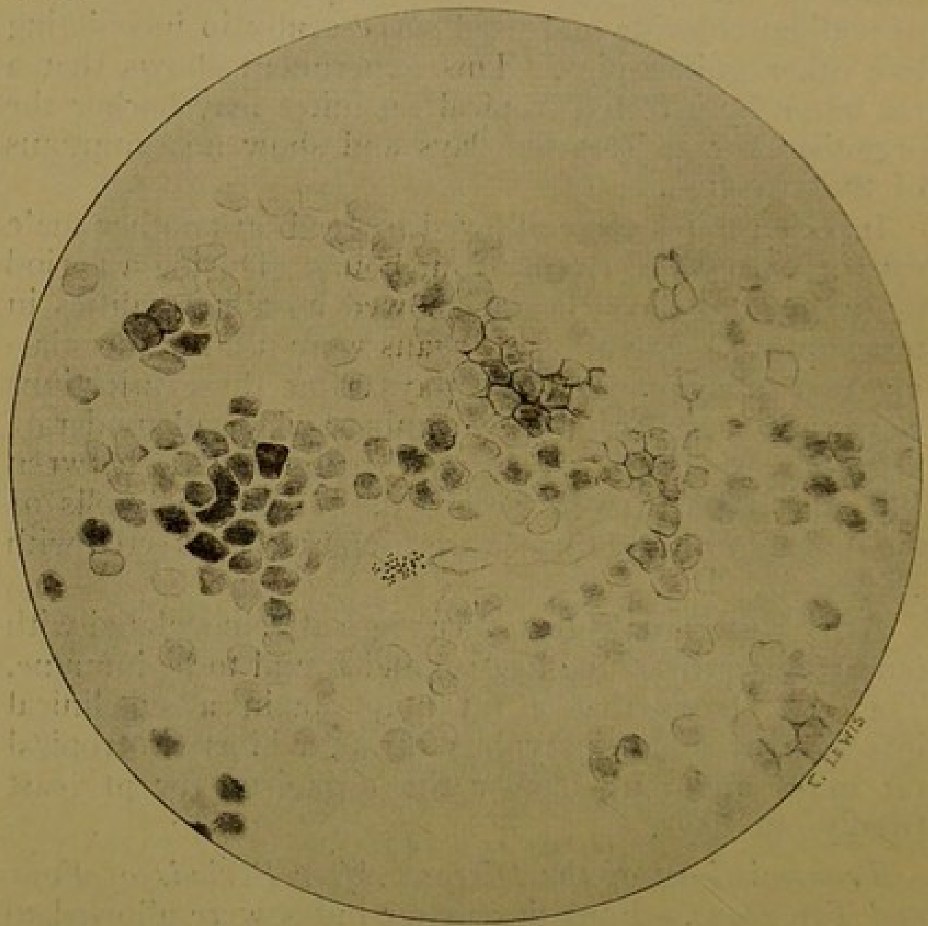

Fig. 2.—Microtome section of brain of guinea-pig. Note Rickettsia in wall of ruptured blood vessel of the parietal lobe. Fixation on the fourth day of fever, seventeen days after ten infected female tropical rat mites fed on guinea-pig. Formaldehyde and Giemsa.

Transmission of the Disease After Periods of Seven Days.—Seven days after mites had fed on the blood of an infected guinea-pig, five experiments were made with mites. In four of these tests the animals became infected with endemic typhus fever.

A pig receiving bites of six adult female mites developed fever on the ninth day. At autopsy on the eleventh day, blood was given intraperitoneally to guinea-pig 78. The latter animal developed fever, and at autopsy petechial hemorrhages were present on the upper pole of a testicle. Microtome sections made of one of these hemorrhages demonstrated the presence of *Rickettsia*. The infection was transferred to guinea-pig 87. Subsequently the symptoms and observations on this animal were comparable to those observed in guinea-pig 78.

Another transmission of the disease was obtained through the bites of six adult mites on guinea-pig

Fig. 3.—Microtome section of testicular cord of guinea-pig showing hemorrhage and an infection by Rickettsia. This is an example of hereditary transmission of endemic typhus. The infection passed from the adult mite through the egg to its offspring. It was transmitted to a guinea-pig through bites of the larval mite. Formaldehyde, iron hematoxylin and Giemsa.

52. The animal developed a fever and was killed on the tenth day following the bites. Blood and spleen from this pig were used in inoculating guinea-pigs 72 and 73. Both of these pigs developed fever. One was subsequently found to be immune to our stock strain of the disease. The other pig was killed for material to be used in inoculating other guinea-pigs.

The animals receiving inoculations from this pig developed small hemorrhages on the tunica vaginalis. Microtome sections made of an adhesion of the tunicas of one of these animals, guinea-pig 89, demonstrated the presence of *Rickettsia*.

A third experiment, made on the seventh day after mites had fed on an infected animal, demonstrated another transmission of the disease. Guinea-pig 66 was bitten by ten adult female mites. Sixteen days later it developed fever. On the seventeenth day the animal was killed and brain tissues were given intra-

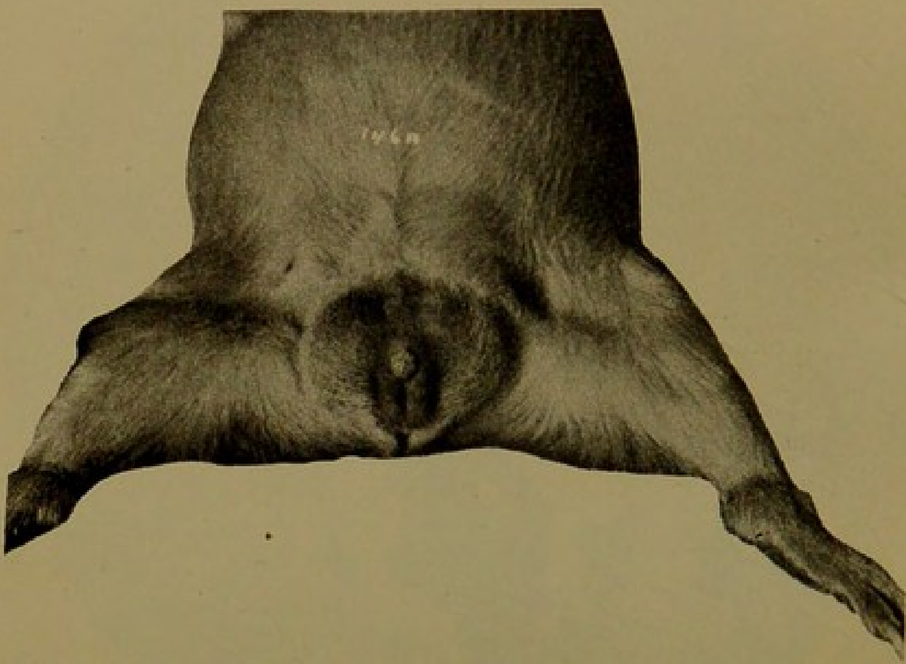

Fig. 4.—Pig 146 A at time of inoculation with emulsified organs of mite-infested rat 146.

peritoneally to guinea-pig 98 (fig. 2). By the end of the fifth day the latter animal had fever. At autopsy, small hemorrhages were found on the tunica vaginalis. A portion of the tunica was cut into microtome sections. Proliferating and swollen endothelial cells demonstrated the presence of *Rickettsia*.

Transmission of the Disease in Larvae Hatched from Eggs of Infected Mites.—Female mites engorging with blood of a guinea-pig infected with typhus were transferred to clean dry tubes and kept at 60 to 70 F. By the end of the fourth day, both larvae and eggs of mites were present. At this time the female mites were transferred to other tubes, so that the eggs and larvae remained in the original tubes. By the end of the seventh day, the original tubes contained only hungry larvae. At this time fifty of the larvae were placed on guinea-pig 53. The animal developed fever. At autopsy on the eleventh day, its blood and brain were given intraperitoneally to two guinea-pigs. Both of them developed fever. One of them was found subsequently to be immune to our stock strain of the disease. Four days after the other pig (77) received crushed spleen and brain intraperitoneally, scrotal swellings were produced. At the end of four days an autopsy was performed on the animal. Microtome sec-

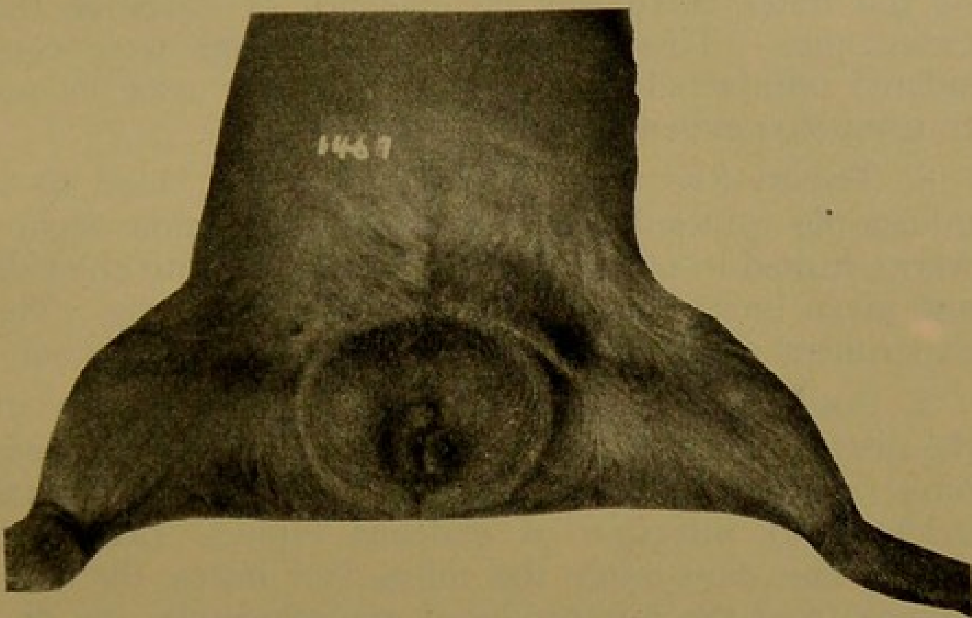

Fig. 5.—Pig 146 A eight days after inoculation with emulsified organs of mite-infested rat 146.

tions made of the cord of this animal demonstrated the presence of *Rickettsia* (fig. 3). This strain was carried through three inoculation generations in guinea-pigs. In four different animals examined, *Rickettsia* was found in smears or sections of the tunica. In four instances, also, in two rats and two guinea-pigs, the animals receiving inoculations of this strain demonstrated that they were immune to subsequent inoculations of our stock strain.

The test demonstrates experimental transmission of endemic typhus from guinea-pig to guinea-pig through bites of tropical rat mite larvae. It demonstrates that infections may pass from female mites through their eggs to the larvae and that such larvae are capable of infecting guinea-pigs.

SUMMARY AND CONCLUSIONS

1. During a high seasonal incidence of endemic typhus in northeastern Texas, a patient having typical symptoms of the disease and a positive Weil-Felix reaction in dilutions of 1 : 320 furnished blood for our experimental strain of this disease.

2. Cross inoculations with a strain of Rocky Mountain spotted fever show that these are different diseases.

3. Mites and guinea-pigs were obtained from separated localities and from premises where there were no indications of typhus infection of man. Following bites of the mites there was no evidence of fever in the guinea-pigs. These mites and guinea-pigs were considered uninfected and were subsequently used in our transmission experiments.

4. Twenty-five mites engorging on the blood of a guinea-pig infected with our strain of endemic typhus were crushed in physiologic solution of sodium chloride and given intraperitoneally to another guinea-pig. The experiment resulted in infection of the latter animal.

5. Positive subclinical evidence of transmission of the disease was obtained when three male rats receiving bites from our infected supply of mites gave no clinical evidence of infection of endemic typhus. Ten and twenty-one days after the mites had bitten the rats, tissues from the rats produced experimentally the disease in guinea-pigs.

6. Four days after "clean" mites fed on the blood of a guinea-pig infected with endemic typhus, the mites fed on another guinea-pig and produced a febrile type of the disease.

7. Ten days after "clean" mites fed on a guinea-pig infected with endemic typhus, they fed on a guinea-pig, and this did not subsequently show clinical evidence of transmission.

8. Seven days after mites fed on the blood of an infected animal, four positive transmissions of endemic typhus were obtained in five tests. The disease was transmitted experimentally from guinea-pig to guinea-pig through bites of tropical rat mites.

9. Positive evidence was obtained experimentally in hereditary transmission of endemic typhus by mite

larvae. The female mites engorged with blood of an infected guinea-pig. Seven days later, when eggs of these females had hatched, the young larvae fed on a "clean" guinea-pig. The guinea-pig receiving bites of the larvae developed endemic typhus.

10. In experiments reported herein, four rats and ten guinea-pigs were used in the transmission of endemic typhus through bites of tropical rat mites. Positive evidence of transmission of the disease was obtained in eight instances.

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NOTES ON THE TICK, *ORNITHODOROS TALAJE* (GUER.), INFESTING A HOUSE IN THE CANAL ZONE

By LAWRENCE H. DUNN

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NOTES ON THE TICK, *ORNITHODOROS TALAJE* (GUER.), INFESTING A HOUSE IN THE CANAL ZONE

BY LAWRENCE H. DUNN

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On February 27, 1929, while at Gatun, Canal Zone, I learned through conversation with Dr. R. P. Curry, Assistant Chief Health Officer of the Canal Zone, and Sanitary Inspector C. A. Roach, of the Gatun District, that a short time previously the occupants of one of the houses at Gatun had complained of their quarters being infested with ticks that were biting them and causing considerable annoyance. They had collected several specimens of these ticks and brought them to the office of the District Physician at Gatun. From there they were sent to the Board of Health Laboratory, at Ancon, Canal Zone, where they were identified as *Ornithodoros talaje*.

Although I had been giving considerable attention to *O. talaje* in Panama for a number of years, this was the first time that I had learned of any definite reports of this species attacking man. Neither had I heard of their being found in houses in the terminal cities of Panama and Colon or in the American villages in the Canal Zone, although many of the rats captured in these places are usually heavily infested with the larval forms of this species. Nymphal and adult forms had been collected only in native huts in some of the interior villages where they were generally found in company with numerous *Ornithodoros venezuelensis* Brumpt. In view of these facts I was greatly interested to learn of this species being present in a dwelling at Gatun and attacking man and wishing to observe the conditions that prevailed, Dr. Curry, Mr. Roach and I visited the infested quarters. The house was one of the regular Canal Zone type of four-family wooden quarters, and it was in one of the two downstairs apartments that the ticks were located. The occupant of this apartment was an American family, consisting of Mr. X, his wife and a ten year old son.

Mr. X was a civilian employee of the U. S. Army and had been occupying these quarters for a period of about three months. The previous occupant, so far as known, had made no complaint of being annoyed by arthropods in the house.

The X family began to be attacked soon after moving into the apartment. Since these attacks seemed to occur only at night and while in bed, it was at first suspected that the apartment was infested with bedbugs. A search was made which failed to reveal any bedbugs, but did result in several of the ticks being found.

The furniture in the house was all supplied through United States government channels, but there were two single beds in one room that had been used by the former occupant. Believing that these beds might be the source of infestation, Mr. X placed them in a storeroom and purchased new ones.

At the time of our visit, Mrs. X gave me a bottle containing ten of the ticks. These had been found during the thirty-three days that had elapsed since the previous lot had been collected and sent in for identification. Four of these were apparently second stage nymphs and six appeared to be in the third stage. All were flat and seemingly unfed and none had molted while in the bottle. Several of these specimens had been found on the white spreads covering the beds and the family believed that they were dropping from the ceiling.

The bedroom was lined with narrow matched pine boards and had been well painted. There were many crevices between the boards, however, that would provide hiding places for Ornithodoros, but a close search aided with flashlights and probing along in the crevices with toothpicks gave only negative results.

The two single beds, which were of iron, that had been placed in the storeroom were examined, and two cast nymphal skins of *O. talaje* were found in a joint in one of the frames.

Upon inquiry regarding the presence of rats in the house, Mrs. X informed me that when they first moved into the apartment, the place was badly infested with them. Efforts were at once made to get rid of these rodents. A carpenter closed all rat holes that could be found in the apartment. That these efforts proved to be successful was evidenced by the fact that no rats had been seen for some time.

On April 6th, Inspector Roach visited the house, and at this time was given a bottle containing twelve of the ticks. These were also second and third stage nymphs, and had been collected during the thirty-eight days since our former visit.

On May 29th, I again visited the house, and at this time Mr. X was suffering from the effects of the bites of three of these ticks. Two of his fingers were badly swollen and were in bandages. The third bite was on his back and had produced a severe local reaction with swelling, considerable irritation and several large wheals appeared in the surrounding area. Two of the ticks had been found a few days before my visit and both of these were third stage nymphs. Mr. X stated that he had taken one of these ticks after it had dropped on one of the beds from the ceiling. Mrs. X claimed that she had swept several from the cracks in the floor of the bedroom.

On September 20th one more tick was received. This was an adult male that had been taken while feeding upon Mr. X.

No more specimens were received from this house, and upon making inquiries a few weeks later I was informed that the family were no longer being bitten and that no more ticks were being found in the apartment.

The twenty-five ticks that I received from this house probably fell short of the total number that was found during that time. It is quite reasonable to believe that many more were destroyed when found and not collected alive.

I am of the opinion that rats were responsible for bringing the *O. talaje* to this apartment. It is quite probable that after the rodent hosts had been either destroyed or prevented from returning to their hiding and nesting places in the apartment, the engorged larvæ that had dropped from them had, after molting and becoming nymphs, been forced to seek their blood meals from the human inhabitants. Since the larvæ of this species remain attached to the host for several days while engorging and none in this stage had been observed by the X family, it is reasonable to believe that if larvæ had hatched from eggs deposited in the house they were not existing upon human blood.

It seems rather remarkable that during the time these ticks were present in the X apartment, the other parts of the house seemed to be free of them. The families occupying the other three apartments stated that they had not been bitten by the ticks and none had been found in their rooms.

Observing the effects produced on Mr. X by the bites of these ticks I fed seven of them on my left forearm in order to study the reaction upon myself. There was a considerable delay in getting them to start feeding, but after they began taking b'ood they all became well engorged and secreted coxal fluid. The longest time required by any of the seven to engorge was sixteen minutes. Five of them were induced to feed by placing them one at a time in a tube applied to the same spot on my arm. Thus all five fed on the same site and each of the last four apparently used the same tiny puncture made in my skin by the first one. The reaction from these bites consisted of a slight swelling with a well-marked hæmorrhagic area surrounding the site of each bite and accompanied by a severe itching which occurred at intervals during the three or four days following the bites. Naturally the effects produced by the multiple bites at the same site were much more pronounced than at the sites of the two single bites. Since the reaction I experienced was so much less severe than in the case of Mr. X, I am led to believe that there is a considerable difference in the susceptibility of individuals to the effects of bites from these ticks.

My thanks and appreciation are due Dr. D. P. Curry for information regarding this house infestation, and to Sanitary Inspector Roach for his kindness in visiting the house on several occasions to secure information and ticks for me.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 986

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. ▼ December 3, 1921

STUDIES ON THE BIOLOGY AND CONTROL OF CHIGGERS.

By H. E. Ewing, *Specialist in Mites.*

CONTENTS.

INTRODUCTION.

Notwithstanding the obvious economic importance of chiggers, and an almost universal acquaintance with their injury, little has been done in the past to ascertain their habits in nature or to find efficient methods for their control. Because of these facts the writer decided early in the season of 1919, with the approval of Dr. L. O. Howard, Chief of the Bureau of Entomology, to begin a series of experiments and observations on their biology and control. The work was started in June of that year and continued until the fall of 1920. For various reasons it was thought advisable to discontinue the work then for some time, hence the results thus far obtained have been prepared for publication. It is the expectation of the writer, in the near future, not only to complete the life history for at least one of our species, but to give a synopsis of the taxonomy and distribution of the species occurring in the United States.

SPECIES CONCERNED.

Years ago C. V. Riley (*10*)[1] described from this country ("southwestern States") two chigger species under the familiar names of

[1] Reference is made by number (italic) in parentheses to "literature cited," page 19.

Leptus americanus and *Leptus irritans*. Although these names have been used frequently in American literature dealing with economic entomology, and the figures of Riley's two species often copied, the present writer is bound to confess that after studying carefully Riley's descriptions and figures and some of his microscope slides (types?) he has been unable to correlate either *americanus* or *irritans* with the two species with which he is familiar. Further than this, it can now be fairly definitely stated that *americanus* is not a species of Trombidiidae at all, but is rather a species of the family Erythraeidae, a group to which the genus Leptus really belongs, as Riley's figure clearly shows. *Leptus irritans* is the larva of a species of Trombidiidae, but the characters given by Riley are not even of generic value; hence it appears that it will never be known certainly what species his *irritans* is.

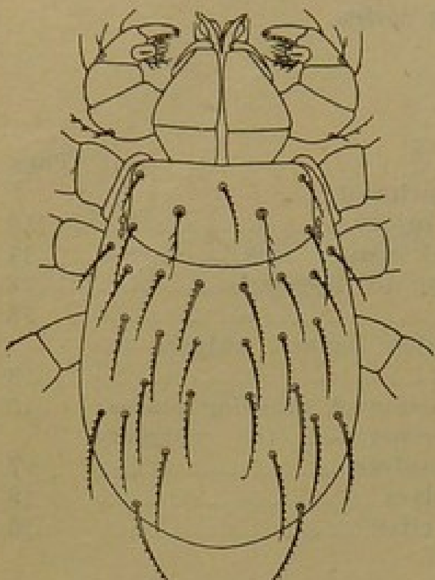

FIG. 1.—Dorsal view of an American chigger (legs omitted), X 150. This drawing was made from specimens in the University of Minnesota collection, which were taken at Lake Minnetonka, Minn.

In New Jersey, Maryland, the District of Columbia, Virginia, and southeastern Iowa there is apparently a single chigger species. The writer has examined many specimens from these sections and finds that they are all the same.

In the northern and western part of the United States there is another very closely related species which has the body shaped exactly like the first mentioned but has more dorsal spines on the abdomen, and fewer branches or barbs on the palpal setæ. This is the species studied by C. W. Howard (*6*). Specimens have been examined from Minnesota and Kansas.

NOTES ON SEASONAL HISTORY.

Chiggers are especially pests of the summer months, as has long been known, but the period of their activity has not been known, even relatively. During the year 1919, at Washington, D. C., the date of the first record of larvæ attaching themselves to man was July 2, and by July 17 larvæ were present in great abundance. On the latter date the writer was severely attacked. During the remainder of July and the whole of August the chigger larvæ continued in great abundance, and almost daily records of their attacks were obtained. In September the attacks were much less severe, yet continued. On September 22 several larvæ attached themselves to man at Chesapeake Beach, Md. No records for the northern part of the United States of chigger attacks in October have been brought to the writer's attention, but some of the larvæ are probably active during this month.

During the season of 1920 the chiggers were first noted in southeastern Iowa on June 24, when several attached themselves at Keosauqua, where they were present in the State park.

How chiggers pass the late fall and winter is not known, and will not be known until more work is done on the life history of the species and something is known of the nymphal and adult instars.

LOCAL DISTRIBUTION.

Investigations of the last year and a half have thrown much light upon the local distribution of our chiggers, which in turn may furnish the clue for locating their natural hosts and thereby give us an opportunity to rear the larvæ to maturity.

Around Washington, D. C., the chiggers usually have been encountered where there was a heavy growth of wild brush or blackberries. They are not found in cultivated fields or where the ground is bare or in well-kept parks and lawns. Usually they are absent from meadows and from weed patches unless some kind of growth of canes or shrubbery is present. They are always encountered to some extent in woodlands, but are present in great numbers only where there is a considerable growth of underbrush.

In the State of Iowa the chiggers have an even more interesting distribution. Here whole counties in the northern part of the State are apparently free from them notwithstanding that conditions for them seem ideal. The writer has collected mites for years about Ames, Iowa, and on many occasions has made special trips in search of chiggers, but has never found a single specimen in this locality. Yet the town of Ames is almost surrounded by woods and hemmed in by two creeks, and there are situations almost exactly like those along the lower Des Moines River, where chiggers are abundant.

Judging from the records up to date, chiggers are only present along the main river courses in the south-central, southeastern, and eastern parts of Iowa. From the city of Des Moines north along the Des Moines River the writer has not been able to collect specimens, although the attempt was made in several localities.

The environment found necessary in Iowa is the same as that in Virginia or Maryland, since nearly all the land is given over to cultivation; however, chiggers are found only in a relatively small area, while in the East they are found over very extensive ones.

HABITS OF UNATTACHED LARVÆ.

The belief has been almost universal that chiggers in this country are found in the grass. Observations have failed to confirm this theory. It was found that our northeastern species occurs almost exclusively at or near the surface of the soil. In this respect the larvæ differ from tick larvæ, which climb up on vegetation of various kinds and remain in wait for a host. People frequently get chiggers when they go into the grass, but our eastern species approaches from the ground. The mites can be found in surface scrapings, but repeated attempts to recover them from growing vegetation have failed.[2]

If chiggers attack man almost solely from the ground the question may be asked, How are we to account for attachments around the waist, under the armpits, and about the eyes? Again, observations show that chigger attacks are seldom made above the waistline, unless the clothes are quite loose around the waist, or the individual has been sitting or reclining on the ground. When one simply walks through a chigger-infested region, the larvæ are first found about the feet and ankles. Here they can be seen with a hand lens. They run with great rapidity, so fast in fact that it is very hard to catch them. From the ankles they spread upward, few as a rule attaching here, unless the clothing is tight; if so, many may attach. As they pass upward many of the larvæ either stop themselves or are stopped at the garters, if these are worn below the knees. If they pass the garters large numbers will attach in the space under the knees. Those that pass the knees usually go as far as the waistline before they attach.

Two factors are of importance in regard to the localization of chigger attachment—the tightness of the clothing at certain parts of the body and the thickness of the skin. The garters around the legs and the belt around the waist act as semieffective barriers. For a great many minutes, sometimes for a few hours, the larvæ run over the skin hunting a favorable place of attachment. These rapidly moving larvæ are halted by the garter or belt pressure, and after struggling some time either to pass through the mesh of the clothing at these points or to extricate themselves may attach without further search. The writer has watched these active larvæ on the skin of man before and after attachment and finds that tight clothing does not aid them in "digging in" by furnishing a fulcrum, as has been supposed. In fact, it was found experimentally that chiggers do not "dig in," as has been so frequently stated, but remain attached externally like a tick does.

The thickness of the skin is of great importance in localizing chigger attachments. Where the skin is unusually thick the larvæ attach with great difficulty or not at all; and of those that do attach

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[2] Dr. F. H. Chittenden has reported to the writer chigger attacks coming from overhead vegetation. The writer has never experienced such attacks, and up to the time of the preparation of this paper none had been reported to him. It may be that a second species, which is relatively rare, occurs in this vicinity, as Dr. Chittenden suggests.

many can not remain attached during the body movements of the host or are not able to reach the lymph supply of the true skin and engorge. Of the thousands of chigger attachments observed by the writer, not a single one was found on the calloused parts of the hands or feet.

HOSTS.

It was the belief of earlier entomologists that chiggers lived upon the juices of plants. That C. V. Riley shared this common belief is evident from the following statement (*10*) which he made in regard to one of his species:

> The normal food * * * must, apparently, consist of the juices of plants and the love of blood proves ruinous to those individuals who get a chance to indulge it.

When it was learned by actual rearing experiments that several of the species of Trombidiidae were normally parasitic on terrestrial tracheates, this older theory was dropped, and it was commonly assumed, and frequently stated, that the chigger larvæ were normally parasitic on insects and closely related invertebrates. This belief was equally shared by the mite specialist and the general entomologist; but that the chigger larvæ could be normally parasitic on vertebrates was never suspected; in fact, the references to their "death feast" on man or domestic animals continued as numerous as before.

When the writer began, in the summer of 1919, his search for the natural host of the species occurring in Virginia and Maryland, he collected all insects found parasitized with trombidiid larvæ. These larvæ were examined to see if any of them belonged to the species attacking man, or were in fact true chiggers. Although many insects and other tracheates were found parasitized, in no instance did these parasitic larvæ prove to be the species attacking man.

Not satisfied with this method of investigation, another was instituted. On some vacant lots that had grown up to a considerable extent in blackberries and which were very heavily infested with chiggers (over a hundred attached in less than two hours), insects of all kinds were collected. There were hundreds of them and scores of species.

These insects were taken to the laboratory and examined both alive and after killing in cyanide bottles, and in no case was a single specimen of our eastern chigger found. The sweepings and other collections were so thorough that this observation convinced the writer that the chigger found in the vicinity of Washington is not a normal parasite on terrestrial tracheates that live above the ground.

Although never believing in the old vegetarian theory of the earlier entomologists, the writer decided to give this theory a test. First a minute examination was made of the blackberry plants, including all parts both in and above the ground. Not a single chigger was found on them. Then the examination was extended to the other plants growing on the vacant lots—goldenrod, several grasses, and a number of common weeds. Each plant species was taken by itself, specimens were pulled up, shaken over white paper, taken to the laboratory, and even examined in parts with the microscope. After several days of fruitless attempts to locate the larvæ feeding on plants the work was stopped, for evidently they could not have been feeding normally on these, or at least a few of their enormous numbers would have been encountered.

About this time there appeared in this country the extensive paper by Drs. T. Kitashima and M. Miyajima (*7*) entitled, "Studien ueber die Tsutsugamushi-krankheit," in which is given, among other things, a summary of the work on the life history and habits of the Japanese chigger, *Trombicula coarctata* Berlese (*1*). These writers claimed to have reared this chigger mite from field mice and to have established the fact that it was normally parasitic on the same. A few days later Dr. Miyajima, who happened to be visiting in this country, called at the Bureau of Entomology while in Washington. During his stay he reiterated his statement that the Japanese chigger was normally parasitic on field mice and also said he believed that it normally parasitized various other mammals.

Following the conference with Dr. Miyajima, it was decided at once to investigate the small rodents which were known to exist in the vicinity and on the ground of the infested lots. A dozen traps were procured and trapping began with these on September 13 and continued until September 24. In all, traps were set in 21 different situations, including 13 in the infested area and 8 on adjoining uninfested ground. Small mammals, chiefly rodents, were caught and examined microscopically in the laboratory as follows:

September 13	4	September 18	2	September 23	1
September 15	3	September 19	1	September 24	1
September 16	1	September 20	1		
September 17	2	September 22	1		

In all, 17 small mammals were caught, all within 11 days. Among those obtained the following were determined by Dr. Ned Dearborn, of the Bureau of Biological Survey: House mouse (*Mus musculus*); common meadow mouse (*Microtus pennsylvanicus*); short-tailed shrew (*Blarina brevicauda*).

Not only were the skins of these mammals examined carefully, but the ears and some of the other parts were removed and washed violently in alcohol and the washings examined. As a result of these examinations not a single chigger was found.

This examination of the small mammals of the infested area, it should be noted, was made late in the season. It is possible that if the trapping had been done earlier, different results would have been obtained. During the summer of 1921 such trappings are planned for the months of June and July. It will be interesting to observe the results.

Among other hosts held under suspicion were reptiles. Tortoises were found in the vicinity of the infested area. These were caught and examined, but no chigger larvæ were found. Early in July, 1920, Mr. William Palmer, of the National Museum, captured a large king snake, *Lampropeltis getulus getulus*, at Chesapeake Beach, Md., that had hundreds of mite larvæ attached to its skin, between the scales. He brought the snake to the Museum, and when it was shown to the writer a few days later it had molted. In the cast skin were found hundreds of trombidiid larvæ in various stages of engorgement. An examination of these showed them to be no other than the chigger that attacks man along the Atlantic slope. Parts of the cast skin with chiggers attached were placed in breeding cells, and chiggers that appeared fully engorged were likewise placed in breeding cells, but in neither case did any of the larvæ transform into nymphs. Those attached to the skin of the snake remained attached and soon died unless forcibly removed. The actions of the chiggers in remaining attached to the skin after the latter was cast and their dying in this attached position would seem to show that the king snake is not a natural host. Further, it is known that chiggers exist in enormous numbers where very few snakes of any kind are found.

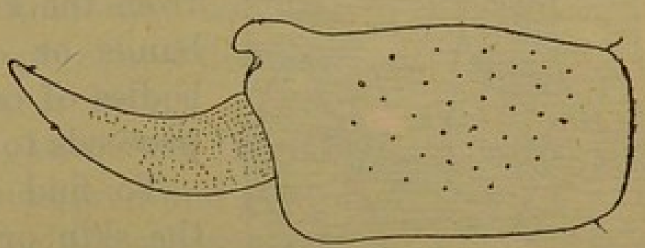

FIG. 2.—Right chelicera of a chigger-mite larva from the inside, X 1,200. Drawing made from specimen taken at Lake Minnetonka, Minn., and belonging to the University of Minnesota collection.

The determination of the natural hosts of our American chiggers has not been made. Further investigation along this line is needed.

INJURY.

CHIGGER INJURY CONFUSED WITH MANY OTHER KINDS OF INJURY.

Of the many complaints about chiggers that have come to the writer, a very large number, fully one-half in certain sections, were found upon investigation to be due to hives, caused by the disagreement of some food eaten and probably accentuated by hot weather. A very large number of complaints supposed to be concerning chigger attacks were found to be due to nettling from some thorned plant. Serious attacks in a front lawn in Virginia, reported to be due to chiggers, were found to be due to *Hyletastes missouriensis* Ewing, a gamasid mite, the habits of which are not well known.

Injury from fleas is very similar to the first-stage injury of chiggers, and since fleas soon leave their hosts and chiggers are so small that they frequently are overlooked, flea injury is mistaken for chigger injury. A careful examination with a hand lens will enable one to see the attached chiggers and prevent confusion of flea injury with an attack by chiggers.

DO CHIGGERS PENETRATE THE SKIN?

Both among entomologists and the public generally there is a belief that chiggers burrow into the skin. C. V. Riley (*10*) states in regard to his *irritans* that "This mite is able to bury itself completely in the flesh." In speaking of the same chigger, Osborn (*8*, *p. 252*) sys: "It is brushed from the leaves of various plants onto the hands or clothing of people and to the bodies of other animals, and the mite then proceeds to burrow into the skin."

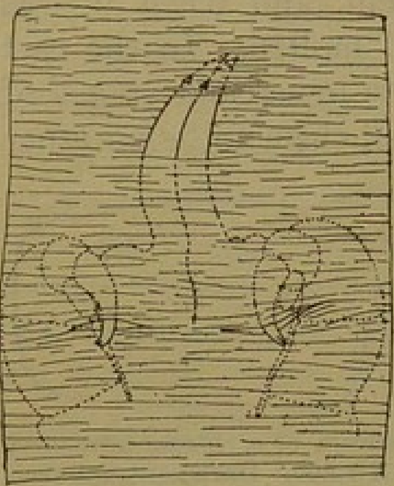

FIG. 3.—View showing the method of attachment of a chigger (northeastern species). Drawing of a part of a "slice" of skin, made from the underside while the larva was attached.

To find out whether chiggers penetrate the skin or not, and also to observe their injury, resort was made to experimentation. On July 15, 1919, the writer exposed the left calf and ankle to chigger attack, and after the mites had settled numbered 10 individuals by writing on the flesh near the mite with ink. Daily observations were made on these chiggers, using low and high power lenses, for the next eight days. It was observed on the first day that the mites attached only by their mouthparts and in no way burrowed into the skin. Observations on the second day showed no change; in fact, after once attaching to the skin by their mouthparts the larvæ became quiescent and did not change their position until they dropped off.

By means of a razor blade several individuals were removed by slicing off a small area of the epidermis around them. When this "slice" of epidermis was examined under a high-power microscope objective it showed the attachment as represented in figure 3. The hooked and ventrally barbed cheliceræ were thrust into the epidermis only, and the palpal claws were found forced downward and backward into the epidermis. After both the chelicerae and the palpi have been inserted in this fashion they hold the larva locked, as it were, to the skin. This was made evident by watching the actions of larvæ with high-power objectives after they had been removed with a "slice" of epidermis. They wriggled first one way, then another, pulled with all their strength backward and forward, gave side twists, and in fact strained in almost every possible way until released. One individual was timed during this process, and it took it seven minutes to free itself from the hold it had obtained on the epidermis.

These observations were repeated upon a lot of 16 individuals for nine successive days. They were numbered as before, and daily observations made upon them. Not only did none of these larvæ burrow into the skin, but they remained attached only by their mouthparts and engorged like ticks. Later they released this hold and fell off.

DO CHIGGERS ENTER THE PORES OF THE SKIN?

Some authorities, while not believing that chiggers burrow into the skin, yet hold that because of their minute size they enter the pores and thereby cause much inflammation and other injury. This point has been carefully investigated. Of the 26 numbered individuals that were observed and studied daily, 21 were attached to the smooth surface of the skin, while 5 were attached at the bases of hairs, each having the capitulum thrust into the mouth of the hair follicle as shown in figure 4. Not a single one had penetrated a pore or hair follicle.

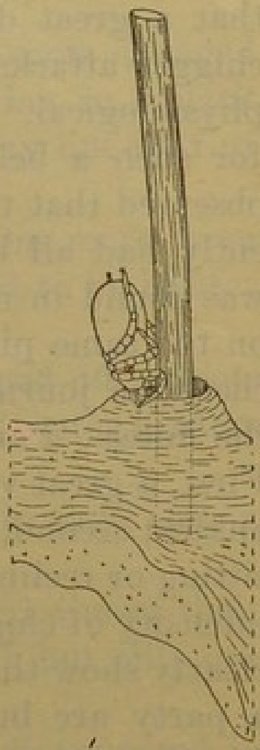

FIG. 4.—"Slice" of epidermis from the skin of calf of leg showing method of attachment of eastern chigger in mouth of hair follicle.

The species occurring in the northeastern part of the United States shows a tendency to attach at the mouth of hair follicles. It may be that the larvæ actually try to enter. They are prevented, however, from doing so under normal conditions of the skin by the small diameter of the follicles themselves. For this same reason it would be impossible for chiggers to enter the pores of the skin, unless the latter were greatly dilated as a result of some skin trouble. In diameter the pores of the skin range from 20 to 50 μ, according to Piersol. The width of an unengorged larva from either the western or eastern part of this country is approximately 150 μ. Thus it is seen that unless the pores were unusually dilated the mites could not enter if they would.

In the case of persons who have just cleaned out the pores of the skin after a long period of negligence, it would be possible for the mites to enter some of them, as, for example, pores dilated by comedones. The writer has observed such pores dilated until they were fully 400 or 500μ in diameter. These pores, however, are most frequently on the face or neck—regions seldom attacked by chiggers. In all the observations made, including many hundred, of chigger attacks, it has always been possible during the early stage of attack to locate the chiggers themselves or their evident places of attachment, and this has always been on the surface of the skin or in the mouths of hair follicles.

DIFFERENCE IN SUSCEPTIBILITY.

Another common belief among the public and entomologists is that a great difference exists between persons in susceptibility to chigger attacks. Such a difference usually has been assumed to be physiological. Observations were made to ascertain the foundation for such a belief, if any existed. Upon several occasions it was observed that there was a difference in injury to people who apparently had all been exposed equally to the attacks of chiggers. It was found in most cases, however, that although all members went on the same picnic, or collected berries in the same patch, or made the same journey, they were not equally exposed to the attacks of the mites. Particularly three fundamental differences were found: First, a great variation in the clothing, especially about the feet and ankles; second, a variation in the actions of the persons, some never sitting or reclining on the ground; and third, a great variation in the intensity of chigger infestation even over a small area. Observations clearly show that these are usually the reasons why some members of a party are but slightly attacked while others are driven almost frantic.

Laboratory tests show that chiggers attack by preference where the skin is very thin and the flesh wrinkled or tender. Field observations also have brought out the fact that women and children suffer more from a given number of chiggers than men do. In other words, a correlation exists between thin skins and seriousness of chigger attacks. This, however, is the only way in which certain differences in the seriousness of chigger attacks between individuals equally exposed could be explained. Although hundreds of people were found susceptible to chigger attacks, no one was found who was clearly shown to be immune.

LOCAL INJURY.

Since there has been so much confusion in regard to chigger injury, a careful tabulation was made daily in the case of two lots of infestations. The first lot of 10 individuals, located on various parts of the leg below the knee, were numbered and notes made daily upon the appearance of the local area around each point of attachment, with the following results:

Attachment of chiggers followed irregularly within a few hours after exposure. The itching which appeared during the latter part of the first 24 hours following attachment grew in intensity. At 24 hours after attachment not a single papule had appeared at any one of the 10 points of attachment. During the second day swelling subsided, and the pinkish coloration around the puncture points was followed, first by a light blood-red and later by a deep blood-red color. The immediate area around each larva changed to a whitish color, and the discolored area as a whole was large and in some cases mottled with light and dark red. The itching sensation reached its maximum the second day.

During the third day after infestation most of the spots changed from the pinkish or light blood red of the second day to a dark blood-red or purplish red. At the end of the third day one-half of the larvæ had become detached.

During the fourth day few changes were noticed. One more larva had dropped off, and a few of the spots were observed to be lighter in color than the day before.

During the fifth day all the remaining larvæ dropped off. Spots retained most of their color and in four instances small water blisters developed near the center of discolored spots.

On the sixth day the color of the spots continued to fade and in one instance was practically lost.

During the seventh day several of the spots regained almost their normal flesh color. Five water blisters were observed, but only one was conspicuous.

On the eighth day the discoloration had entirely disappeared in one instance and almost so in two others. Two water blisters were left.[3]

GENERAL DISTURBANCES.

As has been known for many years, general disturbances frequently follow serious attacks from chiggers. Among the most serious of these is the development of a fever and a temporary upsetting of certain nervous responses. Oudemans has recently called attention (*11, p. 10*) to the narrative of Alfred Russel Wallace relative to the latter's experience with chiggers in the Malay Archipelago. This eminent naturalist wrote:

> All the time I had been in Ceram I had suffered much from the irritating bites of an invisible acarus, which is worse than mosquitoes, ants, and every other pest, because it is impossible to guard against them. This last journey in the forest left me covered from head to foot with inflamed lumps, which after my return to Amboyna, produced a serious disease, confining me to the house for nearly two months * * *.

[3] The appearance of these water blisters is well illustrated by Riley and Johannsen (*11, fig. 43*).

In this country Prof. Herrick (*4, p. 317–325*) has made observations on chiggers in various parts of the United States. He says:

> Very often a slight fever accompanies the eruptions and the patient is liable to lose sleep and suffer almost unbearable torture.

In regard to the general disturbances caused chickens the same authority states (*5, p. 258–260*):

> The chicks seem to contract a diarrhea, grow weaker and weaker, and finally die.

Where the attacks from chiggers are slight, as a rule, no general symptoms are produced. When there is a sudden attachment of several hundred larvæ general symptoms may result. The irritation produced by such a large number may prevent sleep for several nights in succession and thereby upset or disturb digestion. Also, a peculiar nervous disturbance may be caused. This may be brought about by toxins injected by the larvæ or by some other cause.

During the months of July, August, and September, 1919, the writer on many occasions was attacked by chiggers. Some of these attacks were severe and on more than one occasion blood-red spots larger than a half dollar were left. As a result of these repeated attacks a peculiar nervous effect was produced. During parts of the day a feeling of lethargy was noticed, yet to many things a hypersensitiveness was produced. This irritable state became so pronounced at times as to make productive work all but impossible. With this upsetting of the nerves, interference of bodily processes was observed to a considerable extent. It was only after the cool days of November that a normal condition was restored.

RELATION TO DISEASE.

Until the work was begun in Japan on the cause of flood or river fever ("tsutsugamushi-krankheit") some 15 years ago, chiggers had enjoyed an almost complete freedom from suspicion as actual disease carriers. As the work on this deadly disease progressed, however, they were soon held to be implicated in some way and finally shown to be the active carriers of the virus of this disease.

The results of various Japanese workers show that this disease is caused by a nonfilterable virus which is transmitted by means of the chigger bites to man. The natural reservoir is apparently the normal hosts of the chiggers, chiefly field mice, as only a small percentage of the larvæ are infected. Kitashima and Miyajima (*7, p. 232*) state that while "tsutsugamushi-krankheit" is similar to typhus fever and Rocky Mountain spotted fever in that the virus is nonfilterable and arthropod-borne, yet the disease itself is quite different from either.

River fever is a very deadly disease, as about one-third of all the cases are fatal. The only regions of the country affected are those along the water courses or in lowlands. Various attempts have been made to discover and work out the development of the causative organism, but to no avail.

Among the various substances that have been employed in medication in connection with the disease the following have been used with negative results: Quinine, iodine, quicksilver, arsenics, and staining preparations. From the beginning to the subsidence of the fever salvarsan and trypan red have been used with very poor results. An attempt has been made experimentally to utilize a serum for the disease, but without results.

As chiggers are parasitic only in their larva stage and do not change hosts, it appears that the causative organisms must be transmitted from larva to nymph, to adult, thence to egg and to larva again. Such a development, although a little unusual, already has a near parallel in the case of the protozoan *Piroplasma bigeminum*, the organism of Texas fever, which is transmitted from mother to egg to larva or to nymph, in its alternate host, the North American fever tick, *Margaropus annulatus* Say.

In view of what is already known in regard to the transmission of river fever, the biology of the chigger mites, and the general symptoms following their serious attacks on man and domestic animals, the writer now predicts that in the next 50 years other serious diseases will be shown to be transmitted by these acarids. Should these mites become the transmitters of fatal diseases of domestic animals on a large scale it would be found that the protection of cattle or sheep from them would present a very difficult problem, as the mites are so minute and so widely distributed in woodlands and along water courses.

CONTROL.

In the case of man much protection can be had from chigger attacks by properly clothing the lower extremities or by the application of repellents either directly on the skin or on the under garments.

PROTECTION AGAINST CHIGGER ATTACK.

Since the unengorged larvæ are not over 150µ in width, it is seen that they can pass through the mesh of many kinds of garments; it is easy, however, to wear those of a weave tight enough to prohibit the larvæ from passing directly through the cloth. The employment of tightly woven cloth, or other materials which are impervious to the larvæ, nevertheless, is not enough. These garments must be worn so as to fit tightly around the edges or the larvæ will yet have an avenue of entry.

It was frequently noticed that half-shoes exposed the ankles, and for that matter indirectly the whole body, to much more serious

[1] The control of chiggers affecting poultry is considered in Farmers' Bulletin 801. The measures given in the present bulletin have reference more particularly to chiggers as parasites of man.

attacks than topped shoes. This the writer demonstrated himself many times. High-top shoes or, better yet, laced boots, gave a considerable amount of protection. On several occasions the writer was accompanied on his trips by Mr. W. W. Diehl, of the Bureau of Plant Industry. Mr. Diehl demonstrated well how the body could be protected by wearing topped shoes and spiral puttees. The latter were wrapped tightly about the calves and gave almost complete protection.

Concerning this method, however, there are two objections: First, it causes a considerable discomfort to wear such tight and rather heavy clothing during the hot season, and second, if the individual sits down, reclines, or brings the hands in frequent contact with the surface of the ground, the chiggers will attack in considerable numbers.

Another method of gaining protection which has been tried in the past is to use some repellent on the skin or on the clothing. Sulphur has long been recommended for this purpose and Dr. Chittenden (*2, p. 5*) calls it "a sovereign remedy for mites." A test of its efficacy was made as follows:

At East Falls Church, Va., on July 25, 1919, before going into a well-known infested area, the left stocking and the lower part of the underwear on the left leg were dusted inside and out with flowers of sulphur. The sulphur was applied by the "pinch method," followed by rubbing. About a tablespoonful was used. From 2.30 p. m. to 4.20 p. m. there was exposure to attack in the infested area, and at the end of this time a laboratory examination was made. On the calf and ankle of the untreated leg several chiggers were observed, all unattached and running about very energetically. On the calf and ankle of the sulphured leg not a single chigger was found. Later, at 9.45 p. m., another examination was made. The untreated leg had a large number of chiggers attached, these being distributed from the ankle to the hip. The treated leg did not have a single chigger attached.

On August 4, 1919, a test was made to see if a dusting of sulphur on both sides of the clothing was any more efficacious than dusting on one side only. The stocking and underwear below the knee on the left leg were sulphured by the "pinch method," both inside and out. The stocking and underwear below the knee on the right side were sulphured as before, but only on the outside.

At 3.30 p. m., after exposure, an examination of both legs failed to reveal a single chigger. It was noticed also that there was much more sulphur adhering to the left leg than to the right. A later examination at 11.30 a. m. the next day failed to reveal a single chigger on the left leg and only one chigger wheal on the right, this being near the instep of the foot.

It would appear from this that the dusting with sulphur inside the hosiery and underwear is sufficient if it is so applied as to be well distributed. Later tests fully demonstrated that a single application was sufficient if well distributed.

The "pinch method," i. e., applying a powder insecticide by picking up small amounts with the thumb and fore finger, while well adapted for dusting lousy chickens, for example, was observed to be both tedious and wasteful, hence other methods were resorted to.

Application by means of a talcum shaker was made on August 9, 1919, followed by exposure at Vienna, Va. Examination that night showed it to be 100 per cent effective.

On August 15, 1920, application was made with a pepper shaker. A considerable tendency of the sulphur to clog the small holes of the top was noticed, but by violent agitation a fairly even application was made. Only the inside of the stockings and the lower part of the underwear were treated. Exposure for about 3 hours was made in the woods north of Chesapeake Beach, Md. Later examination showed 100 per cent efficiency. It should be added that if sulphur is dusted by means of a salt or pepper shaker, after the operation all unused sulphur should be removed and the container washed. This will prevent the tarnishing of the metal parts of the shaker.

Mr. Flint, of the State Natural History Survey of Illinois, states that he has applied sulphur by means of a small bag and also by the "pinch method," with good results. Dr. J. W. Folsom also reports good results from sulphur treatment by the "pinch method." During the summers of both 1919 and 1920 several members of the bureau staff tried the use of sulphur, and in every case good results were reported and usually complete protection.

DESTRUCTION OF BREEDING PLACES.

It is hoped that the observations made on the habits and local distribution will enable much more to be done to advantage in destroying the breeding places of chiggers. Especially is this method of attack to be recommended about private dwellings and in poorly kept public parks and at summer resorts. Already its feasibility has been demonstrated. In and around Washington many chigger-infested lots or fields have been automatically rendered free of chiggers by turning these to cultivation or cleaning away the rough growth. Prof. F. L. Washburn (*12*) has the following to say in regard to the effect of cutting down bushy growth in Minnesota:

> Capt. Zimmerman, living on Enchantment Island, Lake Minnetonka, having found this pest troublesome on his own island and upon the neighboring Phelps Island, has reduced their numbers materially by cutting out much underbrush, thus letting in the sunlight.

A well-known golf course was laid out west of the District of Columbia in a region heavily infested with chiggers. Later an investigation showed that the sodded areas where the balls were played were quite free from chiggers. When persons went into the patches of rough growth between or around these areas they were attacked by chiggers.

A chigger-infested lot in East Falls Church, Va., was cleared of rough growth and a house put on it during the summer of 1919. These operations destroyed the breeding places of the chiggers.

Of all the growths that favor the harboring of chiggers none is more favorable than wild blackberries or wild dewberries. Wild blackberry patches in Virginia and Maryland invariably were found to harbor immense numbers of chiggers. Where such patches are located at very objectionable places their obliteration would seem justified. The fruit produced by these wild canes is of a good quality, however, and constitutes not a small item in the summer food supply of the country; hence a wholesale destruction of wild blackberries would be both rash and foolish.

Dr. Chittenden has mentioned (*2*) the value of cattle and even of the passing of many persons in destroying chiggers. In 1914 (*3*) he published the results of a conversation which he had with Mr. William N. Irwin (through an error given as E. F. Erwin), who before his death was connected with the Department of Agriculture; in this conversation Mr. Irwin stated that he considered cattle inadequate where a large area was to be dealt with. He claimed, however, that he had experienced good results where sheep were used instead of cattle. The efficacy of sheep in chigger eradication thus being shown, an explanation of their agency and its effect on the chiggers is due. Dr. Chittenden claimed that the value of cattle in chigger control came from the trampling of the pests, and he would explain in the same way the benefits from the utilization of sheep, adding, however, that the sheep are probably more effective, by "keeping the grass more tightly cut than would cattle." Mr. Irwin explained the agency of the sheep as being due in part to the ascent of their legs by the chiggers and their destruction through contact with the oil in their wool. The present writer would explain this observed difference between the efficacy of cattle and sheep as being due chiefly to the food habits of the latter, the sheep not only keeping the grass more closely cropped, but also feeding to a considerable extent on the leaves of shrubbery.

Just what the value of a certain amount of shrubbery is to chiggers is not known in the case of our species. It may furnish a favorable environment for the natural hosts of the parasites, or furnish the necessary environment for either the nymphs or adults of the chiggers, or both these instars, or furnish a proper environment for the larvæ.

It has been stated that the cropping or mowing of grass lets in more sunshine and in this manner destroys the chiggers. This can hardly be the case, however, as larvæ have been handled and exposed frequently in the bright sunshine and no ill effects to them noted. In the field also, where there is only a scant growth of dewberries and an abundance of sunshine chiggers may be found in great numbers.

Chiggers are almost semiaquatic and will endure frequent submergence. In the laboratory they do well, if not their best, in an atmosphere near saturation. This humidity requirement will help explain the advantage of a rough growth to the species, which lives almost exclusively at the surface of the ground. In most situations it may be that the moisture is only sufficient when the ground is clothed with a considerable growth of vegetation. Thus the effect of sunshine would appear to be indirect and to destroy the chiggers in most situations where allowed to act by drying the surface of the ground.

DESTRUCTION OF THE CHIGGERS THEMSELVES.

It is stated that chiggers may be destroyed by a liberal application of sulphur to the field. The use of 50 pounds to the acre has been recommended. For this purpose a dust gun or dust blower could be used to advantage. On lawns the use of sulphur is unnecessary, as chiggers will automatically disappear if the grass is kept cut short.

Chiggers may best be destroyed on the body of man before they become attached or very soon afterwards. If one knows that there has been exposure to chigger attacks the shins and ankles should be examined with a hand lens for the active larvæ even before any itching sensation is felt. Only a few of the active larvæ will be observed. They will be seen to run over the skin very rapidly and can not be captured to advantage.

Larvæ on the body can be easily killed by the application of an acaricide. Various substances applied at the time of bathing have been recommended. On August 10, 1919, after exposure to chigger attacks, a thick lather of soap was applied to the affected parts. The lather was allowed to remain for 10 minutes and was worked continually over the skin. After 10 minutes it was washed off. Examination next day failed to reveal any chiggers and no itching developed.

On August 18, 1919, after exposure at Somerset, Md., and after larvæ had attached, the same application of thick soap lather was tried. On the 19th much itching was felt, yet no chiggers were found. Apparently the soap had acted as an acaricide but not as a palliative.

Dr. Maurice C. Hall, of the Bureau of Animal Industry, reports excellent results from the use of sulphur ointment against the larvæ after they have become attached.

Commercial alcohol (95 per cent) has been used by several acquaintances and by the writer himself to good advantage against the chiggers attached to the skin. When the free larvæ are immersed in alcohol and observed under the miscroscope they are seen to die in short order, usually in from 1 to 3 minutes. The alcohol is an excellent acaricide and also a good antiseptic for the unabraded or slightly abraded skin, and has a further advantageous effect in hardening the dermis. It should be applied quite freely and the application repeated two or three times.

Any of the lighter oils kill the larvæ quite rapidly, and can be used to advantage against the larvæ if the latter are confined to a small area on the body. Sulphur acts slowly, but if applied with soap and allowed several minutes to act should give good results.

PALLIATIVES.

To those who go little afield and are thus ignorant of some of nature's ways warnings that preventive measures should be taken are usually but little heeded, hence it is necessary to give directions in the use of palliatives—the most unsatisfactory of all measures. Undoubtedly most of the so-called palliatives are of value chiefly, if not entirely, because of their acaricide action or because they act antiseptically, or in both these manners.

In the Panama Canal Zone, according to Dr. W. A. Taylor, Chief of the Bureau of Plant Industry, a saturated solution of salicylic acid in alcohol, with a little olive oil added, has been used to good advantage as a palliative. Both he and Mr. H. H. Bennett, of the Bureau of Soils, used this mixture with very beneficial results in the Canal Zone.

In the Southern States, according to Mr. Bennett, butter or lard with a liberal mixture of table salt, or pure kerosene oil, is frequently used as a palliative. With regard to their benefit he says: "I am still not convinced that they are more than moderately efficacious * * *."

Among the other substances recommended as palliatives are the following: Ammonia, cooking soda, dilute solution of iodine, camphor, and alcohol. Statements made to the effect that an acid toxin is injected by the larvæ are not based on observed fact or experimental demonstration. We do not know even that a toxin is injected by these acarids. As before stated, the intelligent use of palliatives awaits experimentation on the nature of chigger injury from the physiological standpoint.

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DEATHS FROM TICK PARALYSIS IN HUMAN BEINGS

BY

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DEATHS FROM TICK PARALYSIS IN HUMAN BEINGS.

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The occurrence of cases of paralysis in human beings as the results of tick infestation in the eastern coastal regions of Australia is now well recognized. The cases actually on record, however, are few and as far as I have been able to trace confined to those reported by Bancroft,[1] Cleland,[2] Eaton[4] and Strickland.[9] Among these occurs the only case of death hitherto recorded (Cleland). The occurrence of a recent death at the Coast Hospital from tick paralysis therefore seems worthy of record and at the same time it has been thought expedient to endeavour to trace other deaths which have occurred, though not recorded in medical literature. The question has assumed some importance through statements appearing in one of the daily papers to the effect that a considerable number of cases of tick paralysis were occurring and that such cases were being wrongly diagnosed as infantile paralysis. Inquiries made from the Government Statistician elicited the information that between 1913 and 1921 four deaths had been certified as due to ticks. Further inquiries were then made from the medical practitioners certifying the deaths and as much information as possible obtained in regard to each case. Unfortunately the data thus obtained proved to be very meagre in some instances, but it has been thought well to include it herein. In addition one or two other cases of earlier date which have come to my knowledge, are also included. My thanks are due to the medical men who saw the patients, for very courteously placing their information at my disposal. Doubtless other cases have occurred and it is to be hoped that any medical practitioner possessing information regarding deaths from ticks will place the same on record.

It is practically certain that the tick responsible for paralysis and death in human beings is the common scrub tick *Ixodes holocyclus,* Neumann.

Unfortunately in only one instance was it possible to identify definitely the species, but it has now been conclusively proved that *Ixodes holocyclus* is the species responsible for paralysis and death in dogs (Dodd). Further information is required in respect to the distribution of this tick in Australia. It is very common throughout the coastal districts of eastern Australia and has also been recorded by Nuttall and Warburton[8] from Western Australia and from India. It is not definitely known, however, whether the tick extends far inland. I have no records, for instance, from the Blue Mountains, though I have seen specimens from the Bunya Mountains in Queensiand.

In nature the tick is a common parasite of marsupials, occurring also on rodents and birds. In none of these animals is there any evidence that the tick is injurious. In dogs on the other hand well defined symptoms occur following a definite syndrome and ending fatally if the tick be not removed. It has also been suggested that this tick exerts a controlling influence in preventing the establishment of the fox in the coastal districts.

It is not proposed to deal with the life history of the species; that has been made the subject of special research by Mr. Clunies Ross at the Veterinary School, University of Sydney. But it may be mentioned that it is the female tick alone which appears to be toxic and that symptoms do not supervene until the tick has been attached for at least three or four days and has reached a certain stage of repletion.

The question as to whether the paralysis is due to a toxin or to an infection, bacterial, parasitic or ultra-microscopic, is as yet uncertain, but the more recent views favour the idea that the condition is a toxæmia due to a toxin secreted by the tick itself.

Notes of Cases.

Eden Case.

The Eden case has been fully reported by Cleland[2] and is here included to complete the series.

The patient was a girl aged thirteen months and the tick was attached behind the left ear. In the opinion of the medical attendant (Dr. G. B. D. Macdonald) death was caused by paralysis, affecting especially the respiratory tract. From the history it appears that the tick was present for at least two days before it was discovered, but the size (12.7 millimetres by 3.2 millimetres) would appear to indicate that it had been there longer. This is supported by the history that the child became ill on the date the tick is supposed to have become attached, whereas it is probable that the tick would have been *in situ* for at least a day before symptoms became manifest.

Auburn Case.

N.R. a male, aged sixteen months, was admitted to the Coast Hospital on November 21, 1923, and died on November 23, 1923. The history obtained from the mother was that the child had not been well for one month; it appeared to be tired and frequently "off its food." On November 20, 1923, he fell down and on being picked up was not able to walk; a little later as he was not able to stand, he was put to bed. Next day he appeared to have some paralysis of the face. A doctor was called in who suspected polio-myelitis encephalitis and secured the patient's admission to the Coast Hospital. The following particulars were furnished by Dr. Millard, Medical Superintendent, Coast Hospital. On admission, the temperature was 36.9° C. (98.4° F.), the pulse rate 160 and the respirations forty. The child was flushed, his breathing rapid with stridor; he had an anxious expression; his pupils were dilated and reacted to light. There was paresis of the masseter muscles; when a finger was put into his mouth the child did not bite. The tongue was not moved when it was pricked with a pin. There was great difficulty in swallowing food, about one-half of the food was regurgitated, partly through the nose. There was mucus in the throat which he apparently could not expel.

Movement of all the limb muscles was elicited by pin prick, but was not vigorous. The knee jerks were elicited on the right side, Babinski's sign was present on the left side. There was nothing abnormal detected in the circulatory or respiratory systems.

On November 23, 1923, the child could not swallow at all; his breathing was rapid and stertorous; cyanosis was present. The pulse was rapid and soft, 168, the temperature was 37.2° C. (99° F.).

A tick was discovered in the scalp half an hour before death. The mother had noticed a lump there several days before, but thought it was a sore and applied ointment. Oxygen and stimulants were administered without effect. The child died at ten o'clock. The medical attendant had noted that after admission the child had steadily lapsed into a state of generalized paralysis and coma.

A *post mortem* examination was made that afternoon and the brain and spinal cord removed for further examination. Macroscopically nothing obvious was detected. The site of the tick bite showed some imflammatory reaction. The child had long hair and there were some sores on the forehead and the tick which could be felt through the hair, had been taken to be one of these sores.

Sections were made of various parts of the brain (medulla, pons, optic thalamus and cerebral cortex) and spinal cord (cervical, dorsal and lumbar regions). All portions of the brain showed intense engorgement of the vessels with the presence of numerous small newly formed capillaries; in places diffuse infiltration with small round cells apparently plasma cells was noted; there were, however, no perivascular sheaths or "cuffs" of small round cells. Some of the vessels contained polymorpho-nuclear leucocytes. In the spinal cord similar congestion was present with some small hæmorrhages. Emulsions of the brain and spinal cord were made and injected into laboratory animals. Two rabbits were injected intra-cranially, one with brain emulsion and the other with cord emulsion. Neither rabbit showed any evidence of paralysis or other ill-effect. Two white mice were injected subcutaneously with brain emulsion, one of these died in two days.

Two further white mice were injected subcutaneously with cord emulsion; both remained alive and well for months.

Two other white mice were injected intraperitoneally, one with brain emulsion and the other with cord emulsion. The latter died in two days. The brains of the two white mice which died, were sectioned and showed some congestion. Cultures from spleen, liver and heart blood showed the presence of *Staphylococcus aureus* and it was held that infection with this organism was probably responsible for the death of these two mice.

The tick removed from the scalp was secured and proved to be a female *Ixodes holocyclus,* not quite half replete. The probable time of attachment of the tick was not ascertained. The child lived at Auburn, but there was no history of the child having been in the bush immediately prior to the illness.

Wagonga Case.

C.M.L., female, aged three years, died on November 23, 1913, and the death was certified by Dr. A. Stuttaford in 1913. As it was impossible to obtain information from the medical attendant, inquiries were made from the Muruya Hospital and subsequently information was obtained from the father of the child. The following extract is taken from his letter: "The tick was on the chest on the left side nearly under the arm and it appeared to have been there, from appearance, about twelve or eighteen hours before it was discovered. The size of the tick was about **O** ; it was not quite filled out round, it was a little flat. It is from the shape of the tick that we judge the time it had been in. When we discovered the tick was about ten o'clock in the morning and the child was helpless in her legs and she was in a high fever with convulsive turns which were about an hour apart and those turns were much closer towards evening and much stronger. Her death was the same day as the tick was discovered, about five o'clock in the evening. The doctor announced that death was due to blood poison from tick bite. I cannot say that she died from heart failure as the doctor did not say and he did not say that she had paralysis. After she was dead large black streaks showed down the left side."

Mullumbimby Case.

For information regarding this case I am indebted to Dr. Leighton Kesteven. The case occurred about 1904 and though no notes were made, Dr. Kesteven retained a clear recollection. I quote from his letter on the subject:

The mother brought the child (aged about thirteen or fourteen) to me one morning to "see if there was not something in her ear." On examination I found the tick, fully distended, fastened on the *membrana tympani*. The child was in a semi-comatose state and only made to give almost unintelligible answers with difficulty. I filled the ear with carbolic oil—1 in 40—and the beastie floated up, sting and all, intact. I administered brandy and strychnine freely, but the patient gradually sank and died about eighteen hours after. The paralysis was chiefly in the legs (she was hardly able to stand), but I do not recollect any other paresis.

Later in answer to a definite inquiry, Dr. Kesteven wrote again that the cause of death was undoubtedly respiratory paralysis.

Bellingen Case.

Information regarding this case is unfortunately meagre. It was mentioned to me by Dr. Lance Hunter, of Bellingen, who had seen the entry made by the late Dr. Myles in the hospital register. No notes were to be found in Dr. Myle's records, but Dr. Hunter was able to secure some information from the local chemist which definitely establishes the case.

From the Register of Deaths at Bellingen the following particulars were ascertained:

L.H.C., male, aged three years, died 1910, cause of death, tick bite. From the chemist it was learned that the site of the bite was in the centre of the forehead and caused a great deal of œdematous swelling over both supraorbital margins extending up over the forehead.

Gosford Cases.

Two cases are registered as occurring in Erina Shire, the cause of death being certified as due to ticks.

These two patients are F.J.C., a male, aged two years, of Gosford, who died on October 9, 1916, and M.D., a male aged ten months, of Matcham, who died on October 9, 1921. Dr. James H. Paul is given as the certifying doctor in each case. In answer to my inquiries Dr. Paul could unfortunately only give me information in respect to the second patient. The following excerpt is from his letter: "I have no data and can only recall the case at Matcham. The child had not been bathed that day and I was sent for when the child was dying. There was a large 'bottle' tick in the left carotid region and it was distended. I have often had cases of ticks in children and the tick has an uncanny sense of knowing where to attach itself. In one case the tick was out of sight in the auditory meatus. The same ticks are usually fatal to dogs, but cats usually recover.

Eastwood Case.

J.H.C.M., a male, aged three years, died on November 21, 1921; the death was certified by Dr. Cuthbert Hall as due to tick bite. In reference to this case Dr. Hall wrote: "He was only in the hospital (Parramatta) seven hours; the temperature was 102° F., no physical signs except extreme cardiac weakness, pulse soft and threading. No paralysis of muscles. The father said he had found a tick on him some days before. . . . In the absence of any other physical sign or cause I could only attribute the death to toxæmia from tick bite. The father said he had been perfectly healthy up till then."

The child resided at Eastwood. Endeavours to obtain further particulars from the parents were fruitless as their present address could not be discovered.

This case would appear to belong to a somewhat different category to the others, as far as details of them are available, the absence of paralysis and the interval (some days) between the discovery of the tick and the death of the child are both noteworthy. Unfortunately none of the early history of the case is available; it would have been of interest to have ascertained whether there had been any transient paralysis either of limbs or of the respiratory apparatus. One would also have liked to ascertain the location of the tick and whether it was replete.

Reviewing the other cases it would appear that definite paralysis or at least paresis of the muscles was present in the Eden, Auburn, Wagonga and Mullumbimby patients, while information is lacking in this respect in the Bellingen, Gosford and Matcham patients. In the first four mentioned patients the legs appear to be most affected. Respiratory paralysis would appear to have been the immediate cause of death of the Eden and Mullumbimby patients and possibly also of the Auburn and Wagonga patients, though precise information on this point is lacking. Fever is noted in the Eden, Auburn, Wagonga and Eastwood cases. The records of the other cases are too meagre to allow of analysis.

Tick paralysis in man is recorded from British Columbia and Oregon in America due to *Dermacentor venustus*. The cases are recorded or discussed in several papers on the subject by Todd,[10] Hadwen,[5] Nuttall[7] and MacArthur.[6]

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tick paralysis

Y. B. Separate 531.

SOME OF THE MORE IMPORTANT TICKS OF THE UNITED STATES.

By

W. D. HUNTER AND F. C. BISHOPP,
Of the Bureau of Entomology.

[FROM YEARBOOK OF DEPARTMENT OF AGRICULTURE FOR 1910.]

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ILLUSTRATIONS.

SOME OF THE MORE IMPORTANT TICKS OF THE UNITED STATES.

By W. D. HUNTER and F. C. BISHOPP,

Of the Bureau of Entomology.

INTRODUCTION.

In recent years considerable attention has been attracted to the tick which transmits splenetic fever of cattle, known as the North American fever tick. The importance of this tick as the sole transmitter of the disease in nature has become common knowledge, at least in the South. As a matter of fact, this tick is of much greater importance than any other species occurring in the United States. Nevertheless there are other forms which should be considered. One species, for instance, transmits a serious disease of human beings which is spread over an extensive region and causes the loss of a considerable number of human lives each year. As in the case of the cattle disease, the human disease, known as Rocky Mountain spotted fever, is transmitted only through the attack of a tick, and the plan that is being followed in dealing with the cattle disease would apply in the case of the human disease; that is, the eradication of the tick would result in the eradication of the disease.

Although ticks are attracting more attention at the present time as transmitters of diseases than in other ways, they are of considerable importance as parasites of domestic animals. Their presence always results in irritation and the loss of blood. The consequence is that the infested animals frequently fail to make proper returns for the expense incurred in feeding, and in some instances the attack is so severe that death follows. (See Pl. XV, fig. 1.)

The object of the present paper is to point out some of the species of ticks occurring in the United States which are of importance either as transmitters of disease or otherwise. It will be noted that in several cases where diseases are not known to be transmitted at present, future investigation may possibly connect the ticks with certain maladies. It is thus very probable that increased knowledge of ticks will show a degree of importance which is not now realized.

All ticks occur in four stages, namely, egg, larva or seed tick, nymph, and adult. The ticks usually seen are adults, in which stage there are, of course, males and females. The females, however, increase greatly in size on account of the engorgement of blood; the males are consequently inconspicuous and generally overlooked, being frequently found attached to the skin of the host directly beneath the females. After fertilization the females quickly become distended by the engorgement of a large amount of blood, which is utilized in the formation of eggs. When the body of the female becomes so distended that it will hold no more blood the tick drops to the ground.[1] Deposition of eggs begins in a short time. Depending upon the species, from 300 to as many as 11,265 eggs are deposited by a single female. Death follows after egg laying is completed. (See Pl. XVI, fig. 5.)

The seed ticks emerging from the eggs are provided with but three pairs of legs. The subsequent stages both have four pairs. The seed ticks remain in the immediate vicinity of the place where the eggs were deposited. There is a strong tendency to move upward on a blade of grass or similar support while awaiting a host animal. No food is taken by the seed ticks until they attach to the host.

Ticks have remarkable ability to exist for long periods without food, but as soon as a host comes within reach the seed ticks attach to the skin and immediately begin to extract blood and in a short time become distended. At this point some species drop to the ground for the purpose of molting and others remain upon the host, the general rule being to drop to the ground. To this there are two important exceptions, namely, the cattle fever tick, *Margaropus annulatus* Say, and the tropical horse tick, *Dermacentor nitens* Neumann, which do not drop for molting. In the case of the ticks which drop from the host as engorged larvæ the molt takes place in a short time. The stage reached after the molt is the nymph, in which stage the tick again awaits a host, often for a long time, and attaches, as in the larval stage, at the first opportunity and immediately fills itself with blood. It then detaches and another molt takes place, which marks the beginning of the adult stage. Again an opportunity is awaited to attach to a suitable host. When this occurs the males and females come together, fertilization takes place, and the engorgement of the females follows shortly, with the formation of eggs, thus beginning another cycle.

THE FOWL TICK (ARGAS MINIATUS KOCH).

The fowl tick is found in many localities in the warmer portions of the earth. Outside of the United States it has been recorded from Russia, Persia, North and South Africa, Australia, Mexico, and Brazil and other localities in South America. Notwithstanding this

[1]Among the species here discussed there are two exceptions to the rule that eggs of ticks are deposited on the ground. These are the spinose ear tick, which crawls upon posts or other supports, where oviposition takes place, and the chicken tick, which secretes itself in cracks in the vicinity of the perches and there deposits its eggs.

wide range over the globe, the species is of rather sharply restricted distribution in the United States. It is found very commonly in southern and western Texas, New Mexico, Arizona, and southern California. The range extends westward from a line drawn from Wichita Falls to Goliad, in Texas. This line corresponds almost exactly to the division between the humid and arid divisions of the Lower Austral zone, which is marked by the eastern limit of the area in which less than 30 inches of annual rainfall occur. There are reports of the occurrence of the species outside of the region indicated—for instance, from Florida—and one occurrence is known in Texas outside of the arid region. The numerous observations that have been made in Texas, however, show that the restricted range is distinctly marked. The occurrence of the species elsewhere is probably due to its shipment along with fowls or coops.

In the United States the fowl tick is probably the most serious pest of chickens in the regions where it occurs. In cases that have come to the attention of the writers, the raising of poultry has been abandoned on account of the death of the fowls as the result of the attack of this tick. Even where the infestation never becomes so heavy as to cause death, the irritation of the skin and the draining of blood interferes to such an extent with fattening and egg laying that the poultry industry has become unprofitable.

There is a possibility that this species may transmit a specific disease of fowls in this country. In Brazil, the Sudan, India, South Australia, and Transcaucasia a disease of fowls, known as spirochætosis, has been demonstrated to be transmitted by this tick. Up to this time no reliable evidence of the occurrence of this disease in the United States has come to hand.

The fowl tick may be identified readily by its appearance. The engorged adult is about one-third of an inch in length, of a bluish or almost blackish color. The conspicuous feature of the structure is the greatly flattened form and the roughened and pitted appearance of the skin. (See Pl. XVI, fig. 3.) The unengorged ticks are smaller, very flat, and have a brownish or yellowish appearance.

The eggs of this tick are deposited in cracks and openings of any kind in the buildings in which fowls are kept. The stage of the tick which hatches from the eggs has but six legs. It is ready to attach itself to fowls soon after hatching, and in from three to eight days it engorges and drops from the host. In about a week's time the larval tick sheds its skin and becomes a nymph, and is then ready to attach again to the host. This attachment is short, probably never occupying more than two hours. The tick drops again from the host, undergoes another molt, and appears in the second nymphal form. As in the preceding stage, the attachment to the fowl is very short. After dropping again, another transformation takes place and the adult ticks emerge. After engorgement and mating, the deposition of eggs takes place. After each deposition the female attaches to the host and fills with blood, then secretes herself, and in due time deposits another mass of eggs, a process which may be repeated as many as six times. At least three separate engorgements and depositions of eggs seem to be normal.

The fowl tick is practically nocturnal in its habits. During the day and in the presence of artificial light it will secrete itself. Attachment to the host as well as dropping occurs normally during the night. While the later stages of the tick attach themselves for only a short time during the night, as has been stated, the first or larval stage remains attached for several days.

One of the most remarkable facts about the fowl tick is its longevity. The larvæ will live at least five months without food. The adults, in several instances, have been kept alive without nourishment for more than two years. It is also remarkable that the adult ticks are extremely resistant to insecticides. Applications of liquid preparations that will kill most insects seem to have but little effect upon them. These ticks are also very resistant to such poisonous gases as quickly kill most species of insects.

The considerations mentioned in the last paragraph indicate that it is not feasible to attempt to "starve out" the fowl tick by removing the birds from the houses, and that the application of insecticides is attended by many difficulties. It is fortunate, under these circumstances, that an economic and effective method of obtaining relief is available. This consists of providing perches for the fowls of such construction that the ticks are unable to reach them. This can easily be accomplished by suspending the perches from the ceiling by means of wires or iron rods. In this manner complete exemption from injury to the roosting fowls can be obtained. In the case of setting hens the same results may be obtained by providing nesting boxes on legs which are placed in cups or pans filled with crude oil.

THE SPINOSE EAR TICK (ORNITHODOROS MEGNINI DUGÈS).

The spinose ear tick has been recorded from a number of localities in the southwestern portion of the United States and in Mexico, as well as from Louisiana, California, Nevada, Idaho, Colorado, Nebraska, Kansas, Iowa, and Kentucky. Recent work which has been done toward obtaining accurate information regarding the distribution of ticks in the United States indicates that the occurrence outside of Texas, New Mexico, Arizona, southern California, southern Colorado, southern Utah, and Mexico are more or less accidental. In northern Louisiana a restricted infested region was found in 1907. In this

FIG. 1.—COW DYING FROM GROSS INFESTATION BY THE NORTH AMERICAN FEVER TICK. (ORIGINAL.)

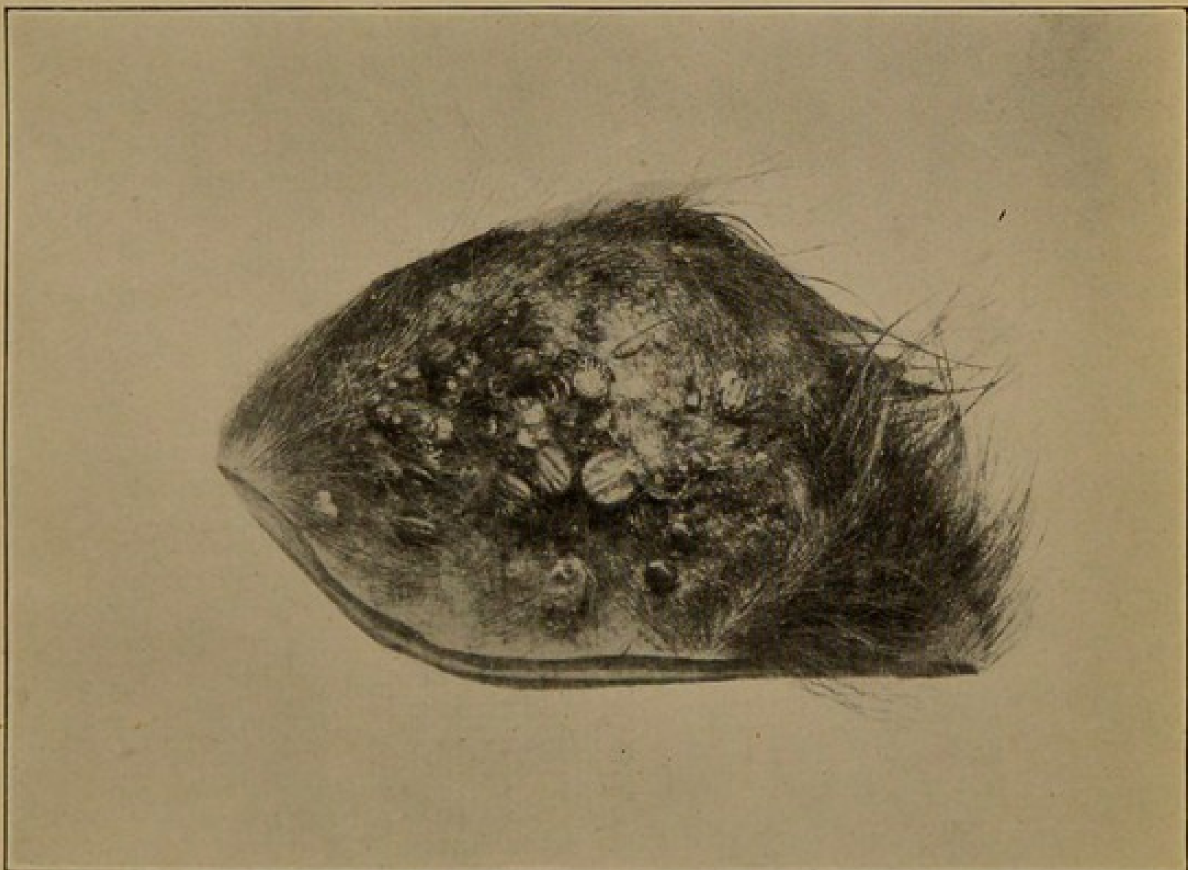
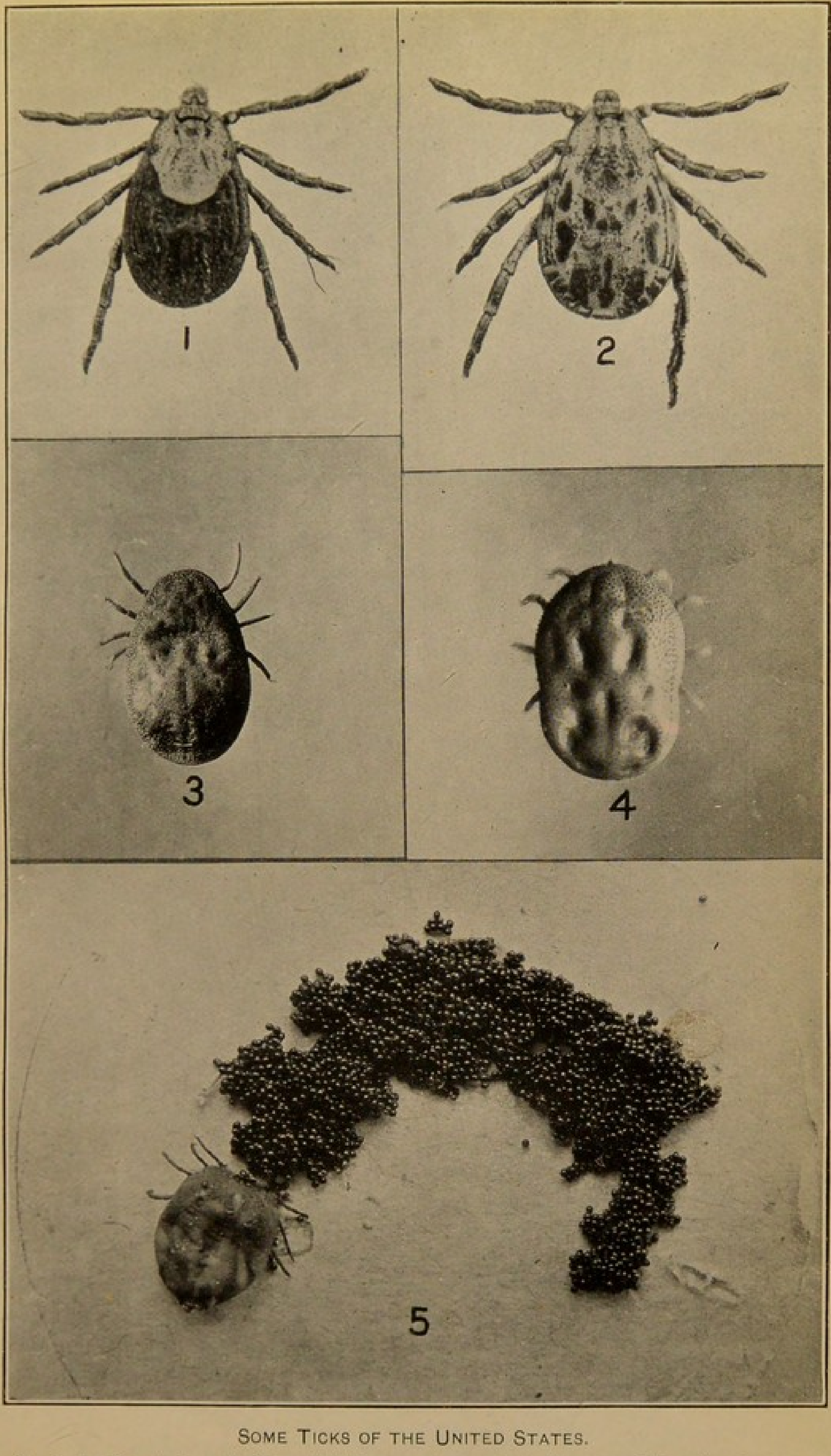


FIG. 2.—EAR OF CALF WITH CLUSTER OF GULF COAST TICKS. (ORIGINAL.)



SOME TICKS OF THE UNITED STATES.

[1.—Rocky Mountain spotted fever tick (*Dermacentor venustus*): Unengorged female. 2.—Same, male. 3.—Fowl tick (*Argas miniatus*): Partially engorged female. 4.—Spinose ear tick (*Ornithodoros megnini*): Engorged nymph. 5.—North American fever tick (*Margaropus annulatus*): Female depositing eggs. All enlarged. (Original.)]

case there is a rather clear history of the introduction of the species with horses from western Texas.

The spinose ear tick is found only in the ears of animals infested by it. The species may be recognized primarily by this restriction in the place of attachment. The more common hosts are horses, cattle, dogs, cats, and man. Its appearance is unmistakable, the general color being yellowish brown or darker, the legs much paler. The engorged females measure about one-third of an inch in length and are irregularly oval in outline, the body being constricted just behind the middle. The surface of the nymphs is covered with small, sharp, spinelike bristles which aid it in maintaining its place in the ears of the host. (See Pl. XVI, fig. 4.)

In western Texas, New Mexico, and Arizona this species is found in the ears of many of the horses and cattle and not uncommonly causes the death of the animals. The irritation which it causes is increased by the fact that its wounds frequently attract the screw-worm fly, *Chrysomyia macellaria* Fab. If an animal is weakened from any cause and suffers from this combined attack it is likely to succumb.

A number of cases have been recorded in which this species has been taken from the ears of human beings. In such instances very great pain was caused, but as far as known no deaths have occurred.

Although this species is not known to be concerned in the transmission of disease, a closely allied form does transmit a disease of human beings in Africa. The same African species, *Ornithodoros moubata* (Murray), was recently found to be capable of transmitting spirochætosis in fowls.

There are certain peculiar features of the life history of this tick. When the nymphs are fully engorged they drop from the ears of the host and crawl upward on any convenient object. They then secrete themselves, molt, and begin deposition. This species never attaches to an animal in the adult stage.

The spinous ear tick, like the fowl tick, is able to exist for a long time without nourishment. Specimens have been kept alive in glass vials for a year and a half.

THE LONE STAR TICK (AMBLYOMMA AMERICANUM L.).

So far as known the lone star tick does not occur outside of North America and South America, but in these continents it has an extended range. It has been recorded from Labrador to Brazil. In the United States it has been taken from Maine to Michigan and from Florida to Texas. It appears to be rare or absent west of the Mississippi River, except in Louisiana and Texas, although it has been taken in Missouri, Arkansas, and Oklahoma. In Texas and Louisiana it is one of the most common ticks.

The lone star tick has been found on cattle, horses, human beings, dogs, goats, hogs, deer, squirrels, wolves, cats, and in the immature stages on certain birds. It appears to have a special predilection for goats. In the vicinity of Kerrville and Llano, Tex., where Angora goats are raised in great numbers, this tick is more common than in any locality known to the writers, far outnumbering all other ticks.

This tick and the Gulf coast tick are probably more frequently found attached to human beings than any species which occurs in the eastern and southern portions of the United States. Its long beak enables it to maintain a firm hold. Cases are on record in which severe results have followed such attachments. In these cases the injury seems to be merely mechanical or due to the ingress of bacteria through the punctures. Two investigators have conducted experiments to determine whether this species is capable of transmitting splenetic fever of cattle. They were unsuccessful in both cases.

The lone star tick may be identified by the presence of a bright metallic spot on the shield of the female. This distinct mark gives it the common name by which it is known. Fully engorged females sometimes measure over one-half inch in length. The general shape is oval and the color generally grayish yellow.

On account of its wide range and the number of animals it attacks, including man, this is one of the more important of the ticks. In localities where it becomes numerous the cattle, horses, goats, and sheep suffer severely from its attack. The long mouthparts, which penetrate deeply into the skin, seem to cause more irritation than is caused by the attack of the fever tick, *Margaropus annulatus*. The large amount of blood taken by this species is an additional factor in causing it to be of considerable importance to stock raisers.

This species is as susceptible as other species to oils and to the arsenical dip. To a certain extent it can be controlled by the same means which are used in controlling the fever species on cattle; at least this is the case in so far as dipping and greasing are concerned. The plans of relieving cattle of the fever tick and of freeing pastures by the starvation plan applied to the fever species are not equally effective against this one. The reason is that, unlike the fever species, it drops to the ground twice for the purpose of molting.

THE GULF COAST TICK (AMBLYOMMA MACULATUM KOCH).

The Gulf coast tick occurs in the United States in a restricted region along the Gulf coast, especially in Louisiana and Texas. It has been recorded from Tennessee, Virginia, and California on single occasions. The occurrence of the species in these States is probably due to its having been carried on some of its hosts from the region in which it occurs commonly. The range of the species extends through Mexico and far into South America.

The Gulf coast tick is found more commonly on the dog than on any other host, although in its range in this country it is frequently found upon cattle, as well as upon human beings. It is probably more inclined to attack human beings than any species found in the United States, except possibly the Rocky Mountain spotted-fever tick.

In size and general appearance this tick resembles the lone star tick, but lacks the metallic spot which very readily distinguishes the female of the lone star tick from all other species. The light marking of the shield forms an irregular lyre-like pattern.

In attacks upon various hosts it has been noted that this species is inclined to form clusters consisting of a half dozen or more individuals. The long mouthparts give it a firm hold upon the host, naturally causing considerable irritation. The clustering thus leads to an amount of local irritation which frequently affects the host severely. (See Pl. XV, fig. 2.) Up to the present time this species has not been found to transmit any disease.

The life history of the Gulf-coast tick is very similar to that of the lone-star species, which has been described. The only control measures that can be suggested are the use of oils or grease applied locally or the dipping in any of several well-known "tickicides."

THE ROCKY MOUNTAIN SPOTTED-FEVER TICK (DERMACENTOR VENUSTUS BANKS).

The Rocky Mountain spotted-fever tick is restricted in range to the western portion of the United States. Recent work by the Bureau of Entomology has shown that it occurs from Wyoming to Washington State, and from New Mexico to California. It is thus essentially a species of the Rocky Mountain region. It is not to be found, however, equally numerous in all portions of that section. The greatest abundance seems to be in Montana, Idaho, and Wyoming. South of Colorado and Utah it is very uncommon. The relative abundance of this species in different States is probably indicated by the number of lots of specimens which were received at the Dallas laboratory during the season of 1910, 85 lots having been received from Montana, 84 from Idaho, 72 from Wyoming, 51 from Washington, 29 from Colorado, 25 each from Oregon and Nevada, and 9 from California. The range of the species also extends into Canada and possibly Alaska, but its occurrence outside of the North American Continent is unknown.

This tick, in certain ways, is not especially restricted as regards hosts. The immature stages are to be found on a large number of rodents, but the adult stage occurs only very exceptionally on these animals. Adults have been taken commonly from only horses, cattle, deer, and mountain goats, in addition to man.

The existence of a number of closely allied species renders it impracticable to give a description of this form which would enable the general observer to identify it. (See Pl. XVI, figs. 1, 2.)

Although of some little importance in the adult stage as a parasite of domestic animals, the injury to man by transmission of Rocky Mountain spotted fever overshadows the importance of this species in all other respects. It is one of the two ticks which are known to transmit diseases of human beings. The other case is an African tick, *Ornithodoros moubata*, which transmits African relapsing fever. The history of the various steps in the demonstration of the connection between this tick and spotted fever is of great interest. The disease itself was not recognized as a distinct malady until a comparatively few years ago. In 1902 Doctors Wilson and Chowning first placed on record the hypothesis that the disease was transmitted through the agency of a tick. In 1906 Dr. H. T. Ricketts undertook the study of the question. As a result of most carefully planned and praiseworthy investigation under many difficulties, Doctor Ricketts demonstrated that this species transmits the disease in nature. The control and eradication of spotted fever has therefore become essentially a matter of the control of the tick, exactly as the control of yellow fever or malaria depends upon the eradication of certain species of mosquitoes.

The importance of this tick may best be considered in connection with the disease which it transmits. Although spotted fever occurs throughout the Rocky Mountain region, the death rate is high in but one locality. Ordinarily the death rate ranges in the neighborhood of 5 per cent. In the Bitterroot Valley, in Montana, however, there exists a type of the disease in which the death rate is much higher; it averaged 70 per cent in 114 cases which were collated in 1902 by Doctors Wilson, Chowning, and Ashburn. It is estimated conservatively that since 1885 at least 400 cases of spotted fever have occurred in the Bitterroot Valley, the percentage of deaths showing that during this period the fever has caused the loss of 280 human lives. The deaths, outside of the Bitterroot Valley, due to the less virulent form of the disease, probably increase the total mortality during the last twenty years to 1,000. It will thus be seen that the tick is of considerable importance in a large portion of the United States.

In addition to the direct loss of lives, a great indirect injury has been done by interfering with the development of large areas of land. Moreover, there is a possibility that this tick may become of even much greater importance. As far as can be seen there is no reason why the virulent form of the disease occurring in the Bitterroot Valley could not be transported to other regions. If a person or animal harboring the organism of the disease should move from the Bitterroot Valley to some other State where the fever tick occurs, opportunity would be given for the introduction of the virulent strain. This consideration emphasizes the great practical importance of attempting the eradication of the tick in the Bitterroot Valley.

As has been indicated, this tick occurs in the immature stages on a large number of small mammals and in the adult stage only on man or a few of the larger animals. It is found in numbers in the adult stage only during a limited season. It is first noticed on domestic animals in very early spring. The season normally begins about the 1st of March and extends until about the 1st of June, after which the tick is not noticed until the following season. This seasonal abundance of ticks corresponds to the period to which cases of spotted fever are restricted.

Like the majority of ticks, the Rocky Mountain spotted fever species engorges and drops from the host for both molts. It is thus radically different in habits from the species which transmits splenetic fever of cattle and its control is correspondingly more difficult.

Recent investigations in Montana by the Bureau of Entomology, in cooperation with the Montana Agricultural College, have indicated certain apparently feasible means for reducing the numbers of this species, or the possibility of eradicating it altogether. The matter will be dealt with fully in a contemplated publication.

THE PACIFIC COAST TICK (DERMACENTOR OCCIDENTALIS NEUMANN).

. So far as now known the Pacific coast tick is limited in its distribution to western and central California and western Oregon. It is probably also to be found in Lower California and northwestern Mexico. It is the most common tick in the Pacific coast region, where it is usually called the wood tick. Cattle, deer, horses, dogs, and man are the more common hosts of the adults. The immature stages undoubtedly attach to various small mammals. On account of the fact that this tick occurs throughout practically the entire season in certain regions, it is of some importance as a pest of live stock. It is said to be most numerous during the rainy season, and at that time is frequently the source of much annoyance to man.

This species resembles quite closely the Rocky Mountain spotted fever tick, but by the trained eye is readily distinguished from that species. It is much the same in color as the fever-transmitting species, but the white markings are interrupted by numerous red points, which give it a characteristic appearance. The engorged females are somewhat smaller than other members of this group of ticks, seldom attaining a length of more than one-third of an inch.

As has been stated, this species frequently attacks man, but no disease is known to be carried by it. Until recently this tick has been confused with the tick *Dermacentor venustus* Banks, which transmits Rocky Mountain spotted fever. The name *Dermacentor occidentalis* erroneously appears in medical literature in connection with that disease.

On account of the fact that this species drops from the host twice during its development in order to molt, it is doubtful if any method other than the use of "tickicides" can be successfully used in keeping it under control.

THE AMERICAN DOG OR WOOD TICK (DERMACENTOR VARIABILIS SAY).

The American dog tick is the most common species occurring east of the Mississippi River. Its range extends from Labrador to Florida; although it occurs in Texas, it is uncommon there. Throughout the central and Rocky Mountain regions it appears to be rare. Recently, however, an area of considerable size in California and Oregon in which this species occurs commonly has come to attention. It is surmised that the species was introduced there by artificial means.

The immature stages of this tick are found upon various small mammals. The dog appears to be the most important host for the adult stage, although in this stage the tick occurs upon various wild animals as well as cattle and man. Although it has a strong tendency to attach in the ears of the host it does not attach far down in the ears, as does the spinose ear tick.

This tick, when engorged, is of a bluish color. When fully engorged the female usually measures nearly one-half inch in length. The shield is reddish brown, marked with white. The marking is more or less variable, but generally maintains a pattern which enables the species to be recognized.

Although of widespread occurrence in the United States, this species is of comparatively little importance. The dog is the only host which ever suffers any serious consequences. The species is rather well known on account of its attaching to human beings, but so far as the records show no special consequences have ever followed its attack. The removal of the ticks from any host is an easy matter.

THE RABBIT TICK (HÆMAPHYSALIS LEPORIS-PALUSTRIS PACKARD).

The rabbit tick is one of our most widely distributed species, being very commonly found on rabbits throughout the United States and Mexico. It has also been reported from South America. In the extreme southwestern portion of the United States and portions of California, however, the common tick found on rabbits is another species.

This rabbit tick has been recorded from horses in one instance. With this one exception the rabbit is the only mammal upon which the adults of the species have been found. The larvæ and nymphs are found very commonly upon ground-inhabiting birds, such as quails and larks.

The engorged ticks are dark blue-gray to almost black in color. They frequently measure one-third of an inch in length when fully engorged. No white markings appear on the shields of either the male or female. In all stages the mouthparts are extended on each side so as to form prominent angles. This character can usually be seen by the naked eye and is a reliable means of distinguishing the species from others found on rabbits.

These ticks usually attach about the rabbits' ears, or on other portions of the head. The engorged larvæ and nymphs drop from the host in order to molt.

On account of the fact that this tick is seldom found on other hosts than the rabbit, it is of little economic importance. In some cases it becomes so numerous upon rabbits and weakens them to such an extent that they are easily captured by any animal that preys upon them. The Bureau of Entomology has a record of 1,033 ticks of this species having been taken from two rabbits in western Montana.

An allied species, *Hæmaphysalis chordeilis* Packard, has recently been reported as causing the death of young turkeys in Vermont. Another related species transmits a disease of the dog, known as malignant jaundice, in certain parts of South Africa.

THE NORTH AMERICAN FEVER TICK (MARGAROPUS ANNULATUS SAY).

The well-known transmitter of splenetic or Texas fever of cattle, *Margaropus annulatus* Say, in importance far exceeds any of the other ticks found in this country. It has received attention in various departmental publications and will consequently be given but brief notice in this paper. It is found throughout the Southern States. The original northern limit of its range in the eastern part of the country corresponded rather closely to Mason and Dixon's line. The work of eradication which has been undertaken recently has reduced the infested area considerably. Closely allied forms occur in other parts of the world, where they transmit diseases of cattle which are very similar, if not identical, with the splenetic fever which occurs in this country.

This tick causes a direct loss of at least $40,000,000 a year in the United States; indirectly the damage is much greater. Although primarily a factor connected with cattle raising, the importance of this species extends far beyond that industry. It practically inhibits the proper utilization of live stock and thus prevents a rational system of agriculture. In this manner the whole structure of the

South is affected and its development held back. A better system of agriculture and rapid development are sure to follow the eradication of the tick.

There are two peculiar features of the life history of this tick: It is practically restricted to cattle as a host, and it does not fall to the ground for the purpose of molting. These two peculiarities render the control of the fever tick a comparatively simple matter. Its failure to exist on other hosts renders it practical to free areas of infestation in a comparatively short time by the simple device of keeping the cattle out. Likewise the dipping or greasing of cattle is a certain and economical method. Both of these means are being practiced by the Bureau of Animal Industry of the Department of Agriculture, which has undertaken extensive work which will ultimately relieve the South of a most important obstacle to development.

THE BROWN DOG TICK (RHIPICEPHALUS SANGUINEUS LATREILLE).

In the United States the brown dog tick occurs numerously only in southern Texas, although there are records from a few other places. Outside of the United States it has a wide range. It occurs commonly in Mexico, Central America, the West Indies, India, the Mediterranean regions, South Africa, and elsewhere. In tropical and subtropical regions throughout the world it appears to be the most common tick of the dog, but sometimes occurs on other hosts, the horse having been recorded. Essentially, however, at least in the United States, it is a parasite of the dog.

The brown dog tick may be known by the reddish-brown color. This is not relieved by lighter colored markings, as is the case with other species of ticks found infesting dogs in this country. Unlike the common dog tick in the eastern portion of the United States, this species is found on any part of the host.

The allies of the brown dog tick which occur in South Africa are among the most important disease-bearing ticks that are known. On account of its close relation to the pathogenic forms, our species is of considerable interest. At present, as a mere parasite of the dog, it is of some importance in southwestern Texas.

In India the brown dog tick has been found to be a transmitter of a protozoan disease of the dog. Up to this time there is no authentic evidence of the occurrence of this disease in the United States. If once introduced, however, there appears to be no reason why it should not spread in the region in which this tick is commonly found. A number of related species which do not occur in North America are concerned in the transmission of several important diseases of live stock in other parts of the world.

Control of this species can be obtained by the systematic use of oils or grease.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 105.
L. O. HOWARD, Entomologist and Chief of Bureau.

THE ROCKY MOUNTAIN SPOTTED FEVER TICK.

WITH SPECIAL REFERENCE TO THE PROBLEM OF ITS CONTROL IN THE BITTER ROOT VALLEY IN MONTANA.

BY

W. D. HUNTER,
In Charge of Southern Field Crop Insect Investigations,

AND

F. C. BISHOPP,
Entomological Assistant.

[In Cooperation with the Biological Survey and the Montana Agricultural College.]

Issued November 17, 1911.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., July 20, 1911.

SIR: I have the honor to transmit herewith a manuscript entitled "The Rocky Mountain Spotted Fever Tick, with Special Reference to the Problem of its Control in the Bitter Root Valley in Montana," prepared by Messrs. W. D. Hunter and F. C. Bishopp, of this bureau.

The work of this bureau on the spotted-fever-tick problem began in 1909. It has been conducted in cooperation with the Biological Survey of this department and the Montana Agricultural Experiment Station. The investigation of the life history and habits of the tick which transmits spotted fever has revealed certain feasible and economical methods of control. These methods render it possible to reduce the numbers of the ticks to such an extent that the cases of spotted fever in the Bitter Root Valley will be very few in number, if, indeed, the disease is not eliminated altogether. The plans for this work are outlined in this manuscript.

It is recommended that the accompanying manuscript be published as Bulletin No. 105 of this bureau.

Respectfully,

L. O. HOWARD,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE ROCKY MOUNTAIN SPOTTED-FEVER TICK, WITH SPECIAL REFERENCE TO THE PROBLEM OF ITS CONTROL IN THE BITTER ROOT VALLEY IN MONTANA.

INTRODUCTION.

For many years a disease of human beings, known as spotted fever, has been known to occur in certain localities in the Rocky Mountain region of the United States. In fact the evidence is rather conclusive that the disease existed before the settlement of the country by white men. At any rate old residents of the Bitter Root Valley in Montana have informed us that the first white settlers were warned by the Indians of the danger of contracting a very serious disease if they visited certain localities. From what has been learned in recent years it is evident that these dangerous localities are the very ones in which spotted fever is now most prevalent.

The States in which the disease occurs most frequently are Montana and Idaho. There is no doubt, however, that it occurs in at least portions of other States, such as Oregon, Washington, Nevada, Utah, Wyoming, and Colorado.

Definite work on the nature and method of transmission of spotted fever was not begun until 1902. In that year Drs. Wilson and Chowning announced the theory that the "wood tick" is the natural agency through which the malady is transmitted from one human being to another. This hypothesis was based upon three observations: First, that the majority of cases of spotted fever showed histories of tick bites; second, that the localities in which the disease was most frequently contracted were those where ticks were most abundant; and, third, that the season of spotted fever coincided with the period when the ticks were most frequently observed. Drs. Wilson and Chowning had no facilities for proving their hypothesis in a scientific manner, but such proof was soon obtained. According to the late Dr. H. T. Ricketts[1] the first experiments which resulted in proof of the transmission of spotted fever by the tick were conducted by Drs. McCalla and Brereton, of Boise, Idaho, in 1905. In these experiments a tick which was found attached to a spotted-fever patient was removed and allowed to bite a healthy person. In

[1] Fourth Biennial Report, Montana State Board of Health, p. 106.

eight days this person developed a typical case of spotted fever. The experiment was continued by allowing the same tick to bite a second person. In this case again a typical case of spotted fever resulted. The results of the important experiments of Drs. McCalla and Brereton were not published by them.

In 1906 Dr. H. T. Ricketts, then connected with the University of Chicago, began a series of investigations which must always be considered classic. Not being aware of the experiments of Drs. McCalla and Brereton, Dr. Ricketts started with the hypothesis of Drs. Wilson and Chowning. His first work was devoted to determining whether guinea pigs and rabbits are susceptible to the disease and consequently suitable for inoculation experiments. The original experiments with rabbits were somewhat inconclusive, but it was found that the injection of blood from a human being suffering with spotted fever invariably brought about the disease in guinea pigs. In fact in these animals the disease was found to run a course very similar to that in human beings. It was thus determined that guinea pigs were suitable subjects for experiments to determine whether ticks could transmit the disease. On August 4, 1906, Dr. Ricketts announced the results of the first experiment in the tick transmission of the disease. A small female tick was placed on a guinea pig which had been inoculated with the blood of a patient who died of spotted fever. The tick was allowed to feed on this inoculated guinea pig for two days. It was then removed and placed in a pill box for two days. At the end of that time it was allowed to attach to the base of the ear of another guinea pig which had not been inoculated with spotted fever. After three and one-half days the temperature of this guinea pig rose and remained above normal for more than seven days. The pig also showed practically all of the other symptoms of spotted fever. In fact, there was no doubt whatever that the guinea pig contracted spotted fever from the bite of the single tick. As a control on the experiment Dr. Ricketts placed two other guinea pigs in the cage occupied by the animal upon which the tick had been placed. They remained there for two weeks. These two pigs showed no indications whatever of fever. Thus the possibility of infection by contact or by feces was eliminated. The only difference between the conditions surrounding the pig which contracted fever and those surrounding the others was that the former was bitten by a fever tick.

During the following year (1907) Dr. Ricketts succeeded in transmitting the disease by ticks in a number of additional cases. In one experiment he found that the male tick as well as the female is capable of transmitting the disease. In other experiments it was determined that the larval or nymphal tick may acquire the disease and retain it through the molting period, and transmit the infection in the following stage to another host. The most interesting experi-

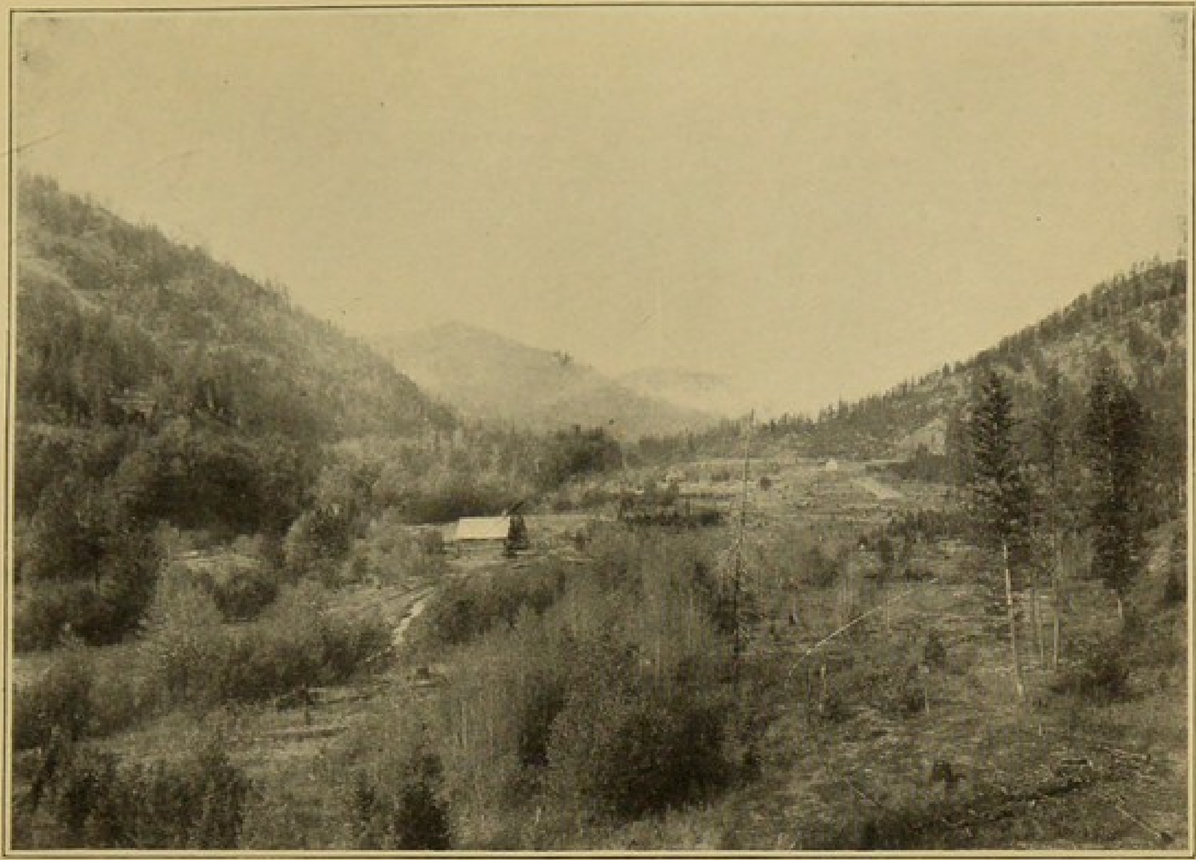


FIG. 1.—VIEW IN LO LO CANYON, WHICH LEADS INTO THE BITTER ROOT VALLEY, SHOWING CONDITIONS UNDER WHICH TICKS THRIVE.

FIG. 2.—CAMP LABORATORY NEAR FLORENCE, MONT., IN ONE OF THE MOST HEAVILY TICK-INFESTED REGIONS KNOWN.

TICKS AND SPOTTED FEVER IN THE BITTER ROOT VALLEY, MONT.

ments, however, were with adult ticks. It was found that when an adult becomes infected with the disease, the infection passes through the eggs developed in the tick, so that the young of the next generation may transmit the disease.[1]

The main points determined by Dr. Ricketts are as follows:

(1) Guinea pigs and certain other animals, as monkeys, are susceptible to spotted fever.

(2) Larval ticks applied to an infected animal contract the infection and are able to transmit it to the following or nymphal stage.

(3) Nymphal ticks feeding upon infected animals acquire the power of transmitting the disease as adults.

(4) Adult ticks are able to acquire the disease by feeding upon an infected animal and to transmit it through the egg stage to the succeeding generation.

(5) Infective ticks are to be found in nature.

The transmission of disease organisms through the egg stage of ticks is known in a number of other instances. It is the case with the tick *Margaropus annulatus* Say, which transmits splenetic fever of cattle in the southern portion of the United States. The causative organism of splenetic fever has actually been found in the eggs of this tick. Dr. Ricketts recently made a tentative announcement of the finding of the spotted-fever organism in the eggs of *Dermacentor venustus* Banks. Future investigation will undoubtedly result in certainty regarding this point.

Some of the main points determined by Dr. Ricketts were corroborated about the same time by Dr. W. W. King, of the Public Health and Marine-Hospital Service, whose results were published in the Public Health Reports of July 27, 1906.

WORK UPON WHICH THIS BULLETIN IS BASED.

The work of the Bureau of Entomology on the spotted-fever tick began in 1908, when the investigation of the life history and habits of the species was undertaken. Plans were made for determining the distribution of the tick and for the exhaustive life-history investigations necessary in the formulation of plans of control. Following the plan for determining the distribution of the tick, two men were selected, one to travel through the southern Rocky Mountain region and the other through the northern. The late Mr. F. C. Pratt made investigations in New Mexico, Arizona, southern California, and Colorado. Mr. W. V. King, whose work as an agent of the bureau began July 1, 1909, made the investiga-

[1] The Rocky Mountain spotted-fever tick, like a number of other species, exists in four distinct stages, namely, egg, larva, nymph, and adult. The eggs are invariably deposited on the ground in large masses. The larvæ which emerge from the eggs are minute six-legged animals. After feeding upon a suitable host, they drop to the ground and molt, becoming nymphs. In this stage they have eight legs. The nymph waits until it can attach to a host, engorges blood, drops, molts its skin, and becomes adult.

tions in the northern Rocky Mountain region. He explored Wyoming, Idaho, portions of Utah, and Oregon and Washington. Prof. R. A. Cooley, of the Montana Agricultural College, consented to cooperate with the bureau by directing the work of Mr. King and by submitting specimens from many localities in Montana. During 1909, Mr. J. D. Mitchell, of the Bureau of Etomology, visited New Mexico, and succeeded in determining the southernmost locality in which the fever tick is at present known to occur.

The life-history work upon the tick was conducted at Dallas, Tex., by Messrs. H. P. Wood, G. N. Wolcott, and the junior author. This began early in 1909 and has continued without interruption.

In February, 1910, a conference was held in Washington, D. C., with Prof. R. A. Cooley and Dr. C. Hart Merriam, then Chief of the Biological Survey, for the purpose of formulating definite plans for the continuation of the work. It was agreed that the determination of the range of the tick should be continued by correspondence rather than by sending men into the field and that the local aspects of the problem in the Bitter Root Valley should be investigated by placing an agent there. The Bureau of Entomology provided the necessary funds and established a laboratory near Florence, Mont. (See Pl. I, fig. 2.) Prof. Cooley agreed to supervise the work in Montana, and was appointed a collaborator in the bureau on March 1, 1910. At the same time Mr. W. V. King was appointed to work under the direction of Prof. Cooley in the Bitter Root Valley. This plan of cooperation has continued down to the present time.

The results obtained have been due, to a large extent, to the energy and acumen of Prof. Cooley and to the high grade of Mr. King's work. But a special word must be said about Mr. King. Undeterred by the possibility of contracting spotted fever, he located on an abandoned farm in the most dangerous locality known. In the immediate vicinity a number of deaths from spotted fever had occurred within a short time. He remained there throughout the season of 1910, subject to the risk of contracting the fever on his daily trips into the field or from the ticks used in the experiments at the camp laboratory. His devotion to the investigation outweighed all considerations of personal safety. Great credit must also be given Mr. C. Birdseye and Mr. A. H. Howell, of the Biological Survey, for assuming the risk of residence at the laboratory during a portion of the season of 1910. Mr. Birdseye continued the investigation of the mammals of the valley in 1911.

In addition to the work in cooperation with the Montana Agricultural College, in 1910, the bureau undertook to obtain information regarding the exact extent of the area in which the spotted-fever tick occurs. By means of a system of circulars and the generous cooperation of many physicians and other persons throughout the Rocky Mountain region, a very large amount of information was obtained. In fact the correspondents sent in altogether 1,400 lots of ticks, 850 of which were of the fever species. These represented 225 localities in California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Very many of the ticks received during the course of this work were in immature stages. Unfortunately our present knowledge of ticks is not sufficient to enable us to determine the species to which immature forms belong. This necessitates very special care in rearing to maturity the immature forms received. This work was done at Dallas, Tex., and naturally involved a large amount of skilled attention.

The information now in hand regarding the spotted-fever tick was greatly increased through the cooperation of the Biological Survey of this department. In 1910 two agents of this survey, Messrs. A. H. Howell and C. Birdseye, were located at the camp laboratory of the Bureau of Entomology near Florence, Mont. These agents were engaged in the collection of wild mammals upon which one stage or another of the spotted-fever tick occurs. This work resulted in showing the relative importance of the different mammals found in the Bitter Root Valley and adjacent mountains as carriers of the spotted-fever tick. It also revealed many points having a bearing on the original source of the disease in nature and on other important matters. The Biological Survey has also studied carefully the possibility of the eradication or control of all the wild mammals which carry the fever ticks.

In September, 1910, Prof. H. A. Morgan, director of the Tennessee Experiment Station, consented to make a trip to the Bitter Root Valley and to advise the forces cooperating regarding the sufficiency of the data obtained and the feasibility of plans of eradication based thereon.

Of course the authors have made full use of the available literature on the investigations that have been conducted by other persons. Most useful have they found the first and second spotted-fever reports of Dr. H. T. Ricketts, published in the Fourth Biennial Report of the State Board of Health of Montana.

POSSIBILITY OF INCREASE OF AREA OF SPOTTED FEVER.

The approximate area in which spotted fever occurs has been indicated in a previous paragraph. Since it has been shown, however, that a certain tick (*Dermacentor venustus* Banks) is the only known agent of transmission of the disease in nature, it follows that the possible area in which spotted fever may occur is at least coincident with the range of the tick, exactly as the possible range of yellow fever is as extensive as is the area in which the mosquito which transmits it is to be found. Extensive work conducted by the Bureau of Entomology has shown with considerable accuracy the area in which spotted fever may be thus propagated. The map (fig. 1, p. 16) shows the area in which the necessary agent for transmission occurs, and consequently the possible geographical distribution of the disease. This map is based upon the examination of 850 lots of spotted-fever ticks received from 230 localities during the seasons of 1909, 1910, and 1911.

One of the most remarkable features of spotted fever is the fact that strains of different degrees of virulence exist in different localities. In Idaho the death rate is from 5 to 7 per cent. In the Bitter Root Valley in Montana, however, the death rate is about 70 per cent. One consideration which has caused the Bureau of Entomology to concentrate its efforts in the Bitter Root Valley is the possibility that the virulent form of the disease, now restricted to that valley, may eventually be carried into other regions where the presence of the tick would make transmission possible.

There are several ways by which the virulent strain of the disease might be carried out of the Bitter Root Valley. It could be taken either by ticks or in the blood of human beings. Carriage by ticks might occur when these animals are transported on men, horses, or cattle. Moreover, tick eggs or other stages of the tick which have been shown to contain the disease organism might be transported in hay or other commodities. There is also a chance that ticks in various stages might be transported on the hides of domestic or wild animals.

As regards carriage of infection in the blood of human beings, our conclusions are largely theoretical. It is not known how long the blood of a person who is attacked with spotted fever remains infective. It is probable, however, that it is infective for some days before the height of the fever and for some time thereafter. During the period either preceding or following the climax of the disease a person might leave the Bitter Root Valley. If in another locality he should be bitten by the fever tick and the specimen should escape, the establishment of the virulent form of the disease would be accomplished. In certain diseases similar to spotted fever, such as splenetic fever of cattle, the organism of the disease remains in the blood for many years without causing an acute or noticeable attack. Nevertheless, all ticks which feed upon these apparently immune animals become infected and can transmit the disease in acute form to other animals. Although nothing is known as to the persistency of the organism of spotted fever in the blood of persons who have apparently recovered, there is a possibility that it may remain for some months or even years. In this way there is a probability of considerable extension of the territory in which the virulent form of the disease occurs, by migration out of the valley.

Naturally the chances of spread will increase with the development of the Bitter Root Valley and the growth of shipments of cattle or movements of people to other regions. These considerations are sufficient to justify very energetic means for control where the virulent form of the disease now occurs and where, as will be shown in this bulletin, the practical eradication of the tick, and, consequently, of spotted fever, is entirely feasible.

It has been shown by experiments conducted in the Institute of Infectious Diseases in Chicago that several species of ticks other than the form which occurs commonly in the Bitter Root Valley are capable of transmitting spotted fever. A very hopeful feature of the situation, however, is that in the valley there is but one tick species which attacks man. Therefore the other species are of no practical importance as regards spotted fever. Even among the species which feed upon the lower animals there are many thousands of specimens of *Dermacentor venustus* to every one of all other varieties. Moreover, means of control of this one species, such as will be described in this bulletin, will serve greatly to lessen the number of the other forms. For these reasons, in formulating plans for practical eradication it is necessary to consider only the one dominant tick in the valley.

There is one respect, however, in which the discovery that species other than *Dermacentor venustus* can transmit the disease may be of importance. The other forms occur over wide areas in the eastern and southern portions of the United States. It is conceivable that if the disease were once introduced in the blood of a human being or otherwise, the other ticks might propagate it and transmit it in regions far outside of the territory in which the fever is now known to occur. But the danger on this score is not so great as might be thought. In the first place, in no localities in the United States are any species of ticks as numerous as is the fever species in the Bitter Root Valley and elsewhere in the Rocky Mountain region. Consequently, the occurrence of anything like an epidemic of the disease would be impossible. Only occasional or rare cases could be expected. In the second place, it can not be foretold whether spotted fever would find general conditions suitable for propagation in localities outside of the Rocky Mountain region. Nevertheless the degree of danger from this source, while perhaps slight, emphasizes the importance of eradication of the spotted-fever tick in the mountain region and also of the discovery of effective means of control for all species of ticks wherever they occur.

IMPORTANCE OF THE CONTROL OF THE SPOTTED-FEVER TICK.

The most conspicuous loss from spotted fever is in human lives. In the Bitter Root Valley it was estimated in 1904 that 200 cases of the severe type of the disease had occurred up to that year. A conservative estimate of the mortality there, as has been stated, is 70 per cent. This means a loss of about 140 lives in this small valley. At the present time, with an increase in the population of the valley, it is estimated that about 20 cases of the disease occur annually. This means a loss of about 15 lives each year and this loss is certain to increase as the population of the valley becomes larger.

In Idaho it was estimated in 1908 by Dr. E. E. Maxey that the annual average of cases of spotted fever was 375. Undoubtedly, as Dr. Maxey pointed out, this estimate is very conservative. In all probability 500 would be a small estimate. The comparatively small mortality in Idaho would give a loss of human lives each year of about 35.

Taking into consideration the whole area over which spotted fever is more or less prevalent, it is conservative to estimate 750 cases each year with probably 75 deaths.

A great indirect injury the tick does in the Bitter Root Valley is in preventing the proper development of a region favored by a rich soil and by remarkable climatic advantages. As long as it is known that a dangerous disease exists there and that persons who farm or go into the country are especially subject to it, the valley can not prosper as it should. Relief from the tick would immediately result in increased land values and larger immigrations into the valley.

In a larger way the possibility of the spread of the virulent form of the disease outside of the valley must be considered. This alone would warrant a much larger expenditure than is actually required for extermination or control in the valley.

SUMMARY OF FACTS BEARING ON IMPORTANCE OF TICK CONTROL.

It has been proved beyond peradventure by the investigations of Dr. Ricketts and others that spotted fever is transmitted in nature only by certain ticks. In the region where the disease now occurs it is transmitted to man by a single species of tick. Therefore the rational method of eradicating the disease is to attack this tick. In this way the proper procedure is exactly analogous to that being followed in the eradication of splenetic fever of cattle from the United States, by the eradication of the tick which transmits it. In the case of splenetic fever, certain more or less effective means of combating the disease itself have been discovered. These are in the form of a method of preventive inoculation and the administration of certain drugs. In spite of this it has been found that the only hope for the eradication of the disease, or even for practical control, is in the destruction of the ticks. Inasmuch as no means of preventing or curing spotted fever are known, the importance of attacking the ticks is much greater than in the case of splenetic fever. The situation is also analogous to that brought about by malaria and yellow fever, which, as is well known, are transmitted by certain mosquitoes. The control of these diseases in all parts of the world has practically resolved itself into a warfare against the mosquitoes.

These considerations seem to make it very evident that the logical course to follow in the eradication or control of spotted fever is the elimination of the tick. The problem becomes purely an entomological one. Under these circumstances, it is most fortunate that certain feasible and economical means of eradication, first outlined in a rather general way by Dr. Ricketts, have been placed upon an exact and certain basis by the recent investigations of the Bureau of Entomology.

DISTRIBUTION OF THE SPOTTED-FEVER TICK.

As is shown in the accompanying map (fig. 1) the range of the Rocky Mountain spotted-fever tick extends throughout the northern part of the Rocky Mountain region across the Great Basin to the eastern edge of the Cascade Range. The southernmost limit of the tick is in the northern edge of New Mexico. Although the distribution of the species in Canada has not been determined, there is little doubt that it extends over the southern half of British Columbia and the western portion of Alberta. However, only one accurate record of the occurrence of this species in Canada has been made, namely, by Dr. H. G. Dyar, who captured two female specimens at Kaslo, British Columbia, in 1903.

While infestation occurs throughout large portions of Montana, Idaho, Washington, Oregon, Nevada, Utah, Wyoming, and Colorado, comparatively small areas in New Mexico and California are infested. The tick probably occurs throughout the entire Black Hills region in South Dakota and Wyoming, although but one collection has been made in that region.

Naturally there is no uniformity in the abundance of the tick throughout the territory in which it occurs.

Our knowledge of the local occurrence of the tick throughout the Western States is not sufficiently complete to enable us to make definite statements as to areas within the whole infested region in which comparatively few ticks are to be found. We do know, however, that certain sections of the country which are unfavorable for the development of the species are only slightly or not at all infested.

During the investigation about 850 lots of the fever species have been collected. The following is a list of the counties and the number of localities within those counties where the species has been taken by the bureau:

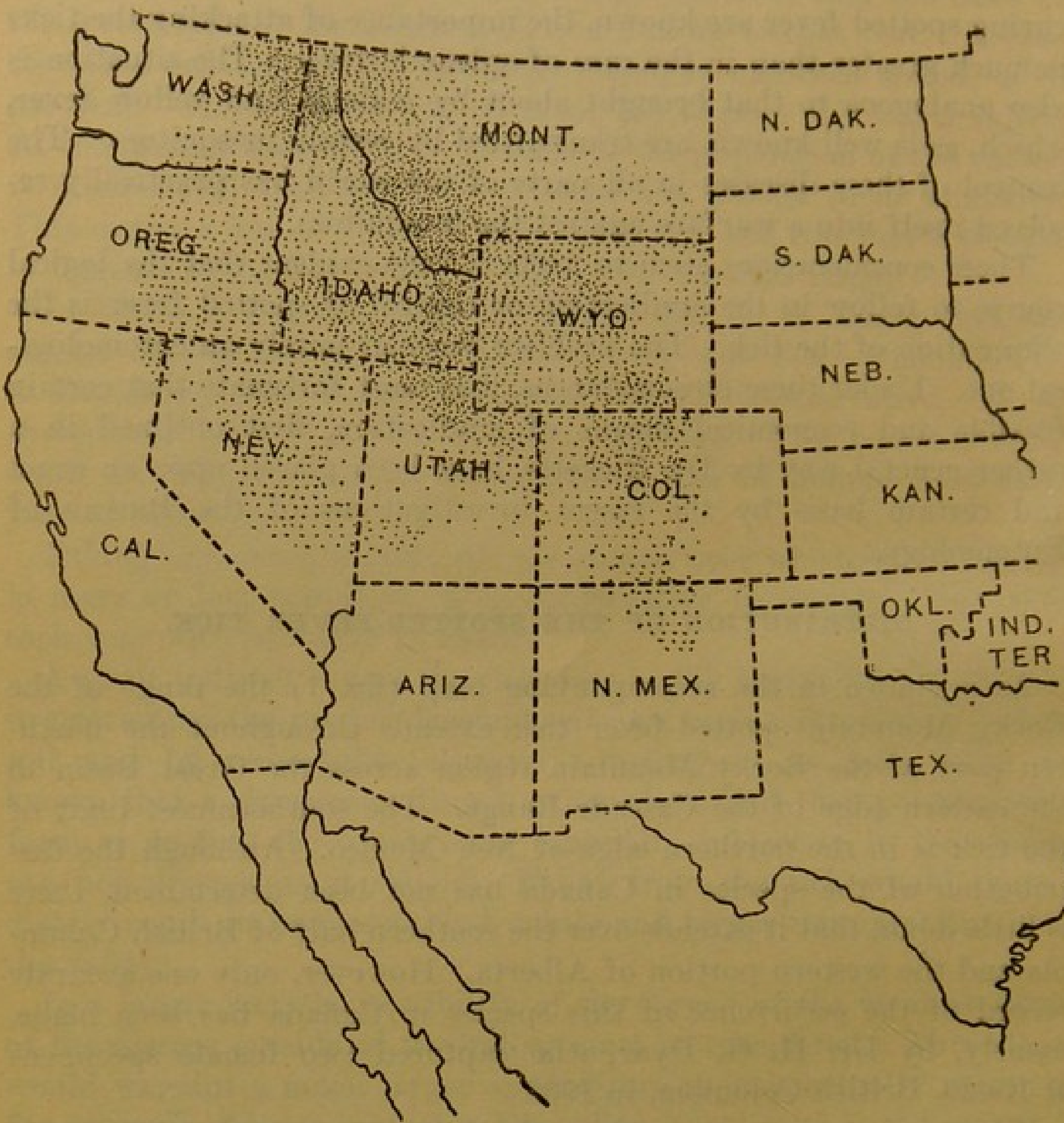


FIG. 1.—Map showing region in the United States in which the Rocky Mountain spotted-fever tick occurs. The degree of shading indicates the relative abundance of the tick in different sections. (From Bishopp.)

NUMBER OF LOCALITIES, BY COUNTIES AND STATES, IN WHICH THE SPOTTED-FEVER TICK IS KNOWN TO OCCUR.

California.—Modoc County, 3; Lassen County, 1.

Colorado.—Boulder County, 4; Clear Creek County, 1; Eagle County, 1; Garfield County, 1; Gunnison County, 1; Jefferson County, 1; Lorimer County, 3; Mesa County, 2; Pitkin County, 1; Summit County, 1.

Idaho.—Bannock County, 7; Bingham County, 2; Blaine County, 3; Boise County, 1; Bonner County, 2; Canyon County, 1; Cassia County, 2; Elmore County, 3; Fremont County, 6; Kootenai County, 2; Lemhi County, 2; Lincoln County, 2; Oneida County, 4; Shoshone County, 1; Washington County, 1; Twin Falls County, 1.

Montana.—Beaver Head County, 3; Broadwater County, 2; Carbon County, 1; Custer County, 1; Flathead County, 4; Gallatin County, 5; Granite County, 5; Lewis and Clark County, 4; Lincoln County, 2; Madison County, 6; Meagher County, 3; Missoula County, 8; Park County, 2; Powell County, 3; Ravalli County, 7; Rosebud County, 4; Sanders County, 5; Silver Bow County, 1; Teton County, 2; Yellowstone County, 1.

Nevada.—Eureka County, 1; Humboldt County, 2; Lander County, 2; Lincoln County, 2; Nye County, 3.

New Mexico.—Rio Arriba County, 1; San Miguel County, 1.

Oregon.—Baker County, 1; Crook County, 3; Grant County, 1; Harney County, 3; Klamath County, 1; Lake County, 1; Malheur County, 2; Sherman County, 1; Umatilla County, 2; Union County, 1.

Utah.—Boxelder County, 2; Cache County, 2; Iron County, 1; Uinta County, 1; Utah County, 3; Wasatch County, 3.

Washington.—Asotin County, 2; Chelan County, 2; Douglas County, 1; Grant County, 1; Kittitas County, 1; Spokane County, 3; Stevens County, 14; Yakima County, 3.

Wyoming.—Albany County, 3; Bighorn County, 6; Carbon County, 3; Fremont County, 6; Latrona County, 3; Park County, 2; Uinta County, 2; Weston County, 1.

The above is far from being a complete list of those counties in which the spotted-fever tick occurs, yet it gives a definite idea of the territory infested. It should be understood that the number of localities given for a county does not represent the relative abundance of the tick in that county. The table includes only the number of localities from which the tick has actually been received. Greater population or a larger number of collectors in some counties has given more localities than in others, while the actual abundance of the tick may be exactly the reverse. Further investigation throughout the Rocky Mountain region will undoubtedly show the tick to be present in the majority of the counties included in the area shown to be infested in figure 1. Dr. E. E. Maxey[1] (1908, p. 4) reports that the tick has been found to occur in all of the counties of Idaho with the exception of Latah.

As is pointed out in Circular No. 136 of the Bureau of Entomology, the fever tick is known to occur at various elevations from slightly over 500 feet to nearly 9,000 feet above sea level. The species occurs in greatest abundance in the area known as the transition zone. It is also commonly found in the Canadian and Upper Sonoran life zones.

FACTORS INFLUENCING ABUNDANCE.

The occurrence and abundance of this tick within a given locality are dependent, to a large extent, upon the presence of favorable conditions for development. These conditions are, first, the existence of the small mammals which serve as hosts for the immature stages; second, the presence of large mammals upon which the adults may

[1] See Bibliography, p. 45.

engorge, and, third, the existence of a certain amount of protection for the development of the stages when not on hosts. As a rule the abundance of ticks is dependent upon the amount of vegetation. Lands upon which some fallen timber and undergrowth occurs are usually found to harbor ticks in abundance, provided the hosts—certain small mammals and domestic animals—are also present. In the Bitter Root Valley the areas in which more or less heavy second growth has followed the removal of the original timber have been found to be most heavily infested with ticks. These areas are locally known as "slashings." (See Pl. I, fig. 1.)

It has been determined that the direct rays of the sun during the summer have a markedly injurious effect upon the early stages of the tick. This fact may be utilized to some extent, as will be shown later, in the control of the species by clearing the land of timber and underbrush. In small experiments it has been found that when the seed ticks are exposed to the sun during very hot weather they immediately crawl down the grass to the surface of the soil to seek protection, and in the absence of an abundance of moisture death results in a very few days. The exposure of freshly deposited eggs to the sun at Dallas, Tex., has been found to cause them to shrivel and dry within less than a day's time.

The relative abundance of rain, especially during the spring months, in different years has a marked effect upon the number of ticks occurring in a given locality. This factor is of little importance in the natural control of the adult stage of the tick, but is a potent factor in the destruction of the eggs and immature stages, particularly after the latter have become engorged and dropped from the animal.

Several other natural means of control of minor importance are also operating to some extent to keep the species in check. In barn lots, chickens have been observed to destroy the females which drop to the ground after becoming filled with blood. Some wild birds are known to feed upon various species of ticks, and in one instance, at least, they have been observed to destroy the engorged females of the spotted-fever tick. Certain species of ants are also thought to be important enemies of the pest, particularly when the ticks are in the immature stages.

Owing to the fact that the Rocky Mountain spotted-fever tick is primarily a northern form, and therefore accustomed to severe cold, it is doubtful whether severe winters are of much importance in its destruction. This is particularly true where there is an abundance of protection provided by brush and litter on the ground.

SUMMARY OF LIFE HISTORY OF THE SPOTTED-FEVER TICK.

As is the case with nearly all species of ticks, this one passes through four distinct stages, namely, the egg, the larva or seed tick, the nymph, and the adult.

THE EGG AND LARVA.

The eggs (Pl. II, fig. 5) are small, ovoid, brownish objects, about one thirty-eighth of an inch long. These hatch into minute, light brown, active six-legged creatures known as larvæ or seed ticks. (Pl. III, fig. 2.) Before further development takes place it is necessary for these seed ticks to feed upon the blood of some animal. They usually attach to small mammals, such as ground squirrels, and become filled with blood in from 3 to 8 days. They then drop off the host and find a convenient protected place in which to continue their development. Before engorging the seed tick measures about one thirty-seventh of an inch in length, but during feeding the body is considerably distended, so that it measures about one-eighteenth of an inch in length by one thirty-first of an inch in width when engorgement is complete. The color of the larvæ when engorged is slate-gray. Activity is greatly reduced on account of the weight of the blood imbibed.

THE NYMPH.

After a resting period of from 6 to 21 days the skin is shed from the body of the engorged seed tick and an active eight-legged nymph appears. The extra pair of legs is gained during the resting stage. This character is sufficient to distinguish the nymphs from the preceding or larval stage. In this stage it is necessary for the young tick again to find a host and fill with blood. This feeding period requires from 3 to 9 days. When engorgement is complete (see Pl. III, figs. 3, 4), the nymphs measure about one-sixth of an inch in length, while before engorgement the length is usually about one-seventeenth of an inch. The engorged nymphs are bluish gray in color and not very active.

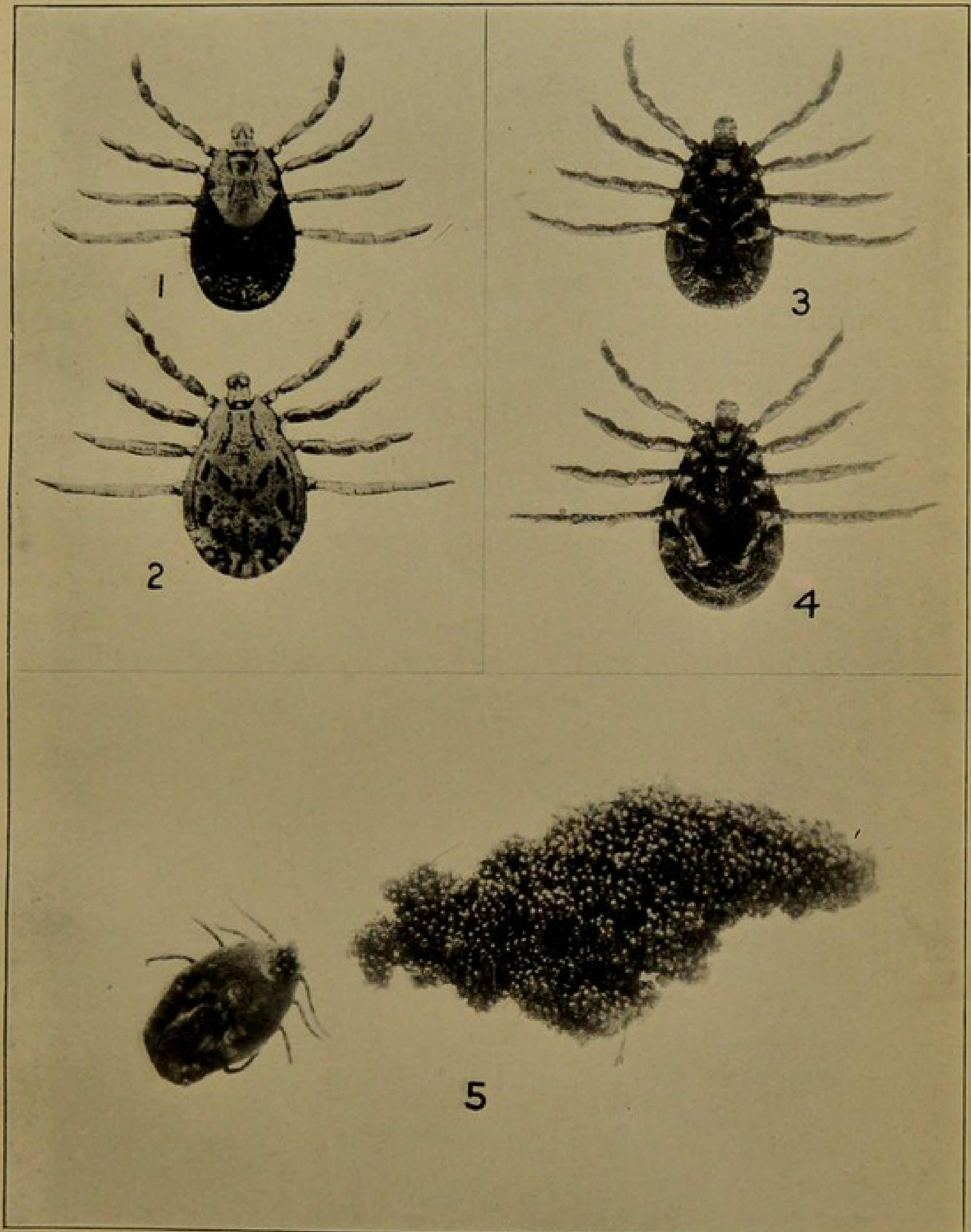
THE ADULT.

As in the case of the engorged larvæ, the nymphs, after dropping, seek a protected place in which to transform, and there become completely inactive. This resting stage requires a longer period than the preceding. During this time the sexual organs of the ticks develop. When the skins are shed the ticks appear as mature males and females. Shortly before the molting of the nymphs the light-colored shields on the back of the adult ticks can be seen through the thin skins which are soon to be shed. After the mature ticks escape from the nymphal skins they are rather soft and comparatively inactive. They soon become dried out and the external structures become thoroughly hardened. The color pattern becomes more pronounced and activity increases. This is the stage in which the ticks are ordinarily observed in the spring months. The males (Pl. II, figs. 2, 4) and females (Pl. II, figs. 1, 3) are nearly the same size, but the former have a hard plate or shield covering the entire back. Upon this shield is a somewhat complicated pattern formed by white bands or stripes. In the female the shield is much smaller, covering only the anterior portion of the body. Almost its entire surface is covered with white. The portion of the body of the female behind the shield is rather soft and elastic. It is usually somewhat wrinkled and of a dark reddish-brown color. In this stage, as well as in the preceding, the ticks have eight legs, but the white markings on the backs of both sexes and the presence of a small genital opening on the underside near the "heads" of the ticks serve to distinguish them readily from the other stages. Of course the size of the adult ticks is considerably greater than that of either of the immature stages. Prior to feeding they usually measure about one-sixth of an inch in length by one-tenth of an inch in width.

Before reproduction can begin it is necessary for both the males and females to feed upon the blood of some animal. They usually attach to the large domestic animals, and after feeding about 4 days or more the males start in search of mates. Fertilization takes place on the host, and in from 8 to 14 days after attachment the females, having become filled with blood, drop from the host and seek a protected place in which to deposit their eggs. During the course of feeding the portion of the body of the female behind the shield is greatly distended, so that the specimens now measure about one-half inch long by one-third inch wide by one-fourth inch thick. On account of the enormous distention of the back part of the body of the female, the legs and head are rendered inconspicuous. A close examination, however, will show the white shield on the back just behind the "head." When the females are filled with blood the back part of the body is usually a bluish-gray color. Although the males imbibe a certain amount of blood when attached to an animal they never increase greatly in size as do the females.

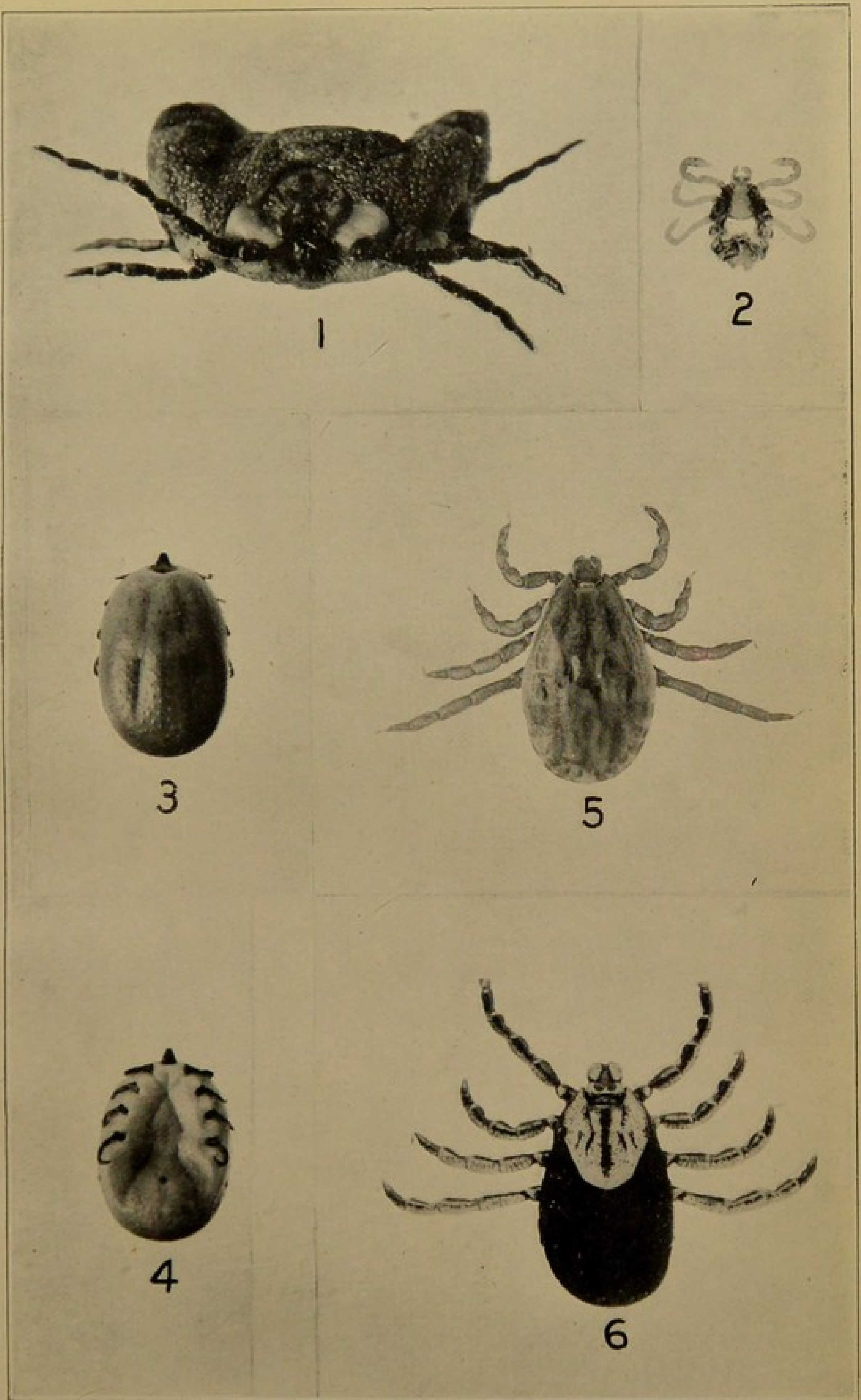
The females always drop from the host animal before beginning the deposition of eggs. Deposition continues for about 30 days, during which time several thousand eggs are deposited. (See Pl. II, fig. 5.) During the process of deposition the female gradually shrinks in size. When all of the eggs are expelled the tick is much shriveled (Pl. III, fig. 1) and has changed in color to a mottled yellowish. She dies within a few days after the last eggs are deposited.

While depositing her eggs the female remains in the same place, so that all of the eggs are in one large mass. The eggs hatch into seed ticks in from 16 to 51 days and the life cycle is again repeated.



THE ROCKY MOUNTAIN SPOTTED-FEVER TICK (DERMACENTOR VENUSTUS).

Fig. 1.—Adult female, unengorged, dorsal view. Fig. 2.—Adult male, dorsal view. Fig. 3.—Adult female, unengorged, ventral view. Fig. 4.—Adult male, ventral view. Fig. 5.—Adult female in act of depositing eggs. (Original.)



THE SPOTTED-FEVER TICK (DERMACENTOR VENUSTUS) AND DERMACENTOR ALBIPICTUS.

Fig. 1.—Adult spotted-fever tick which has deposited eggs. Fig. 2.—Larva of spotted-fever tick. Fig. 3.—Engorged nymph of spotted-fever tick. Fig. 4.—Same, ventral view. Fig. 5.—Adult male of *Dermacentor albipictus*. Fig. 6.—Adult female of *D. albipictus*, unengorged. (Original.)

SEASONAL HISTORY AND HABITS.

For convenience in tracing the life cycle of the Rocky Mountain spotted-fever tick we will begin with the appearance of the flat or unengorged females and males which appear with the first warm days of spring. It should be remembered that these ticks have remained dormant throughout the winter months. When they are rendered active during the warm spring days they are immediately ready to attach to an animal and engorge. Some of these ticks pass the winter in places where they are not readily reached by the warmth of the sun. Such specimens become active later than others. Emergence from winter quarters is therefore gradual, usually extending over a period of a few months, beginning about the 1st of March.

The time of the beginning of activity in the spring is also dependent to a considerable extent upon the relative earliness of the season and upon the locality. In lesser altitudes, and at the southern limit of the range of the species, activity may begin as early as the middle of February, while in the Bitter Root Valley it is probable that the ticks seldom become active in numbers before nearly the middle of March.

After leaving their winter quarters the adult ticks begin crawling about and usually ascend brush to await a host. They may crawl upon trees or other objects so as to get several feet above the ground.

In all ticks the anterior legs have well-developed sense organs located near their tips. These front legs are used as feelers. When the tick is disturbed it immediately begins to wave them in an endeavor to catch any passing object.

Having found a host, the ticks crawl about upon it until a suitable place for attachment is found. On cattle they are usually found in numbers on the dewlap, between the fore and hind legs, and along the belly. On horses they are commonly found between the legs and sometimes in the mane. They may, however, attach to any part of the host.

Attachment to the host is accomplished by means of a spiny beak, which has an opening in the end through which the blood of the animal is drawn. In from 4 to 8 days after attaching the males begin searching for mates. In order to fertilize the females they crawl beneath them, and after mating usually attach to the animal immediately under their mates. When the females have become one-half engorged the blood is rapidly imbibed, and complete engorgement is reached in a very short time, after which they loosen their hold and drop to the ground. Table I shows the time required for the engorgement of females on different hosts and during different times of the year.

TABLE I.—*Time required for engorgement of females of Dermacentor venustus at Dallas, Tex.*

Adults attached.		Dates of dropping as engorged females.		Period of engorgement.
Date.	Host.	First.	Last.	
				Days.
May 15, 1908	Ox	May 23	June 1	8–17
Mar. 19, 1910	Guinea pig	Mar. 28	Mar. 28	9
Apr. 1, 1910	Ox	Apr. 12	Apr. 13	11–12
May 4, 1910	Ox	May 12	May 17	8–13
Mar. 29, 1911	Ox	Apr. 7	Apr. 12	9–14
May 29, 1911[1]	Goat	June 3	June 15	5–17

[1] The specimens in this lot were fertilized and slightly engorged when applied.

After the dropping of the females the males usually remain on the host for some time. We have found that they crawl about over the animal, reattaching in different places and fertilizing a number of different females after one infestation of females has become engorged and dropped from the host.

Immediately after leaving the host engorged females endeavor to find some protected place in which to deposit their eggs. As has been stated, deposition may begin as soon as the seventh day after dropping, and all of the eggs, which usually number about 4,000, are deposited within 30 days. During the process of egg laying the female gradually shrinks in size and death takes place within a few days after all of the eggs have been laid. The length of time before the beginning of egg laying depends largely upon the temperature. During cool weather a period of 41 days has been known to pass after dropping before the first eggs were deposited.

The development of the seed tick begins within the egg as soon as it is deposited. After the embryonic tick has grown for about two weeks, a small white spot appears on one side of the egg. The appearance of this spot enables one to determine whether the eggs will hatch. The time required for incubation is largely dependent upon temperature conditions. In the Bitter Root Valley Mr. W. V. King has determined that this period ranges from 34 to 51 days, the longer period occurring in the early spring months. At Dallas, Tex., we have observed eggs to hatch as early as 15 days after they were deposited, the longest incubation period observed in that locality being 41 days. After the small seed ticks hatch from the eggs they usually remain clustered upon the eggshells for a few days and then crawl upon any object in their immediate vicinity to await a host. In this stage also the front legs are used as feelers, and when an animal comes into contact with the seed ticks, these immediately catch hold. Naturally during the larval stage, as well as during the adult stage, large numbers of the ticks starve before finding a suitable host upon which to engorge. The larvæ die much sooner from starvation than do the other stages of the tick.

During the summer months we have found that all of the seed ticks hatching from a mass of eggs usually die within one month after the first eggs hatch. In one instance a period of 117 days elapsed between the beginning of hatching of the eggs and the death of the last seed tick. This is the greatest longevity which we have observed.

Table II indicates the variations in the time required for the beginning of egg laying, incubation of the eggs, and length of time required for the starvation of the seed ticks:

TABLE II.—*Time required for beginning of deposition of eggs, hatching, and starvation of seed ticks of Dermacentor venustus.*

Date engorged female dropped or was picked from host.	Date first eggs were deposited	Period from dropping of female to beginning of deposition.	Date hatching of eggs began.	Period from beginning of deposition to beginning of hatching.	Date all seed ticks were dead.	Period from beginning of hatching to death of last seed tick.	Mean daily temperature during incubation.
		Days.		*Days.*		*Days.*	*°F.*
June 11, 1909	June 27, 1909	16	July 15, 1909	18	Sept. 5	52	91.8
Mar. 28, 1910	Apr. 7, 1910	10	May 10, 1910	33	July 25	76	70.49
Apr. 2, 1910[1]	May 13, 1910	41	July 3, 1910	51	Aug. 1	30	....
Apr. 7, 1910	Apr. 17, 1910	10	May 19, 1910	32	July 19	61	74.6
Apr. 13, 1910	Apr. 20, 1910	7	May 25, 1910	35	Aug. 15	82	71.78
Apr. 26, 1910	May 2, 1910	6	May 31, 1910	29	July 30	60	71.63
May 1, 1910[1]	May 19, 1910	18	July 9, 1910	51	Sept. 3	56	....
May 14, 1910	May 23, 1910	9	June 12, 1910	20	Aug. 31	80	79.64
May — 1910[1]	.....do	....	July 9, 1910	47	Nov. 3	117	....
June 4, 1910	June 13, 1910	9	June 29, 1910	16	Sept. 29	92	84.37
June 4, 1910[1]	June 17, 1910	13	July 21, 1910	34	Aug. 11	21	....
July 16, 1910	July 25, 1910	9	Before Aug. 10, 1910	16	Sept. 30	51	84.59

[1] These records were made in the Bitter Root Valley in Montana; all others were made at Dallas, Tex.

Those larvæ which succeed in finding an animal upon which to engorge usually attach about the head and ears of the host, become filled with blood, and drop from the animal between the third and eighth days. In nature the larvæ feed almost entirely upon the small wild mammals, although experimentally they have been forced to engorge upon cattle. As has been stated, the larvæ after becoming engorged drop from the animal, find a protected place, shed their skins, and become active eight-legged creatures known as nymphs. These nymphs emerge from the quiescent seed-tick stage from about the middle of July to the beginning of cold weather. Some of those transforming during the summer find hosts, become engorged, and drop for molting. A few of these probably molt to adults before cold weather begins and hibernation takes place in the adult stage. These few individuals are the only ones which complete their life cycle in a single season. It should be emphasized that these nymphs, as well as the seed ticks, feed almost exclusively on small wild mammals. Tables III and IV show the length of the engorgement and molting periods of larvæ and nymphs.

TABLE III.—*Time required for molting of seed ticks and nymphs of Dermacentor venustus.*

Seed ticks dropped engorged.		Date seed ticks molted.		Period from dropping to molting.	Nymphs dropped engorged.		Date nymphs molted.		Period from dropping to molting.
Date.	Number.	First.	Last.		Date.	Number.	First.	Last.	
1908. Apr. 5	23	1908. Apr. 20	1908. Apr. 24	*Days.* 15–19	1908. Aug. 6	17	1908. Aug. 20	1908. Aug. 22	*Days.* 14–16
May 17	15	May 27	May 30	10–13	1909. Sept. 15	5	1909. Aug. 6	1909. Aug. 7	21–22
1909. Aug. 6	7	1909. Aug. 13	1909. Aug. 16	7–10	Oct. 3	3	Oct. 21	1910. Mar. 22	18–170
Sept. 1	56	Sept. 7	Sept. 10	6–9	1910. Mar. 23	2	1910. May 4	May 23	42–61
1910. July 4[1]	Many.	1910. July 18	1910. July 25	14–21	Apr. 14	13	May 24	May 30	40–46
July 8[1]	Many.	July 19	...do.....	11–17	July 21	1	Aug. 1	Aug. 1	11
July 22[1]	Many.	Aug. 8	Aug. 11	17–20	Aug. 1	6	Aug. 14	Aug. 16	13–15
1911. May 22	110	1911. May 30	1911. June 2	8–11	Aug. 19	12	Aug. 31	Sept. 4	12–16

[1] These records were made in the Bitter Root Valley, Mont.; all others were made at Dallas, Tex.

TABLE IV.—*Time required for engorgement of seed ticks and nymphs of Dermacentor venustus.*

Seed ticks applied.		Date of dropping as engorged seed ticks.		Period of engorgement.	Nymphs applied.		Date of dropping as engorged nymphs.		Period of engorgement.
Date.	Host.	First.	Last.		Date.	Host.	First.	Last.	
1908. Apr. 2	Ox.........	1908. Apr. 5	1908. Apr. 10	*Days.* 3–8	1908. Apr. 1	Ox.........	1908. Apr. 5	1908. Apr. 8	*Days.* 4–7
July 12	......do......	July 15	July 18	3–6	1909. Aug. 13	Guinea pig.	1909. Aug. 17	1909. Aug. 18	4–5
1909. July 28	Guinea pig.	1909. Aug. 2	1909. Aug. 4	5–7	Sept. 10	Rabbit......	Sept. 14	Sept. 15	4–5
Aug. 2	Rabbit......	Aug. 7	Aug. 7	5	1910. May 24	Bovine......	1910. May 30	1910. May 30	6
Aug. 27	Guinea pig.	Aug. 29	Sept. 3	2–7	Aug. 13	Rabbit......	Aug. 18	Aug. 20	5–7
1910. July 19[1]	Ground squirrel.	1910. July 22	1910. July 23	3–4	Aug. 19	Rabbit......	Aug. 23	Aug. 28	4–9
1911. May 18	Guinea pig.	1911. May 21	1911. May 24	3–6	Aug. 17[2]	Ground squirrel.	Aug. 22	Aug. 27	5–9

[1] This record was made by W. V. King in the Bitter Root Valley, Mont. Dropping probably began on July 21, or the second day after application.
[2] This record was made in the Bitter Root Valley, Mont. Records not referred to in footnotes were made at Dallas, Tex.

Those larvæ which hatch from eggs deposited by females which do not find hosts until late in the spring become engorged during July and August and do not molt to nymphs until shortly before winter. It is thus necessary for the nymphs which appear late in the summer to pass the winter in that stage. These nymphs appear in the spring shortly after the emergence of the adult ticks; that is, shortly after the middle of March. They continue to emerge from their winter quarters for some time, the last individuals not securing hosts upon which to engorge until early in July. These individuals molt to adults during the latter part of the summer, and the resulting adults pass the winter before feeding.

In contrast to the short length of life as exhibited by the larvæ, we find the vitality of the nymphs and adults to be remarkably great. It has been determined that adults collected on vegetation during the spring months may survive for a period of 413 days without food. These individuals undoubtedly passed the winter in the adult stage, and therefore the total length of life must have been approximately one and two-thirds years. However, in nature the great majority of the ticks with a vitality equal to this lot would probably find hosts and become engorged. Unfed nymphs have been found to survive a period of more than 300 days. It is thus possible for ticks which pass the winter in the nymphal stage to live until at least July 15 of the following year. Under natural conditions this longevity is probably even greater.

The following is a summary of the life cycle of the tick: The winter is passed as flat or unengorged males and females and as unengorged nymphs. The former are present from about March 15 to July 15, during which time they find hosts and become engorged. It is during this period that the pest attacks man and communicates to him the germs of Rocky Mountain spotted fever. The eggs deposited by the females which find hosts early in the spring hatch into larvæ, which may develop into adults by the first or middle of September. The offspring of the females which become engorged late in the season succeed in developing only as far as the unengorged nymphal stage before cold weather begins. The overwintered nymphs begin appearing from their winter quarters during the latter part of March. They are to be found upon small wild mammals from that time until about the middle of July, at which time the nymphs which have developed from the females engorged during that spring are also present. Overwintered nymphs transform to adults during the summer and fall, and the majority of these adults pass the winter in the unfed condition. A few of the first nymphs to find hosts early in the spring may molt to adults sufficiently early in the summer to allow the adults to become engorged, deposit eggs, and the transformation to proceed to the unfed nymphal stage by the approach of cold weather, thus completing a life cycle in one year. However, the individuals which proceed with development beyond the unengorged adult stage during the same season must be very exceptional. When the mean temperature is low during the spring and early summer it is almost certain that none of the individuals which have passed the winter as unengorged nymphs develop further than unengorged adults during that season.

It has been observed that even though the adults which transform from overwintered nymphs are kept confined with the host animal during the summer or fall following their maturity, they show no marked desire to feed, usually endeavoring to crawl away and become quiet. Thus the habit of the adults of attaching to hosts in the spring appears to be so well established that they can scarcely be induced to attach to a host after midsummer.

From the foregoing statements it is evident that although a few of the ticks may complete their life cycle—that is, the transformation from unengorged adults to unengorged adults of the next generation, or from unengorged nymphs to unengorged nymphs of the next generation—during one season, the majority require two years for this cycle. Should overwintered nymphs not find hosts until late in the season and thus not become adult until the approach of winter, the resulting adults, if unable to find hosts, may survive until the second spring following. Ticks which pass the winter in the adult stage may survive until the second spring following, then engorge and produce offspring which develop to nymphs the second summer, pass the winter in the nymphal stage, and complete development to unengorged adults during the third season. Thus it is apparent that under certain conditions three years might be required for the completion of the life cycle. This would necessitate the destruction of the adult ticks during three successive seasons in order to eradicate the species.

Figure 2 shows several of the ways in which development may proceed.

THE HOST ANIMALS OF THE SPOTTED-FEVER TICK.

The investigations conducted by Dr. Ricketts indicated that the Rocky Mountain spotted fever tick is restricted in regard to its host relations. Our investigation has shown that this restriction of certain stages of the tick to certain classes of animals is very well marked. *The examination during three seasons of nearly 800 wild mammals which are inhabitants of the Bitter Root Valley and numerous observations made elsewhere have shown that, with few exceptions, only the immature stages of the tick are to be found on this class of hosts. On the other hand, the large domestic animals are the principal hosts of the adult ticks, and the immature stages are rarely, if ever, found upon them.* This restriction of the adult stage to the larger mammals, now a firmly fixed habit of the tick, undoubtedly arose from the fact that the adult ticks are so large that they can be easily removed by the smaller mammals. As will be pointed out in the discussion of remedial measures, this habit of the Rocky Mountain spotted-fever tick may be taken advantage of in the control or eradication of the species.

FIG. 2.—*Diagram showing the possible seasonal history of the Rocky Mountain spotted-fever tick.*

Overwintered individuals.	Unengorged adults.	Some fail to engorge the following season.	But engorge and deposit eggs the second spring.	These develop to unengorged nymphs that season and pass the winter in that stage.	These engorge and molt to adults the following summer.	These require three years, to complete the life cycle.
		Some become engorged early in spring.	Eggs deposited by these hatch in early summer.	Some seed ticks engorge and molt to nymphs in midsummer.	A few of these nymphs may engorge and molt to adults in the fall. These pass the winter as unengorged adults.	These require but one year to complete the life cycle from unengorged adults to unengorged adults.
					The majority do not feed but pass the winter as unengorged nymphs.	These engorge and molt the following spring, thus requiring two years to complete the life cycle.
				Others engorge and molt to nymphs in late summer.	These pass the winter as unengorged nymphs.	
		Others become engorged in late spring and early summer.	Eggs deposited by these hatch in mid or late summer.	Some seed ticks engorge and molt to nymphs in late summer or early fall.	These pass the winter as unengorged nymphs or a few may engorge and pass the winter as engorged nymphs.	
				A very few remain unengorged or engorge in the fall.	These enter the winter as unengorged or engorged larvæ and die during the winter.	
	Unengorged nymphs.	Some become engorged in spring.	These molt to adults in spring or early summer.	A few may engorge in summer and deposit eggs.	A few of the earlier hatch and the larvæ engorge and molt to nymphs which pass the winter in this stage.	These complete the life cycle from unengorged nymph to unengorged nymph in one year.
					The later-deposited eggs either fail to hatch or die during winter as seed ticks.	
		Others become engorged in summer.	These molt to adults in late summer or fall.	Remain quiet during the rest of the summer.	And pass the winter as unengorged adults.	Some of these engorge, deposit eggs, and the resulting seed ticks transform to nymphs the following year, thus requiring two years to complete the life cycle. Others fail to find hosts and do not engorge until the second spring, development proceeding that season to unengorged nymphs, thus requiring three years to complete the life cycle.

Among the domestic animals which act as hosts for the adult stage of the tick, horses and cattle are of prime importance. A number of collections indicates that sheep are frequently attacked, but with smaller numbers of ticks. Dogs have also been found to harbor this species, but in limited numbers only. Among nearly 100 collections of ticks made on dogs in the territory in which this species occurs only 12 lots of this tick have been obtained. Only 2 of these 12 lots contained females which were sufficiently engorged to deposit eggs. This indicates that the majority of the ticks are scratched off by the dogs before becoming fully filled with blood. Mules and asses have also been found infested with this species, and in two instances collections have been made upon hogs. It is not likely that the latter host is of much importance, particularly when the animals are kept confined in pens and thus not exposed to the ticks.

Among the wild animals which act as hosts for the adults, the mountain goat harbors by far the greatest number. In addition to specimens of the adults, nymphs have also been found upon them. The brown bear and coyote have been found to be infested with considerable numbers of spotted-fever ticks, some of the specimens being sufficiently engorged to deposit eggs. The snowshoe rabbit and jack rabbit have occasionally been observed to be infested with limited numbers of adults, but on neither of these hosts have engorged specimens been captured. The woodchuck has also been found to act as a host for the adult stage. In only one instance, however, were specimens taken upon this host, although 51 of the animals were examined during the investigation.

The Columbian ground squirrel is undoubtedly by far the most important host of the immature stages of this tick in the Bitter Root Valley. In other parts of the Western States, where this species of ground squirrel does not occur, related species have been found to act as hosts for both of the immature stages of this tick. In the Bitter Root Valley 65 per cent of the 341 Columbian ground squirrels examined were found to be infested with immature ticks of the genus Dermacentor. Owing to the fact that very large numbers of the immature stages of ticks belonging to the genus Dermacentor collected in the Bitter Root Valley were reared to adult and all found to be the Rocky Mountain spotted-fever tick, we can say with practical certainty that this is the only species of this genus which occurs on the small mammals in that locality. Second in importance as a host of the immature stages of this tick in the Bitter Root Valley is the yellow-bellied chipmunk. Thirty-seven per cent of 131 of these mammals which were examined were found to be infested with seed ticks and nymphs. The pine squirrel is also of much importance, as 29 per cent of the 181 mammals examined were in-

Table V.—*Wild mammals examined in the Bitter Root Valley during 1910–11, with number and stages of Dermacentor venustus found thereon.*

Common names.	Scientific names.	Number of animals examined.	Number of animals with spotted-fever ticks.	Per cent of animals examined which were infested with spotted-fever ticks.	Number of spotted-fever ticks found. Seed ticks.	Nymphs.	Adults.	Total.	Per animal.	State of engorgement of adult females.
Columbian ground squirrel	Citellus columbianus	341	240	64.5	841	1,234	0	2,075	6.09	
Yellow-bellied chipmunk	Eutamias b. luteiventris	131	49	37.4	539	60	0	599	4.57	
Pine squirrel	Sciurus h. richardsoni	181	53	29.3	503+	83	0	586+	3.24	
Woodchuck	Marmota flaviventer	47	26	55.3	9	379	2 or 3	390	8.29	Slight.
Side-striped ground squirrel	Callospermophilus l. cinerascens.	48	25	52.1	31	100	0	131	2.72	
Wood rat	Neotoma cinerea	16	11	68.8	8	12	0	20	1.25	
Snowshoe rabbit	Lepus bairdi	4	3	75.0	0	3	[1] 3	6	1.50	One-seventh.
Cottontail rabbit	Sylvilagus nuttalli	16	5	31.3	11	4	0	15	.94	
White-footed mouse	Peromyscus m. artemisiæ	50	[2] 6	12.0	16	4	0	20	.40	
White-bellied chipmunk	Eutamias q. umbrinus	58	5	8.6	44	4	0	48	.83	
Large meadow mouse	Microtus modestus	32	[2] 6	18.8	0	7	0	7	.22	
Jumping mouse	Zapus princeps	13	[2] 1	7.7	1	0	0	1	.08	
Pika or rock rabbit	Ochotona princeps	28	1	3.6	0	1	0	1	.04	
Pocket gopher	Thomomys fuscus	12	1	8.3	1	0	0	1	.08	
Longtailed meadow mouse	Microtus mordax	5	[2] 0	0	0	0	0	0	0	
Gray meadow mouse	Microtus n. canescens	2	[2] 0	0	0	0	0	0	0	
Red-backed mouse	Evotomys idahoensis	4	[2] 0	0	0	0	0	0	0	
Flying squirrel	Sciuropterus alpinus	3	0	0	0	0	0	0	0	
Shrews	Sorex sp.	10	[2] 0	0	0	0	0	0	0	
Mountain goat	Oreamnos montanus	3	3	100.0	0	([3])	300+	300+	100.0+	Unengorged to fully engorged.
Brown bear	Ursus americanus	1	1	100.0	0	0	[4] 13	13	13.0	Slightly to one-fourth.
Coyote	Canis lestes	2	2	100.0	0	0	[5] 33	33	16.5	Unengorged to slightly.
Mule deer	Odocoileus hemionus	6	0	0	0	0	0	0	0	
White-tailed deer	Odocoileus leucurus	2	0	0	0	0	0	0	0	
Elk	Cervus canadensis	1	0	0	0	0	0	0	0	
Badger	Taxidea taxus	3	1	33.3	0	0	[6] 1	1	.3	
Weasel	Putorius arizonensis	5	0	0	0	0	0	0	0	
Muskrat	Fiber zibethicus	3	0	0	0	0	0	0	0	
Bats	Vespertilionidæ	7	0	0	0	0	0	0	0	

[1] 2 males, 1 female.
[2] Several dead before being examined. Some ticks may have left the animals.
[3] A few. These may have been nymphs of D. albipictus. They were lost before being examined.
[4] 4 males, 9 females.
[5] 15 males, 18 females. A few others escaped.
[6] 1 male (dead).

fested. Among the other mammals which are of considerable importance as hosts of the immature stages are the large chipmunk, the woodchuck, snowshoe rabbit, rock squirrel, wood rat, white-footed mouse, and meadow mouse.

Our knowledge of the tick hosts in the valley was greatly increased by the cooperation of the Biological Survey of this department. Messrs. Howell and Birdseye, of the Survey, were located at the camp laboratory and made extensive collections during 1910. This work was continued in 1911 by Mr. Birdseye. Table V furnishes a list of the wild mammal hosts of this tick. It includes all the records of the Biological Survey,[1] as well as a number made independently by Mr. King, of the Bureau of Entomology. The mammals are listed in the table according to their relative importance as hosts of the immature stages. It is especially worthy of note that among the wild mammals which act as hosts for the adult stage the mountain goat and brown bear are the only ones which were found to have ticks upon them which were engorged sufficiently to deposit eggs.

One hundred specimens of the birds commonly found in the valley were examined and found to be free from ticks.

TABLE VI.—*Host animals on which Dermacentor venustus in the adult stage has been found.*

ON DOMESTIC ANIMALS AND MAN.

Common names.	Scientific names.	Approximate number of hosts examined.	Approximate number of ticks collected.			State of engorgement of females.
			Males.	Females.	Total.	
Ox	Bos taurus	200	2,000	2,000	4,000	Unengorged to fully.
Horse	Equus caballus	800	2,500	2,500	5,000	Do.
Ass	Equus asinus	5	9	5	14	Do.
Mule	Equus asinus×caballus.	9	14	17	31	Do.
Sheep	Ovis airies	75	22	32	54	Unengorged to one-half.
Dog	Canis familiaris	100	18	20	38	Unengorged to three-fourths.
Goat	Capra hircus	5	0	4	4	Unengorged to slightly.
Hog	Sus scrofa	10	2	4	6	Unengorged to one-third.
Man	Homo sapiens	900	400	400	800	Unengorged to one-fourth.
Domestic cat	Felis domesticus	1	1	0	1	Unattached.

ON WILD ANIMALS.

Common names.	Scientific names.	Approximate number of hosts examined.	Males.	Females.	Total.	State of engorgement of females.
Mountain goat	Oreamnos montanus.	3	150	150	300	Unengorged to fully.
Coyote	Canis lestes	1	15	16	31	Unengorged to slightly.
Brown bear	Ursus americanus	1	4	9	13	Slightly to one-fourth.
Jackrabbit	Lepus sp	15	3	6	9	Slightly to one-sixth.
Woodchuck	Marmota flaviventer.	51	2 or 3	2 or 3	5	Slightly.
Snowshoe rabbit	Lepus bairdi	4	2	1	3	One-seventh engorged.
Wild cat	Lynx uinta	1	1	0	1	
Badger	Taxidea taxus	4	[2] 1	0	1	

[1] See United States Department of Agriculture, Biological Survey, Cir. No. 82.
[2] Dead.

OTHER SPECIES OF TICKS FOUND IN REGIONS WHERE ROCKY MOUNTAIN SPOTTED FEVER OCCURS.

Five species of ticks other than *Dermacentor venustus* have been found to occur more or less commonly in the Bitter Root Valley of Montana. These are: *Dermacentor albipictus* Pack. (Pl. III, figs. 5, 6), *Ixodes angustus* Neum., *Ixodes texanus* Banks, *Ixodes kingi* Bishopp, and *Haemaphysalis leporis-palustris* Pack. On account of the host relations of these ticks it is impossible for them to play any important part in the dissemination of Rocky Mountain spotted fever. *Dermacentor albipictus* has been found to occur on practically no other animals than horses, cattle, and mountain goats. It never attacks man. Neither one of the three species of Ixodes has been found to occur on man, and they very seldom attack the domestic animals, being confined to certain of the small wild mammals. The last-named species confines its attack exclusively to rabbits with the exception of the immature stages, which are occasionally found upon birds.

In parts of Idaho, Oregon, Nevada, and Utah, the rabbit Dermacentor (*Dermacentor parumapertus marginatus* Banks) is found quite commonly. Like the other common rabbit tick this species confines its attack exclusively to that host.

SPECIES OF TICKS WHICH MIGHT PLAY AN IMPORTANT PART IN THE DISSEMINATION OF THE DISEASE SHOULD IT BE INTRODUCED INTO NEW REGIONS.

Since it has been shown by Dr. Maver, of the University of Chicago, that Rocky Mountain spotted fever may be transmitted by several different species of ticks, the importance of limiting the disease-infested area to the territory now covered is strongly emphasized.

A closely related species, namely, *Dermacentor occidentalis* Neum., has been found to occur throughout western California and southwestern Oregon. At present the range of this species does not overlap that of the Rocky Mountain spotted-fever tick. On account of the fact that this species is an important pest of man, should the disease become introduced into the territory where it occurs its dissemination would be certain. In the eastern and southern United States several species occur which commonly attack man. Nearly all of these have host relations very similar to that of the Rocky Mountain spotted-fever tick, and therefore the disease might readily be transmitted from animal to animal and from animal to man by any of these species. The following species would probably be of principal importance in the Southern and Eastern States: The lone-star tick (*Amblyomma americanum* L.); the American dog tick (*Dermacentor variabilis* Say), and the gulf-coast tick (*Amblyomma maculatum* Koch). In the extreme southern portions of

Texas and New Mexico the Cayenne tick (*Amblyomma cajennense* Fab.), is a common pest of man.

PRACTICAL CONTROL OR ERADICATION OF THE SPOTTED-FEVER TICK.

In 1909 Dr. Ricketts suggested, in a general way, a plan for the practical eradication of spotted fever from the Bitter Root Valley by a campaign against the ticks. It became evident to Dr. Ricketts as the result of his work on spotted fever that the only method of controlling the disease was by destroying the natural agency of transmission. The work of the Bureau of Entomology in cooperation with the Montana Agricultural College and the Biological Survey in obtaining exact information about the life history and hosts of the tick has served to elaborate upon the suggestions made by Dr. Ricketts and to make it possible to lay down definite plans that should be followed.

It has been pointed out in this bulletin that the plan of eradication, which is dependent upon a knowledge of the tick, is entirely feasible and economical. The question now is whether the loss of 25 or more human lives per year in the Bitter Root Valley, the onus placed upon the development of the valley by the presence of spotted fever, and the danger of the spread of the virulent strain of spotted fever to other regions are not of sufficient importance to justify the small cost that the work will entail. A considerable portion of this cost would be offset by the improved condition of the live stock which would result from the destruction of the ticks as well as of certain other parasites.

CONDITIONS FAVORING CONTROL.

It will be understood from the discussion of the life history of the spotted-fever tick that several facts will assist greatly in an attack against it. Among these are the following:

(1) The vast majority of fever ticks which develop to the adult stage in the Bitter Root Valley do so upon horses and cattle, although small numbers develop upon sheep and a very few upon dogs. The only other domestic animal of any importance in the Bitter Root Valley is the hog. Although no fever ticks have ever been found upon hogs in the valley the adult form was taken in considerable numbers on that host on one occasion in Wyoming. It is therefore evident that under some conditions the hog is to be looked upon as an agency for the breeding of the ticks. The danger on this score, however, is exceedingly remote on account of the method of management of hogs in the valley. In the first place the number of these animals is not large. In the second place they are not allowed to roam at large but are confined to pens or small inclosures where the chances of their picking up fever ticks are very small. If hogs were

allowed to roam into the brushy land on the edges of the valley they might assume importance, but as the present plan of keeping them confined to areas where, for all practical purposes, ticks do not occur will undoubtedly be continued in the future, it is considered safe to ignore them in a plan of practical eradication.

(2) Aside from the domestic animals the wild species which have been found to carry the tick must be considered. These wild mammals can be divided for the purposes of this discussion into two groups, namely, those small forms which frequent the floor of the valley and extend in some cases to considerable elevations in the mountains, and the larger forms, like the bear, deer, elk, and mountain goat, which are more or less confined to the mountainous walls of the valley, but nevertheless sometimes visit the fields below.

Regarding the small wild mammals found throughout the valley, it was ascertained by examination of very large numbers of specimens that they seldom or never serve as hosts for the adult ticks. The immature forms of the fever tick are frequently to be found upon these mammals, but the *development of the adults is practically restricted to the larger domestic animals.*

Regarding the larger wild mammals it may be said that their numbers are rapidly decreasing. Some of them are practically extinct. The mountain goat, which appears more or less frequently to carry the adult fever tick, never invades the valley proper. In the winter it is to be found upon the lower rocks of the mountain walls, but it moves back to higher elevations as the snow melts. Therefore mountain goats tend rather to remove ticks from the valley than to plant them there. Among the other possible hosts, the two species of deer are rapidly becoming scarce. Moreover, in our investigations no fever ticks have been found attached to deer. The bear, among the wild mammals, is probably the most likely to serve as a host for the fever tick. It can not be considered that this mammal is abundant enough, however, to have any important bearing on the situation. The same is true of the coyote. In fact the number of ticks that could possibly be reared upon all the larger wild hosts would not be sufficient to cause any considerable infestation of the valley. These mammals can not be ignored altogether, but it is safe to consider them as comparatively unimportant. They might be of considerable importance if the project were to exterminate the fever in the valley and surrounding regions absolutely. But the plan here proposed is to reduce the cases of spotted fever to a practically negligible number in the valley. This is feasible and can be accomplished at small cost, while total eradication of the fever ticks in the mountains is not necessary to relieve the situation.

Since it has been pointed out that the larger domestic animals—horses, cattle, sheep, and dogs—are necessary hosts for the propagation of the fever tick, the problem of control becomes very greatly simplified. The immature stages may be allowed to develop on the small mammals in the valley so long as the adult stage may be destroyed upon the domestic animals which are necessary for its development.

Of course the reduction of the number of rodents in the valley, especially the Columbian ground squirrel, is advisable. These animals are more or less serious agricultural pests. They destroy a considerable amount of produce, and the inhabitants of the valley are in the habit of waging warfare against them. Undoubtedly the damage done is abundantly sufficient to warrant this work. The reduction of the rodents should be encouraged both on general economic principles and because they carry the immature stages of the spotted-fever tick. This line of work may well supplement the main work which must be done with the larger domestic animals, and will undoubtedly hasten the removal of the fever tick from the valley.

In one respect work against the rodents is of more than incidental value. It was found by Dr. Ricketts that five of these animals, namely, the gopher, rock squirrel, woodchuck, chipmunk, and mountain rat, are susceptible to spotted fever, and may serve as the original source of the disease in nature, or, at any rate, furnish a reservoir from which is derived the infection of human beings by the agency of ticks. The main point, however, is to destroy the tick which is necessary for the propagation of the disease, and this can be done by directing the principal efforts against the ticks on the larger animals which are under the control of man.

There are several facts, in addition to the practical restriction of the adult fever tick to the larger domestic animals, which will serve to render a campaign of eradication feasible. One of these is that the adult ticks are to be found on domestic animals or elsewhere during only a part of the year. Efforts toward eradication need not begin before March 1 and there would be no necessity for their continuance far beyond June 15. This is the season when the work can be done most easily and with smallest risk to the stock. A line of attack extending throughout the year is entirely unnecessary. Another favorable factor is the small number of live stock that would have to be treated. This is shown by the table below:

Table VII.—*Number of live stock in Bitter Root Valley. (U. S. Census, 1900.)*

	Ravalli County.	Missoula County.
Neat cattle	22,461	13,684
Horses	6,713	4,125
Mules	18	36
Sheep	58,212	4,942

Moreover, in the Bitter Root Valley eradication would not suffer the drawbacks connected with the ownership of large bodies of land by single persons which have attended similar work that has been undertaken in other parts of the country. The total number of farms in Ravalli County, as given in the census of 1900, was 891; their average size 199.4 acres. In Missoula County the same authority gives 615 farms of an average size of 241.6 acres.

An additional advantage will be found in the large proportion of farms in the county which are operated by their owners. Very little difficulty on account of nonresident ownership is to be expected. In Ravalli County 77 per cent of the farms are operated by the owners, and in Missoula County 89.

Aside from the specific factors which would operate to facilitate eradication of the spotted fever tick, others of a general nature may be mentioned, namely, the small size of the valley and its practical inclosure by high mountains, and the public interest in eradication which has already arisen. The Bitter Root Valley lies between high ranges of mountains over which there is practically no travel. The upper end of the valley is also closed by high mountains over which a very inconsiderable amount of traffic takes place. The lower end is narrowed almost to a gorge. Practically all the traffic into or out of the valley goes through this narrow opening at the northern end. The lay of the land gives an isolated region into which infection from the outside would be very unlikely to take place. For all practical purposes the guarding of the lower end for a portion of the year would be sufficient to prevent reinfection in case eradication is undertaken. The soil of the Bitter Root Valley has been found to be exceedingly fertile and especially adapted to certain profitable crops. It is recognized by all intelligent residents that the principal obstacle to the rapid development which has already begun is the occurrence of spotted fever. There is consequently a firmly embedded popular opinion that the destiny of the valley demands the eradication of the fever tick.

We may summarize the more important facts and conditions which would facilitate eradication of the fever tick as follows:

(1) Practical restriction of the adult stage of the tick to the larger domestic animals.

(2) The short season in the spring over which it would be necessary to carry on the principal work of eradication.

(3) The small number of animals that would have to be treated.

(4) The small size of the farms.

(5) The preponderance of resident farm owners.

(6) The isolation of the valley and the existence of effective natural barriers against reinfestation.

(7) A commendable public opinion in favor of removing an important obstacle to development.

IMPORTANCE OF CONTROL THROUGHOUT THE BITTER ROOT VALLEY.

For several reasons it is necessary to carry on this plan of eradication on both sides of the valley. It is known that the fever is very much less prevalent on the east than on the west side. This situation, however, is undoubtedly in part due to the heavier population on the west side and the greater number of live stock. There is every reason to believe that the settlement of the east side, with the inevitable increase in the number of live stock and, consequently, of opportunities for the ticks to breed to maturity, would result in an increased number of cases of spotted fever. That this is not a remote danger is shown by the fact that the development of the east side has already begun and will undoubtedly continue with rapidity. We do not wish to be understood as believing that the comparatively unsettled condition of the east side is the only reason for the scarcity of ticks. There are undoubtedly others. Among these is the greater abundance of rodent hosts for the immature stages of the tick on the west side. This is due primarily to the larger amount of protection in the brush or "slashings," although the settlement of the land and the planting of crops may have tended, by furnishing food, toward the multiplication of the rodents. Soil conditions may also have something to do with the difference.

The main point, however, is that the comparative immunity of the east side is not likely to continue. Destroying the ticks on both sides would cost but little more than on one. It would prevent the reinfestation of the west side. If it were not done, it would be necessary to establish and to maintain a quarantine against live stock on the east side. From every point of view it is wise to conduct a thorough work and clear both sides of the valley at the same time.

METHODS OF DESTROYING TICKS.

The two methods of eradicating ticks which will be found to be adapted to the conditions of the Bitter Root Valley are (1) the dipping of live stock in vats provided for the purpose, and (2) the hand treatment of such animals as can not conveniently be dipped.

In the case of the tick (*Margaropus annulatus* Say) which transmits splenetic fever of cattle, a third method has been found to be of great importance. This is the elimination of the ticks from pastures by "starving" them. This is accomplished by keeping the cattle out. During the warm portions of the year, at least, only a few months time without hosts will result in the death of the cattle ticks. Important differences between the life history of the splenetic-fever tick and that of the spotted-fever tick make that plan entirely impracticable in the case of the latter species. The problem of the splenetic-fever tick is not complicated by the existence of different hosts for the immature and the adult stages. That tick is absolutely dependent upon cattle and remains on its host until mature. The spotted fever tick, however, drops to the ground twice for the purpose of molting and develops through the immature stages upon certain rodents and other animals. In the opinion of the Biological Survey the extermination of these rodents within reasonable time appears to be impracticable because of the necessary expense. The problem is even further complicated by the remarkable ability of the fever ticks to live for long periods without hosts. As shown in the discussion of the longevity of the stages of the spotted fever tick, a period of three years, in which horses and cattle were kept out of the pastures, would be required before eradication could be brought about. This long period renders the so-called starvation plan entirely impracticable.

DIPPING.

Undoubtedly the so-called arsenical dip is the one best adapted for use in the Bitter Root Valley. In fact this dip has practically displaced all others for the destruction of ticks in various parts of the world. Crude oils have been used to a considerable extent in some cases. They are more expensive than the arsenical dip and dangerous to cattle under some conditions. Serious losses have followed the use of heavy oils in dry regions or where it has been necessary to drive the cattle any considerable distance after dipping.

Another advantage that the arsenical dip will be found to have over crude oil for the work in the Bitter Root Valley is that it will not act as a repellent. When cattle are oiled a portion of the oil remains in the hair and upon the skin for several days. This will prevent ticks from attaching. In the case of the arsenical dip, however, there is very little repellent effect. As the object of the work is to kill the ticks rather than to keep them from the animals, the more that can be caused to attach the better.

The formula for the arsenical dip is as follows:

Sodium carbonate (sal soda)	pounds	24
Arsenic trioxid (white arsenic)	do	8
Pine tar	gallons	2
Water to make	do	500

The preparation of the arsenical dip is described in Farmers' Bulletin No. 378, Methods of Exterminating the Texas-fever Tick, prepared by the Bureau of Animal Industry of this department, as follows:

In preparing the dip, a large caldron or galvanized tank is required for heating the water in which to dissolve the chemicals. Thirty or forty gallons of water should be placed in the caldron or tank and brought to a boil. The sodium carbonate is then added and dissolved by stirring. When this is accomplished, the arsenic is added and dissolved in a similar manner. The fire is then drawn and the pine tar added slowly in a thin stream and thoroughly mixed with the dip by constant stirring. This strong stock solution is diluted to make 500 gallons before using.

The only precautions necessary are to see that live stock are not allowed to drink it and to avoid heating the animals either before or after dipping. The dip can be used repeatedly until it becomes

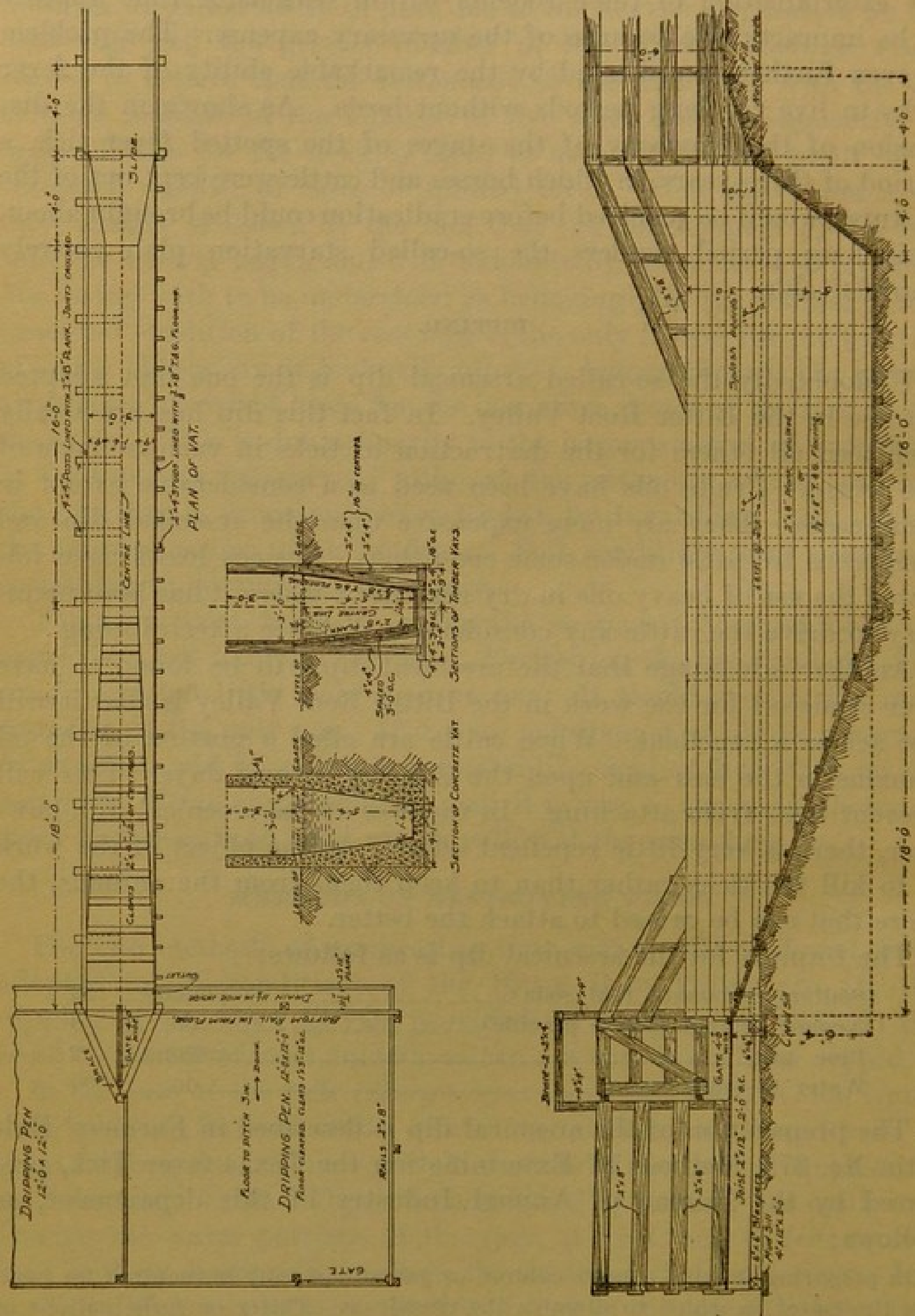


FIG. 3.—Drawings for wood or concrete dipping vat. (From Graybill, Farmers' Bulletin 378.)

befouled by foreign matter. A reasonable estimate of the cost of preparing this dip in the valley is $0.0031 per gallon, or $6.20 for an amount sufficient to fill a vat of 2,000 gallons capacity.

CONSTRUCTION OF VATS.

The specifications for such vats as will be found best adapted to use in Montana are taken from Farmers' Bulletin No. 378, already referred to, as follows:

SPECIFICATIONS AND MATERIALS FOR A DIPPING VAT.

A vat constructed according to the accompanying plans will hold 2,088 gallons when filled to a depth of 5 feet.

Excavation.—Excavate for the vat, as shown by the drawings [fig. 3], to the proper depth. Level the bottom of the pit for the sills. After the vat is completed fill in around it, using the surplus natural grade, and slope the surface away from the vat. Dig the holes required for all posts, etc.

Carpenter work.—The drawings show the vat constructed according to two methods. One method is to make the sides of 4 by 4 inch posts spaced about 3 feet apart and lined with 2 by 8 inch dressed, sized, and bevel-edged plank, using 20-penny spikes to fasten them to the posts and braces. All the joints are to be calked with oakum, well driven in with a calking iron, and pitched. The floor of the vat and the inclines are to be made of 2-inch plank, with joints calked; the exit incline to have 2 by 4 inch cleats spiked to the plank flooring. The slide should have an angle of about 25° and should be covered with No. 16 galvanized iron.

The other method is to build the sides of the vat of 2 by 4 inch posts and 2 by 4 inch braces spaced about 16 inches on centers. The 2 by 4 inch posts and braces are to be lined with ⅞ by 8 inch tongued-and-grooved flooring, blind nailed at every bearing with 10-penny nails. All the joints are to be laid in white-lead paste and the boards firmly driven up.

Lumber.—The lumber used in the construction of the vat must be thoroughly dried and seasoned stock, free from large and loose knots, straight grained, and free from sap.

Gutters.—The gutters for the dripping pens should be made of sound stock, the bottom plank housed into the sides and ends, and the ends housed into the sides. All the joints are to be laid in white-lead paste and thoroughly nailed. Gutters are to have a 3-inch fall in 11 feet.

Bill of materials for vat and draining pens.

Vat:

- Sills, 8 pieces 4 by 4 inches by 10 feet long.
- Posts—
  - 1 piece 4 by 4 inches by 16 feet long.
  - 1 piece 4 by 4 inches by 14 feet long.
  - 6 pieces 4 by 4 inches by 12 feet long.
  - 5 pieces 4 by 4 inches by 10 feet long.
- Braces—
  - 1 piece 4 by 4 inches by 16 feet long.
  - 6 pieces 4 by 4 inches by 12 feet long.
  - 1 piece 4 by 4 inches by 10 feet long.
  - 1 piece 4 by 4 inches by 6 feet long.
- Guards—
  - 2 pieces 2 by 8 inches by 18 feet long.
  - 1 piece 2 by 8 inches by 16 feet long.
  - 2 pieces 2 by 8 inches by 12 feet long.
  - 1 piece 2 by 8 inches by 10 feet long.

Vat—Continued.

Sides—

18 pieces 2 by 8 inches by 20 feet long.
25 pieces 2 by 8 inches by 18 feet long.
2 pieces 2 by 8 inches by 16 feet long.
2 pieces 2 by 6 inches by 18 feet long.
Dressed one side and two edges.
Edges beveled for calking.

Floor—

3 pieces 2 by 10 inches by 20 feet long.
2 pieces 2 by 10 inches by 16 feet long.
1 piece 2 by 10 inches by 14 feet long.
1 piece 2 by 10 inches by 7 feet long.
1 piece 2 by 12 inches by 12 feet long.
Dressed one side and two edges.
Edges beveled for calking.

Cleats, 4 pieces 2 by 4 inches by 12 feet long.

Lumber for draining pens:

Mud sills, 10 pieces 4 by 12 inches by 2 feet long (cedar or cypress).
Sleepers, 4 pieces 6 by 6 inches by 12 feet long.
Joists, 13 pieces 2 by 12 inches by 12 feet long.
Floor, 360 feet b. m. tongue-and-groove flooring $\frac{7}{8}$ by 8 inches, 12-foot pieces.
Cleats, 265 linear feet 1 by 3 inches.

Gutters—

Sides, 4 pieces 2 by 12 inches by 11 feet long (dressed).
Bottom and ends, 2 pieces 2 by 12 inches by 12 feet (dressed).
Bottom housed into side and ends. Ends housed into sides. All joints calked and white leaded or pitched.

Posts—

11 pieces 4 by 4 inches by 7 feet long.
2 pieces 4 by 4 inches by 8 feet long.
2 pieces 4 by 4 inches by 9 feet long.

Rails—

2 pieces 2 by 8 inches by 18 feet long.
5 pieces 2 by 8 inches by 16 feet long.
18 pieces 2 by 8 inches by 12 feet long.

Braces, 2 pieces 2 by 4 inches by 10 feet long.

Gates—

7 pieces 1 by 6 inches by 12 feet long.
6 pieces 1 by 6 inches by 10 feet long.

Hardware for vat and draining pens:

4 pairs 12-inch heavy T hinges and screws.
4 wrought-iron hooks and staples.
1 pair wrought-iron hook hinges, 12-inch, wood screw hooks, and screws.
50 pounds 20-penny wire nails.
15 pounds 10-penny wire nails.
12 square feet No. 16 galvanized iron.

The vat described is of the proper depth for cattle and horses. For sheep a platform should be provided which will rest on legs long enough to bring this platform 4 feet below the surface of the dip. This can be easily made so that it can be removed or replaced in a few minutes to allow, if necessary, for the alternate dipping of cattle and sheep.

In selecting a site for the construction of the vat the desirability of having the ground slope away from it on one side should be kept in mind. This allows for the draining of the vat through a pipe inserted at its bottom. This drain should lead to a basin, preferably on waste land. Care should be exercised to prevent animals from drinking from the pool into which the old dip is drained and also to prevent the dip from being washed into streams used for domestic purposes.

In order to prevent the dip from becoming diluted by rains and to check evaporation, a roof of boards or canvas over the vat is desirable.

HANDWORK IN THE DESTRUCTION OF THE SPOTTED-FEVER TICK.

For the most part the use of dipping vats will furnish all facilities necessary for the eradication of the ticks. However, in certain cases, as, for instance, in the narrow valleys running some distance into the mountains, the expense of constructing dipping vats for the small number of cattle present would be prohibitive. Instead of driving these cattle considerable distances to dipping vats, it will be found sufficient to treat them thoroughly by hand methods. The procedure is simply to apply the arsenical dipping mixture liberally by means of rags, mops, or brushes, or by means of spray pumps. It may be found advisable in some cases to use oil instead of the dip, although the main reliance should be placed upon the use of the dip. Oil from Wyoming, which will be found perfectly adapted to this use, can be obtained in the Bitter Root Valley, when purchased in large quantities, at a cost of about $1.25 per barrel.

DEFINITE RECOMMENDATIONS FOR CONTROL OR ERADICATION OF THE SPOTTED-FEVER TICK IN THE BITTER ROOT VALLEY.

The following are the steps that should be followed for the control or eradication of the spotted-fever tick in the Bitter Root Valley:

(1) A campaign of education whereby all the residents of the valley will be made thoroughly familiar with the feasibility of the plan of eradication and with what it will mean in the development of the valley.

(2) The obtaining of legislation to make it possible to dip or oil all live stock in the Bitter Root Valley. In general, public opinion would be sufficient to bring about the treatment of a large majority of the animals. In a few cases objections would undoubtedly be raised by farmers. Without the treatment of all live stock, the plan would necessarily fail. For this reason it is absolutely essential to

provide such legislation as will make it possible to enforce the treatment of all the animals.

(3) The obtaining of an accurate census of the horses, cattle, sheep, mules, and dogs in the valley.

(4) The construction of 10 or more dipping vats.

(5) The providing of materials to be used in the dipping mixture.

(6) The organization of a corps of workers to carry on the operations.

(7) The systematic dipping of the horses, cattle, sheep, and dogs of the valley on a definite schedule. The time of beginning and of discontinuing this work will depend somewhat upon the seasons, but should be about as indicated below. Weekly dippings are necessary, because, as pointed out in the discussion of the life history of the tick, adults may attach to domestic animals, engorge, and drop to the ground in a minimum of eight days:

March 10.
March 17.
March 24.
March 31. (Vat refilled on this date.)
April 7.
April 14.
April 21. (Vat refilled on this date.)
April 28.
May 5.
May 12.
May 19. (Vat refilled on this date.)
May 26.
June 2.
June 9.

(8) The treatment by hand of the animals in localities remote from vats should be undertaken on this same schedule.

One season's work would certainly result in a very large reduction in the number of fever ticks present in the valley. The second season's operations would bring about still further reduction in numbers, if not practical eradication. Nevertheless, a third season's work is required to make certain of the results.

ESTIMATED EXPENSES OF PRACTICAL ERADICATION OF SPOTTED-FEVER TICK IN THE BITTER ROOT VALLEY, MONT., NOT INCLUDING THE COST OF EXPERT SUPERVISION AND NECESSARY INVESTIGATION.

The approximate cost of the work for the three seasons is indicated in the statement given herewith, which does not, however, include the cost of such expert supervision and additional investigation as are required.

First year:	
10 vats, costing $200 each	$2,000
Each vat to have a capacity of 2,000 gallons.	
Cost of filling vats four times during season, at $0.0031 per gallon.[1]	248
Salary of one superintendent, 12 months	1,800
Salaries of 10 assistants for 5 months, at $80 each	4,000
The period to be covered by these men extends from Feb. 15 to July 15.	
Incidentals	1,000
Total, first year	9,048
Second year:	
Repairs to vats	200
Cost of filling vats four times during season	248
Salary of one superintendent	1,800
Salaries of 10 assistants	4,000
Incidentals	1,000
Total, second year	7,248
Third year:	
Repairs to vats	300
Cost of filling vats four times	248
Salary of one superintendent	1,800
Salaries of 10 assistants	4,000
Incidentals	1,000
Total, third year	7,348
Grand total	23,692

It may be found that more than 10 vats will be required. In that case the output for materials would be increased somewhat.

After three seasons' operations a very small annual expenditure will be necessary to avoid reinfestation of the valley by the incoming of cattle from other places. This could be easily accomplished by employing an inspector at a salary of, say, $100 per month for six months' service each year.

SUPPLEMENTARY MEANS OF CONTROL.

The main reliance in work of controlling the spotted-fever tick must be placed upon the dipping and hand treatment of domestic animals. However, there are certain supplementary means of control which should be practiced. These are (1) the reduction in the number of rodents in the valley and (2) the clearing of the brush land along the edges of the valley.

As has been explained in this bulletin, the destruction of the rodents is not a vital part of the plan of eradication we propose.

[1] The cost of dip per gallon is computed as follows: Arsenate trioxide, 5½ cents per pound; sodium carbonate, 2 cents per pound; tar, 33⅓ cents per gallon.

Nevertheless, if the number of these animals can be reduced, it will have an important effect in lessening the number of ticks present. In addition to this reason for control, the rodents are pests of considerable importance. Their extermination from the valley, if possible, would amply repay the residents in the preventing of losses to their crops.

The conditions existing in the brushy land or "slashings" along the edge of the valley are especially favorable to the tick. Not only is shade and protection furnished, but the presence of the timber furnishes the rodent hosts favorable opportunities for multiplication. In this way the presence of the brush has an important bearing upon the abundance of ticks. If the land should be cleared, the ticks would be considerably affected. Clearing the lands will, of course, increase their value and make possible their planting in orchards or other crops without loss of time when the fever tick shall have come under subjection.

For a full list of the mammals found in and around the valley and for methods for their extermination the reader is referred to Circular 82 of the Biological Survey of this department.

It is not considered necessary to have these supplementary means of control supported by funds raised for the main operations. The work of destroying rodents and of clearing the brush lands should be conducted by residents on their own initiative. The matter should be sufficiently explained and the residents should by every means possible be encouraged to undertake the work.

NECESSITY FOR EXPERT SUPERVISION.

In the work of controlling the spotted-fever tick in the Bitter Root Valley it is absolutely essential that expert entomological supervision be provided. Since the whole campaign depends upon a knowledge of the habits and life history of ticks it must be evident that the work must be in the hands of persons who are thoroughly familiar with the subject. Among the many reasons why this expert supervision is necessary are—

(1) The proper time to begin and to discontinue the dipping or oiling must be determined. This will depend upon the seasons and the time when the tick begins to develop in the spring. Unless men are at hand to determine when to begin and when to end, much unnecessary work might be done or, what is worse, many ticks might escape.

(2) It is necessary to be certain that the dipping solution is kept up to a strength sufficient to kill and to see that the dipping is properly done. The test of the strength of the solution should be conducted by experiments the results of which could be interpreted safely only by experts.

(3) The campaign of education which should be conducted in connection with the other work can only be carried on effectively by persons who by training and experience know thoroughly the points upon which the system is based. The best work can only be done by those who have had experience in similar problems and who are familiar with data sufficient to refute such fallacious arguments as may be adduced from time to time.

(4) It is possible that means of control additional to those enumerated in this bulletin may be discovered. The chance of such discoveries and the consequent hastening of the work will be increased if persons trained in entomological work are in charge.

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The important papers of Dr. Ricketts have recently (May, 1911) been reprinted by the University of Chicago Press in a memorial volume entitled "Contributions to Medical Science."

Ticks:
Control

H. E. Freeman Esq.
With the author's Compts.

Cheyletus venustissimus

REPRINTED FROM THE

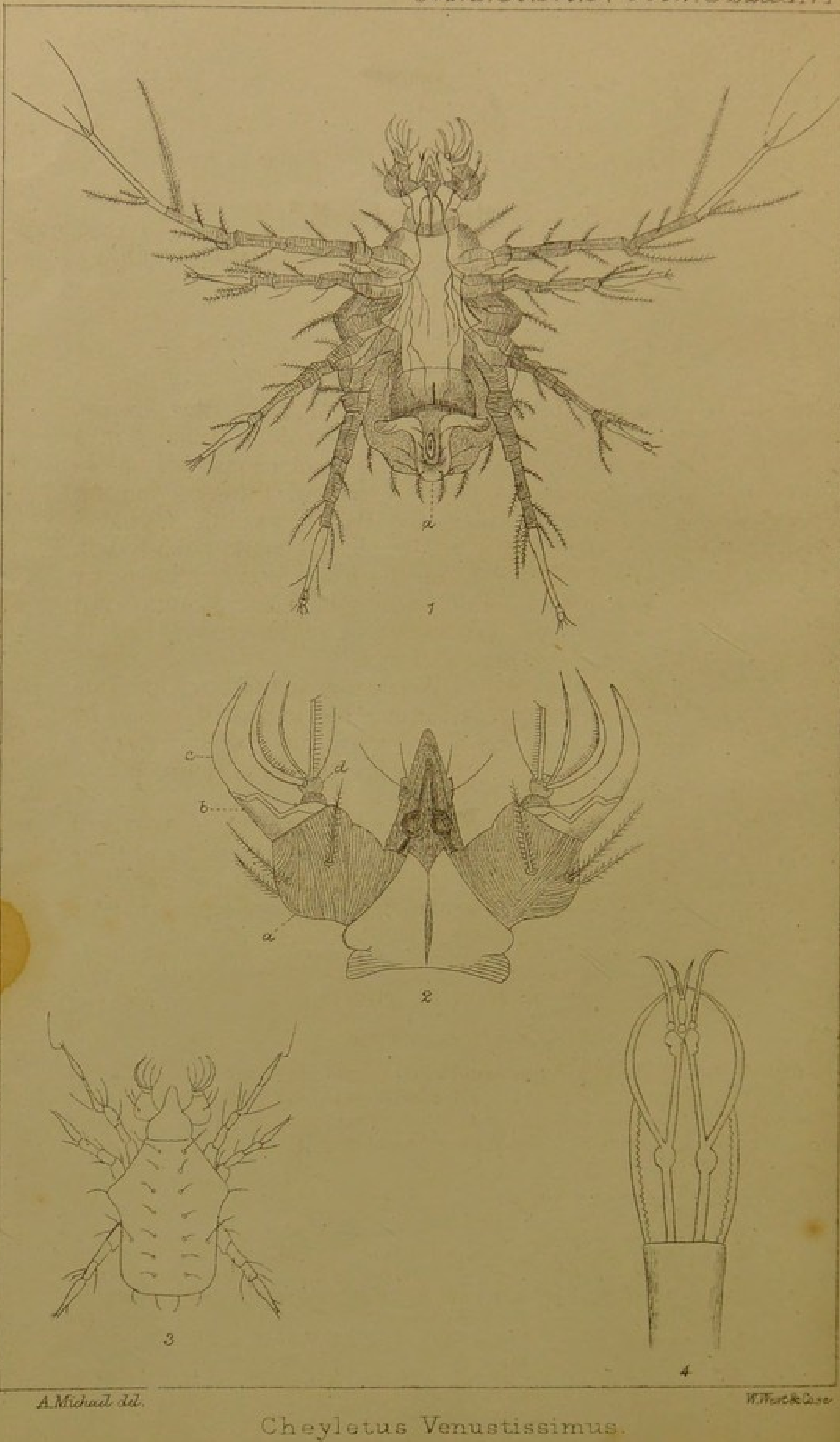
Journal of the Royal Microscopical Society,

CONTAINING ITS

TRANSACTIONS AND PROCEEDINGS,

WITH OTHER

MICROSCOPICAL INTELLIGENCE.



A. Michael del. W. West & Co. sc.

Cheyletus Venustissimus.

I.—*On a Species of Acarus, believed to be new to Britain.*

By A. D. Michael, F.R.M.S.

(*Read before the* Royal Microscopical Society, *1st May and 13th December*, 1878.)

Plate XVI.

Cheyletus venustissimus.

In the beginning of January last (1878) I found this species, which I believe has not hitherto been detected in Britain,* in a stable; near Tamworth I noticed one or two minute red specks running rapidly over the fodder. I secured three or four for examination, and I then ascertained that it was the *Cheyletus venustissimus* of Koch;† that author, in his work published in 1839, describes and figures the species in a manner sufficient for identification, although somewhat wanting in detail; he states that it was then found in the neighbourhood of Regensburg and in Rhenish Bavaria, and was somewhat rare.

The species is not noticed by Walckenaer and Gervais, and I am not aware that any subsequent author has noticed it, except by stating that Koch gives it as one of the genus; as Koch's notice is not very full and does not mention the larva, pupa, &c., a description may possibly be acceptable.

The species, while thoroughly preserving all the above-named characters of the genus, which are very marked, is, as far as those characteristics will allow, a complete contrast to that last described, its red or orange colour, lighter build, and longer legs, evidently

---

EXPLANATION OF THE PLATE.

Cheyletus venustissimus.

Fig 1.—Under side of female × about 70 (the imbrication of the hairs is somewhat exaggerated); *a*, horseshoe-shaped ridge round anus.

„ 2.—Rostrum and palpi × about 200; *a*, first joint of palpus; *b*, second ditto; *c*, falx; *d*, third joint of palpus.

„ 3.—Larva.

„ 4.—Foot highly magnified.

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* Subsequent to the reading of this paper Mr. McIntire was good enough to show me a slide of unnamed *Cheyletus* captured by him. It has been mounted some years, but I think it quite possible that it may have been this species.

† 'Deutschland's Crustaceen,' Heft xxiii. p. 22.

adapted for speed and activity, making it a remarkably different-looking creature.

The median stripe in this species is very conspicuous, and extends from the widened œsophagus to near the anus, and is formed by the alimentary canal showing through the skin; the normal shape of the stripe is that of an hour-glass, and the colour is opaque white; the shape of the marking, however, varies considerably, both in different individuals, and in the same individual from time to time, according to the position of the food in the canal, and the quantity contained. The body on each side of the median stripe is red or orange, the palpi, legs, and œsophagus clear light yellow or yellowish white.

The shape of the body, as in all the Cheyleti, is diamond or coffin shaped, with the anterior part of the diamond shorter than the posterior, and the front and anal angles rounded off, the points of the lateral angles being formed as in the last species; but the body in *Venustissimus* is longer in shape, being nearly twice as long as it is broad, without the rostrum, and much flatter, the thickness not being above a sixth of the width at the widest part. The diamond shape is not so conspicuous as in the last species; the body is marked by five slight constrictions, which produce a somewhat scalloped outline; the constriction between the cephalothorax, which occupies over two-thirds of the whole bulk, and the abdomen, is only slightly marked on the upper side or at the edges, but on the under surface it is marked by a very deep depression, widest on the ventral surface, and narrowing inwards; the raised median portion of the under surface of the cephalothorax slopes suddenly down from nearly opposite the insertion of the fourth pair of legs to the bottom of this depression, forming a blunt oblique triangle. The anus is placed in the centre of a strong horseshoe-shaped ridge, with the points drawn out laterally, which is marked with numerous folds, and is probably contractile. The skin of the legs, palpi, and under side of the body is very finely striated; the striation is, however, not nearly so strong as in the last species, and on the body the colour renders it difficult to see.

The anterior pair of legs are far the longest, and very thin and fine; these legs constitute the most marked characteristic of the species, being strikingly different from the comparatively short firm legs of the other Cheyleti, particularly the last species. The coxa is short, stouter than the other joints, and is somewhat angled on the posterior side. The second joint (or trochanter) is long and straight; it is decidedly striated. The third joint (the femur) is not much above half the length of the second. The fourth joint * is

* This joint is called the tibia by Nicolet. Robin rejects this name, and calls it "la jambe," following Savigny in reserving tibia for the lower half, where this joint is divided into two shorter ones.

nearly as long as the second, and has the inner side of the posterior articulation projecting. The tarsus has a slight shoulder a little beyond the articulation, from this point it narrows in and becomes very fine; the tarsus is the longest joint of the leg; the tarsal sucker of this particular leg is small and fine, and the claw very small and difficult to make out.

The use of this first pair of legs, and the distribution of the hairs on all the legs, are mentioned below.

The second, third, and fourth pairs of legs, although longer than in the last species, do not vary from the usual type of the genus sufficiently to render it necessary to describe them. The sucker and claw and its supports are given in the drawing (Plate XVI., Fig. 4).

There is a row of seven or eight strong hairs on the upper side of the body, a little within the edge, the first three near together; each coxa bears a strong short curved hair pointing downwards and towards the foot. The first pair of legs have on the second joint two longer straight hairs a little beyond the middle, one on the upper and one on the under side; on the third joint two similar on the upper side, a little before the middle; on the fourth joint two similar at the commencement on the outer and upper side, and one short one on the hinder and under side, one short and one long about the middle of the joint, and one very long strong one on the upper and outer front end of the same joint, this is the longest and strongest hair on the creature; on the tarsus there is a similar hair, not quite so long as the last, springing from the upper surface at the before-mentioned shoulder. All these hairs are conspicuously imbricated, like those of the Indian bat; on each side of the point of the tarsus is a long strong hair, and in the centre is a shorter and finer one; these hairs are closely jointed or ringed, but are not imbricated.

The second pair of legs have a pair of hairs on the third joint, and two pairs on the fourth joint, all imbricated; one small one half-way down the tarsus, and two pairs at the extreme end, all small and plain. The third pair of legs have a pair of hairs, and the fourth pair of legs one hair on the second joint, the hairs on the remaining joints being like those of the second pair of legs.

The palpi in this species are without teeth on the falces, otherwise like the last species but slighter (Plate XVI., Fig. 2).

It is well known that in the acari the first pair of legs are modified palpi, and M. Robin has remarked that in some instances they appear not entirely to have lost the office of organs of touch; my observations on the present species lead me to the conclusion that it is a striking instance of this, indeed it would be more correct to say that they have hardly acquired the office of legs; they do not seem to bear any of the weight, but when the creature is moving, they are held slightly elevated, nearly horizontal, are constantly trembling, and seem to touch the ground very lightly at every step, and when the mite is about to ascend any obstacle, they are always put out, evidently to feel, first, but it does not climb by them.

I brought one living specimen from the country on the 5th of January, 1878 (the other two or three which I had caught having been mounted), by confining it in the manner before named, with a little dust from the fodder; I kept it alive for nearly three months, it became quite accustomed to its cage, and seemed, up to the time of its death, on 29th of March, which was after it had deposited its eggs, and some of the young had emerged, strong and well. Its habits seemed different from those of the last species; it used to lie in wait with the front legs, and the palpi widely extended, and generally hanging from the under surface of something; whenever I have put a cheese mite near it, or whenever I have seen one go there, it has retreated without attacking them, but those I put in one day were almost always dead and sucked dry by the next day. On one occasion only I saw it seize its prey: then the cheese mite came well between its palpi, and with one vigorous stroke it drove the great falces at the end of the second joint right into the body of the mite, and then plunged its rostrum in, and the mite was dead directly.

I brought the creature from the country, as before stated, on the 5th of January, and put it alone in the cell, inspecting it very frequently, hoping to breed from it, but for a long time I was unsuccessful, and began to fear it was either a male or unimpregnated female; on the 19th of March, however, I saw a nymph emerge from under the dust. I examined, and found some eggs, which could not have been there long. The next day a larva appeared, and I have subsequently bred others. I cannot ascertain that anyone has before discovered any of the earlier stages of this species. Koch does not mention them.

The eggs are short ellipses with blunted ends, very polished, and of a pearly white; they are laid singly, i. e. apart from each other, and each egg is attached to the substance it is laid on by a few very fine threads.

The larva is hexapod; much smaller and shorter than the perfect creature, but otherwise similar in form; the colour, however, is clear yellowish white or light yellow, like the legs of the adult; the front legs are similar, but the tarsus is terminated by a single long bristle instead of two, and this one, although springing from the outer side, is sharply bent round almost immediately, so as nearly to continue the line of the leg.

The nymph is octopod, very like the perfect acarid, but smaller and shorter; it has the red colour of the adult.

Since the above paper was read I have succeeded in finding the male. I continued breeding the creature in hopes of obtaining it, but without result, until nearly the end of August, when suddenly a batch appeared nearly all males. The chief differences between them and the females are that the former are considerably smaller in size, about ·018 inch long instead of about ·025, which is the average length of the females. The body in the male is more elliptical, less diamond-shaped, the difference in shape being mainly the result of the smaller proportionate size of the mammillary process at the side. The anus, moreover, is prolonged in a short point, whereas that of the female is rounded. The penis, which is very long and cylindrical, is retractile within the abdomen, but emerges at the posterior end immediately above the anus, an arrangement unusual among the Acarina. The legs are rather stouter in proportion in the male and the hairs less strongly imbricated, and the inner pair at the posterior of the abdomen are smaller. I am not aware that the male has been previously observed. It is difficult to account fo the males appearing so suddenly, but possibly the *nubile* femrales may be found at one time of year only—this I have not yet ascertained.

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Royaume de Belgique

Ministère des Colonies
Service de l'Agriculture

Études de Biologie agricole: No. 2

Les Tiques du Congo Belge et les Maladies qu'elles transmettent

Par

GEORGE H. F. NUTTALL

M.D., Ph.D., Sc.D., F.R.S.

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LES TIQUES DU CONGO BELGE ET LES MALADIES QU'ELLES TRANSMETTENT.

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Professeur de Biologie à l'Université de Cambridge; avec l'assistance de C. WARBURTON, M.A., F.Z.S.[1]

(48 Figures dans le Texte.)

Sommaire.

Introduction.

DANS une contrée telle que le Congo Belge, l'étude des tiques et des maladies qu'elles transmettent présente une importance pratique, tant pour les agronomes que pour les pathologistes. Parmi les espèces de tiques dont l'existence a été signalée au Congo, une transmet à l'homme la fièvre récurrente et il a été démontré que huit autres communiquent des maladies aux animaux domestiques, dans diverses régions de l'Afrique.

Nous donnons dans les pages suivantes un court résumé de la classification des tiques. Pour des raisons pratiques et d l'espoir que cette notice sera surtout utile aux agents colons, nous avons intentionnellement omis une long tion des différentes espèces. Puisque nous n'

[1] Traduit de l'anglais par E. Hegh, ingénieur agricol des Colonies de Belgique.

occuper ici que des tiques dont l'existence est actuellement reconnue au Congo (quelque 29 espèces) il suffira que nous donnions quelques-uns des principaux caractères par lesquels les espèces peuvent être distinguées. A cette fin, nous comptons surtout sur les figures qui simplifieront suffisamment les descriptions pour permettre la détermination rapide de certaines des espèces les plus répandues. D'autre part, il ne faut pas perdre de vue, qu'il y a souvent des difficultés considérables, même pour une personne expérimentée, à déterminer l'espèce à laquelle une tique appartient. Certaines tiques sont aisément reconnaissables à l'œil nu, d'autres requièrent un examen soigneux au microscope. Dans ce dernier cas, elles sont le mieux étudiées comme objets opaques, posées sur un petit cône de cire à modeler, qui peut être déplacé et permet ainsi de donner au spécimen l'orientation désirée. Il est presqu'indispensable d'avoir un microscope binoculaire, combiné à un bon éclairage.

La meilleure façon, pour un débutant, d'entreprendre l'étude des tiques, consiste à récolter les spécimens et à les soumettre, pour détermination, à un spécialiste; il épargnera ainsi beaucoup de temps et, si les spécimens déterminés lui sont renvoyés, ceux-ci pourront servir de type de comparaison pour tous autres spécimens récoltés.

Nous avons traité la question de la biologie des tiques d'une manière complète, spécialement la biologie des espèces existant au Congo Belge et nous avons donné un court aperçu des maladies transmises par ces parasites.

Les personnes qui désirent des renseignements plus détaillés, pourront consulter l'ouvrage: "Ticks, a Monograph of the Ixodoidea," par Nuttall, Warburton, Robinson et Cooper, Parties I, II et III, et les bibliographies I et II accompagnant ce travail, ainsi que la Revue *Parasitology*, Vols. I à VIII. Ces deux publications de l'University Press de Cambridge.

Classification.

Les tiques sont des Acariens appartenant au sous-ordre des Metastigmata, c.-à-d. dont les ouvertures respiratoires (stigmates ou péritrèmes) sont situées quelque peu en arrière sur le corps. Elles possèdent un capitulum ou fausse tête caractéristique (fig. 1) consistant en (*a*) la base du capitulum, portant (*b*) des palpes paires, (*c*) des chélicères paires, avec des doigts à apophyses ou dents dirigées vers l'extérieur et (*d*) un hypostome rigide, dentelé sur la face ventrale.

Les tiques sont des parasites suceurs de sang des mammifères, oiseaux, reptiles terrestres et amphibies; certaines espèces sont seulement parasites des oiseaux, d'autres des reptiles, d'autres encore se rencontrent à la fois sur les mammifères, les oiseaux et les reptiles.

Les tiques constituent une surfamille (Ixodoidea) qui com-

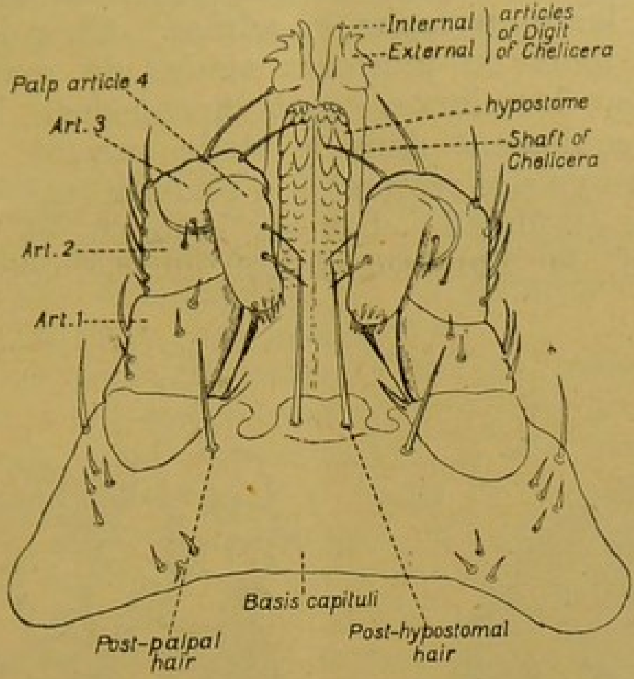

Fig. 1.—*Argas persicus* (Oken 1818) ♂ : Capitulum, face ventrale. (Nuttall 1908.)

prend deux familles : (1) les Argasidæ et (2) les Ixodidæ. La différence la plus frappante entre ces deux familles (figs. 2 et 3) consiste dans le fait que les Ixodidæ possèdent un écusson dur, qui recouvre tout le corps du mâle et la partie antérieure du corps

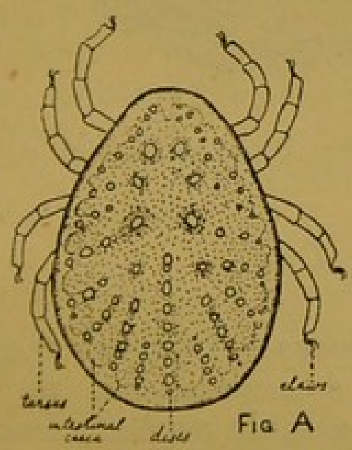

Fig. 2.—Argasidæ (*Argas persicus*). (Nuttall et Warburton 1908.)

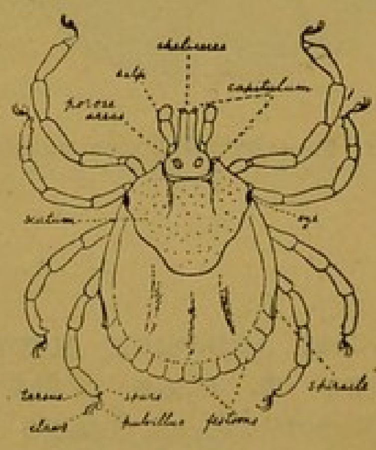

Fig. 3.—Ixodidæ (*Amblyomma* ♀) (Nuttall et Warburton 1908.)

de la femelle, de la nymphe et de la larve. Les Argasidæ ne possèdent pas un tel écusson et les sexes ne peuvent être distingués que par la forme de l'orifice sexuel.

Chez les Argasidæ, nymphes et adultes, le capitulum est recouvert complètement par le corps ; chez les Ixodidæ, il est terminal et visible dorsalement.

Le développement des tiques présente au moins quatre stades : œuf, larve, nymphe et adulte. Chez les Argasidæ, il peut y avoir deux ou plusieurs stades de nymphe. Chez les deux familles, les larves sont hexapodes, les huit pattes apparaissant seulement dans le stade suivant, c.-à-d., chez la nymphe. La nymphe ressemble à l'adulte (mâle et femelle chez les Argasidæ et femelle chez les Ixodidæ) et n'en diffère que par l'absence de l'orifice génital et des caractères sexuels secondaires.

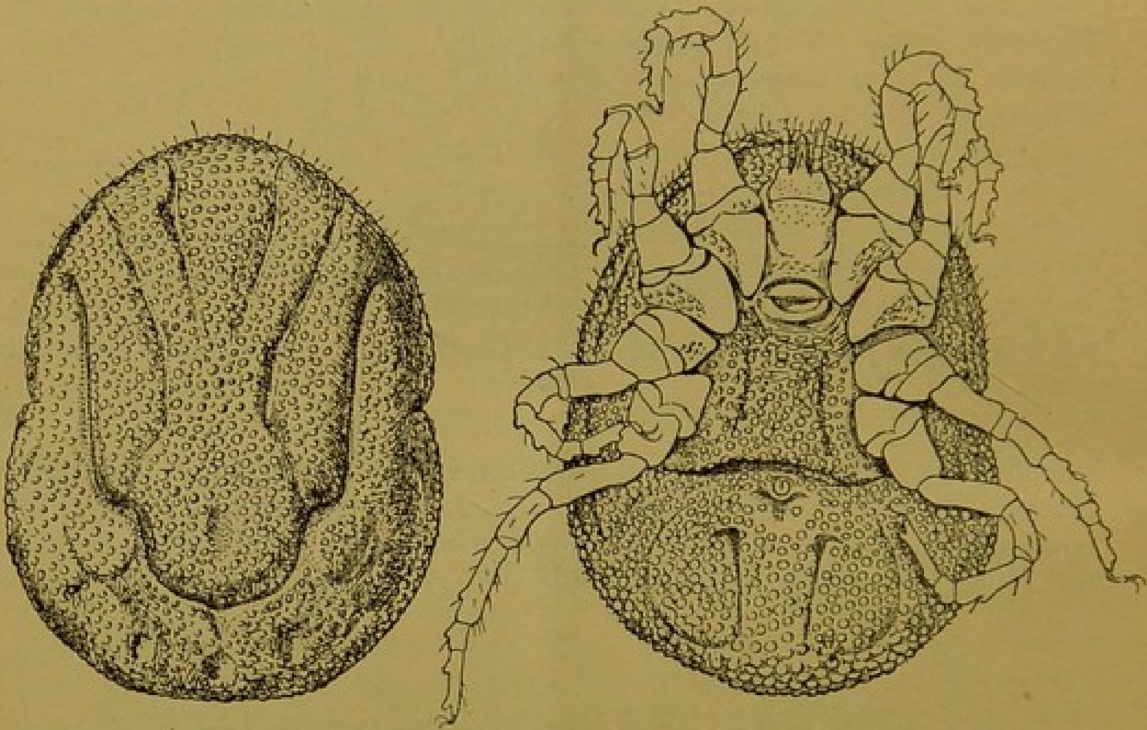

Fig. 4.—*Ornithodorus moubata* (Murray 1877) ♀ : Faces dorsale et ventrale. (Nuttall 1908.)

1. ARGASIDÆ.

Les Argasidæ comprennent deux genres : *Argas* et *Ornithodorus* et, dans l'état actuel de nos connaissances, ne sont représentées au Congo Belge que par une seule espèce : *Ornithodorus moubata* (fig. 4), dont l'adulte mesure ordinairement 8 mm. environ de longueur, mais peut atteindre 12 mm. Cette tique, en vie, est de couleur brun-sale ou verdâtre. Le tégument a une apparence granuleuse et les pattes portent des bosses caractéristiques.

Cette espèce est dépourvue d'yeux ; les plus grandes nymphes ressemblent aux adultes. Le premier stade de nymphe, à jeun, mesure ordinairement une longueur d'un millimètre et est de couleur jaunâtre. Comme aspect, il rappelle l'adulte. Cette espèce est importante, puisqu'elle transmet la fièvre récurrente de l'homme, en Afrique tropicale. (Voir plus loin, page 39.)

2. IXODIDÆ.

Les Ixodidæ comprennent neuf genres, qui tous, à l'exception d'un seul (*Margaropus*), ont des représentants au Congo Belge. Avant d'examiner les différences que présentent ces genres, nous devons insister brièvement sur la structure d'une tique de la famille des Ixodidæ (voir figs. 5 et 6).

Les sexes sont très distincts. Chez le mâle, la surface dorsale du corps est recouverte d'un écusson dur, tandis que chez la femelle cet écusson ne recouvre qu'une partie du corps.

Lorsque le mâle se gorge, son corps ne s'enfle que légèrement, tandis que lorsque la femelle se gorge, son corps se gonfle jusqu'à atteindre de grandes dimensions, le tégument étant fortement extensible. Sur la surface dorsale de la base du capitulum, l'on notera les deux aires poreuses qui caractérisent les femelles de toutes les tiques de la famille des Ixodidæ.

Les détails de structure à noter dans la description d'une tique concernent (1) *l'écusson* (scutum): taille, forme, sillons, échancrure, ponctuations, coloration; (2) *le capitulum:* forme de la base du capitulum, forme des palpes et structure de l'hypostome; (3) *l'aspect ventral:* position de l'orifice sexuel, anus, sillons anaux, écussons ou plaques et stigmates; (4) *les pattes:* structure des coxaux (hanches), trochanters et tarses.

Les neuf genres d'Ixodidæ sont les: *Ixodes*, *Hæmaphysalis*, *Dermacentor*, *Rhipicentor*, *Rhipicephalus*, *Margaropus*, *Boophilus*, *Hyalomma* et *Amblyomma* (y compris le sous-genre *Aponomma*).

Leur degré d'affinité est indiqué par le diagramme ci-dessous (Warburton):—

- Ixodidae
  - Prostriata
    - 1. Ixodes
  - Metastriata
    - Brevirostrata
      - Groupe 1
        - 2. Hæmaphysalis
      - Groupe 2
        - 3. Dermacentor
        - 4. Rhipicentor
        - 5. Rhipicephalus
        - 6. Margaropus
        - 7. Boophilus
    - Longirostrata
      - Groupe 1
        - 8. Hyalomma
      - Groupe 2
        - 9. Amblyomma (Aponomma)

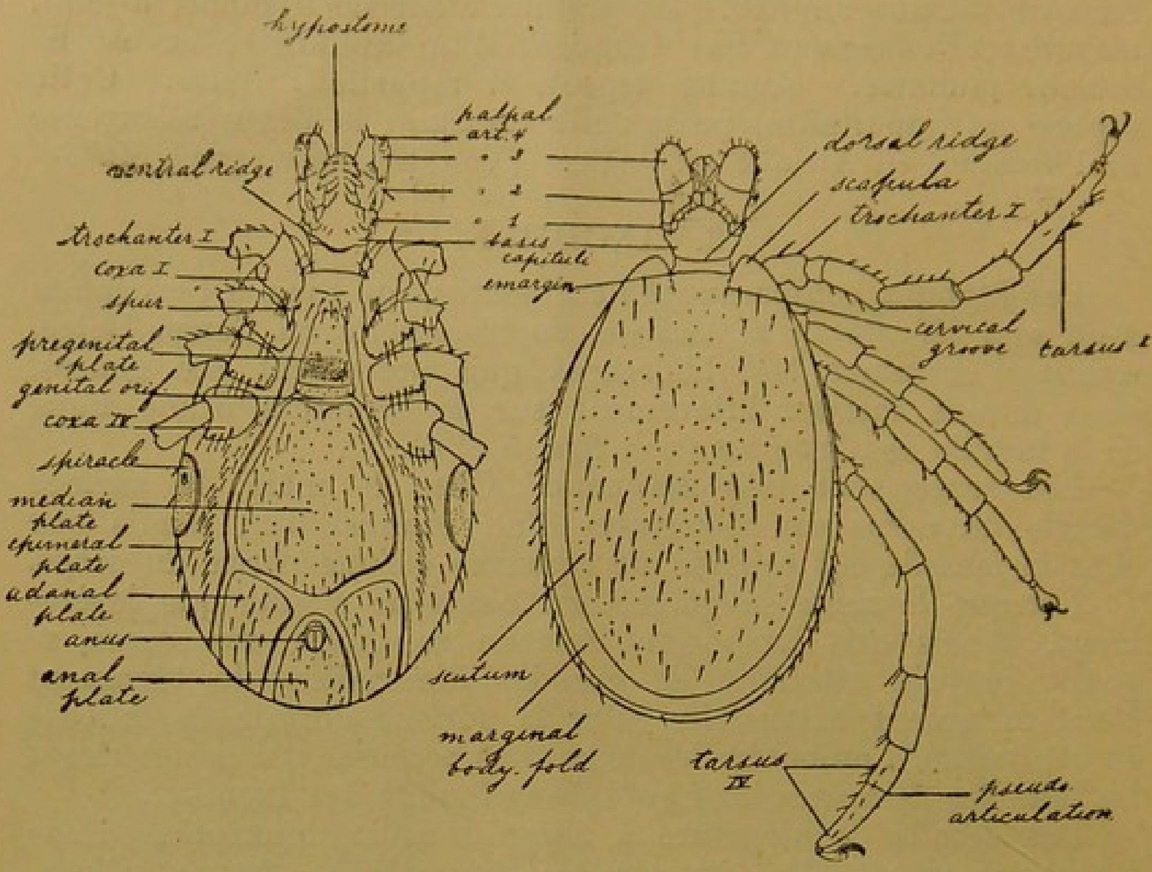

FIG. 5.—*Ixodes ricinus* (Linn.) ♂ : Faces ventrale et dorsale. En Afrique, cette espèce est limitée aux bords de la Méditerranée. (Nuttall 1908.)

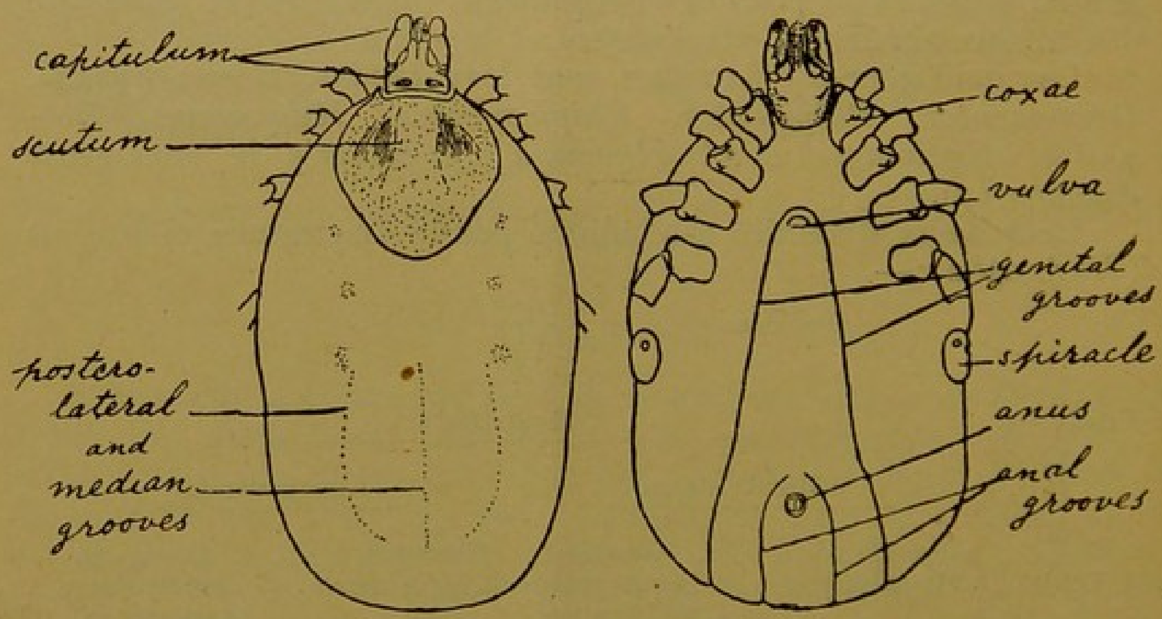

FIG. 6.—*Ixodes hexagonus*, Leach 1815, ♀ repue. Faces dorsale et ventrale. Cette espèce ne se rencontre pas en Afrique. (Nuttall 1911.)

Les Ixodidæ se groupent en deux divisions, *les Prostriata* et les *Metastriata*, dont la première ne compte qu'un genre, la seconde renfermant les huit genres restants. Les termes *Prostriata* et *Metastriata* ont rapport à la position des *sillons anaux*, qui chez les *Ixodes* contournent l'anus sur le devant, tandis que chez les autres tiques Ixodidæ ces sillons sont plutôt postérieurs à l'anus, ou absents.

Prostriata.

Genre 1. Ixodes.

Caractères généraux: Sillons anaux contournant l'anus au devant, écusson sans dessins colorés (concolore). Yeux et festons absents, péritrèmes (stigmates) ronds ou ovales. Dimorphisme sexuel prononcé, en ce qui concerne le capitulum. Chez les mâles, la surface ventrale du corps est couverte de plaques dures, non saillantes.

Ce genre est pauvrement représenté en Afrique; jusqu'ici deux espèces seulement ont été signalées au Congo.

(1) *Ixodes rasus*, Neumann 1899, est unique parmi les Ixodes africains, par la possession d'un petit sillon anal parfaitement circulaire (figs. 7 et 8).

(2) *Ixodes rubicundus* var. *limbatus*, Neumann 1908; ♂ inconnu, ♀ ressemblant à *I. hexagonus* (fig. 6), mais les palpes sont plus longues, plus concaves extérieurement et les coxaux (hanches), 1re, 2me et 3me paires, ne portent pas d'éperons. Récolté une fois seulement au Katanga.

Metastriata.

Avec festons, avec sillons anaux contournant l'anus postérieurement, excepté chez les *Boophilus* et *Margaropus*, chez lesquels les festons et les sillons anaux sont absents.

(a) *BREVIROSTRATA.*

Groupe I.

Genre 2. Hæmaphysalis.

Caractères généraux: Concolores, dépourvus d'yeux, festons présents, avec ordinairement de courtes palpes coniques, dont les seconds articles se projettent latéralement au-delà de la base du capitulum. Avec un éperon dorsal sur le premier trochanter. Ordinairement de petite taille. Dimorphisme sexuel faible, le mâle n'a pas de plaques ventrales ou écussons. Stigmates ordinairement ovoïdes ou en forme de courte virgule.

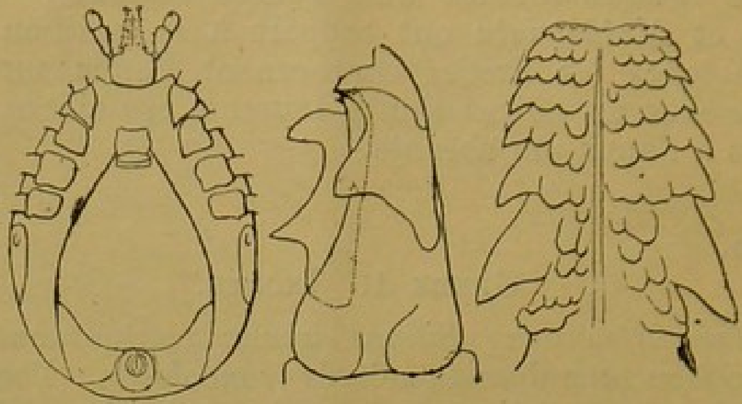

FIG. 7.—*Ixodes rasus*, Neumann 1899, ♂ : Face ventrale ; doigt de la chélicère gauche (× 210) ; hypostome (× 135). (Neumann 1899.)

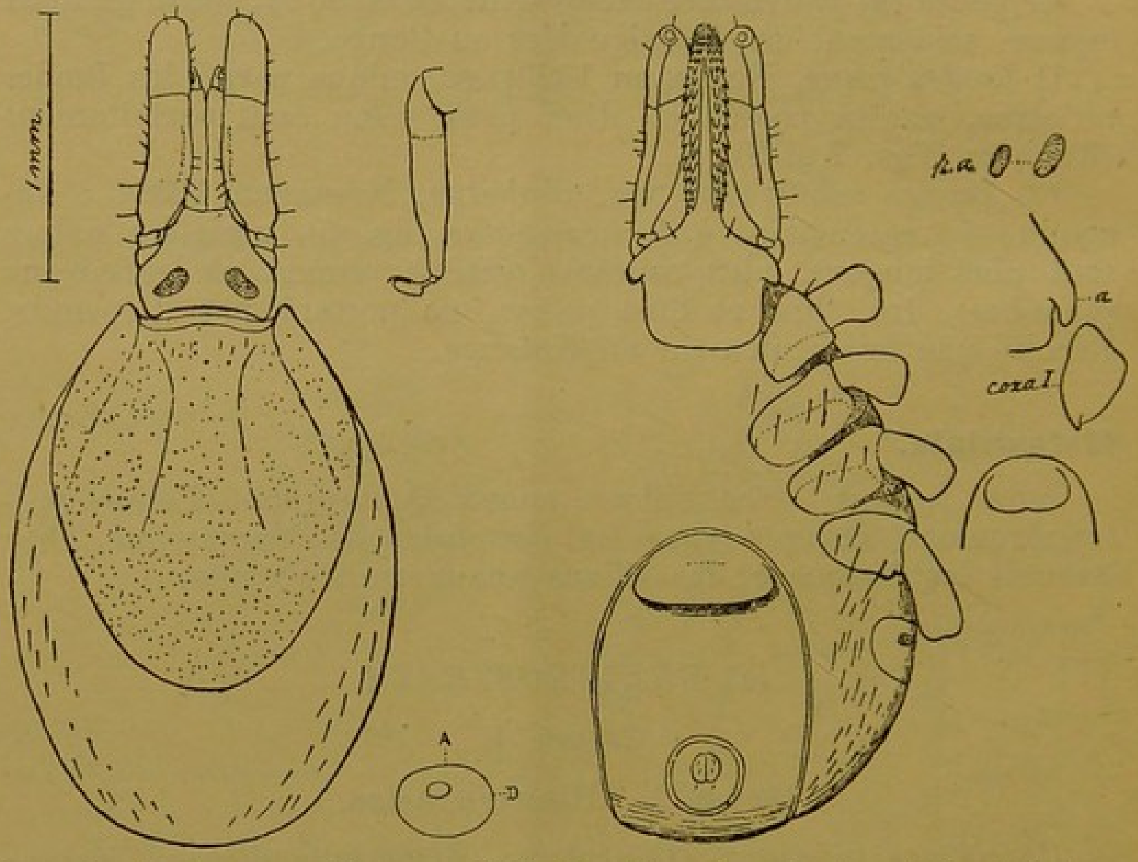

FIG. 8.—*Ixodes rasus*, Neumann 1899, ♀ : Faces dorsale et ventrale, péritrème, tarse iv, etc. (Nuttall 1911.)

Deux espèces d'*Hæmaphysalis* ont été signalées au Congo :

(1) *Hæmaphysalis leachi* (Audouin 1827), chez laquelle les palpes font fortement saillie sur les côtés, chez la tique adulte et les stades imparfaits (figs. 9 et 10). Pour la biologie de cette espèce, voir page 39.

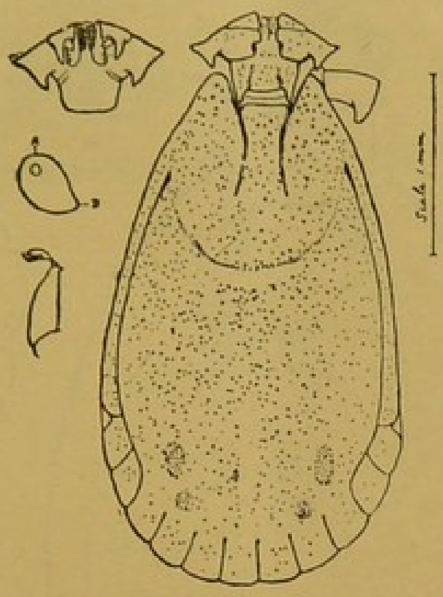

FIG. 9.—*Hæmaphysalis leachi* (Audouin 1827) ♂ : Face dorsale ; capitulum, aspect ventral ; péritrème et tarse iv. (Nuttall 1913.)

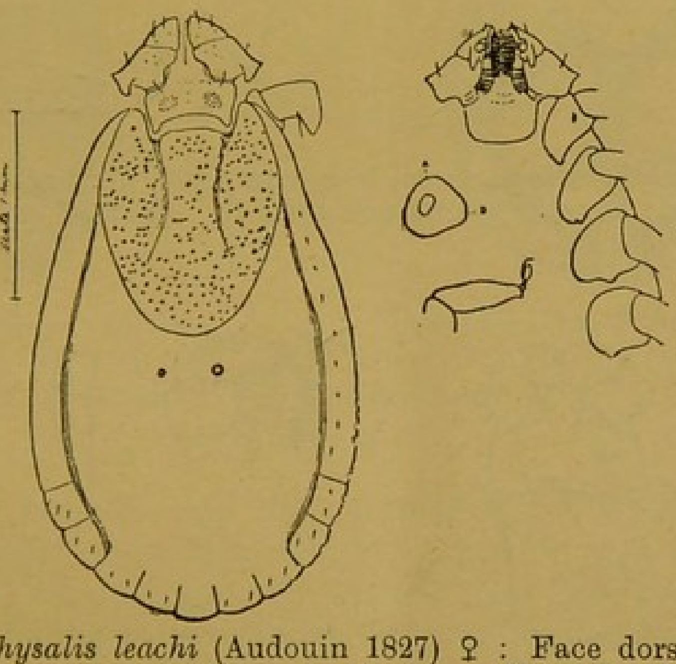

FIG. 10.—*Hæmaphysalis leachi* (Audouin 1827) ♀ : Face dorsale, partie de la face ventrale, péritrème et tarse iv. (Nuttall 1913.)

(2) *Hæmaphysalis parmata*, Neumann 1905, chez laquelle les palpes ne font que faiblement saillie sur les côtés, chez l'adulte et les stades imparfaits (figs. 11 et 12).

Groupe II.

GENRE 3. DERMACENTOR.

Caractères généraux: Ordinairement marqués de dessins colorés, avec yeux et festons, avec des palpes courtes et larges

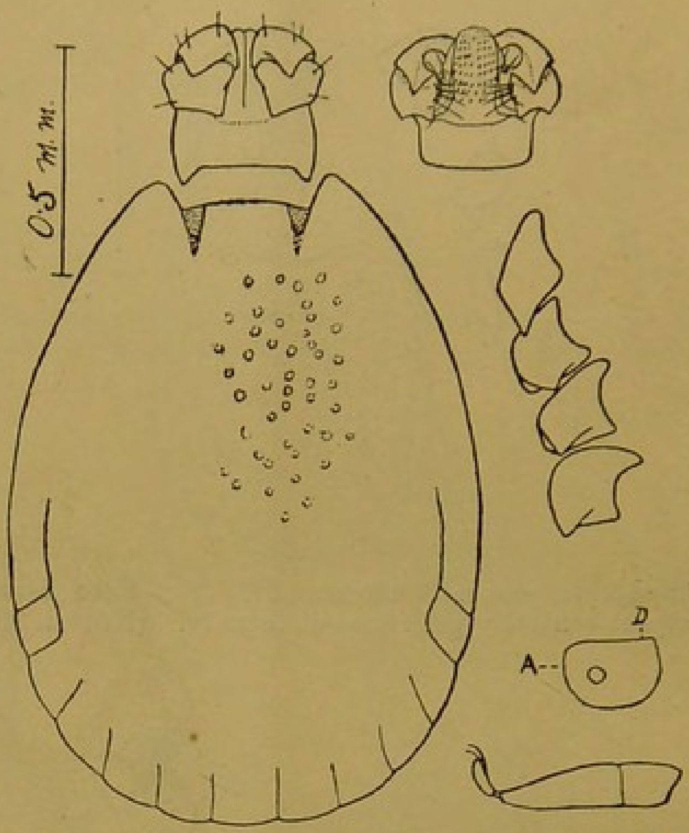

FIG. 11.—*Hæmaphysalis parmata*, Neumann 1905, ♂ : Face dorsale ; capitulum, face ventrale ; hanches, péritrème, tarse iv. (Nuttall et Warburton 1915.)

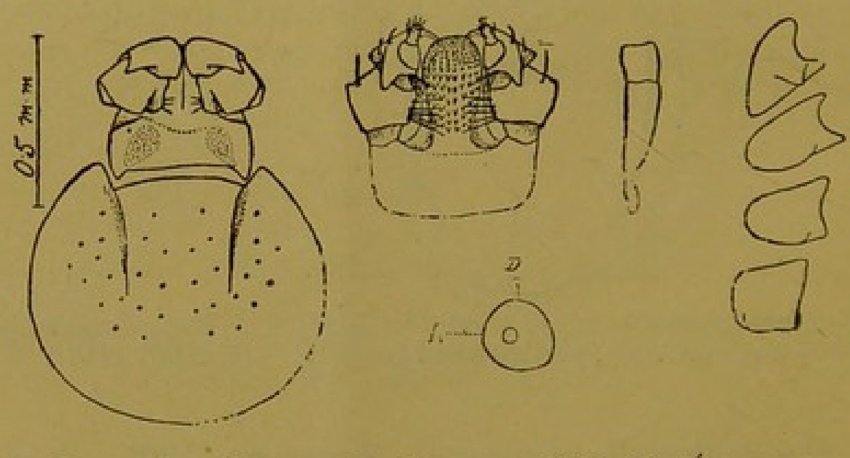

FIG. 12.—*Hæmaphysalis parmata*, Neumann 1905, ♀ : Écusson ; capitulum, faces dorsale et ventrale ; hanches, péritrème, tarse iv. (Nuttall et Warburton 1915.)

ou moyennes, base du capitulum rectangulaire dorsalement. Les coxaux (hanches) IV sont de loin les plus grands (comme chez Rhipicentor, voir page 14). *Le mâle, sans plaques ou écussons ventraux. Coxaux I, bifides chez les deux sexes.*

Deux espèces de *Dermacentor* ont été signalées au Congo :

(1) *Dermacentor circumguttatus*, Neumann 1897. Chez le mâle, l'ornementation consiste en huit taches pâles, situées près des bords de l'écusson. L'écusson de la femelle porte trois de ces taches (fig. 13).

(2) *Dermacentor rhinocerotis* (de Geer 1778). Chez le mâle,

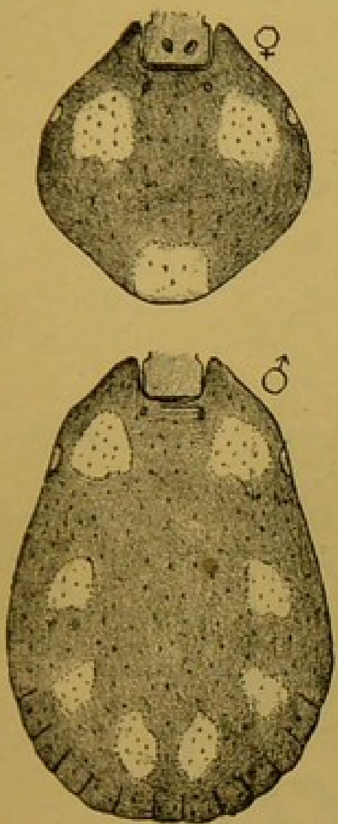

Fig. 13.—*Dermacentor circumguttatus*, Neumann 1897, ♀ et ♂ : écussons dorsaux. (Neumann 1897.)

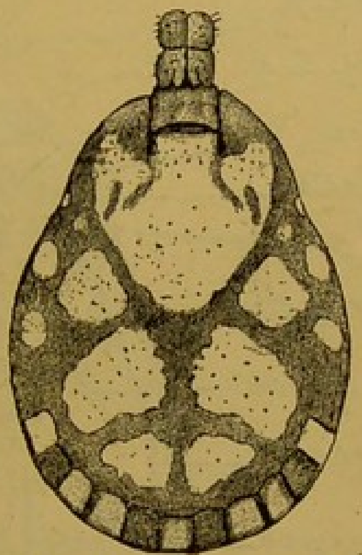

Fig. 14.—*Dermacentor rhinocerotis* (de Geer 1778) ♂ : Face dorsale. (Neumann 1897.)

l'ornementation consiste en de grandes taches jaunâtres ou brunâtres, disposées symétriquement, l'une de ces taches affectant la forme d'un écusson de femelle, et les autres taches, plus petites, occupant la périphérie et certains des festons. Chez la femelle, presque tout l'écusson est pâle et deux taches rouges, rondes, se voient sur le dos, derrière l'écusson (figs. 14 et 15).

Genre 4. Rhipicentor.

Caractères généraux: Concolores, avec yeux et festons, avec palpes courtes, la base du capitulum hexagonale dorsalement *et ayant des angles latéraux proéminents. Coxaux I bifides. Le mâle ressemble, vu ventralement, au type Dermacentor et vu*

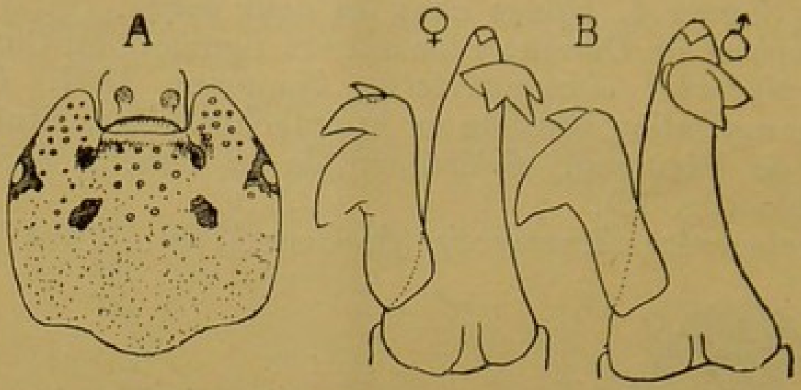

FIG. 15.—*Dermacentor rhinocerotis* (de Geer 1778): Écusson ♀ ; chélicères ♀ et ♂ (× 130). (Neumann 1897.)

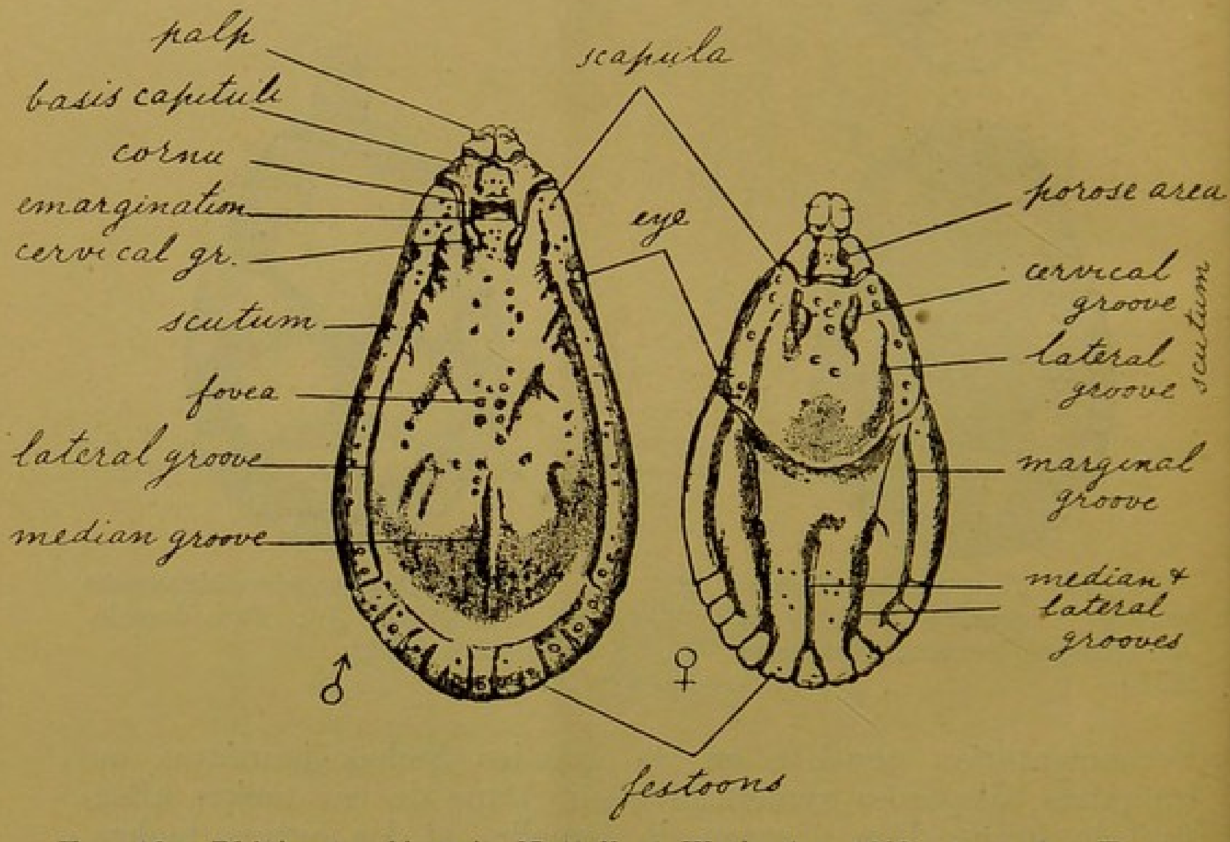

FIG. 16.—*Rhipicentor bicornis*, Nuttall et Warburton 1908, ♂ et ♀ : Faces dorsales. (N. et W. 1908.)

dorsalement, au type Rhipicephalus. Sur les deux espèces appartenant à ce genre, une a été trouvée au Congo :—

(1) *Rhipicentor bicornis*, Nuttall et Warburton 1908. Les figures 16 et 17 montrent d'une façon très claire les caractères distinctifs de cette espèce.

Genre 5. Rhipicephalus.

Caractères généraux: Ordinairement concolores avec yeux et festons, avec palpes courtes et la base du capitulum ordinairement hexagonale dorsalement; les coxaux I bifides. Le mâle possède une paire d'écussons adanaux et d'habitude une paire d'écussons adanaux accessoires; certains mâles, lorsqu'ils sont complètement gorgés, présentent un prolongement caudal. Les stigmates sont en forme de virgule.

Neuf espèces de *Rhipicephalus* ont été récoltées au Congo. Il est difficile de déterminer les espèces de ce genre, à cause des

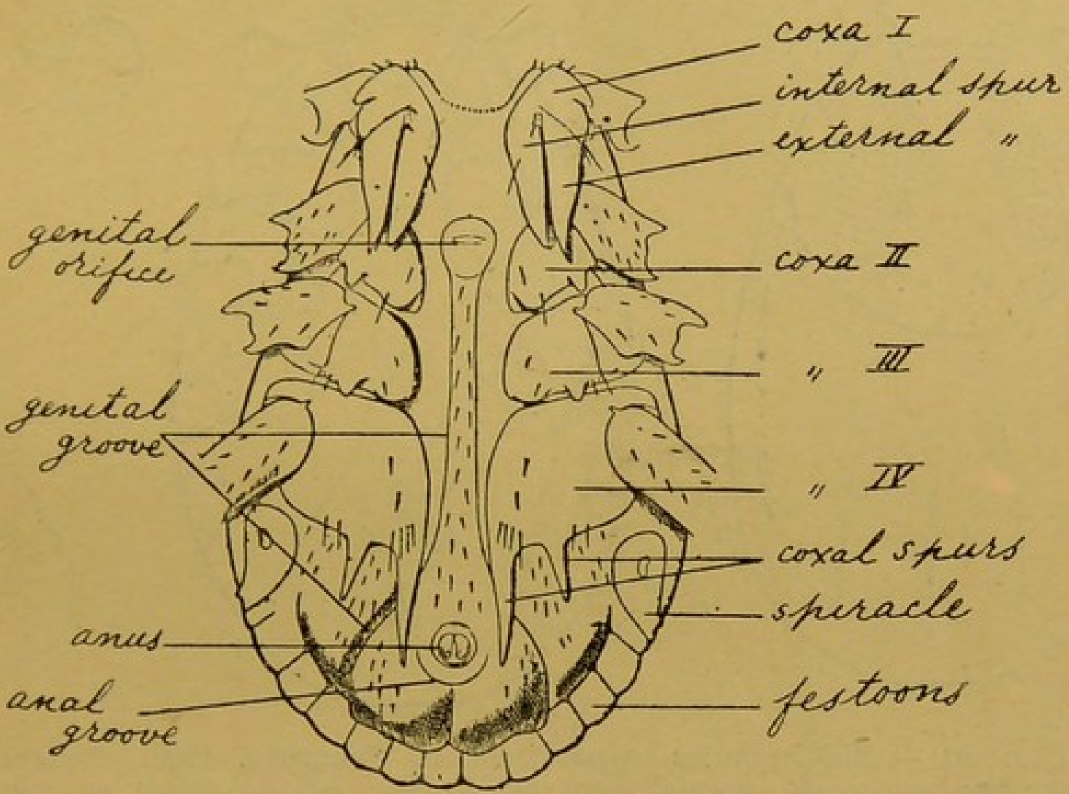

Fig. 17.—*Rhipicentor bicornis*, Nuttall et Warburton 1908, ♂ : Face ventrale. (Nuttall 1908.)

variations individuelles de taille et de structure, qui sont bien montrées dans les figures 18, 19, 25, et 26, se rapportant à deux espèces existant au Congo. La difficulté est considérablement amoindrie, lorsque l'on examine des exemplaires types, spécialement lorsqu'il s'agit de mâles. Les femelles sont plus difficiles à déterminer et il est à conseiller aux débutants de consulter un spécialiste, avant de tirer des conclusions quant à l'espèce envisagée. Les principaux caractères suivants permettront de déterminer, grosso modo, *les spécimens mâles types* des neuf espèces congolaises de *Rhipicephalus*.

(1) *Rhipicephalus appendiculatus*, Neumann 1901, caractérisé par le fait que les écussons adanaux tendent à se terminer en pointe postérieurement; écusson avec beaucoup de ponctuations. Les coxaux I proéminents, lorsqu'ils sont vus dorsalement. A noter dans les figures ci-jointes, la forme de la base du capitulum. Les mâles complètement gorgés de sang ont un long prolongement caudal (figs. 18 à 21). Pour la biologie, voir page 40.

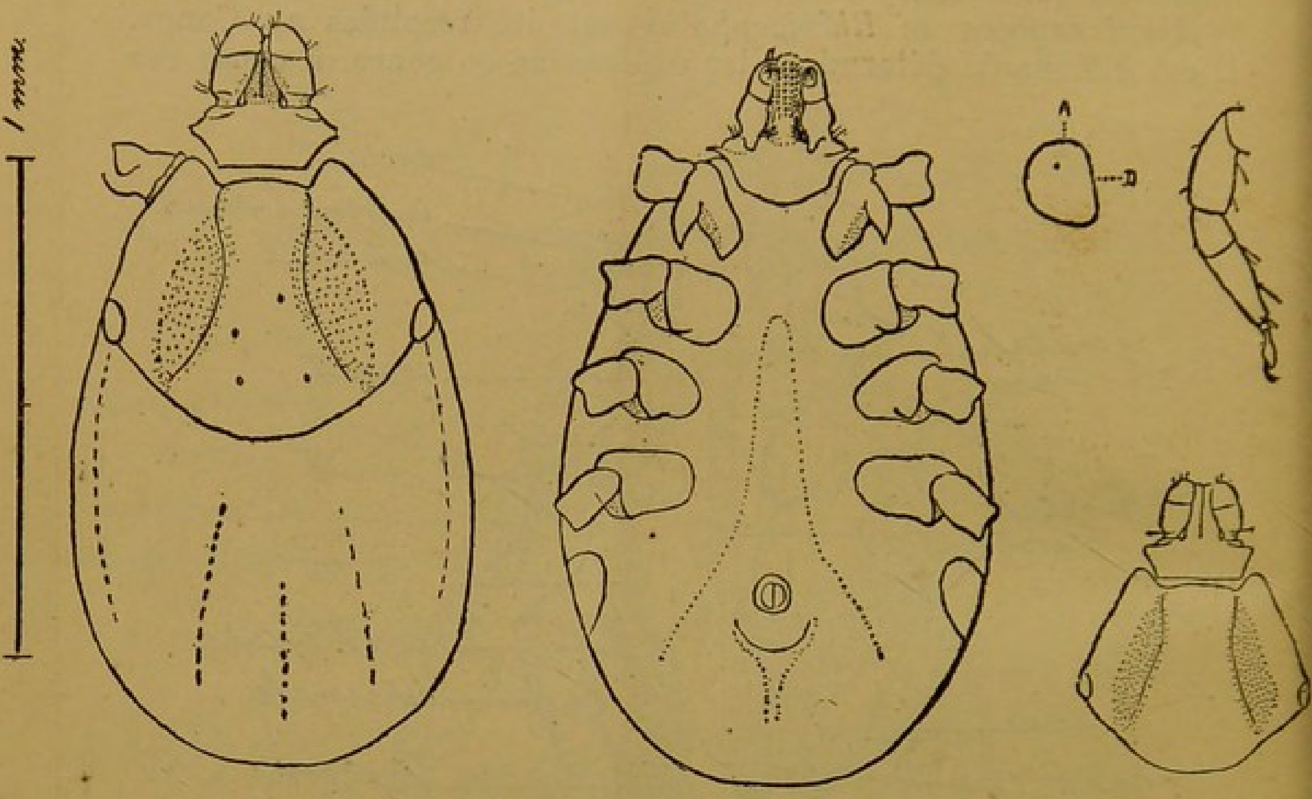

FIG. 20. — *Rhipicephalus appendiculatus*, Neumann, 1901. Nymphes: (*a*) nymphe non-gorgée, normalement développée; aspects dorsal et ventral; péritrèmes et tarse iv; (*b*) capitulum et écusson d'une nymphe provenant d'une larve enlevée de l'hôte avant de s'être complètement gorgée. Des petites nymphes de ce genre existent dans la nature. (Nuttall, 1913.)

(2) *Rhipicephalus capensis*, Koch 1844. L'écusson montre beaucoup de ponctuations et ceci, combiné avec les rugosités qui recouvrent sa surface, lui donne un aspect terne. Les écussons adanaux sont arrondis postérieurement. Cette espèce est peu commune et sa détermination est difficile. Pour la biologie, voir page 41.

(3) *Rhipicephalus evertsi*, Neumann 1897. Caractérisé par son écusson brun-foncé, ses yeux en forme de perles et ses pattes jaunes-rougeâtres; on désigne communément cette tique en Afrique du Sud sous le nom de " Tique à pattes rouges " (fig. 22). Pour la biologie, voir page 41.

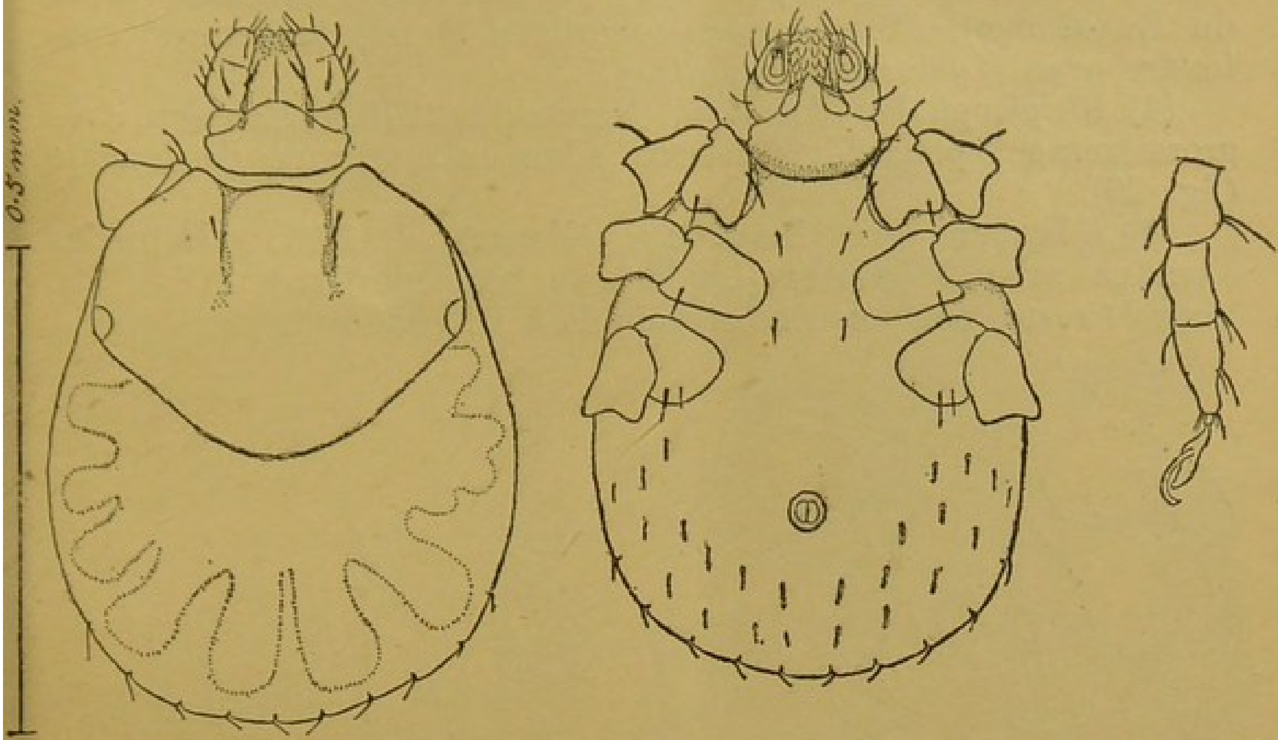

FIG. 21.—*Rhipicephalus appendiculatus*, Neumann 1901, larve non gorgée : Faces dorsale et ventrale, tarse III. (Nuttall 1913.)

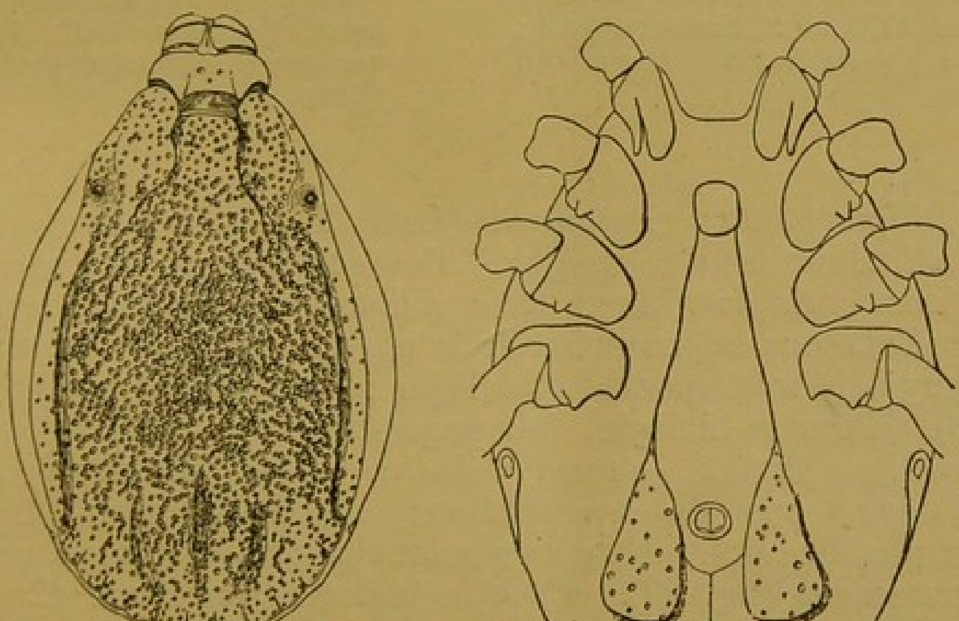

FIG. 22.—*Rhipicephalus evertsi*, Neumann 1897, ♂ : Face dorsale × 12 ; face ventrale × 15. (Original, L. E. Robinson.)

R. evertsi var. *albigeniculatus*, Warburton 1915 (n. var.), diffère seulement de l'espèce type par ses pattes annelées (reçue du Bas-Congo). Un examen superficiel la fait facilement confondre avec *Hyalomma ægyptium*.

(4) *Rhipicephalus falcatus*, Neumann 1908. Ecusson très grossièrement ponctué; écussons adanaux en forme de faucille (fig. 23).

(5) *Rhipicephalus lunulatus*, Neumann 1907. Ecussons adanaux avec 2 pointes (bifides) au bord postérieur (fig. 24). Pour le reste, cette espèce ressemble à *R. simus* (7).

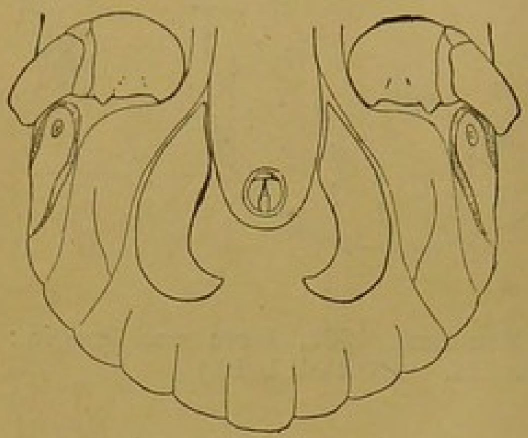

FIG. 23. — *Rhipicephalus falcatus*, Neumann 1908, ♂ : Face ventrale ; extrémité postérieure. (Neumann 1908.)

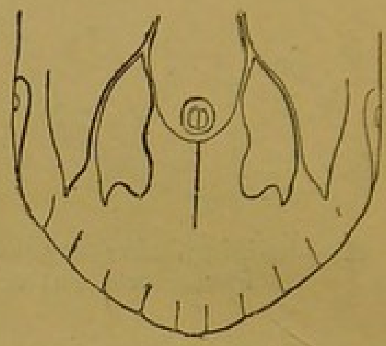

FIG. 24.—*Rhipicephalus lunulatus*, Neumann 1907, ♂ : Face ventrale ; extrémité postérieure. (Neumann 1907.)

(6) *Rhipicephalus sanguineus* (Latreille 1804). Espèce commune. Couleur brun-rougeâtre. Ecusson avec ponctuations de dimensions variables, avec trois sillons postérieurs caractéristiques. Ecussons adanaux arrondis postérieurement. Complètement gorgé, le mâle possède un léger prolongement caudal (figs. 25 à 28). Pour la biologie, voir page 42.

(7) *Rhipicephalus simus*, Koch 1844. Ecusson foncé, luisant, avec peu de ponctuations, disposées d'une manière quelque peu linéaire. Ecussons adanaux ordinairement arrondis postérieurement (fig. 29). Pour la biologie, voir page 42.

(8) *Rhipicephalus supertritus*, Neumann 1907. Ecusson très rugueux. Ecussons adanaux arrondis postérieurement. Gorgé de sang, le tégument mou fait saillie postérieurement, sous la forme de trois lobes (fig. 30).

(9) *Rhipicephalus tricuspis*, Dönitz 1906. Ressemble à *R. sanguineus*, mais les écussons adanaux sont bifides, comme chez *R. lunulatus* (figs. 31 et 32).

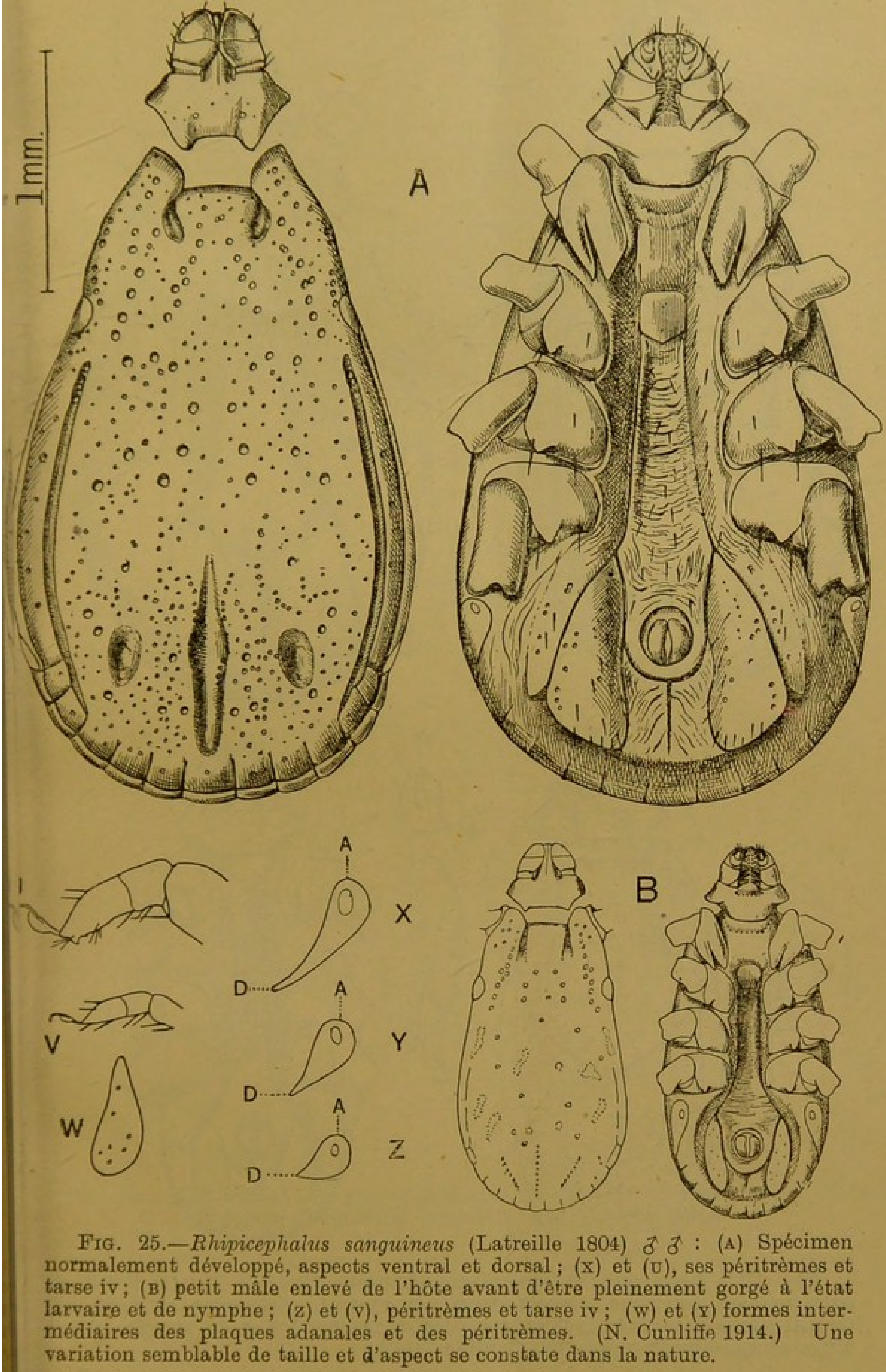

FIG. 25.—*Rhipicephalus sanguineus* (Latreille 1804) ♂♂ : (A) Spécimen normalement développé, aspects ventral et dorsal ; (X) et (U), ses péritrèmes et tarse IV ; (B) petit mâle enlevé de l'hôte avant d'être pleinement gorgé à l'état larvaire et de nymphe ; (Z) et (V), péritrèmes et tarse IV ; (W) et (Y) formes intermédiaires des plaques adanales et des péritrèmes. (N. Cunliffe 1914.) Une variation semblable de taille et d'aspect se constate dans la nature.

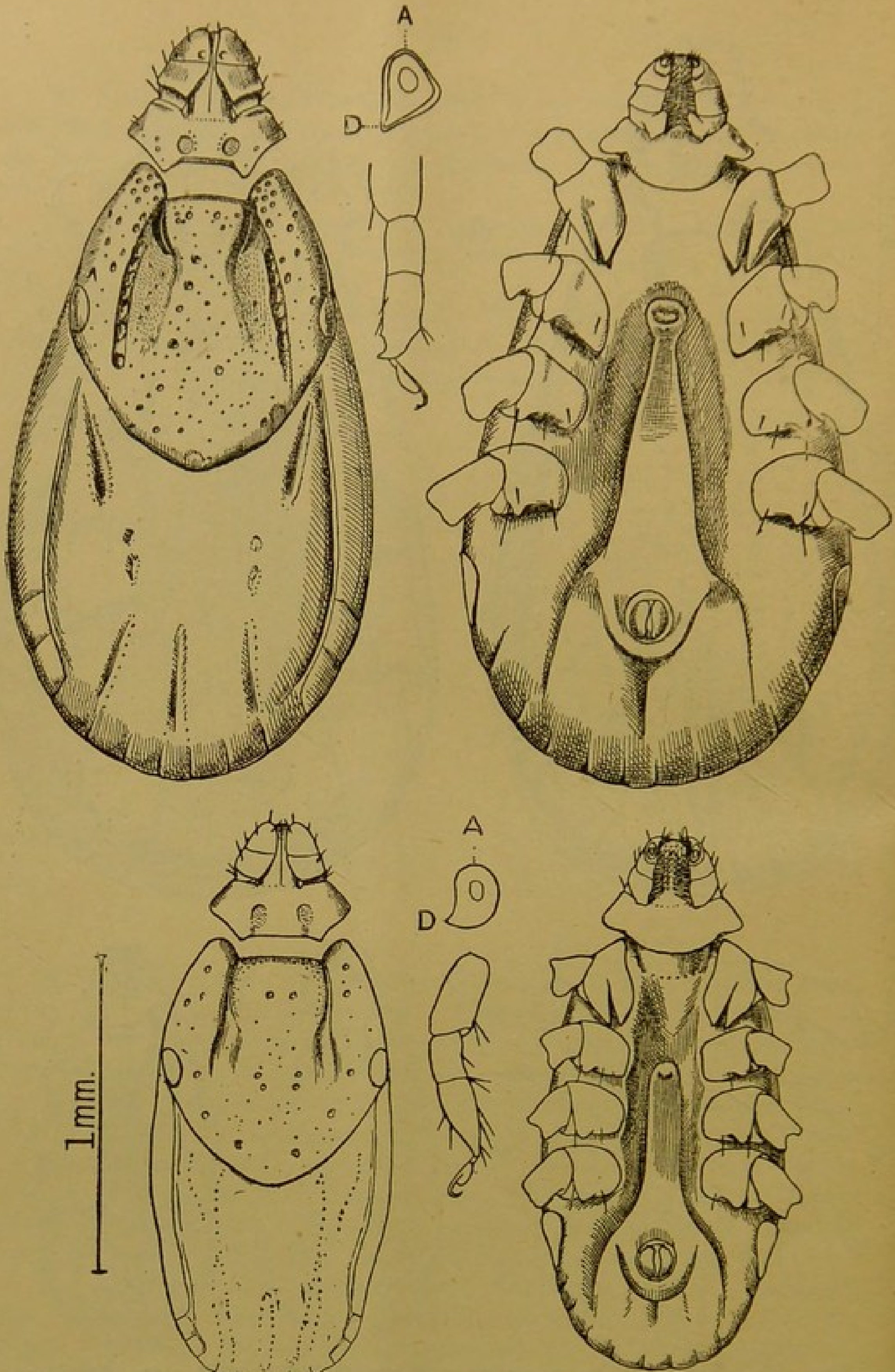

FIG. 26.—*Rhipicephalus sanguineus* (Latreille 1804) ♀♀ : (1) Spécimen normalement développé, aspects dorsal et ventral, péritrèmes et tarse iv; (2) petite femelle enlevée de l'hôte dans les stades larvaire et de nymphe, avant d'être complètement gorgée. (N. Cunliffe 1914.)

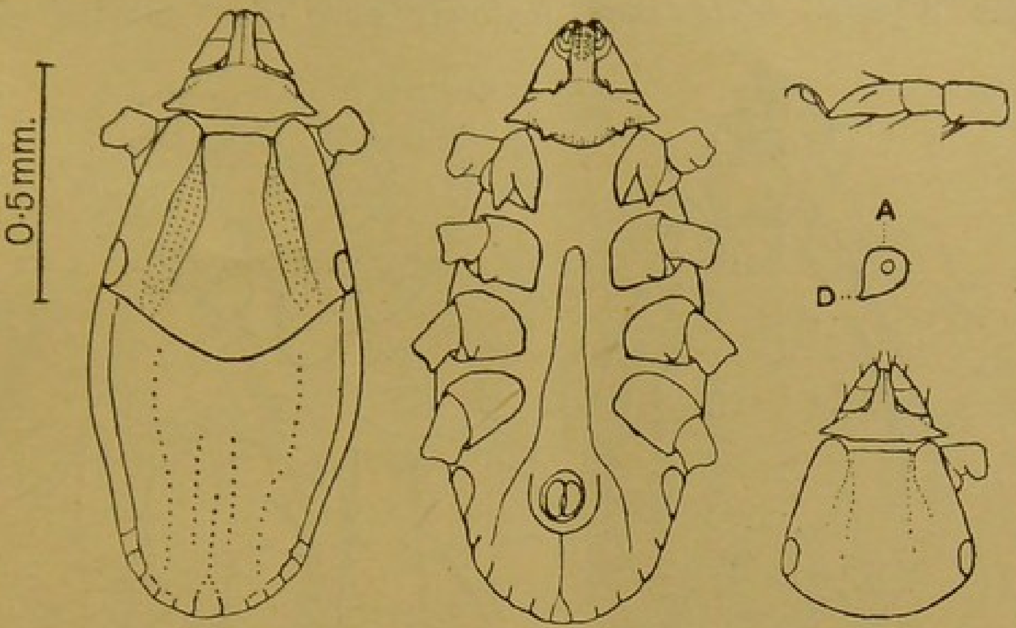

FIG. 27.—*Rhipicephalus sanguineus* (Latreille 1804), nymphe : (1) Spécimen normalement développé non-gorgé ; aspects dorsal et ventral, péritrèmes et tarse iv ; (2) capitulum et écusson de la nymphe provenant d'une larve partiellement gorgée. (N. Cunliffe 1914.)

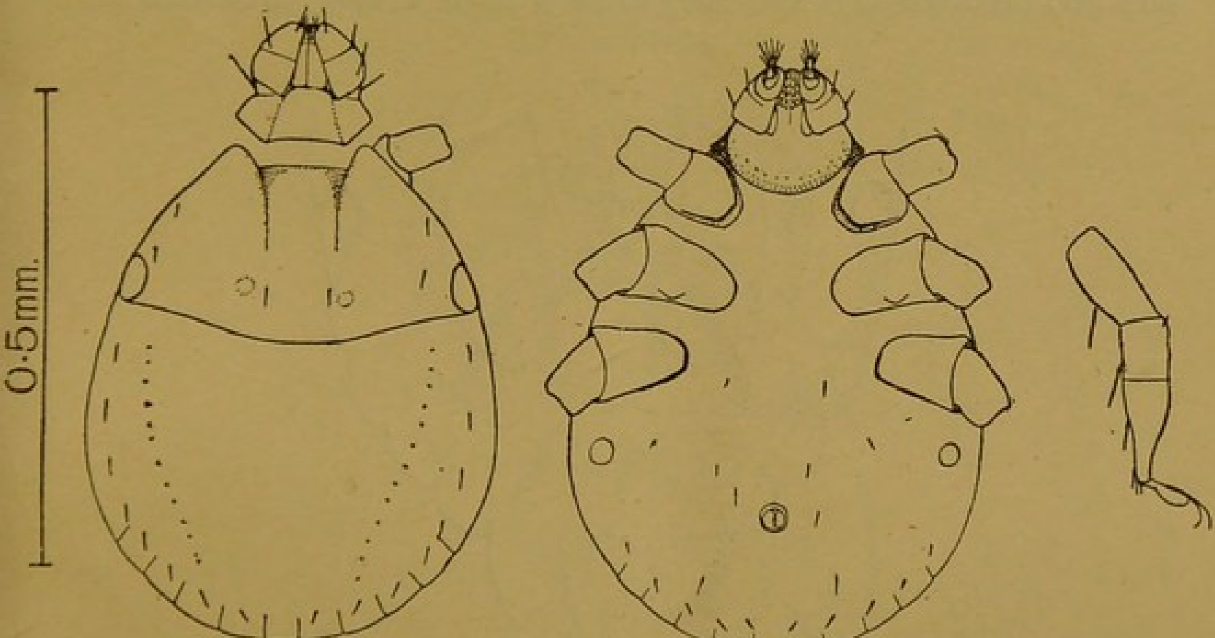

FIG. 28.—*Rhipicephalus sanguineus* (Latreille 1804), larve non gorgée : Faces dorsale et ventrale, tarse III. (N. Cunliffe 1914.)

Genre C. Margaropus.

Caractères généraux: Sillons anaux absents; concolore, pourvu d'yeux, mais sans festons, avec des courtes palpes

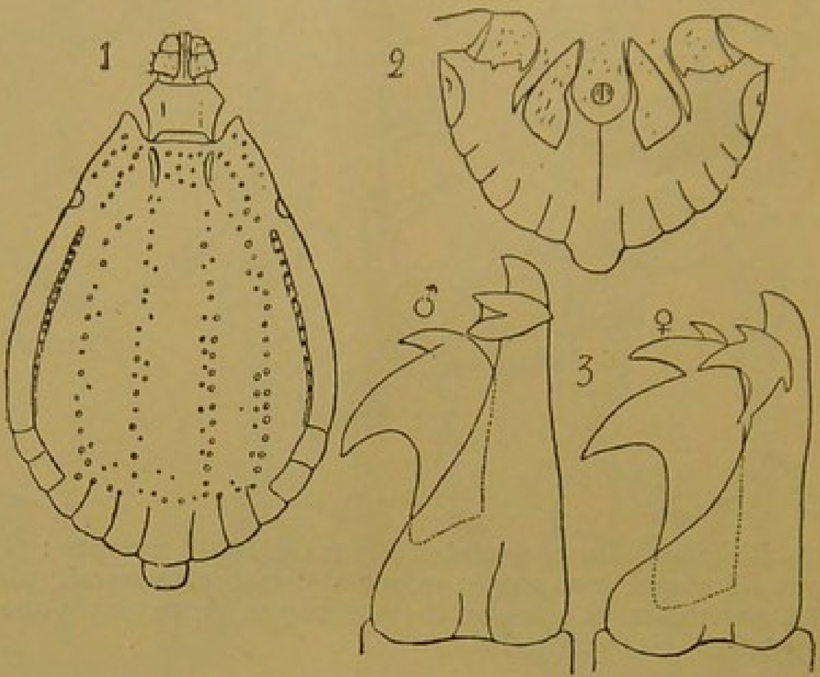

Fig. 29.—*Rhipicephalus simus*, Koch 1844, ♂ : (1) Face dorsale ; (2) face ventrale ; (3) doigts de la chélicère gauche ♂ et ♀ × 195. (Neumann 1897.)

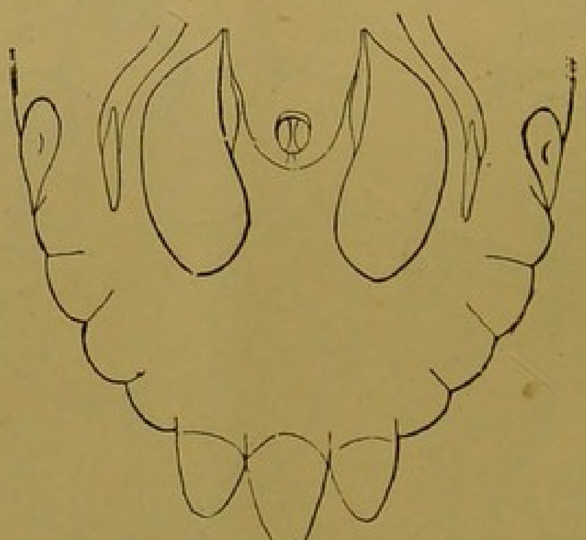

Fig. 30.—*Rhipicephalus supertritus*, Neumann 1907, ♂ repu : Extrémité de la face ventrale. (Neumann 1907.)

et un capitulum intermédiaire entre celui de Rhipicephalus et de Boophilus, fortement chitinisé et de grande taille. La *femelle avec un écusson très petit. Le mâle avec une plaque abdominale médiane prolongée par deux longues épines projetées au-delà et de chaque côté de l'anus. Les articles des*

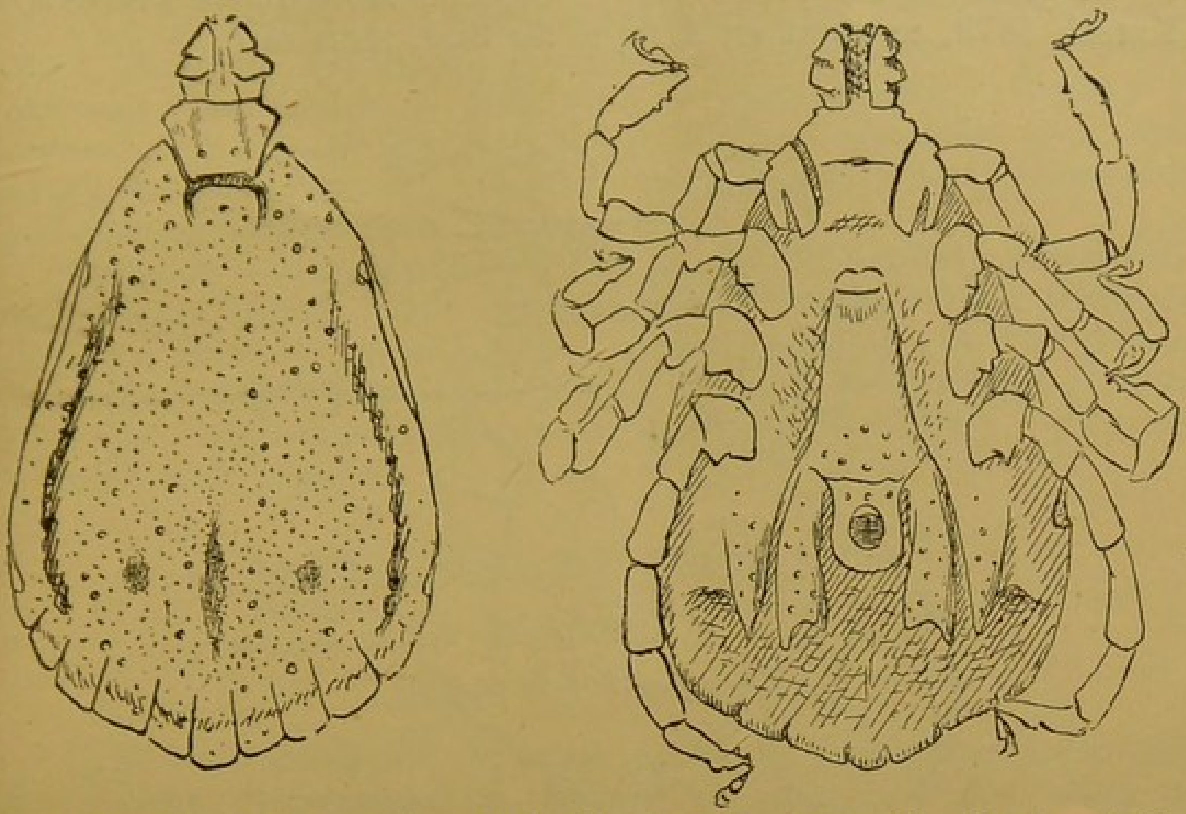

FIG. 31.—*Rhipicephalus tricuspis*, Dönitz 1906, ♂ : Faces dorsale et ventrale. (Dönitz 1906.)

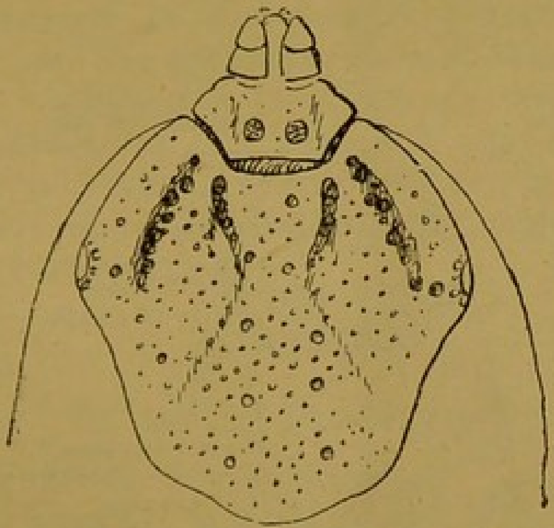

FIG. 32.—*Rhipicephalus tricuspis*, Dönitz 1906, ♀ : Partie antérieure de la face dorsale. (Dönitz 1906.)

pattes, spécialement de la quatrième paire, fortement renflés; les tarses, chez les deux sexes, avec un long éperon pointu, s'étendant bien plus loin que les griffes, qui sont petites et sans *fonctions; présence d'un prolongement caudal chez le mâle. Les stigmates arrondis ou courtement ovales chez les deux sexes* (figs. 33 et 34).

Ce genre ne comprend qu'une espèce : *Margaropus winthemi*, Karsch 1879, existant en Afrique du Sud, mais rare.

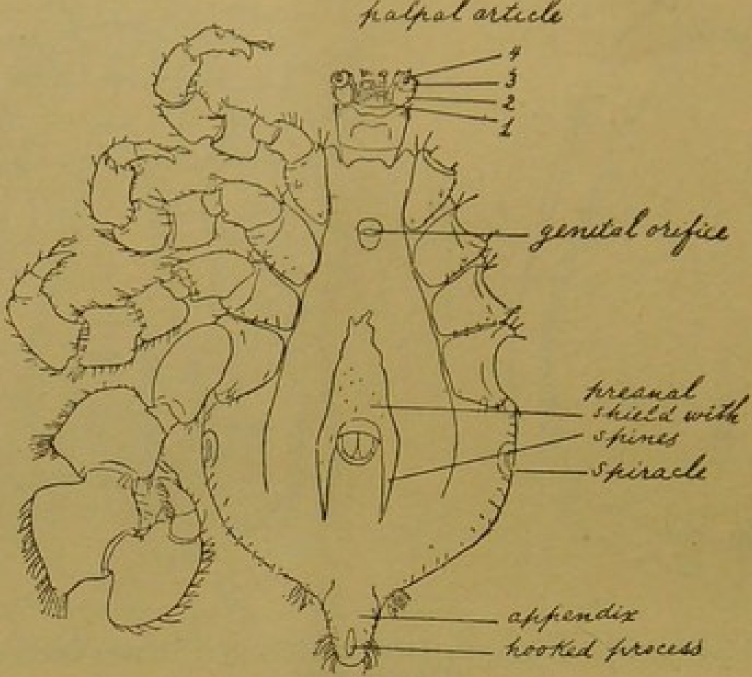

FIG. 33.—*Margaropus winthemi*, Karsch 1879, ♂ : Face ventrale. (Neumann 1907.)

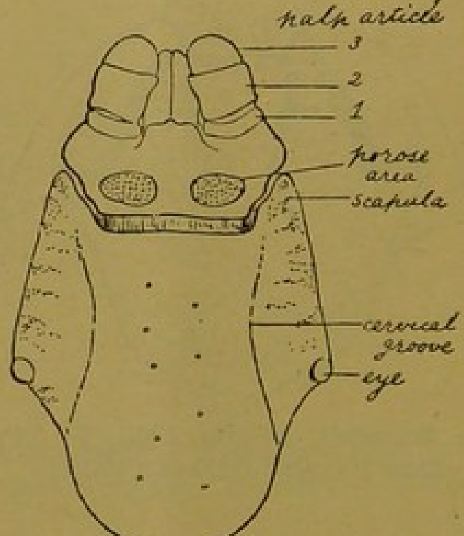

FIG. 34.—*Margaropus winthemi*, Karsch 1879, ♀ : Capitulum, écusson. (Nuttall et Warburton 1911.)

Genre 7. Boophilus.

Caractères généraux: Sillons anaux presqu'absents; concolore, pourvu d'yeux, mais sans festons; avec des palpes très courtes, comprimées, portant dorsalement et latéralement des côtes; base du capitulum hexagonale dorsalement; faiblement chitinisé; les adultes à jeun sont de petite taille. Coxaux I bifides. La femelle avec un petit écusson; le mâle avec des écussons adanaux et adanaux accessoires. Les stigmates arrondis ou ovales chez les deux sexes.

Ce genre est représenté au Congo par une espèce: *Boophilus decoloratus* (Koch 1844), dont les caractères sont bien indiqués dans les illustrations ci-jointes. (Il est possible que l'existence d'une espèce très proche parente ou variété: *B. australis*, Fuller, sera également constatée au Congo) (figs. 35 et 36). Pour la biologie, voir page 42.

(*b*) *LONGIROSTRATA.*

Groupe I.

Genre 8. Hyalomma.

Caractères généraux: Ecusson concolore ou rarement marqué de dessins colorés; pattes parfois annelées par des marques légères; pourvu d'yeux, avec ou sans festons, avec palpes longues, la base du capitulum subtriangulaire dorsalement. La femelle approchant comme aspect d'Amblyomma. Le mâle avec écussons adanaux et des pointes postérieures chitinisées, prenant naissance sur des prolongements abdominaux postérieurs. Coxaux I bifides. Stigmates en forme de virgule.

Ce genre est représenté au Congo par une espèce: *Hyalomma ægyptium* (Linnæus), qui peut être facilement reconnue par les caractères indiqués dans les illustrations (figs. 37, 38 et 39). Pour la biologie, voir page 44.

Groupe II.

Genre 9. Amblyomma.

Caractères généraux: Généralement marqué de dessins colorés, pourvu d'yeux et avec festons. Avec longues palpes; base du capitulum de forme variable. Le mâle sans écussons adanaux, mais ayant occasionnellement de petites plaques ventrales près des festons; stigmates subtriangulaires ou en forme de virgule.

L'existence de 8 espèces d'*Amblyomma* a été constatée au Congo. Les mâles sont plus facilement identifiés que les

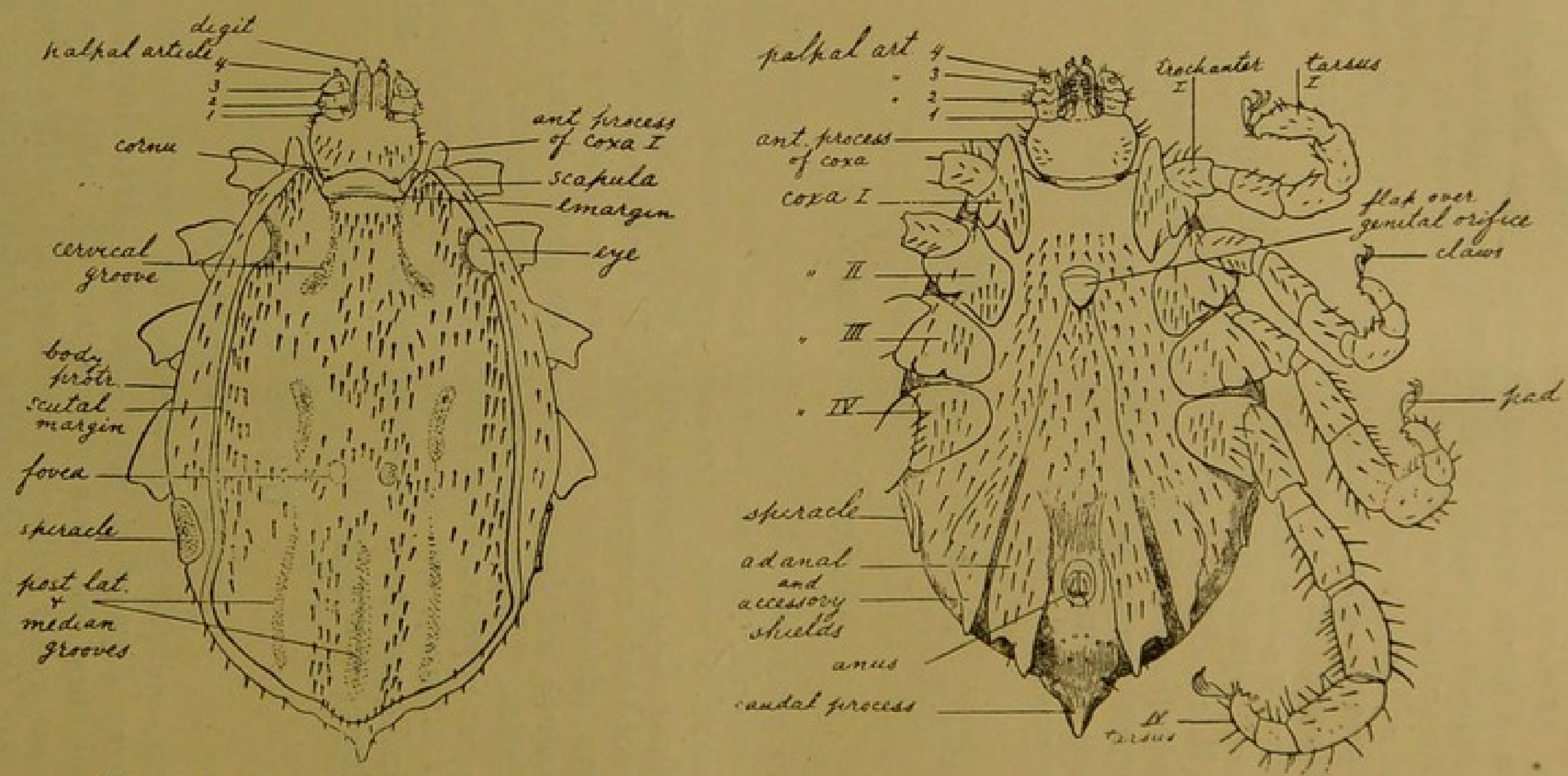

FIG. 35.—*Boophilus decoloratus* (Koch 1844), ♂ : Faces dorsale et ventrale. (Nuttall 1909.)

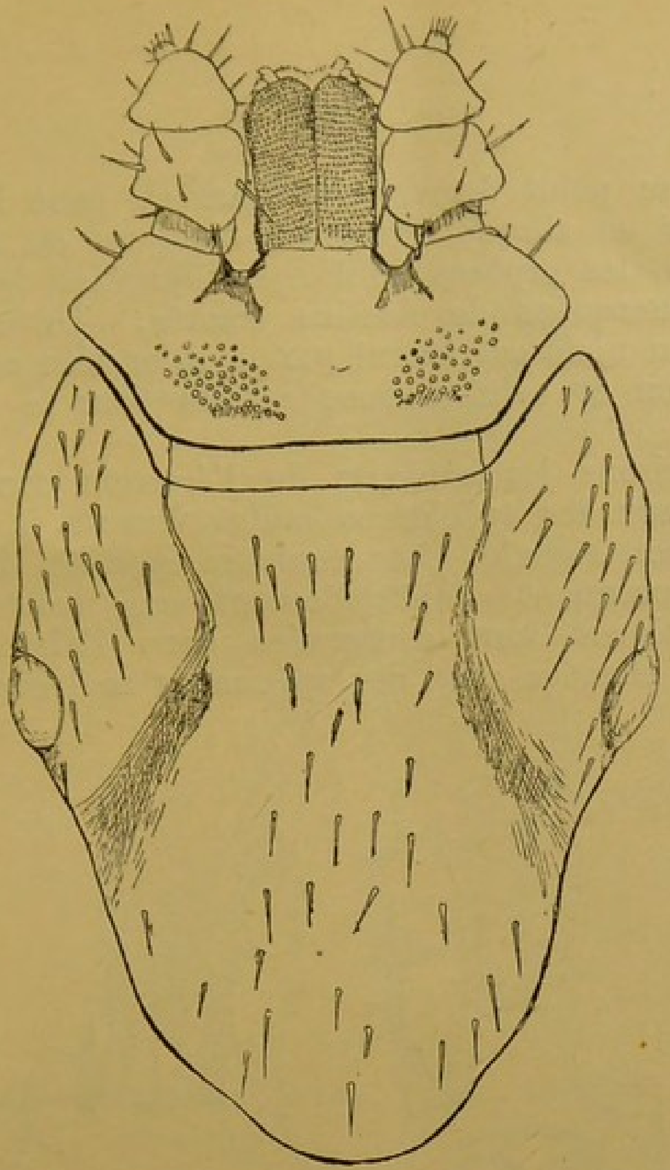

FIG. 36.—*Boophilus decoloratus* (Koch 1844), ♀ : Capitulum et écusson. (Original, G.H.F.N.)

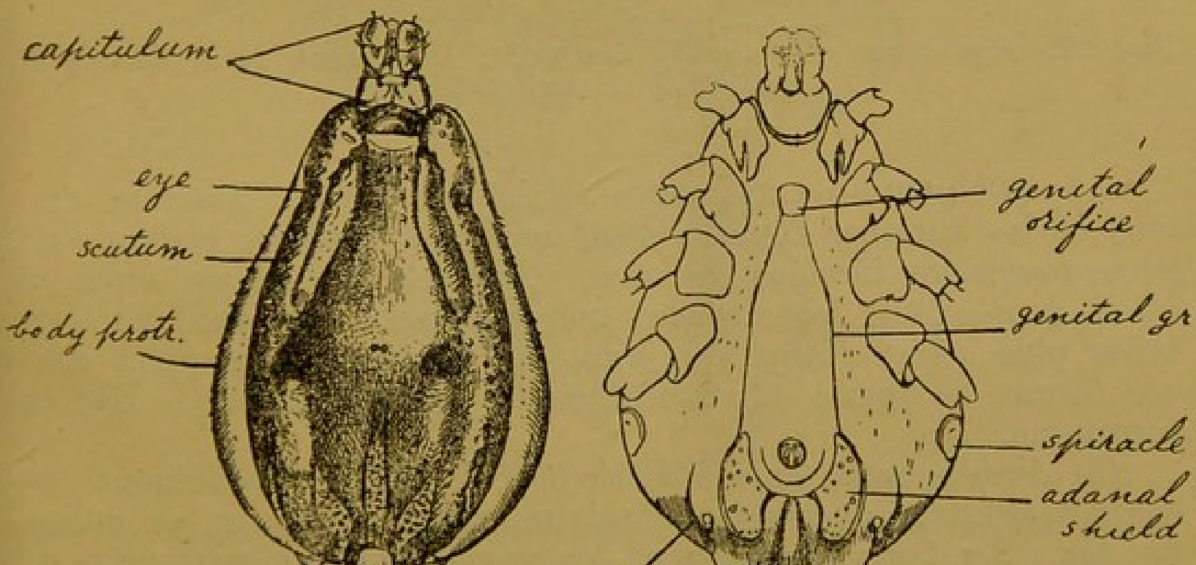

FIG. 37.—*Hyalomma aegyptium* (Linn.), ♂ : Faces dorsale et ventrale. (Nuttall et Warburton 1909.)

femelles et au point de vue pratique on peut les déterminer sur place par un simple examen à l'œil nu ou à l'aide d'une loupe à main, les espèces dont il est question ici étant toutes grandes et marquées de dessins colorés. Un moyen simple d'identification nous est fourni par la coloration et la nature de l'ornementation et celui-ci nous servira pour le but que nous poursuivons.

Nous décrirons les couleurs de l'écusson comme nous les avons vues, sur des spécimens *mâles* vivants, à moins que le contraire ne soit signalé. Les couleurs chez les *Amblyomma* et *Aponomma* prennent habituellement un lustre métallique, lorsque les tiques sont conservées dans l'alcool; elles sont fréquemment effacées chez des spécimens mal conservés.

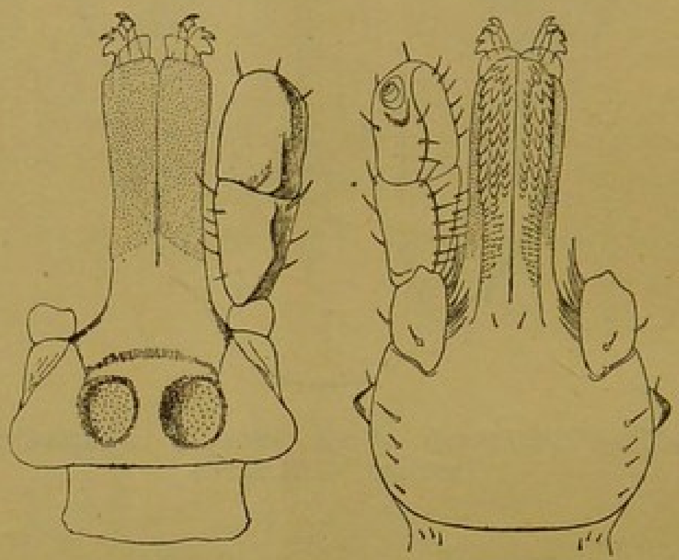

FIG. 38.—*Hyalomma aegyptium* (Linn.), ♀ : Capitulum, faces dorsale et ventrale. (Nuttall 1911.)

(1) *Amblyomma variegatum* (Fabricius 1794). Tous les festons et les surfaces foncées sont noirs, les surfaces claires sont jaune-rougeâtre bordées de vert. Lorsque les tiques meurent et se dessèchent, les surfaces noires passent au brun, les surfaces plus pâles virent du jaune à l'orange. Les yeux sont en forme de perle chez les deux sexes (fig. 40). Espèce commune.

(2) *Amblyomma splendidum* Giebel 1877. Facilement reconnaissable par une tache circulaire orange, brillante, au milieu du dos. Le feston médian et les parties foncées sont noirs et les 4 festons flanquant le médian sont blancs. Les aires médianes claires de l'écusson sont violettes, les latérales roses, mais elles passent au jaune chez les tiques mortes et sèches,

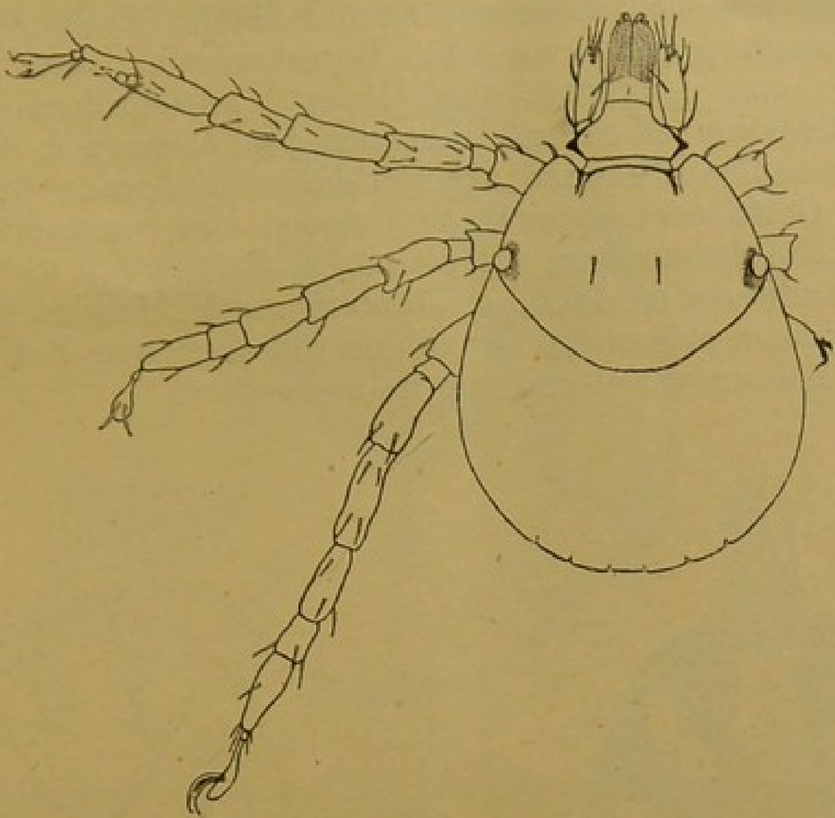

Fig. 39.—*Hyalomma aegyptium* (Linn.) : Larve. (Original, G.H.F.N. del.)

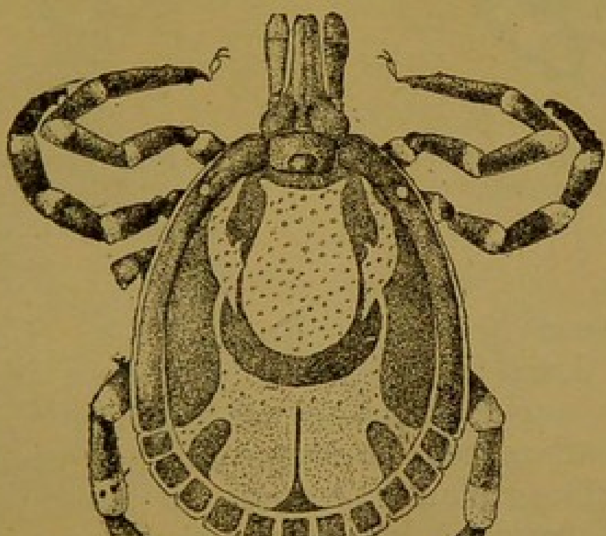

Fig. 40.—*Amblyomma variegatum* (Fabricius 1794), ♂ : Face dorsale. (Dessin de J. Marx, publié par Neumann 1899.)

tandis que la tache orange persiste (figs. 41-42). Semble commune.

(3) *Amblyomma cohaerens*, Dönitz 1909. Nous n'avons pas encore jusqu'à présent vu cette tique en vie. Les spécimens séchés et ceux conservés dans l'alcool ressemblent fortement comme coloration et comme marques de l'écusson à *A. splendidum*. La seule différence observable est l'absence de la tache orangée. Cette espèce paraît également être commune.

Il serait intéressant de déterminer la distribution géographique de *A. splendidum* et de *A. cohaerens*, car les faibles différences que ces tiques présentent semblent indiquer que l'on a plutôt affaire ici à deux variétés d'une même espèce.

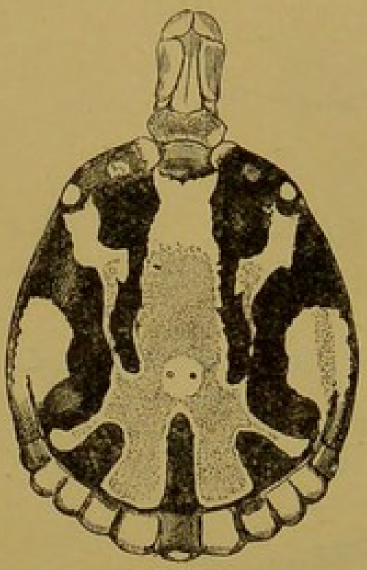

FIG. 41.—*Amblyomma splendidum*, Giebel 1877, ♂ : Face dorsale. (Original, G.H.F.N.)

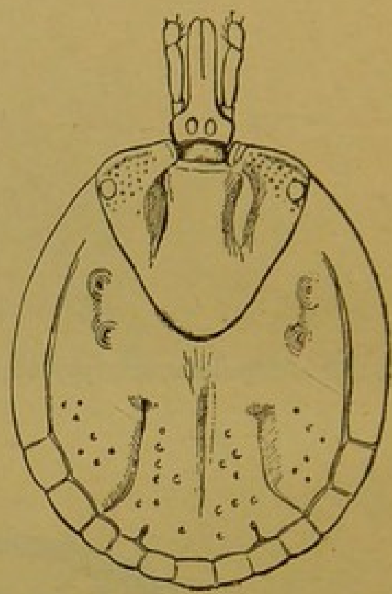

FIG. 42.—*Amblyomma splendidum*, Giebel 1877, ♀ : Face dorsale. (Original, G.H.F.N.)

(4) *Amblyomma hebræum*, Koch 1844. Les festons sont blanchâtres, les deux taches sur le côté sont jaunâtres, la plus grande partie des surfaces claires est violet-pâle ou rosâtre et les parties foncées sont noires. Lorsque la tique meurt et est laissée à sécher, les surfaces claires passent au jaune-pâle. Les mâles qui ont séjourné pendant longtemps sur leur hôte (70 jours ou plus) virent au rougeâtre dans les surfaces pâles, aux environs des yeux et des côtés, et les aires claires du dos deviennent verdâtres. Les surfaces claires sont jaunâtres chez la femelle et deviennent plus pâles lorsqu'elle meurt (fig. 43). Pour la biologie, voir page 45.

(5) *Amblyomma pomposum*, Dönitz 1909. Les festons sont foncés et les trois surfaces claires antérieures sont jaunes; une

grande tache médiane et deux taches latérales sont rouges; les marques postérieures et postéro-latérales sont verdâtres. Cet aspect est celui de spécimens morts, conservés dans l'alcool ou

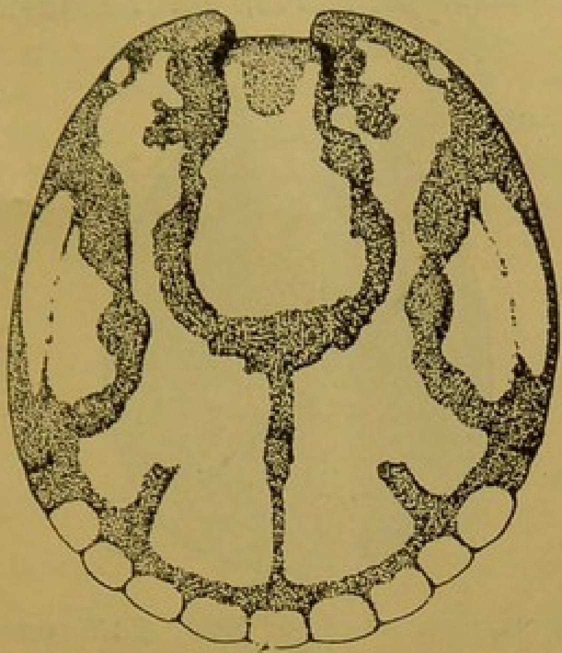

Fig. 43.—*Amblyomma hebraeum*, Koch 1844, ♂ : Écusson dorsal. (Robinson 1915.)

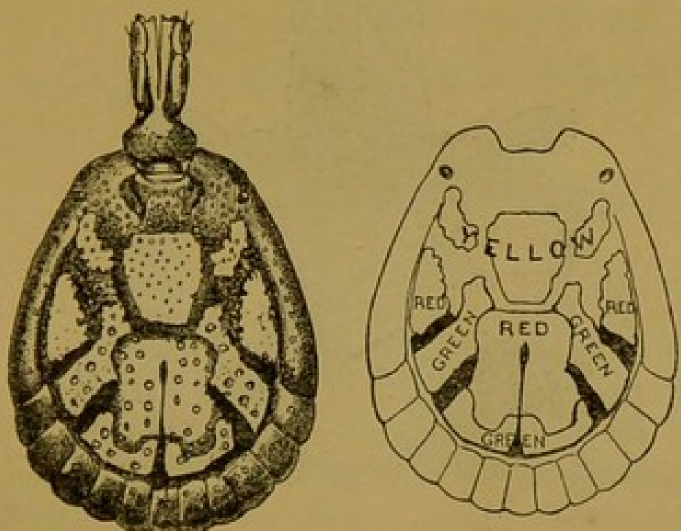

Fig. 44.—*Amblyomma pomposum*, Dönitz 1909, ♂ : Face dorsale avec indication des couleurs : yellow, red, green = jaune, rouge, vert. (Original, G.H.F.N.)

séchés. L'illustration ci-dessus donne exactement la disposition des différentes surfaces colorées (fig. 44).

(6) *Amblyomma tholloni*, Neumann 1899. Chez les spécimens conservés dans l'alcool les surfaces foncées sont brunes,

tandis que huit petites taches jaunes se dessinent sur les côtés, s'étendent en arrière depuis les angles scapulaires et sont presqu'équidistantes les unes des autres.

(7) *Amblyomma marmoreum*, Koch 1844. Nombreuses surfaces irrégulières pâles, jaunâtres, sur l'écusson et les festons;

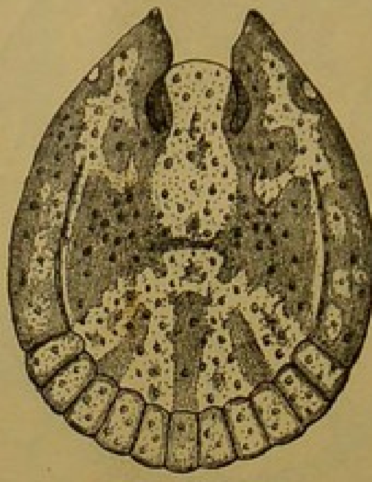

FIG. 45.—*Amblyomma marmoreum*, Koch 1844, ♂ : Écusson dorsal. (Neumann 1901.)

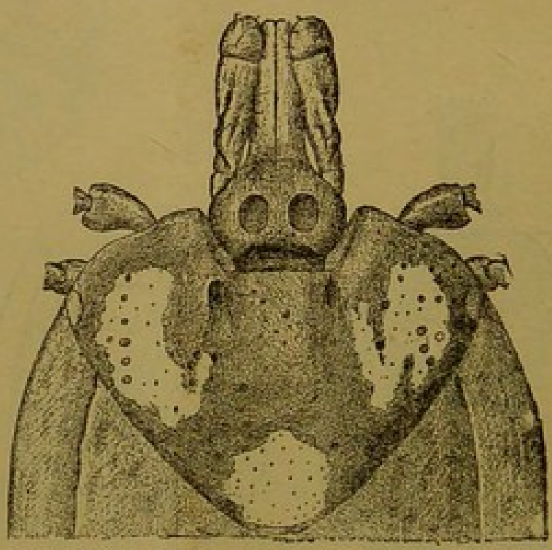

FIG. 46.—*Amblyomma trimaculatum*, Neumann 1908, ♀ : Capitulum et écusson. (Neumann 1908.)

elles peuvent être plus ou moins effacées chez les vieilles tiques ou chez des spécimens mal conservés (fig. 45).

(8) *Amblyomma trimaculatum*, Neumann 1908. Nous n'avons pas encore vu le mâle de cette espèce. L'écusson de la femelle possède 3 taches claires (fig. 46).

Sous-Genre Aponomma.

Les *Aponomma* peuvent être considérés comme étant simplement des *Amblyomma* sans yeux, ou chez lesquels les yeux sont faiblement développés. Leur corps est souvent large. On ne les rencontre en Afrique que sur les reptiles.

Deux espèces ont été récoltées au Congo.

(1) *Aponomma exornatum*, Koch 1844. Le mâle possède neuf taches claires sur l'écusson; deux situées sur les angles scapulaires, deux antéro-latérales, une grande centrale et quatre postérieures aux précédentes. Il y a trois taches sur l'écusson de la femelle (fig. 47).

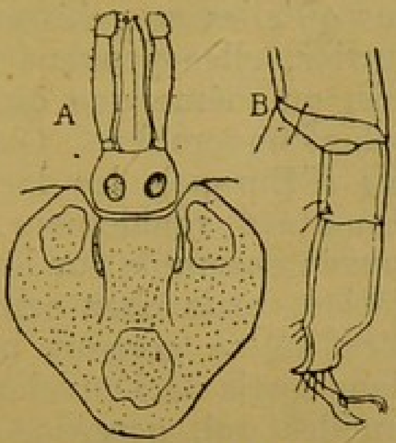

Fig. 47.—*Aponomma exornatum* (Koch 1844), ♀ : (A) Écusson et capitulum ; (B) tarse de la ive paire. (Neumann 1899.)

(2) *Aponomma læve*, Neumann 1899. Coloration brun-pâle, concolore.

Biologie générale des Tiques.

1. *Mœurs alimentaires.*

Toutes les tiques sont parasites et leur nourriture consiste dans le sang qu'elles sucent de leurs hôtes. Eventuellement, elles peuvent absorber une certaine quantité de lymphe, si elles ne parviennent pas à atteindre un vaisseau sanguin à l'aide de leurs pièces buccales.

Il existe une différence considérable, au point de vue des mœurs alimentaires, entre les Argasidæ et les Ixodidæ. Les larves des deux groupes se nourrissent, en règle générale, de la même manière, restant ordinairement sur leur hôte pendant moins d'une semaine.

Les nymphes et adultes d'Argasidæ, sauf une seule exception (*Ornithodorus megnini*, en Amérique), se nourrissent rapidement et fréquemment, se gorgeant de sang ordinairement en 15 à 30 minutes; tout comme les punaises de lit, ils attaquent leur hôte principalement la nuit et infestent ses habitats ou lieux de repos. Les femelles ne déposent qu'un nombre modéré d'œufs, ordinairement moins de 200, en amas et cela après chaque prise de sang. Les ARGASIDÆ peuvent éventuellement jeûner pendant 3 à 4 ans. Les deux sexes sont suceurs de sang (*O. megnini* ♂ excepté).

Les nymphes et adultes des IXODIDÆ séjournent pendant une semaine ou plus sur leur hôte. Les femelles déposent plusieurs milliers d'œufs, se gorgent une seule fois et meurent lorsque la ponte est terminée. Quand des IXODIDÆ partiellement gorgées sont enlevées de leur hôte, elles meurent ordinairement en quelques jours, à moins qu'elles ne subissent de métamorphoses. D'autre part, non nourries, elles peuvent rester en vie pendant des semaines, des mois, ou même une ou deux années, pourvu que les conditions soient favorables. Chez une seule espèce (*Hæmaphysalis inermis* d'Europe), les larves et nymphes sont connues comme s'alimentant rapidement. En règle générale, les deux sexes sont trouvés ensemble sur leur hôte, occasionnellement même en copulation, mais chez certains IXODIDÆ (*Ixodes* spécialement) les mâles ne se gorgent pas. Dans ce dernier cas, les mâles, après leur sortie de l'enveloppe nymphale, restent dans l'attente des femelles qui, gorgées, se laissent tomber de leur hôte, dans son terrier ou nid. Cette différence dans la manière de se comporter des deux sexes, dépend, comme je l'ai démontré, des mœurs de l'hôte.

Des animaux errants portent ordinairement des espèces de tiques dont les deux sexes cohabitent sur l'hôte, tandis que des animaux à habitats fixes (terriers ou nids) ne portent, habituellement, que des femelles. Alors que les mâles des ARGASIDÆ prennent comme les femelles une pleine gorgée de sang, les mâles des IXODIDÆ s'alimentent très sobrement et principalement, semble-t-il, de lymphe, car nous n'avons pas réussi à trouver des globules sanguins rouges dans leur canal alimentaire, quoique nous ayons examiné beaucoup de spécimens.

En règle générale, les larves et nymphes de tiques abandonnent leur hôte après s'être gorgées et tombent sur le sol, où elles se métamorphosent en nymphes ou imago.

De telles tiques sont appelées "Tiques à trois hôtes," car elles ont besoin d'accéder à un hôte en trois occasions, lorsqu'elles se nourrissent comme larve, nymphe et adulte. Comme exemple de tiques congolaises à trois hôtes, nous pouvons citer: *Amblyomma hebræum*, *A. variegatum* et *Hæmaphysalis leachi*. D'autres tiques subissent une mue sur leur hôte et se rattachent à celui-ci lorsqu'elles se sont débarrassées de l'ancienne peau. Un exemple de tiques à deux hôtes est le

Rhipicephalus evertsi, chez qui la transformation de larve à nymphe se produit sur l'hôte.

D'autre part, chez *Boophilus*, nous avons une tique à un hôte, car elle reste durant tout son développement de larve à adulte gorgée, sur un seul animal.

Comme établi précédemment, les mâles d'IXODIDÆ, lorsqu'ils se nourrissent, le font très sobrement. Tous les autres stades absorbent, par rapport à leur taille, une grande quantité de sang. Chez les mâles, la surface dorsale du corps est entièrement couverte d'un écusson dur, tandis que, dans les autres stades, l'écusson est petit et couvre seulement la portion antérieure du corps. La plus grande partie de ce dernier est molle, et conséquemment capable d'une grande extension, par suite de son tégument élastique. Beaucoup de tiques sont incapables d'un développement ultérieur, si elles ne se gorgent pas jusqu'à réplétion; chez d'autres, des larves et nymphes partiellement gorgées donnent naissance à de petites nymphes et à de petits adultes. Ceci explique les grandes variations de taille constatées chez certaines espèces, dont *Rhipicephalus appendiculatus* et *R. sanguineus* peuvent servir d'exemples (figs. 18, 19, 25, 26). Des femelles imparfaitement repues pondent fréquemment des œufs stériles, de même le nombre des œufs déposés est inférieur à la normale et varie d'après le degré de la réplétion.

Le mécanisme de la piqûre est semblable chez toutes les tiques. Les organes coupants pairs, ou doigts des chélicères, pénétrent dans la peau, au moyen de leurs dents recourbées et très tranchantes. Chaque chélicère (fig. 48) consiste en une tige faisant saillie à la base du capitulum et pourvue à son extrémité libre d'un organe coupeur ou doigt. Ce dernier se meut latéralement, au moyen de deux tendons: un tendon interne extenseur et un tendon externe plus puissant, qui le tourne en dehors. Un examen de la figure permet de se rendre clairement compte de la façon dont les chélicères pénétrent dans les tissus de l'hôte, lorsque les tendons agissent alternativement sur l'organe coupeur terminal, avec ses dents recourbées tranchantes. Dans une position ventrale par rapport aux chélicères se trouve l'hypostome rigide, portant des dents recourbées pointues. L'hypostome est amené dans la blessure infligée par les chélicères et ses dents servent à ancrer la tique à l'hôte, sans plus d'efforts de la part du parasite. Lorsque les chélicères et l'hypostome ont pénétré suffisamment et que les doigts ont sectionné les plus petits vaisseaux sanguins, la tique commence à pomper le sang par le moyen d'un puissant organe aspiratoire, le pharynx, qui est situé dans le capitulum. Le sang, traversant le pharynx et l'œsophage, entre dans les cæcums intestinaux fortement extensibles et la tique commence à s'enfler. Le sang est absorbé lentement d'abord, le maximum d'accroissement dans l'absorption se produisant ordinairement durant les 24 heures qui précèdent l'abandon de l'hôte par le parasite.

Etant donnée la structure des pièces buccales de la tique, celles-ci sont fréquemment abîmées lorsque le parasite est détaché sans précautions de son point d'attache. Il faudra donc prendre beaucoup de soins pour l'enlèvement de la tique et l'on se servira avec avantage dans ce but d'une fine paire de pinces, avec lesquelles les pièces buccales seront saisies. Si les pièces buccales brisées sont laissées dans la blessure, il pourra en

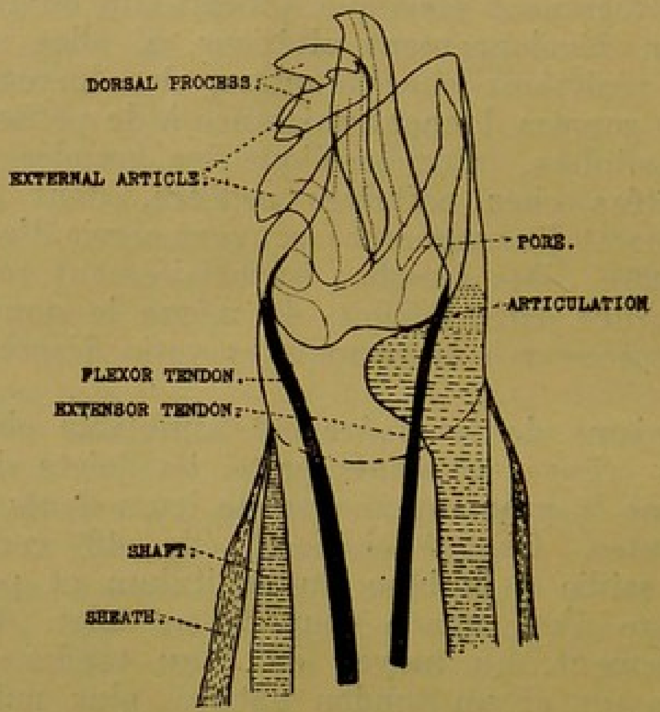

FIG. 48.—*Haemaphysalis cinnabarina* var. *punctata* (Canestrini et Fanzago 1877), ♀ : Mécanisme de la chélicère gauche. (Nuttall, Cooper et Robinson, 1908.)

résulter une irritation considérable, qui s'ajoutera à celle occasionnellement causée par la piqûre elle-même. J'ai démontré ailleurs, que la sécrétion salivaire des tiques contient une substance anti-coagulante et il y a des raisons de supposer qu'elle peut parfois exercer une action toxique.

Pendant qu'elles se gorgent, les tiques peuvent sécréter des quantités considérables d'un fluide clair, provenant de glandes dont les conduits émergent entre les coxaux de la première et de la deuxième paire de pattes. Ceci est particulièrement visible chez les ARGASIDÆ (*Ornithodorus moubata* et à un moindre degré chez *Argas persicus*). Cette sécrétion des glandes coxales contient aussi un anti-coagulant. Les tiques évacuent fréquemment des excréments pendant qu'elles se gorgent. La fonction de l'anti-coagulant est évidemment d'empêcher la coagulation du sang et conséquemment de faciliter son afflux (voir page 39, biologie de l'*O. moubata*). Il paraît évident qu'une attaque en masse par les tiques peut être mortelle. L'on a vu des animaux mourir à la suite de nombreuses morsures des tiques.

2. *Ponte.*

La femelle gorgée et fécondée cherche un abri sur le sol et après un laps de temps variable, dépendant de la température, procède au dépôt des œufs. Lorsqu'on la trouble ou lorsqu'on la manie rudement pendant la ponte, la femelle peut cesser de déposer des œufs ou peut mourir. Le nombre d'œufs qu'une femelle peut pondre varie de quelques centaines à des milliers, suivant l'espèce. *Amblyomma hebræum* peut déposer jusqu'à 18,500 œufs, *Rhipicephalus sanguineus* 4,000, *R. appendiculatus* 5,800, *Hæmaphysalis leachi* 4,800, *Hyalomma ægyptium* 15,500. Le processus de ponte est très intéressant à observer. L'on trouvera des descriptions illustrées de ce processus dans l'ouvrage : " Ticks " (Parties II et III).

3. *Développement.*

Lorsque les œufs viennent d'être pondus, ils sont brunâtres et transparents. Pour leur développement, ils ont besoin d'un degré convenable de température et d'humidité. Après quelques jours, les œufs paraissent nuageux et une tache blanche (due aux glandes de Malpighi développant et accumulant des excréments) apparaît sur le côté de l'œuf. Quelques jours plus tard, la coque se fend et la petite larve hexapode en sort. Les larves foncent bientôt, leur exosquelette chitineux se durcit et elles s'éparpillent à la recherche d'un hôte. Les larves des tiques Ixodidæ s'accumulent fréquemment en grappes de plusieurs centaines ou milliers, sur les extrémités des feuilles de graminées ou herbages et restent tranquilles, dans l'attente de l'hôte qui passe. Si la fortune les favorise, elles s'agriffent à leur hôte, à l'aide de leurs pattes à griffes aiguës, qui sont de plus pourvues de pulvilles. Cherchant un point convenable de la peau de l'hôte, elles y insèrent leurs pièces buccales et procèdent à l'alimentation. Ordinairement, elles sont repues au bout de trois à cinq jours et tombent alors de l'hôte.

La larve repue reste engourdie jusqu'à ce qu'elle abandonne sa peau larvaire et apparaît comme nymphe à huit pattes, qui escalade les herbes et attend son hôte. Si elles trouvent un hôte, les nymphes se comportent comme le firent les larves. Les nymphes donnent naissance aux adultes, qui, à leur tour, attendent un hôte et l'attaquent de la même manière que le font les larves et les nymphes.

Le temps pendant lequel les tiques restent sur leur hôte varie quelque peu suivant l'espèce. On trouvera des exemples de différentes périodes de parasitisme dans les notes biologiques données dans les pages suivantes. Si les tiques n'absorbent pas une quantité suffisante de sang, elles peuvent séjourner plus longtemps sur leur hôte. De plus, si l'hôte est un animal à sang froid, la période de parasitisme peut être fortement prolongée. Les mâles restent fréquemment sur l'hôte pendant plusieurs semaines après la chute des femelles, ce qui explique pourquoi les mâles peuvent parfois être présents en grand nombre sur un même animal.

Les métamorphoses sont nettement influencées par la température, étant fortement accélérées par la chaleur et retardées ou complètement enrayées par le froid. *Les rapports de certaines tiques avec les maladies* sont brièvement indiqués pour les espèces dont la biologie est décrite dans le chapitre qui suit.

Biologie spéciale des Tiques congolaises et leurs Rapports avec les Maladies.[1]

Ornithodorus moubata.—Se rencontre dans les huttes indigènes et les lieux de halte, se cachant dans la poussière ou le chaume. Cette tique se nourrit principalement la nuit et absorbe le sang rapidement, comme la punaise de lit. La femelle fécondée se nourrit à plusieurs reprises et pond un nombre variable d'œufs après chaque repas, le nombre total des œufs déposés par chaque femelle étant de 100 à 150. Les œufs, comme ceux des autres tiques, sont agglutinés en masse et sont bien plus grands que chez les Ixodidæ. Vers le sixième jour, à 29° C., la larve s'est développée dans l'œuf, mais c'est une créature faible, incapable de se nourrir. Lorsqu'elle est encore dans l'œuf, la nymphe se développe à son tour dans la peau larvaire, et ordinairement 10 à 15 jours après la ponte elle éclôt, rejetant à la fois la coque de l'œuf et la peau de larve. Cette nymphe est désignée sous le nom de nymphe de premier stade, car il peut y avoir 3 à 4 stades de nymphe, avant que la tique n'atteigne sa maturité sexuelle. Le premier stade de nymphe est prêt à se nourrir très peu de temps après

[1] Les observations ici notées ont été faites par moi à Cambridge (G. H. F. N.).

la naissance, et, s'étant gorgé, subit la métamorphose pour se nourrir à nouveau dans le deuxième stade nymphal et ainsi de suite. Les nymphes et adultes ont besoin de 10 à 120 minutes pour se gorger. Les adultes s'accouplent loin de leur hôte. La tique à jeun subsiste de nombreux mois; au laboratoire, elle a survécu pendant deux ans. Comme elle est dépendante de la température, elle peut avoir besoin d'un ou deux ans pour parcourir son cycle vital.

Rapports avec la maladie.—*O. moubata* transmet à l'homme la fièvre récurrente, dans les nombreuses régions de l'Afrique tropicale où ce parasite est largement distribué. Lorsque la tique absorbe du sang contenant des *Spirochæta duttoni*, elle peut infecter les personnes sur lesquelles elle se nourrit ensuite. La progéniture d'une femelle infectée est capable de produire une infection jusqu'à la troisième génération et peut-être plus longtemps encore. Les Spirochètes sont, par conséquent, parasites à la fois de l'homme et de la tique. Pendant qu'elle suce le sang, la tique exsude fréquemment des excréments blancs et un fluide aqueux, ce dernier sortant de grands pores placés latéralement entre la première et la seconde patte. Ce fluide empêche la coagulation du sang. Les excréments sont infectants et les Spirochètes peuvent pénétrer dans la blessure, soit par les excréments mélangés au fluide anti-coagulant aux environs de la morsure, soit plus directement, par les pièces buccales de la tique.

Mesures préventives.—Lorsque la chose est possible, les endroits infectés sont détruits par le feu. Les huttes indigènes où les tiques existent seront évitées. Un moyen de se protéger consiste à dormir dans des hamacs ou sous des moustiquaires. L'on peut rencontrer les tiques dans les places de halte et les vieux camps et elles peuvent être transportées dans les bagages des voyageurs.

Hæmaphysalis leachi.—A besoin de trois hôtes sur lesquels elle se nourrit aux états de larve, de nymphe et d'adulte. Les femelles peuvent déposer jusqu'à 5,000 *œufs*, dont les *larves* éclosent en environ 30 jours, à 20° C. Après une semaine environ, les larves sont prêtes à se gorger. Elles séjournent de 2 à 7 jours sur l'hôte, comme le font du reste les *nymphes* qui sortent des peaux larvaires après quelque 30 jours. Les nymphes repues s'étant à leur tour laissé tomber de l'hôte, subissent leur métamorphose sur le sol, en 15 jours, à 24° C., et les adultes, mâle et femelle, sortent. Les deux sexes se cramponnent promptement à leur hôte. Tout d'abord, ils s'éparpillent, mais après deux ou trois jours les ♂ et ♀ peuvent être trouvés attachés tout près l'un de l'autre. La copulation a lieu sur l'hôte; la femelle a ordinairement besoin de 12 jours pour se nourrir, tandis que le mâle peut rester attaché pendant des semaines. La femelle commence à pondre au bout de 3 à 5 jours, à 23° C. Dans les conditions optima, le cycle vital peut se compléter en 123 jours.

Rapports avec la maladie.—*H. leachi* est l'agent de transmission habituel de la piroplasmose canine en Afrique. Cette tique existe dans tout le continent. On la trouve le plus communément sur les carnivores, mais elle est spécialement observée sur le chien. Lorsqu'une tique femelle se gorge sur un chien infecté, les parasites poursuivent leur développement dans la tique et pénètrent dans les œufs. La progéniture des tiques n'est capable de convoyer la maladie que lorsque les jeunes ont atteint la maturité sexuelle. En d'autres termes, les larves et les nymphes infectées ne sont infectieuses que lorsqu'elles sont adultes. Des tiques adultes infectées, ayant jeuné jusqu'à 7 mois, ont été placées sur un chien et ont communiqué une piroplasmose mortelle après une période d'incubation d'environ 12 jours. La piroplasmose est la plus mortelle des maladies canines, si on la laisse sans traitement. Comme l'ont démontré Nuttall et Hadwen, le trypanbleu guérit près de 100 pour cent des animaux infectés, si ceux-ci reçoivent à un stade peu avancé de la maladie une injection intraveineuse ou sous-cutanée de 10 c.c. d'une solution aqueuse à $1\frac{1}{2}$ pour cent du médicament. La guérison de cas apparemment désespérés est commune. Les principaux symptômes de la maladie sont ordinairement une forte fièvre, de l'hémoglobinurie, de la jaunisse, de l'anémie et un aspect aqueux du sang. Les parasites caractéristiques *Piroplasma canis* sont trouvés dans les globules sanguins, qui sont en grande partie détruits, le nombre de globules parasités s'accroissant ordinairement, jusqu'à ce que la mort ou la guérison se produise.

Rhipicephalus appendiculatus.—C'est une tique à 3 hôtes assez largement distribuée en Afrique. La femelle pond de 3,000 à 5,700 œufs, qui ont besoin pour éclore de 32 à 65 jours, à la température de 17 à 19° C. Les larves séjournent habituellement de 3 à 7 jours sur leur hôte et après en être tombées, subissent la métamorphose en nymphes, en 4 à 6 jours, à 30° C. Les nymphes restent 5 à 11 jours sur leur hôte et requièrent ensuite 10 jours à 37° C., avant de prendre l'état adulte. La copulation se produit sur l'hôte, les femelles repues tombent après 6 à 14 jours, si elles sont fécondées, après 24 jours si elles ne le sont pas. La ponte commence 6 à 23 jours après la chute de la femelle et ce processus peut durer de 15 à 56 jours. Les mâles restent sur l'hôte après le départ des femelles. Les sexes se rencontrent en nombre à peu près égal.

La tique à jeun peut rester longtemps en vie; c'est ainsi que des larves et nymphes ont survécu respectivement plus de 333 et de 164 jours et qu'un seul adulte est resté vivre plus de 682 jours. Dans les conditions de laboratoire, le cycle vital peut être complété en 115 jours.

Rapports avec la maladie.—*R. appendiculatus* est l'agent de transmission ordinaire de la fièvre rhodésienne ou "East Coast Fever" du bétail, causée par le parasite protozoïque du sang: *Theileria parva.* Ce parasite n'est pas transmis héréditairement dans la tique, mais seulement d'un stade à l'autre; ainsi, si la larve se gorge sur du bétail infecté, la nymphe à laquelle elle donne naissance est infectieuse et de même, si la nymphe s'infecte, l'adulte qu'elle produit communique la maladie à des animaux non infectés. Il est probable qu'une tique ou deux suffisent pour donner l'infection. Dans une expérience faite à Cambridge, 7 adultes ont communiqué la maladie à un veau. L'East Coast Fever débute par une forte fièvre qui se produit 10 à 17 jours après avoir placé les tiques sur l'animal. Les parasites caractéristiques sont trouvés dans les globules sanguins, 5 à 6 jours plus tard. Le nombre des globules infectés s'accroît constamment jusqu'à la mort, qui se produit ordinairement 22 à 23 jours après l'attaque des tiques. Lorsque les bestiaux se guérissent de l'East Coast Fever, ils ne sont plus capables d'infecter les tiques, ce qui est le contraire de ce qui a été observé pour la piroplasmose (voir page 43).

Rhipicephalus capensis.—C'est une tique à 3 hôtes. La larve et la nymphe abandonnent chacune l'hôte après avoir absorbé du sang pendant 5 à 8 jours environ. Les femelles restent sur l'hôte pendant 11 à 13 jours, et commencent la ponte après 5 jours environ.

Rapports avec la maladie.—Suivant Lounsbury, cette tique peut transmettre l'East Coast Fever dans des conditions expérimentales. La tique transmet le parasite d'une manière semblable à celle de *R. appendiculatus* et *R. simus*, décrite plus haut.

Rhipicephalus evertsi.—C'est une tique à deux hôtes. Lorsqu'on la place sur l'hôte comme larve, elle en tombe après 10 à 14 jours, comme nymphe repue. L'adulte sort après 22 à 25 jours, à la température intérieure. Les femelles restent de 6 à 9 jours sur l'hôte.

Rapports avec la maladie.—Suivant Theiler, *R. evertsi* transmet au Transvaal la piroplasmose équine. Il reste à déterminer lequel des deux parasites (*Piroplasma caballi*, Nuttall, ou *Nuttallia equi* (Laveran) França), cette tique convoie, puisque ces deux parasites, qui causent des symptômes semblables, étaient autrefois confondus. Lorsque la larve + nymphe se gorge sur un animal infecté, la tique adulte est infectieuse.

Rhipicephalus sanguineus.—Existe dans maintes parties du monde, sous des climats chauds et humides, étant commune sur le chien, mais parasitant également d'autres mammifères. C'est une tique à 3 hôtes, dont la biologie est semblable sous ce rapport à celle de la plupart des autres tiques. Les femelles déposent 1,400 à 3,400 œufs, qui demandent 17 à 19 jours pour éclore à 30° C. Les larves et nymphes restent habituellement 4 jours sur leur hôte et ont besoin respectivement de 5 à 8 et 11 à 12 jours pour subir leurs métamorphoses en nymphes et *adultes*.

Les femelles restent sur l'hôte de 7 à 21 jours avant d'être repues. La copulation se produit sur l'hôte, les mâles restant pendant une période indéfinie après la chute des femelles. Les femelles commencent la ponte 3 à 6 jours après être tombées sur le sol. Les mâles sont plus nombreux que les femelles.

Ces tiques, non nourries, ont une longévité remarquable; ainsi, dans les conditions de laboratoire, les larves survécurent 253 jours, les nymphes 97 jours et les adultes plus de 570 jours. Dans les conditions optima, le cycle vital peut se compléter en 63 jours, à 30° C.

Rapports avec la maladie.—Il a été démontré que *R. sanguineus* est l'agent de transmission de la piroplasmose canine aux Indes et il paraît certain que cette tique peut à l'occasion convoyer la maladie en Afrique et ailleurs. Il a été constaté qu'en Afrique le principal agent de transmission est *Hæmaphysalis leachi* (voir page 40).

Dans le cas de *R. sanguineus*, cependant, le *Piroplasma* a une manière de se comporter différente de celle qu'il affecte vis-à-vis de *H. leachi*, car les nymphes descendant de femelles infectées et les adultes provenant de nymphes repues sur un chien souffrant de piroplasmose, sont capables de communiquer la maladie à d'autres chiens, sur lesquels elles s'attachent (Christophers).

Rhipicephalus simus.—C'est une tique à 3 hôtes, à biologie semblable à celle de *R. appendiculatus*.

Rapports avec la maladie.—*R. simus* communique la fièvre rhodésienne au bétail, mais n'en est pas l'agent de transmission ordinaire. Les parasites ne sont pas transmis héréditairement dans la tique; c'est, au contraire, un cas d'infection d'un stade à l'autre, comme chez *R. appendiculatus*, qui est l'agent de transmission habituel (voir page 41). Chez les deux espèces, les tiques infectées cessent d'être infectieuses, après alimentation; en d'autres termes, elles se purifient.

Boophilus decoloratus.—C'est une tique à un seul hôte qui se rencontre dans toute l'Afrique tropicale et méridionale. Lorsqu'on la place sur l'hôte à l'état larvaire, elle ne se laisse ordinairement tomber que lorsqu'elle a atteint le stade adulte. La femelle tombe 22 à 34 jours après l'attache de la larve sur l'hôte et, durant cette période, tous les stades de développement peuvent être observés sur l'animal parasité. Lorsque les larves se sont repues, elles adhèrent à la peau de l'hôte, subissent leur métamorphose sur place, réapparaîssent sous forme de nymphes légèrement chitinisées, qui immédiatement se rattachent et procèdent à la prise de sang. Repues, elles restent en place, subissent à leur tour la métamorphose et émergent sous forme d'adultes, qui se rattachent également promptement. La copulation se produit sur l'hôte. La femelle dépose de 1,000 à 2,500 œufs.

Cette tique ne vit pas longtemps sans nourriture; les larves survivent rarement à un jeun de 90 jours et les autres stades périssent rapidement lorsqu'on les enlève de l'hôte. Le cycle vital d'œuf à œuf peut se compléter en 25 jours environ.

Hôtes.—Les bestiaux, quoiqu'on trouve à l'occasion cette espèce sur d'autres animaux.

Rapports avec la maladie.—*B. decoloratus* est l'agent ordinaire de transmission de la piroplasmose bovine dans toute l'Afrique tropicale et méridionale; cette maladie est occasionnée par *Piroplasma bovis* (= *bigeminum*), qui se multiplie dans les globules sanguins du bétail. Lorsqu'une tique femelle absorbe du sang contenant ce parasite, elle transmet ce dernier à sa progéniture larvaire. La fièvre se montre ordinairement chez le bétail, environ 10 jours après la contamination par des larves infectées. Le parasite apparaît ensuite dans le sang de l'hôte et réinfecte les tiques lorsqu'elles atteignent la maturité. En plus de la fièvre, les bestiaux atteints montrent ordinairement de l'amaigrissement progressif et de l'anémie; leur urine est sanguinolente, etc., et comme chez les chiens souffrant de piroplasmose (page 40), le sang devient aqueux et la rate s'agrandit beaucoup.

La mortalité occasionnée par la maladie peut être très élevée et il n'est pas rare, principalement chez le bétail fraîchement importé, que 40 à 100 pour cent des animaux atteints ne succombent. La persistance de la maladie dans la nature est expliquée (comme pour les piroplasmoses équine et canine) par le fait que lorsque les bestiaux guérissent, ils peuvent continuer (quoique apparemment en santé parfaite) à héberger pendant des années les parasites dans leur sang. Les bestiaux indigènes, apparemment immunisés, sont en réalité tous infectés et servent de réservoirs à *Piroplasma* pour *Boophilus*.

La piroplasmose du bétail peut être traitée avec succès par une injection intraveineuse de 200 c.c. d'une solution aqueuse à 1.5 pour cent de trypanbleu (Nuttall et Hadwen). Les animaux qui ont été guéris par ce traitement sont dans les mêmes conditions que les animaux " salés," c.-à-d., qui se sont guéris naturellement. Les bestiaux traités au trypanbleu (comme également les chiens) continuent à héberger les parasites dans leur sang.

Extirpation.—*Boophilus decoloratus* est la tique qui a été détruite avec le plus de succès par le procédé du " dipping " et le changement de pâturage des animaux susceptibles d'être contaminés. Des milliers de milles carrés ont été, par ces mesures, débarrassés de la tique et de la maladie, aux Etats-Unis, en Afrique du Sud et en Australie.

Hyalomma ægyptium.—Se rencontre dans toute l'Afrique, en Europe méridionale et dans diverses parties de l'Asie, notamment aux Indes.

La tique peut requérir, soit deux, soit *trois* hôtes. La femelle pond de 10,000 à 15,500 *œufs*, qui demandent 35 jours pour éclore à 18° C. Les *larves* se gorgent en 4 à 15 jours et fréquemment se laissent ensuite tomber sur le sol, pour subir leur métamorphose; d'autres peuvent cependant, tout en restant attachées à l'hôte, se métamorphoser sur place et apparaitre comme *nymphes* qui se rattachent promptement et, s'étant gorgées jusqu'à réplétion, tombent sur le sol pour se transformer en adultes. Lorsque les larves et nymphes restent attachées à un seul hôte, les nymphes gorgées tombent 25 à 46 jours après avoir été placées sur l'animal comme larves à jeun. Les femelles séjournent 6 à 8 jours sur l'hôte, tandis que les mâles peuvent rester accrochés pendant des mois, à l'endroit où la copulation a eu lieu. Il y a environ trois fois autant de femelles que de mâles.

Longévité.—Non repues, des larves ont été conservées en vie, en tubes, au laboratoire, plus de 369 jours. Les nymphes vivent rarement plus de 90 jours, tandis que les adultes subsistent bien plus longtemps. Deux femelles après avoir jeûné 817 jours, ont été nourries sur un mouton et placées avec des mâles qui avaient jeûné 210 jours; ces femelles donnèrent leur progéniture en temps voulu. Le cycle vital de cette espèce peut être complété en 116 jours.

Hôtes.—Bétail, moutons, chevaux, et bien d'autres animaux sauvages et domestiques.

Rapports avec la maladie.—Il n'a pas encore été démontré jusqu'à présent, qu'*Hyalomma ægyptium* transmet quelque maladie, mais cette tique est soupçonnée de convoyer *Nuttallia equi*, une des deux espèces de parasites (ressemblant à *Piroplasma*) qui causent chez les chevaux la fièvre biliaire. Cette suspicion est basée sur la concordance qui existe entre la distribution géographique du parasite sanguin et de la tique en Afrique, en Europe méridionale et en Asie. Cette question est actuellement étudiée expérimentalement à Cambridge.

Les effets de la piqûre peuvent être fâcheux.

Amblyomma hebræum.—Les deux seules espèces d'*Amblyomma* africaines dont la biologie soit connue, sont *A. hebræum* et *A. variegatum*. La dernière ne paraît pas avoir d'importance pathogénique; elle a les mêmes mœurs qu'*A. hebræum* et demande trois hôtes successifs sur lesquels elle se nourrit dans les stades larvaire, nymphal et adulte. Une femelle d'*A. hebræum* peut déposer jusqu'à 18,500 œufs en 8 à 11 jours à 30° C., le processus perdurant plus longtemps à des températures plus basses. Les œufs, déposés sur le sol, éclosent après 50 jours et une semaine après les larves sont prêtes à se gorger. Elles infestent également une grande variété d'hôtes et tombent repues après 5 jours ou plus, subissant ensuite leur métamorphose. Au bout d'une douzaine de jours, la nymphe rejette la peau larvaire. Les nymphes sont prêtes à se nourrir au bout d'une semaine environ, séjournent ordinairement six jours sur leur hôte et, lorsqu'elles sont repues, tombent sur le sol. Les *adultes*, mâle et femelle, apparaissent après 18 jours. Les mâles sont plus nombreux que les femelles et ces dernières ne s'attachent promptement à leur hôte, que si elles y trouvent des mâles déjà accrochés. La copulation se produit sur l'hôte. La femelle se gonfle jusqu'à atteindre de grandes dimensions (environ 3 cm. de longueur) et abandonne son hôte après 6 à 12 jours environ. Cette femelle, après s'être cachée dans le sol, commence la ponte qui perdure de 8 à 74 jours, suivant la température. Les mâles peuvent rester sur leur hôte, de 41 à 355 jours, dans l'attente d'une femelle fraîche. Au laboratoire, dans des conditions optima, le cycle vital d'œuf à œuf a été complété en 171 jours.

Rapports avec la maladie.—Dans l'état actuel de nos connaissances, *A. hebræum* est la seule espèce d'*Amblyomma* qui transmette une maladie. Cette tique est redoutée en Afrique du Sud, parce qu'elle y convoie l'" Heartwater," maladie fréquemment fatale aux moutons, chèvres et bestiaux et due à un organisme indéterminé, probablement ultramicroscopique. La maladie et la tique sont confinées à l'Afrique. Lorsqu'une tique se nourrit, à l'état larvaire ou de nymphe, sur un animal infecté, elle transmet la maladie après avoir atteint le stade suivant, nymphal ou adulte (Lounsbury).

De plus, cette tique se rend encore très incommode par ses piqûres, qui peuvent entraîner un boursouflement et de la suppuration.

Extirpation.—On a réussi à détruire cette tique dans certaines parties de l'Afrique du Sud, par la fréquente application du procédé du "dipping." La tique résiste pendant de longues périodes à la privation de nourriture; c'est ainsi que des expériences de laboratoire ont démontré que des larves non nourries peuvent survivre pendant 346 jours, des nymphes pendant 250 jours et des adultes pendant plus de deux ans. Les adultes peuvent rester attachés à un hôte mort, jusqu'à ce qu'ils meurent également.

Récolte des Tiques.

Les tiques sont ordinairement récoltées sur les hôtes qu'elles parasitent. Ces hôtes peuvent être des mammifères, oiseaux, reptiles (serpents, lézards, tortues) ou amphibies (crapauds). Elles peuvent également être capturées sur les herbes ou sur le sol, quoiqu'on les trouve moins fréquemment de cette façon, à moins qu'elles ne soient abondantes. Une méthode facile de récolter des spécimens dans ce dernier cas consiste à traîner sur la surface du sol ou des herbes une pièce de flanelle grossière ou d'une étoffe semblable (blanche de préférence). Les tiques s'accrochent promptement à ce drap et sont ensuite enlevées et mises dans des boîtes à pilules ou des tubes. *Ornithodorus moubata* se trouve dans les huttes indigènes, parmi la poussière ou dans les crevasses de boue du plancher et des murs et dans le chaume, près des endroits de repos. On la rencontre également dans la poussière des lieux de haltes, le long des routes fréquentées par les voyageurs.

Lorsque les tiques Ixodidæ sont attachées à un hôte, il faudra les enlever avec grand soin, car autrement les pièces buccales peuvent se rompre, ce qui abîmerait les spécimens. On les enlève le mieux en saisissant la base du capitulum avec une paire de petites pinces et en exécutant un faible mouvement de rotation, tandis qu'on le retire prudemment. Si le rostre est fortement enfoncé, une goutte d'une huile quelconque étendue sur la tique facilitera l'opération. Les spécimens de tiques ayant des pièces buccales abîmées sont ordinairement de peu de valeur pour l'étude et les femelles ainsi endommagées ne déposent d'habitude pas d'œufs.

Les larves se récoltent en raclant la peau avec une lame de couteau, leurs pièces buccales étant plus petites et moins profondément enfoncées que celles des nymphes et adultes. Les tiques ayant un long hypostome à dents aiguës, spécialement les espèces d'*Ixodes*, sont difficiles à enlever sans les abîmer. Si l'on éprouve une grande difficulté à détacher les tiques d'un hôte mort, l'on peut découper la pièce de peau à laquelle ces tiques sont attachées et ces dernières peuvent être ensuite enlevées, si elles ne se détachent pas d'elles-mêmes.

Toutes les tiques récoltées sur une espèce d'animal, dans une même localité, peuvent être introduites dans le même tube, mais il faudra veiller à ne pas mélanger les tiques prises sur différents hôtes dans la même localité. Il est spécialement important de conserver séparément les tiques provenant de localités différentes.

Mise à mort et conservation des tiques.—Si la chose est possible, la meilleure façon de tuer les tiques consiste à les jeter dans de petits tubes de verre, à bouchon de liège, contenant de l'alcool à 25 ou 30 pour cent, auquel deux ou trois gouttes d'éther ont été ajoutées. Les tiques ainsi traitées meurent les pattes étendues, ce qui facilite l'examen. Après 24 à 48 heures, les spécimens seront placés dans de l'alcool à 60 pour cent, qui est le meilleur et le plus simple des liquides conservateurs et qui peut, du reste, être utilisé directement, si l'on ne dispose pas d'alcool plus faible additionné d'éther. Des alcools plus forts durcissent les spécimens et les rendent trop fragiles pour un examen convenable. Les mêmes objections s'appliquent aux solutions de formol. A défaut d'alcool, on peut conserver les tiques dans du cognac, du whisky, etc. L'on n'entassera pas trop de spécimens dans un même tube. S'il n'y a pas moyen de se procurer de l'alcool et si l'atmosphère est sèche, l'on peut laisser mourir les tiques dans des tubes ou dans des boîtes à pilules contenant du papier de soie chiffonné (pas d'ouate), ou bien encore les spécimens peuvent être transpercés à l'aide de fines épingles entomologiques, comme il est fait d'habitude pour les insectes. Toutefois, les spécimens ainsi conservés sont très facilement endommagés et demandent à être manipulés et emballés avec très grand soin.

Etiquetage des spécimens.—Il est de la plus grande importance que les spécimens soient convenablement étiquetés. Ecrivez *lisiblement*, avec un crayon doux, à la mine de plomb (H.B.), et à pointe bien taillée, sur du bon papier blanc et placez l'étiquette à l'intérieur du tube. Ecrivez le nom de l'hôte (le nom scientifique si possible), la date et l'endroit de récolte et le nom du collecteur. Si l'on possède d'autres particularités en ce qui concerne les tiques—par ex. : leurs mœurs, leur fréquence ou abondance, leurs rapports avec les maladies, etc—ces données seront notées sur des feuilles séparées, portant un numéro correspondant à celui des spécimens conservés dans les tubes. *Il faudra prendre spécialement soin d'écrire très clairement et lisiblement les noms des localités et celui du collecteur.*

Emballage des spécimens.—Les tubes seront hermétiquement bouchés avec le bouchon de liège et, si possible, l'extrémité bouchée sera plongée dans de la cire fondue ou de la stéarine comme protection supplémentaire contre l'évaporation. Les tubes seront bien remplis d'alcool. Chaque tube sera enroulé dans un morceau de papier séparé et entouré d'une feuille d'ouate. Cette précaution est prise afin que, si le tube se brise, les tiques restent à l'intérieur du papier et l'ouate absorbe l'alcool échappé. A défaut d'ouate, toute autre fibre végétale ou même de la sciure de bois pourra être employée. Emballez les tubes dans des boîtes de bois solides.

Que faut-il récolter?—Les tiques seront récoltées dans tous les stades; ce ne sont pas toujours les plus grandes (femelles) qui sont les plus intéressantes. Il faut se rappeler que le mâle est petit et est fréquemment attaché tout près de la femelle. Les nymphes et larves peuvent être très petites et échappent fréquemment à la vue du collecteur, dont l'attention est plus facilement attirée sur les femelles gorgées, à l'exclusion des autres stades.

Que faut-il observer?—Il faut noter la place du corps de l'hôte où l'on trouve les tiques et indiquer la manière de se comporter des sexes. Chez les oiseaux, les tiques sont ordinairement attachées aux environs de la tête; chez les mammifères, aux endroits de la peau où celle-ci est mince ou où il y a moins de poils (aux environs de l'anus, du pis, des parties génitales, dans les replis de peau molle, près des oreilles, etc.). L'on devra noter si l'animal sur lequel les tiques ont été prises présente quelque symptôme de maladie ou possède des parasites protozoïques (*Piroplasma*, etc.) dans le sang.

Lorsque des espèces de tiques peu communes, dont la biologie est inconnue, sont récoltées et si l'on peut disposer de femelles gorgées et fécondées, il est très à conseiller d'entreprendre l'élevage de ces espèces dans leurs différents stades. Même si l'on n'obtient pas un succès complet, on pourra toujours réunir des informations de valeur sur une partie plus ou moins importante de la biologie de ces tiques. En vue d'être utile à ceux qui veulent essayer d'élever des tiques expérimentalement, nous donnons pour finir un court aperçu des méthodes qui peuvent être adoptées.

Comment élever les Tiques?

Nous supposons que le chercheur s'est procuré une ou plusieurs tiques femelles complètement gorgées et fécondées, qui ont abandonné leur hôte d'elles-mêmes ou qui ont été très soigneusement enlevées, afin que leurs pièces buccales restent intactes.

Les femelles gorgées devront être maniées prudemment, autrement elles meurent. On les placera dans des boîtes à pilules en bois, chaque femelle dans une boîte séparée, marquée d'une manière spéciale. Si l'atmosphère est sèche, une petite quantité d'humidité peut être fournie en plaçant les boîtes sur de la terre ou sur du sable mouillé, dans un récipient couvert ou non couvert. Les boîtes devront être ouvertes journellement pour inspection, en prenant bien soin de ne pas déranger les femelles plus qu'il n'est absolument nécessaire. Prenez exactement note de tous les faits: date de récolte, hôtes sur lesquels les tiques ont été récoltées, date à laquelle la ponte a commencé et s'est terminée, quand la femelle est morte, etc.

Comme les œufs s'accumulent, on peut les enlever et les introduire dans un tube bouché, portant un numéro correspondant à celui de la femelle qui a fourni les œufs. En recouvrant le bouchon avec du papier filtre à l'intérieur du tube et en laissant ressortir un petit bout de ce papier, on peut humecter périodiquement ce dernier (si nécessaire), avec une goutte d'eau. Il faut noter quand les premiers œufs ont été déposés et quand les premières larves sont sorties. Conservez quelques-unes de ces larves dans de l'alcool.

Une semaine ou plus après la naissance des larves, placez celles-ci sur un petit animal dont vous disposez et qui est capable de supporter la captivité. Nous avons trouvé que le hérisson (*Erinaceus europæus*) convenait très bien pour l'élevage de beaucoup de tiques qui infestent les mammifères en Europe et en Afrique, parce que les piquants de cet animal l'empêchent de se gratter pour enlever les tiques.

L'hôte (chien, cobaye, etc.) sera placé dans une cage métallique qui peut facilement être soumise à une inspection journalière et qui est pourvue d'un plancher en toile métallique à larges mailles, au travers desquelles les tiques gorgées peuvent tomber dans un plateau placé en dessous.

Des feuilles de papier blanc, étendues chaque jour sur le plateau, faciliteront grandement la découverte des petites tiques repues (larves) qui peuvent tomber de l'hôte. Toute la cage sera placée sur un plateau peint en blanc, entouré d'une gouttière contenant de l'eau qui empêche efficacement les tiques de s'échapper. Il faudra inspecter journellement le plateau et noter quand les premières larves repues y sont récoltées. Les larves seront facilement ramassées à l'aide d'un fin pinceau en poils de chameau et elles seront introduites ensuite dans des tubes bouchés, semblables à ceux dans lesquels les œufs sont conservés. Comptez le nombre de larves gorgées récoltées journellement, et inscrivez soigneusement ce nombre. Ayant noté quand elles tombent de l'hôte, la donnée suivante à recueillir au sujet des tiques élevées, est la date de leur sortie comme nymphes. Les nymphes ont besoin d'une semaine ou plus avant d'être prêtes à se nourrir sur un hôte. Le procédé décrit pour la larve est utilisé également pour la nymphe et finalement le stade adulte est atteint.

Les adultes et dans certains cas les larves et nymphes peuvent également être élevées d'une manière convenable sur de plus grands animaux, si l'on en a à sa disposition. Les tiques à jeun sont, dans ce but, introduites dans des sacs de toile blanche solide, qui peuvent être liés autour des oreilles (bestiaux et chevaux) ou du scrotum (bélier, bouc, taureau). Ces sacs seront alors inspectés périodiquement et les tiques repues seront enlevées.

Le temps employé pour les métamorphoses d'œuf à larve, de larve à nymphe et de nymphe à adulte étant fort influencé par la température, il est par conséquent nécessaire d'inscrire journellement la température à laquelle les tiques sont maintenues pendant qu'elles subissent ces transformations. La manière de se comporter des sexes sur l'hôte sera notée, ainsi que le nombre proportionnel d'individus de chaque sexe qui émergent d'un nombre donné de nymphes. Le nombre d'œufs déposés par chaque femelle peut être estimé avec une grande exactitude, en mettant les œufs en suspension dans l'eau, en les déversant ensuite et en les étendant en une couche uniforme, entre les quatre côtés d'un châssis carré, fait de lamelles de verre fixées sur une plaque de verre de dimensions appropriées. Comptez les œufs d'une rangée sur deux côtés du carré et multipliez ces chiffres pour obtenir le nombre total d'œufs.

Quoique ces indications semblent suggérer que l'élevage des tiques dans des conditions expérimentales est chose fort simple, ceci n'est bien souvent pas le cas en pratique. Certaines tiques n'ont pu encore être élevées par nous, quoique des essais répétés aient été faits dans diverses conditions, alors que pour d'autres tiques l'élevage a été poursuivi à maintes reprises pendant plusieurs générations, sans aucune difficulté particulière. Pour certains cas, nous ne connaissons pas la cause de notre insuccès, tandis que pour d'autres, nous l'avons attribuée à des conditions peu favorables d'humidité et de température. Certaines tiques doivent être conservées durant leurs métamorphoses dans une atmosphère sèche; d'autres dans une atmosphère légèrement humide; d'autres encore dans une atmosphère saturée d'humidité. Les moisissures sont une source fréquente d'ennuis dans ces derniers cas. La température optimum nécessaire pour le développement des tiques reçues des contrées tropicales semble être d'environ 32° C., tandis que les tiques vivant sous les climats tempérés semblent subir plus rapidement leurs métamorphoses à une température approchant de 20° C. Il est bon de rechercher quel est l'hôte qui convient le mieux pour élever une espèce de tique déterminée; les hôtes à longs poils sont les meilleurs

Nous voulons ainsi faire comprendre qu'il est parfois très difficile de réussir à élever des tiques. Il est naturellement beaucoup plus facile d'élever des tiques à un seul hôte que des tiques à deux hôtes et des tiques à trois hôtes, à cause des pertes de plus en plus grandes qui se produisent au cours des métamorphoses, spécialement dans des conditions artificielles. Il est clair qu'une connaissance approfondie de la biologie des tiques transmettant des maladies est essentielle pour l'étude de ces maladies elles-mêmes et qu'une telle connaissance présente une grande utilité pratique pour l'application de mesures préventives efficaces.

Index des Tiques du Congo Belge et de leurs Hôtes.

* Ce signe indique les espèces qui transmettent des maladies et dont la biologie est décrite dans le texte.

† Biologie décrite dans le texte.

‡ Les noms en *italiques* désignent les hôtes desquels nous avons reçu le plus de spécimens.

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Inhaltsverzeichnis siehe III. Umschlagseite!

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(Aus dem Zoologischen Institut der Militär-medizinischen Akademie — Direktor: Prof. *E. N. Pawlowsky* — Leningrad — und aus der Klinik für Hautkrankheiten an dem Staatsinstitut für medizinische Wissenschaften — Direktor: Prof. *A. K. Stein* — Leningrad.)

Experimentelle Untersuchung über die Wirkung der, eine eigenartige Dermatitis beim Menschen hervorrufenden, Milbe Rhyzoglyphus hyacinthi (Fam. Tyroglyphidae).

Von

Prof. Dr. **E. N. Pawlowsky** und Prof. Dr. **A. K. Stein.**

Mit 4 Textabbildungen.

(*Eingegangen am 4. April 1929.*)

Einer von uns (*E. N. Pawlowsky*) hat von *J. F. Bajschew* (Pensa, Station zur Bekämpfung der Pflanzenschädlinge) Zwiebeln mit zahlreichen Milben erhalten, die von *W. W. Redikorzew* als Rhyzoglyphus hyacinthi bestimmt wurden. Dieses Material wurde aus der Dorfschaft Bessonowka, Gouvernement Pensa, erhalten. Die Landleute daselbst pflanzen sehr viel Zwiebeln, welche in der Wohnung auf einem Bettgestell unterhalb der Decke aufbewahrt werden. Beim Faulen der Zwiebeln erscheinen an ihnen zahlreiche Milben, die von dem Bettgestelle fallen und auf die Menschenhaut gelangen, wobei sie ein Jucken und eine krätzeähnliche Erkrankung verursachen. Es gelang uns nicht, ein genaueres klinisches Bild zu erhalten und deshalb mußten vor allem Experimente mit den Milben angestellt werden.

Die Milbenkultur läßt sich leicht durch Hinzulegen frischer Zwiebeln (Abb. 1) oder durch das Übertragen eines Teils des mit Milben infizierten Materials in ein neues Gefäß mit Zwiebeln, von welchen das obere Häutchen entfernt wurde, züchten. Die Milben vermehren sich gut bei Zimmertemperatur.

Beim Bestehen der Kultur werden die Zwiebeln rot und beginnen in einigen Zylindern zu faulen, wobei sie in eine halbflüssige, schmutzigrote Masse von der Konsistenz des Tomatenpürees zerfallen. In dieser Masse befinden sich, abgesehen von den Milben in allen Entwicklungsstadien, von den Eiern bis zur Imago, unzählige Nematoden.

Es unterliegt keinem Zweifel, daß die sich zersetzende Masse mit den Nematoden und Milben unter natürlichen Bedingungen auf die Menschenhaut gelangen und beim Zerkratzen in die Haut eingerieben werden kann. Bei unseren weiteren Versuchen waren wir bestrebt, solche natürliche Verhältnisse zu imitieren.

Es wurden folgende Versuchsserien angestellt:

Serie A. Ganze Zwiebelmilben, Einreibung in die normale Haut.

Versuche 1—2. 3. III. 1928. Die Milben wurden mit einem Glasstäbchen in die Haut des Vorderarms zweier Personen eingerieben.

Versuche 3—4. 7. III. 1928. Wiederholung des Versuches an 2 anderen Personen.

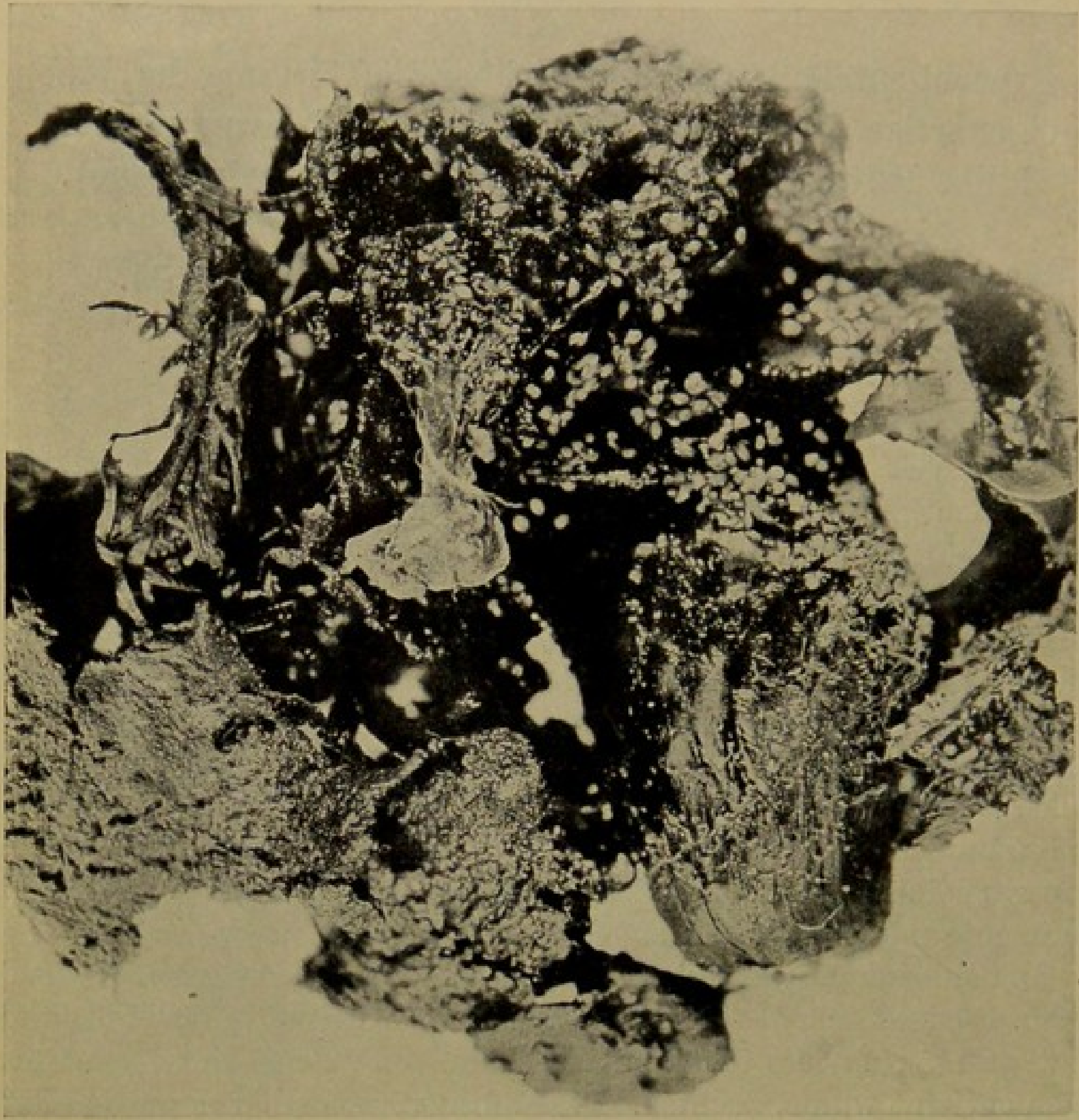

Abb. 1. Rhyzoglyphus hyacinthi an den Zwiebeln. Die größeren, ovalen, weißen Körper sind die erwachsenen Weibchen; die kleinen weißen Punkte sind die Larven und die übrigen Verwandlungsstadien. Origin. Mikrophotographie von N. D. Mitrofanow.

Während der Versuche wurde eine gleichmäßige Rötung mit schwachem Jucken oder Brennen beobachtet, die bald nach Beendigung der Manipulationen schwanden.

Serie B. Einreibung zerdrückter Milben in die normale Menschenhaut.

Versuche 5—6. 15. III. 1928. Eine Masse von in einem Uhrglas zerdrückter Milben wurde 2 verschiedenen Personen in die Haut des Vorderarms eingerieben. Es kam eine gleichmäßige schwach ausgesprochene Rötung mit schwacher Juckempfindung zustande; alle diese Erscheinungen schwanden 15 Minuten nach Beendigung des Versuches.

Versuche 7—8. 28. III. 1928. Es wurden, ebenfalls 2 Personen, zerdrückte, von Nematoden gereinigte Milben eingerieben. Während des Versuches wurde eine gleichmäßige Rötung mit schwachem Jucken beobachtet. Nach beendigter Einreibung schwanden diese Erscheinungen. Einen Tag später wurde ebenfalls Jucken empfunden. *An den Einreibungsstellen waren nach einigen Stunden kaum merkliche rosiggelbe Fleckchen und Papeln erschienen, die gegen Ende desselben Tages verschwunden waren.*

Versuche 9—10. 2. XI. 1928. Wiederholung der Versuche 7—8. Während der Einreibung kam eine Rötung mit schwachem Jucken zum Vorschein, welche bald schwand.

Serie C. Einreibung der Milben in die leicht geritzte Menschenhaut.

Versuche 11—12. 21. III. 1928. Mit einer sterilen Nadel wurde die Hornschicht der Haut des Vorderarms bei 2 Personen leicht geritzt; in die geritzte Stelle wurden die von Nematoden gereinigten Milben eingerieben.

Während der Einreibung wurde eine Rötung mit Jucken und Brennen beobachtet; diese Erscheinungen schwanden nach 30 Minuten. Am folgenden Tage bildeten sich an demselben Hautabschnitte *kleine rosig-gelbliche Papeln, die bald verschwanden.*

Versuche 13—14. Die von den Nematoden gereinigten, zerdrückten Zwiebelmilben wurden in die mit einer sterilen Nadel geritzte Haut des Vorderarms 2 Personen eingerieben.

20 Minuten nach Beendigung der Einreibung waren die erschienene Rötung und das Jucken geschwunden. Einen Tag später waren an dem der Einreibung ausgesetzten Hautabschnitte gleichsam *gelblich-bräunliche kleine Papeln sichtbar, welche bald schwanden.*

Serie D. Versuche, in welchen lebende Milben auf die Haut gebracht wurden.

Versuche 15—16. 8. III. 1928. 2 Gruppen lebender Milben wurden 2 Personen auf die Haut des Vorderarms gebracht und mit einem Uhrglase bedeckt, welches mit Heftpflaster an der Haut befestigt wurde.

Nach 20—24 Stunden wurde Jucken empfunden. Nach Abnahme des Uhrglases, kamen nach Ablauf von 24 Stunden an der Peripherie des bedeckten Hautabschnittes kleine, rosig-gelbe, in Reihen angeordnete einzeln gelegene *Papeln* zum Vorschein. Es wurde ein Stückchen Haut mit Papeln zur mikroskopischen Untersuchung ausgeschnitten (siehe weiter unten).

Versuche 17—18. 2. XI. 1928. Wiederholung des vorhergehenden Versuches an 2 anderen Personen.

Einen Tag später wurde Jucken empfunden. Das Uhrglas wurde nach 2 Tagen weggenommen. In der Haut sind kleine rosig-gelbe Papeln deutlich sichtbar, die vornehmlich reihenweise am Rande des Uhrglases angeordnet sind und abgesehen davon einzeln verstreut sind. Auf der Haut waren zahlreiche dunkle Punkte sichtbar, die sich als Milbenfaeces erwiesen. Dieser Umstand zeugt davon, daß die Milben während des Versuches in einem mehr oder weniger normalen Zustande waren, da die Verdauungsprozesse normal verliefen.

Serie E. Kontrollversuche.

Versuche 19—20. 7. III. 1928. Zwiebelstückchen, die zu faulen begonnen hatten, aber keine Milben aufzuweisen schienen, wurden 2 Personen in die Haut des Vorderarms eingerieben.

Während der Einreibung kam eine Rötung zum Vorschein, die bald schwand.

Versuche 21—22. 15. III. 1928. Die Nematoden und die zersetzte Zwiebelmasse wurden 2 Personen in die Haut des Vorderarms eingerieben.

Während des Versuches wurde eine gleichmäßige Rötung, mit schwachem Brennen und Hitzegefühl beobachtet. Nach 5—10 Minuten waren alle diese Erscheinungen geschwunden.

Versuche 23—24. 5. V. 1928. Die rote Zwiebelmasse mit Nematoden und Milben wurde 2 Personen in die Haut des Vorderarms eingerieben.

Die Rötung an der Einreibungsstelle und das Gefühl des Brennens wurden etwa 30 Minuten lang beobachtet.

Auf Grund der Ergebnisse sämtlicher Versuche kann man zur Schlußfolgerung gelangen, daß die Milbe R. hyacinthi einen die Menschenhaut reizenden Bestandteil enthält. Er übt aber eine mehr oder weniger charakteristische Wirkung auf die Haut nur in dem Falle aus, wenn die Milben in die etwas geschädigte Epidermis (Versuche NN 11—12) eingerieben werden oder wenn die lebenden Milben im Laufe einer längeren Zeit auf der Haut verbleiben. Im letzten Falle müssen die Milben selbst, mit ihren Kiefern, die Hornschicht auf irgendeine Weise schädigen und dabei irgendeinen wirksamen Bestandteil in die Haut einführen. Der eingesogene Zwiebelsaft ist an und für sich nicht ein die Haut rei-

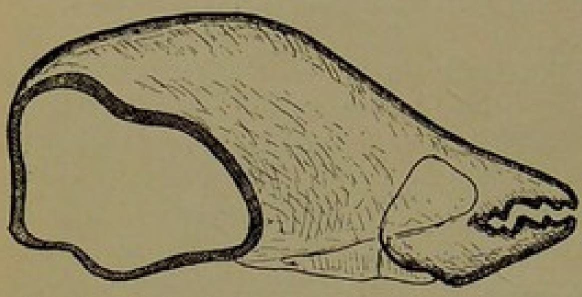

Abb. 2. Rhyzoglyphus hyacinthi. Chelizere. Origin.

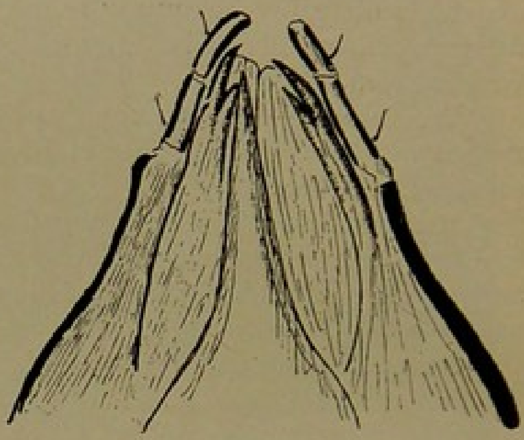

Abb. 3. Rhyzoglyphus hyacinthi. Hypostom. Origin.

zender Bestandteil: die Einreibung des Zwiebelgewebes (Versuche 19—20) verursacht nur eine bald vorübergehende Rötung. Es ist aber sehr wahrscheinlich, daß der wirksame Bestandteil von R. hyacinthi ein Stoffwechselprodukt dieses Spinnentieres ist. Bei der Beobachtung der lebenden Milben auf den Zwiebeln kann man die fortwährende Arbeit ihrer scherenförmigen Kiefer sehen (Abb. 2), mit denen sie das Zwiebelgewebe zerdrücken. Die auf der Abb. 2 dargestellte Form der Kiefer zeigt, daß die Milben die verhornten Epidermisschuppen der Menschenhaut bei lange dauerndem Verbleiben der R. hyacinthi unter einem Uhrglase abkratzen können. Die normalen Lebensfunktionen der Milben gehen unter solchen Bedingungen ihren Gang, wovon man sich bei der Beobachtung der Faecesausscheidung überzeugen kann. Es ist möglich, daß bei einer relativ hohen Temperatur unter dem Uhrglase, auf der Menschenhaut, die Milben, im Zusammenhang mit der Entleerung ihres Darmkanals hungrig werden und deshalb die Hornschicht der Epidermis anzugreifen beginnen. Zur Auflockerung der Epidermis kann auch das Hypostom, dank der in ihm vorhandenen Dornen, verhelfen (Abb. 3).

Zur Aufklärung der Pathologie des Prozesses wurde ein Stückchen Haut mit kleinen papulösen Gebilden ausgeschnitten, in Formalin fixiert, in Celloidin eingebettet und mit Hämatoxylin-Eosin und nach *van Gieson* gefärbt. Auf dem Präparate sind alle Hautschichten sichtbar (Abb. 4). Die Epidermis ist überhaupt dünner geworden. Die aus verhornten Platten bestehende Hornschicht ist verdickt. Die körnigen Zellen sind in einer Reihe angeordnet. Die Stachelzellenschicht besteht in der Mehrzahl der Fälle aus 2—3 Zellreihen. Die intercellulären Zwischenräume sind stellenweise merklich vergrößert. Hier und da ist in der Umgebung der Stachelzellenkerne ein heller Saum sichtbar. Die interpapillären Retezapfen

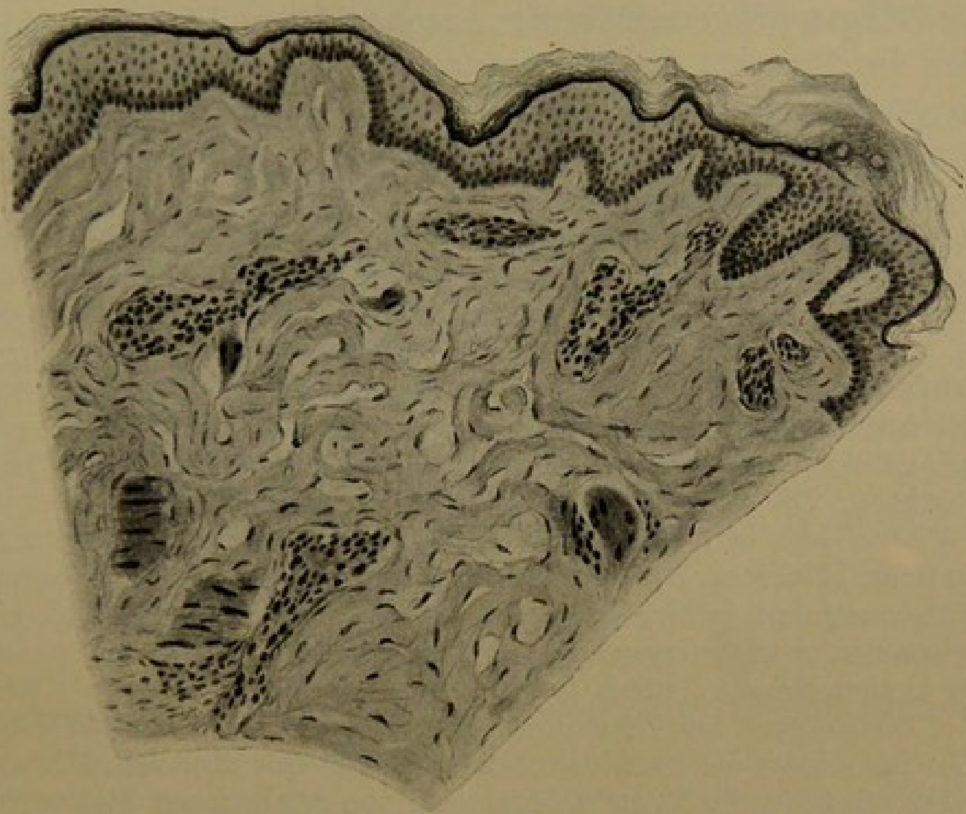

Abb. 4. Schnitt durch die Menschenhaut in der Wirkungsstelle von Rhyzoglyphus hyacinthi. Entzündliches Dermaödem, Infiltration in der Umgebung der Gefäße, vergrößerte und gleichsam gequollene Fibroblasten. Formalin. Zelloidin. Hämatoxylin. *Van Gieson*. Origin.

sind schwach ausgeprägt, zuweilen sogar auf einer gewissen Strecke ausgeglichen. Im Epithel sind stellenweise Wanderzellelemente sichtbar, die zuweilen in ganzen Zügen hierher eindringen.

Der bindegewebige Teil der Haut ist gut ausgebildet. Die Papillenschicht ist schwach entwickelt, die Papillen sind zuweilen auf einer gewissen Strecke ausgeglichen. Die kollagenen Fasern sind auseinandergerückt; es sind spaltförmige Zwischenräume von verschiedener Länge und Breite sichtbar. Sie sind im ganzen Corium gleichmäßig verteilt, mit einem gewissen Überwiegen in den oberflächlichen Dermalagen. Die Gefäße sind erweitert, ihre Lichtungen sind von Wanderzellen angefüllt. Das Endothel der Capillaren ist stark gequollen. In der Umgebung der Gefäße sind kleine Wanderzellenansammlungen sichtbar: Lymphocyten, Polyblasten und eine gewisse Anzahl Polynucleäre.

Die Fibroblasten sind vergrößert und gleichsam gequollen. Ihre Zahl ist stellenweise vergrößert; hier und da finden sich kleine gruppenartige Ansammlungen derselben. Die Anhangsgebilde der Haut bleiben unverändert.

Auf Grund des entzündlichen Dermaödems, der Erweiterung der Gefäße mit entzündlicher Infiltration in deren Umgebung, der Schwellung des Endothels der Gefäße und der Anfüllung des Gefäßlumens mit Blut muß die in Rede stehende Hautveränderung für das Anfangsstadium eines akuten, durch die Zwiebelmilben verursachten Entzündungsprozesses erklärt werden.

Welche Teile der Zwiebelmilbe verursachen das vorstehend beschriebene Bild der Hautveränderungen? Es sind zweifellos diejenigen Stoffe wirksam, die aus der lebenden Milbe in die Menschenhaut eintreten können. Das kann der bei der Nahrungsaufnahme nach außen ausgestoßene Magensaft (was für einige Arachnoidea und Insekten eine Regel ist), oder der Speichel der Milbe sein. Die Fäkalmassen spielen dabei kaum irgendeine Rolle, da sie überhaupt von dicker Konsistenz sind.

Die Frage über die Speicheldrüsen der Tyroglyphidae ist nicht ganz klar. Beim Glyciphagus platygaster befindet sich, nach den alten Angaben von *Michael*[1], auf beiden Körperseiten je ein Paar Speicheldrüsen, die der Seite des vorderen Abschnittes fest anliegen. Diese Drüsen sind von verschiedener Größe; dem Bau nach sehen sie den Speicheldrüsen des Trombidium nicht ähnlich und sind diesen letzteren nicht homolog. Die größere Speicheldrüse ist abgeplattet, zum Teil nierenförmig und besteht aus sehr großen, im allgemeinen dreieckigen Zellen, die in Gestalt einer Rosette angeordnet sind; aus dem Zentrum dieser letzteren tritt ein feiner Ausführungsgang hervor (*Gudden* hat ähnliche Gebilde beim Tyroglyphus siro beobachtet). Die 2. kleinere Drüse besteht im ganzen aus 2—3 ebenso großen Zellen. *Michael* hält es für möglich, diese Drüsen mit den Speicheldrüsen von Bdella zu homologisieren. Der Verlauf des sehr feinen und schwer zu untersuchenden Ausführungsganges ist, wie es scheint, derselbe, wie bei Thyas und Bdella, d. h. die gemeinsamen Ausführungsgänge der Drüse jeder Körperseite vereinigen sich zu einem kurzen Kanale „which passes a short distance along the underside of the roof of the rostrum, and discharges into the rear of the mouth" (*Michael*, l. c. **1**, 80). *Gudden* erklärt die Speicheldrüsen für giftig, was aber von *Michael* in Abrede gestellt wird, da die Tyroglyphidae sich von pflanzlichen Stoffen ernähren. *Michael* äußert selbst in bezug auf die Bezeichnung „*Speichel*drüsen" folgende Meinung: „it probably expresses their principal function, but I have elsewhere expressed a doubt whether it is absolutely a correct name" (*Michael*, **1**, 79).

In der vorliegenden Arbeit stellen wir uns zum Ziele aufzuklären, ob R. hyacinthi in der Tat eine *native* Wirkung auf die Menschenhaut besitzt. Die Verscuhe (15—18), in denen die Milben auf die Menschenhaut gebracht wurden, haben ganz bestimmte Resultate ergeben: mit ihnen stimmen die Ergebnisse der Versuche der Einreihung lebender zerdrückter Milben in die etwas geschädigte Epidermisoberfläche (Serie C, Versuche 11—14) vollkommen überein.

Es kann behauptet werden, daß durch die Wirkung der Zwiebelmilben auf der Haut kleine rosige Papeln erscheinen, wobei Jucken empfunden wird. Diese Erscheinungen können das Zerkratzen und die Infektion mit verschiedenen Bakterien, in der Mehrzahl der Fälle mit Staphylokokken, zur Folge haben. Die dabei beobachteten verschiedenen Pyodermienformen können im Zusammenhang mit den oben beschrie-

[1] British Tyroglyphidae.

benen primären Hautveränderungen bei lange dauerndem wiederholtem Aufenthalt der Milben auf der Menschenhaut das Gröberwerden und eine Verhärtung dieser letzten verursachen.

Die Richtigkeit unserer Schlußfolgerung wird auch durch indirekte Angaben bestätigt. Der Rhyzoglyphus parasiticus *Dalgetty* (1910) wurde „in cutaneous eruption on tea-plantations, India" gefunden, was *C. W. Stiles* und *A. Hassal* veranlaßt hat, in ihrem „Key-Catalogue of the Crustacea and Arachnids of importance in public health" (Washington 1927) die Rhyzoglyphusgattung in die Gruppe „Mites, often causing various types of itch" zu stellen.

Abgesehen davon, sind die dem Rhyzoglyphus nahestehenden Tyroglyphus bei den mit Vanille Arbeitenden die Ursache von Hautaffektionen, die als Berufsvanilismus bezeichnet werden.

Die Frage über die Lokalisation des auf die Haut einwirkenden wirksamen Bestandteiles von Rhyzoglyphus hyacinthi kann einstweilen infolge rein technischer Hindernisse, nicht gelöst werden. Unsere Untersuchung berechtigt uns aber zu folgenden Schlußfolgerungen:

1. Der Rhyzoglyphus hyacinthi ist ein neuer Schädling des Menschen.

2. Der Rhyzoglyphus hyacinthi verursacht, bei der natürlichen Wirkung auf die Menschenhaut oder beim Einreiben in die etwas verletzte Epidermis, eine eigenartige Dermatitis.

3. Die wichtigsten unter der Wirkung von Rhyzoglyphus hyacinthi eintretenden Veränderungen der Menschenhaut sind: die Vergrößerung und gleichsam die Schwellung der Fibroblasten und deren Ansammlung in kleine Gruppen an einigen Stellen.

4. Die Haut verschiedener Personen ist nicht gleich empfindlich für die Wirkung des Rhyzoglyphus hyacinthi; durch diesen Umstand erklärt sich das Ausbleiben der typischen Hautreaktion in einem Teile der Versuche mit der Einreibung zerdrückter Rhyzoglyphus hyacinthi in die ungeschädigte Menschenhaut.

5. Auf Grund der primären Hautveränderungen unter der Wirkung des Rhyzoglyphus hyacinthi können sich, als nachfolgende sekundäre Erscheinungen, Pyodermien mit den weiteren Folgen derselben entwickeln.

6. Die Form und Funktion der Kiefer von Rhyzoglyphus hyacinthi ermöglicht das Zerkratzen der Epidermishornschicht durch dieselben und das Eindringen der Säfte des Rhyzoglyphus hyacinthi (Speichel? Magensaft?) in die Menschenhaut.

7. Der Rhyzoglyphus hyacinthi kann für die erste Ursache der Hautveränderung bei den Landleuten gelten, die Zwiebeln pflanzen und sie unter der Decke in ihrer Wohnung aufbewahren.

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The Tropical Rat Mite, Liponyssus Bacoti Hirst, 1914

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THE TROPICAL RAT MITE, LIPONYSSUS BACOTI HIRST, 1914

THE CAUSE OF A SKIN ERUPTION OF MAN, AND A POSSIBLE VECTOR OF ENDEMIC TYPHUS FEVER *

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DALLAS, TEXAS
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The present paper reports that in northern Texas an acariasis of the human skin is caused by bites of a blood-sucking rat mite (*Leiognathus*) *Liponyssus bacoti* Hirst. Attention is invited to the history of the parasite, to the types of lesions caused by bites of the mites, and to attempts to correlate the presence of these mites with the occurrence of endemic typhus fever.

HISTORICAL

The tropical rat mite was first recorded from rats in Egypt. In 1913, specimens of the mite collected at Assuit, Egypt, were described by Hirst [1] as *Leiognathus bacoti*. A few months later other specimens were obtained from Egypt, Abyssinia, Australia and Argentina. The latter specimens were recognized by Hirst [2] as the same species. For them he considers the brown rat, *Mus norvegicus*, as the principal host.

The tropical rat mite was first reported [2] as a blood sucker of man at Sydney, Australia. Specimens were obtained from man, from the walls of a boot factory

* Read before the Section on Dermatology and Syphilology at the Eighty-First Annual Session of the American Medical Association, Detroit, June 26, 1930.

* Contribution of the Department of Dermatology, Baylor University College of Medicine, and of the Division of Insects Affecting Man and Animals, U. S. Bureau of Entomology.

1. Hirst, S.: Leiognathus Bacoti, Bull. Ent. Res. **4**: 122, 1913.
2. Hirst, S.: On the Parasitic Acari Found on the Species of Rodents Frequenting Human Habitations in Egypt, Bull. Ent. Res. **5**: 225-229, 1914.

and from a bed made by rats. In that city the mites were also reported as attacking workers in a seed store and causing "considerable irritation to the skin." In cities of western Australia, specimens of the mites also were found on man.

In the United States this species made its appearance in 1921. Bishopp[3] reported that they were extremely annoying to man in the vicinities of Dallas and Fort Worth, Texas. They were troublesome especially in business buildings. Persons in department stores, grocery stores, a railroad office, a motion picture theater, federal buildings, and houses adjoining restaurants were annoyed by bites. In one office building the parasites were present on the tenth floor. Bishopp attributes the advent of the mites to migrations of rats and to the tremendous increase in their number during 1920 and 1921.

INCIDENCE AND ORIGIN OF "RAT MITE DERMATITIS"

Approximately three years ago, three members of a family consulted one of us (B. S.) for a skin eruption which had been diagnosed as scabies by a local physician. When these persons reported to us the eruption had not been influenced by various forms of sulphur medication. The dermatitis presented by the father and mother might easily have passed for a mild infection of *Sarcoptes scabei.* The third member of this family, a girl, aged 18 months, presented a diffuse, extremely pruritic, papular eruption over the body with secondary excoriations and pustules. On the face, neck and scalp a few scattered papules were present. The latter finding eliminated the possibility of scabies. A search of the patient's apartment revealed a heavy infestation of mites. Specimens were collected and identified by one of us (W. E. D.) as the tropical rat mite, *Liponyssus bacoti.* They were found on the walls of the room, on the bed of the child, and on the child's body. Many of them were engorged with blood. Inquiries revealed the fact that five additional families of the apartment house were affected with bites of these parasites. Since then, as many as 200 additional cases of this acariasis have been brought to our attention. Approximately 100 persons reported for treat-

3. Bishopp, F. C.: The Rat Mite Attacking Man, Circular 294, U. S. Dept. Agric., October, 1923, pp. 1-4.

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ment of the skin, and as many reported by telephone to the United States Bureau of Entomology. The frequent occurrence of cases of the condition caused us to adopt the popular name "rat mite dermatitis." According to the case histories there was a wide variation in the kinds of places where bites were received.

Theaters.—In our private practice (J. B. Shelmire and Bedford Shelmire) women were seen who had visited a local motion picture theater. On them there were groups of papular and urticarial lesions, which were confined to the backs of their thighs and legs. An investigation of the theater revealed an infestation of

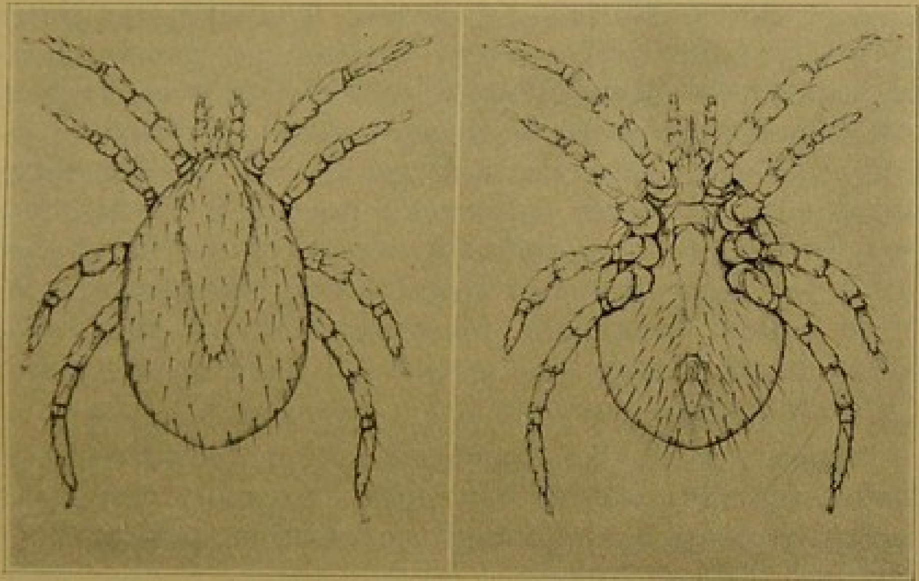

Fig. 1.—Dorsal and ventral view of a female specimen of the tropical rat mite.

tropical rat mites. The building was fumigated with hydrocyanic acid gas, with the result that cases ceased to be seen at our office. Several months after the fumigation other persons having evidences of such bites were seen at our office. Some of them had visited the theater that had been fumigated, and others had visited another theater in the same neighborhood. We were impressed with the origin of the bites of these persons. It seemed that the semidarkness of the picture theater was favorable for the mites to bite. We made inquiry of Dr. J. C. Michael of Houston, Texas. He states that he has seen about a dozen cases of eruptions of this type in which there was a history of visits to picture theaters. Bedbugs were excluded in all instances.

Baylor Clinic.—In the clinic building of Baylor Hospital a mild infestation of tropical rat mites caused five nurses and twelve patients to present evidences of bites from these parasites. The mites were found in the drawers of a desk and on the walls near hot water pipes. In the department of bacteriology, some distance from the clinic building, the mites were present during the spring months of the past two years. Three workers in this laboratory presented evidences of bites and called attention to the painful sensations that were produced by the feeding of the mites. When such sensations were felt, these men were able to find the mites and to remove them from their bodies.

Department Stores.—In several instances, rat mites have bitten the employees of department stores. During a period of three months, nineteen girls working in one department store were seen with such skin eruptions. The bites were received shortly after a large number of rats were trapped or poisoned. When rats were destroyed, the mites were forced to find other hosts for their meals of blood. The bites on persons often follow campaigns for destruction of rats. We have observed them on workers in seed stores, hardware stores, a shoe shop and a restaurant.

Private Dwellings.—Our observations indicate that in Dallas the mite is well established in many residences and apartments. At some of the locations, persons have been annoyed during successive years. At other locations, living quarters are vacated on account of the mites. In one instance the mites caused five families to move from an apartment hotel. These vacancies resulted in a loss of rent which amounted to $1,000. The loss represented 20 per cent of the income of the hotel for a period of three months. It is seen that the rat mite problem is one of economic importance as well as one of interest to physicians and biologists.

During the past three years, approximately fifty persons affected with the bites of rat mites were seen in private homes. From telephone calls requesting information on these parasites we estimate that as many more persons did not report to physicians. In our opinion about one half of the number of persons received bites in the vicinity of their homes. Some of the patients found the mites when biting sensations were felt and were able to submit specimens for identification.

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Others did not suspect mites as the cause of the skin eruption and did not look for them. When mites were not found by the patients, we made visits to their residences. At such locations we were often able to find the mites on the walls of the rooms. They were found in the bath room or kitchen but were present in other places where heat was furnished. During low atmospheric temperatures they were found on the walls near lighted stoves.

When persons were suspected of having "rat mite dermatitis" and we were unable to find mites on the premises of the home or about the places of work, inquiries were made regarding the presence of sparrows, chickens and other animals. There was seldom any indication that mites of such birds, fowls or animals were concerned in causing the skin eruption. The histories of these cases were correlated with the presence of rats. In some instances rats had been trapped or poisoned. In other instances the mites apparently came from beds abandoned by young rats. From these and other observations we consider rat mites as incidental parasites of man.

Out-of-Town Cases.—A tentative diagnosis of "rat mite dermatitis" was made on eighteen persons residing outside the city of Dallas. In one of these cases the provisional diagnosis was confirmed by finding mites. One of us (W. E. D.) visited a patient from Sherman, Texas, and found mites on the walls and floor of the residence. The mites were identified as *Liponyssus bacoti* Hirst. Five of the other seventeen patients found mites on themselves or in the home but did not send in specimens for identification. The tropical rat mite has been obtained at Sherman, Longview, Henderson, Dallas, Plano and Fort Worth, Texas. From these collections and from the reports of bites it appears to be well established in northern and eastern Texas.

TYPES OF ERUPTIONS

On adults the primary lesions of rat mite bites are small urticarial wheals and papules varying in size from that of a pinhead to that of a split pea. The former lack the central hemorrhagic punctures that are considered characteristic of the bite of the bedbug, *Cimex lectularius.* On young children papules, urticarial welts and frank vesicles are often present. The vesicles are not confined to the hands and feet as in scabies but are diffusely distributed on the affected portions of the body. In the more diffuse eruptions the severe pruritus causes the patient to scratch and this results in secondary excoriations.

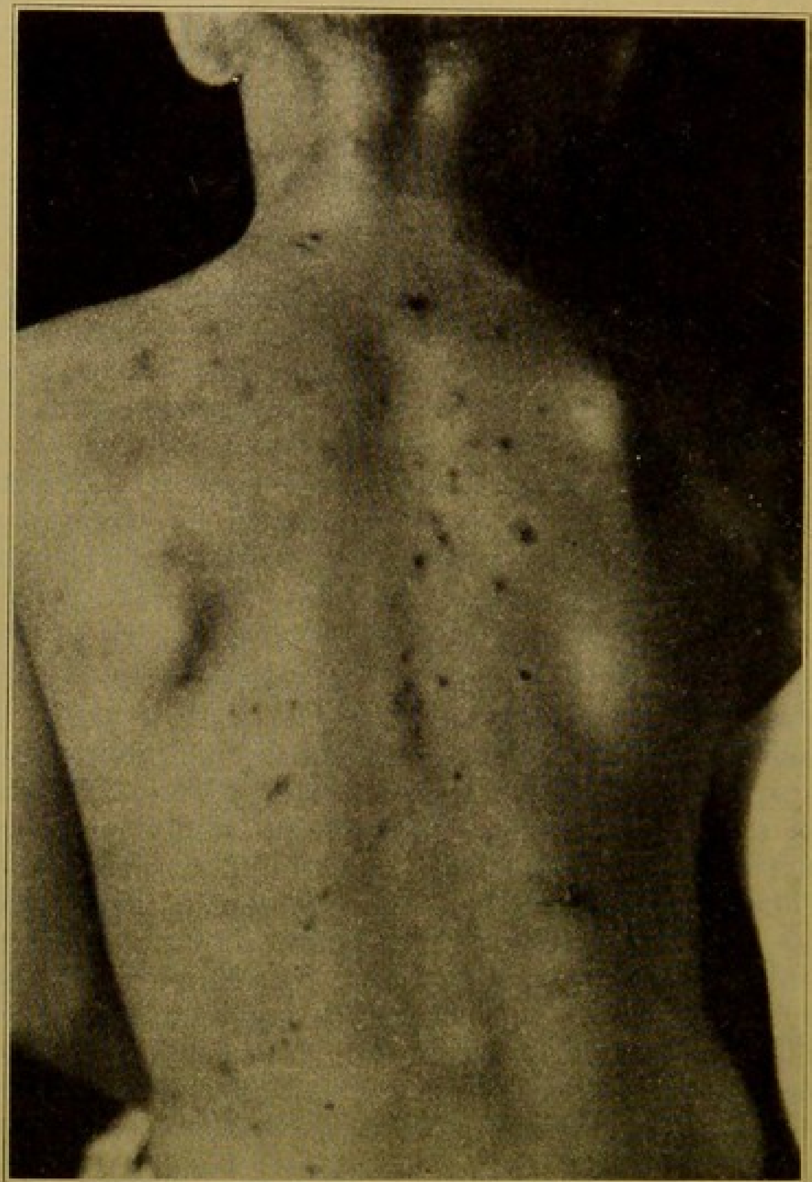

Fig. 2.—Papular lesions from mite bites limited to the back and neck.

On adults the lesions are usually few in number. Often there are no more than from six to twelve lesions grouped about the ankles or on the trunk. Rarely, an adult presents generalized evidence of mite bites. In some of the homes where infants were bitten by mites the adults showed less evidence of

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the bites. They were annoyed so little that they did not volunteer the information until they were examined. In both adults and infants there is a definite tendency toward grouping of the bites. This is attributed to the piecemeal feeding of the mites.

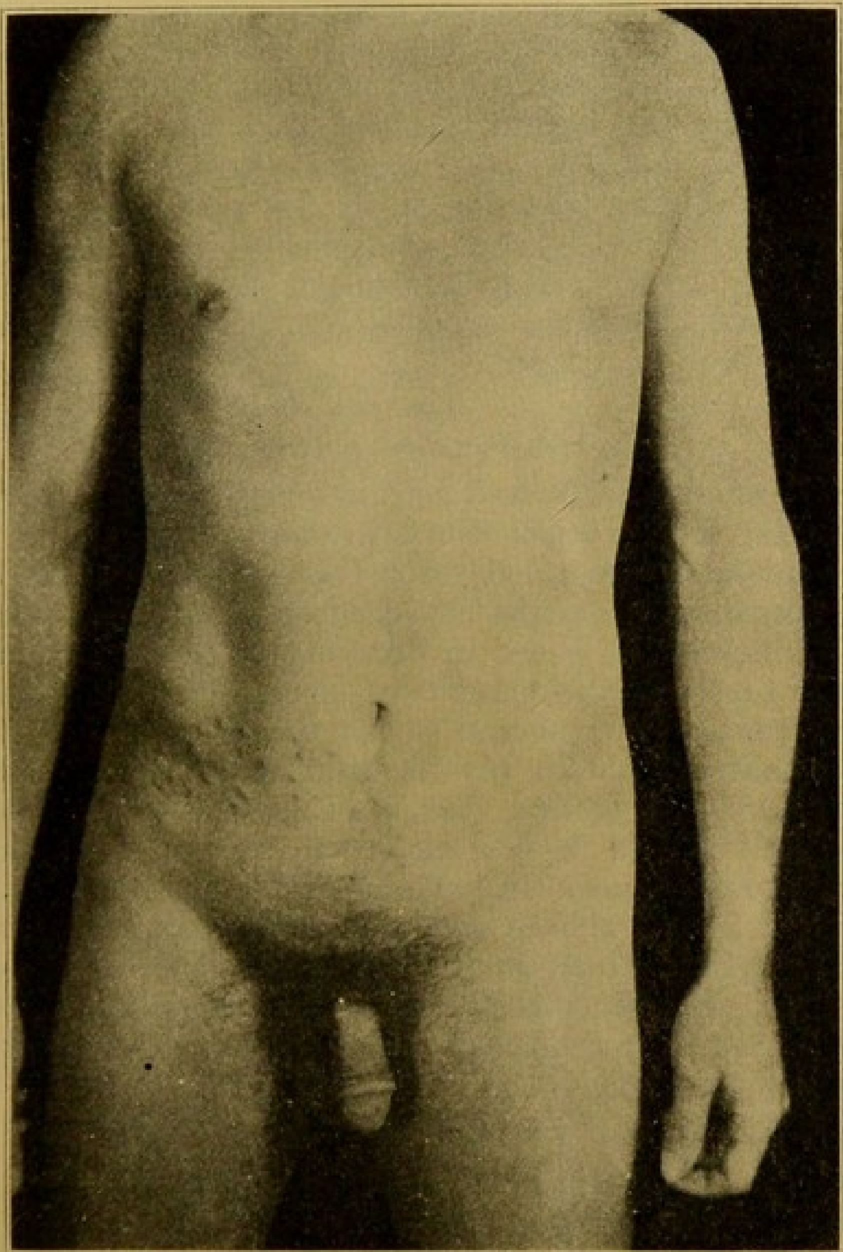

Fig. 3.—Papular lesions from mite bites grouped at the belt line.

The sites of predilection are not only those portions of the body which come into contact with the mites but also the areas having clothing to press on the mites. In addition to the face and hands of children, lesions are found about the ankles, belt line, upper shoulders and neck. On women visiting motion picture theaters, lesions occur on the flexor surface of the lower part of the thighs and the upper part of the legs.

In diagnosis, "rat mite dermatitis" must be differentiated from scabies, pediculosis corporis, and bites from chiggers, bedbugs, fleas, grain mites and other blood-sucking insects. In children having vesicular lesions, the eruption must be differentiated from chickenpox. In one of our patients, a little girl of 18 months, the lesions resulted in a quarantine for chickenpox until it was proved that the intensely pruritic eruption was due to the bites of the tropical rat mite. Scabies and pediculosis can usually be excluded on clinical grounds, but in other cases a differential diagnosis depends on the recovery and identification of the mite.

IDENTIFICATION OF MITES

The adult female is illustrated in figure 1. It has definite characters which enable one to identify it. It is more easily identified when the specimen is cleared. In order to avoid the possibility of confusing this species with mites which breed in decaying wood or vegetable matter, or with at least two species of fowl mites, *Liponyssus sylviarum* and *L. bursa*, it is suggested that specimens be sent in for identification. Living mites may be placed in dry vials with small bits of paper. The vials should be well corked to prevent the escape of any of the mites. In selecting specimens for identification, it is desirable to obtain the adult females. They are much larger than other stages of this species. When engorged with blood they are rather clumsy in crawling and are easily transferred to vials with a camel's-hair brush.

HABITS AND LIFE CYCLES OF MITES

When the female mites engorge with blood, they do not remain attached to the skin. They may remain in the hair of rats for several hours, but usually they leave the host and seek cracks, crevices or other protected places. They prefer dark locations where there is no moisture. In such locations a female having a single meal of blood may deposit from three to eight eggs. The eggs hatch in about four to six days. If within twelve days the young mites are unable to find a suitable host, they die of starvation. If the period of incubation is added to the period of longevity of newly hatched mites, it is seen that a period of about eighteen days is necessary for incubation of the eggs and starvation of the young mites emerging therefrom. This means that, following the destruction of all rats, a period of about eighteen days must elapse before the mites will all have perished of starvation. It is possible that starvation of the nymphal stages of the mites may require slightly longer periods. The female mite is capable of living approximately ten days without feeding.

The newly hatched mites attach to the skin of the rats or mice for approximately two days. Some of them may be observed on the eyelids, feet and thighs of the animals. From many locations on the body, the rat is able to remove the mites by scratching and to devour them. When newly hatched mites become engorged with blood they drop from the animal. At a later time they molt their skins. Following molting they reattach themselves to an animal for another meal of blood. There are apparently four or five feedings and three or four moltings before the larvae attain maturity. Such engorgements may take place on one animal or on different ones.

On man a mite may obtain a meal of blood from several places. The piecemeal feeding may be attributed to the disturbance of the mites, or to the fact that man is an abnormal host.

ENDEMIC TYPHUS, OR BRILL'S DISEASE

There is endemic in certain sections of the United States a disease which resembles typhus fever and gives a positive Weil-Felix reaction in high dilutions. Most of the records of cases are from the Atlantic seaboard and Gulf ports. The cases occur in mild epidemic or sporadic form, run a definite febrile course of approximately two weeks, and are accompanied by a characteristic erythematomacular and petechial cutaneous eruption. The American form of the disease differs from Old World typhus in its relative mildness and in certain well marked epidemiologic characteristics. The former is clinically indistinguishable from the mild typhus occurring during interepidemic periods in the Old World and Mexico. According to Maxey,[4] the North American strain seems to be derived from the

4. Maxey, K. F.: Typhus Fever in the United States, Pub. Health Rep. **44**: 1735-1742 (July 19) 1929.

Old World source. In contrast to Old World typhus, there is evidence that the disease is not transmitted from one person to another by the body louse. In the United States there is a summer and fall incidence, and the disease does not seem to be communicated directly from one person to another.

Maxey, an outstanding authority on endemic typhus, or Brill's disease, believes that "a reservoir for the disease may exist other than in man, a rodent reservoir with accidental transmission to man through the bite of some parasitic blood-sucking insect or arachnid. The rodents upon which suspicion immediately falls are rats and mice, and the parasitic intermediaries which are first suspected are fleas, mites, and possibly ticks." He bases this hypothesis on "(1) the uneven focal distribution of the disease, (2) its sporadic occurrence, (3) its apparent lack of direct communicability from an infected person, (4) its association with the place of business rather than with the home, particularly with those premises upon which foodstuffs are handled or stored, (5) the reoccurrence of cases on the same premises after considerable intervals of time, and (6) its seasonal incidence."

POSSIBLE RELATIONSHIP OF THE TROPICAL RAT MITE TO ENDEMIC TYPHUS

With the occurrence of "rat mite dermatitis" in northern and eastern Texas, endemic typhus fever, or Brill's disease, made its appearance. The coincidental advent of the disease and of the parasite causes us to question whether or not there is a possible relationship between them. Reports have been received of the occurrence of 11 proved and 125 probable cases of the disease. This section of the present paper reports the occurrence of *Liponyssus bacoti* in four localities furnishing proved cases of endemic typhus. It reports some evidence of "insect" bites previous to the onset of endemic typhus.

Cases at Dallas and Fort Worth.—During the past year six cases of endemic typhus were reported at Dallas. They were clinically typical of the disease and the blood samples gave a positive Weil-Felix reaction in high dilutions. Three additional cases originating in the vicinity of Fort Worth proved to be typhus. At both Dallas and Fort Worth the tropical rat mites have been of economic importance and of medical interest. Of a large number of persons receiving bites of the mites who reported for treatment of the skin eruption, we do not know of any who developed symptoms of endemic typhus. However, we were able to question only a small number of our patients regarding illness subsequent to their cutaneous eruptions. We would expect only a small percentage of the mites to harbor the organisms of endemic typhus. In Old World typhus only the infected lice are capable of transmitting the disease.

The persons affected with endemic typhus at Dallas and Fort Worth did not recall having been bitten by insects. Two of these persons assisted us in examinations of their places of business. In these locations we were able to find rats infested with *L. bacoti* and rat fleas.

Cases at Gilmer.—During the past year clinical symptoms indicated that five cases of endemic typhus occurred in the vicinity of Gilmer, Texas. Also, blood samples drawn from two of these persons during their illness gave a positive Weil-Felix reaction in high dilutions. In the proved cases the patients did not recall whether or not they were affected by "insect bites." A visit was made to the bakery that was operated by these persons. Beneath the floor of the bakery a large number of rats were present in the ground. As yet we have been unable to trap these rats or to obtain parasites from them.

Cases at Longview.—From talks with physicians in the vicinity of Longview, Texas, it appears that many cases of endemic typhus were diagnosed as "short typhoid" or "unknown fever."

Since one of the proved cases of endemic typhus reported at Dallas from Longview, a questionnaire regarding this disease was sent to Dr. C. C. Adams of that city. He reported that during the past three years he has seen approximately fifty cases of what he now believes to be Brill's disease. His last case was the only one tested for the Weil-Felix reaction. According to the report, all the cases had negative tests for typhoid and paratyphoid fever. The blood counts were somewhat higher than in typhoid, but sometimes as low as would be expected in typhoid. About the fifth day a rash came on the skin of some of the patients. The lesions were more marked and considerably more numerous than the rose spots of typhoid. Rigors were nearly always present early in the disease. As compared with typhoid, the bronchial symptoms were more common, pain was more severe, and nervous symptoms were more marked. Occasionally there was considerable embarrassment of the heart and a faster pulse. Until recently, Dr.

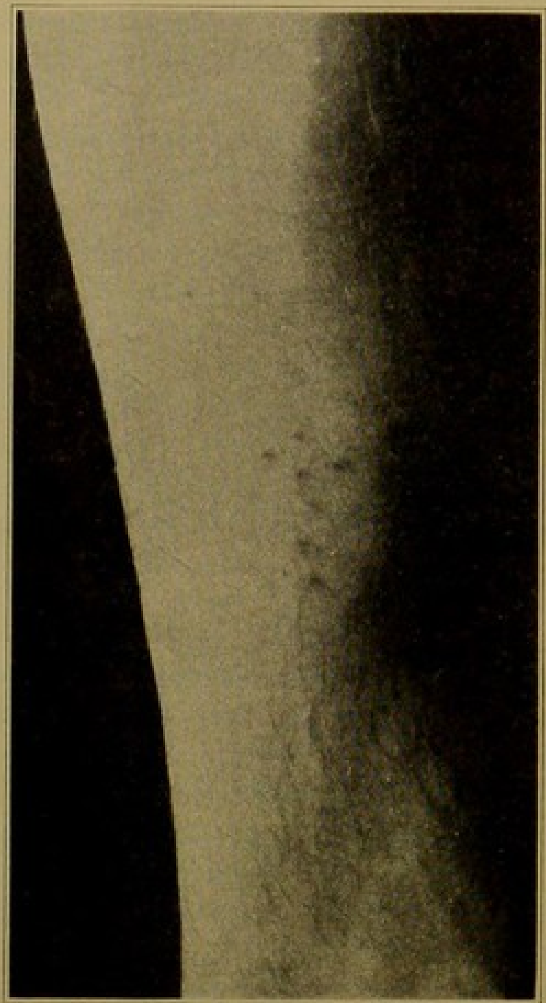

Fig. 4.—Typical grouping of bites on the lower part of the leg. The patient also had a few isolated lesions over the body.

Adams believed that these were cases of paratyphoid of a strain that was not represented in the triple vaccine. With such a vaccine he was unable to get immunity for this disease. About ten of his patients were administered the triple vaccine within from six weeks to six months before they became sick. The duration of his cases was from ten to fifteen days. From these patients no specific inquiry was made regarding "insect bites" prior to the onset of the illness. In the proved case from Longview there was a definite history of "insect bites" seven days before onset of the illness. Serum of his blood was positive for the Weil-Felix test up to 1 : 640. According to him, the bites

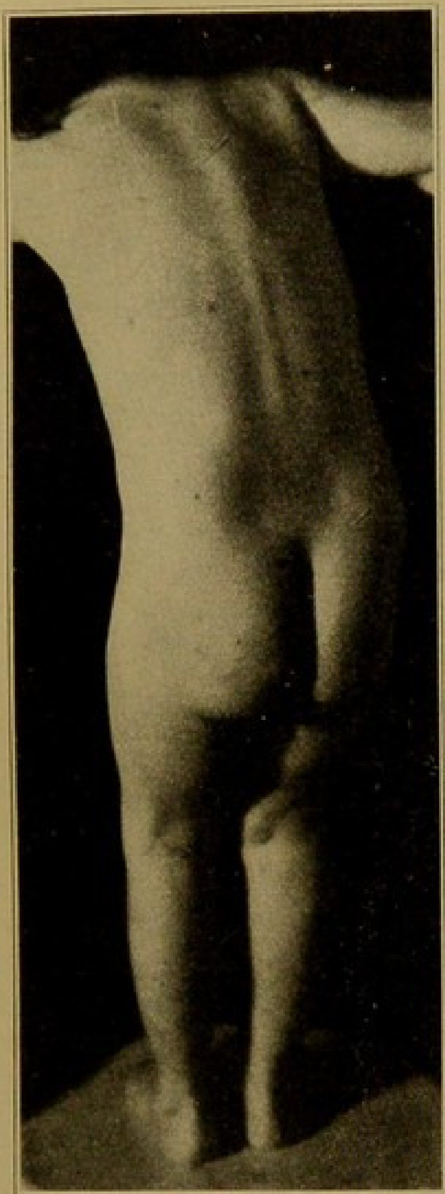

Fig. 5.—Mite bites scattered diffusely over the body, face and scalp. As many lesions were vesicular, the eruption closely resembled chickenpox.

were received in the room of a hotel. When the bites were felt he made a search for bedbugs but was unable to find them.

Inquiries were made of the city manager of Longview. According to him, approximately 100 cases occurred there during the past three years. He says that the cases had a course of fourteen days almost to the day. His records show that the greater number of cases occurred during August, October and November. During the early half of last November the cases were as numerous as those of any preceding month. His records indicate also that cases occurred among the workers of at least two stores. Five persons working in a grocery store from March 23 to Aug. 31, 1929, were affected with the so-called unknown fever.

Rats were trapped in stores at Longview and from them we were able to recover specimens of the tropical rat mite. The rats examined were infested also with fleas.

Cases in Other Towns.—In other towns within a radius of 25 miles of Longview, cases of "short typhoid," or "unknown fever," were reported. At Henderson, Texas, at least seventeen patients reported for treatment during the last calendar year. Rats obtained in this locality were found to be infested with tropical rat mites and rat fleas. Some of the towns reporting cases of the fever were not visited by us.

WEIL-FELIX TESTS ON PERSONS RECOVERING FROM ENDEMIC TYPHUS

Following the recovery of five persons with proved infections of endemic typhus, samples of blood were drawn and the Weil-Felix tests were repeated. The latter specimens were sent to Dr. R. E. Dyer, Hygienic Laboratory, Washington, D. C. Two of the samples represented patients who gave positive reactions in dilutions of 1 : 160 during their illness. Approximately six and eight months after illness the blood samples gave positive reactions in dilutions of 1 : 40. Samples of blood obtained from two other patients during illness gave positive reactions in dilutions of 1 : 640. Four and eight months after illness the latter cases were negative for similar tests. A fifth patient, whose blood gave a positive reaction of 1 : 320 during illness, furnished a sample of blood two months later which gave a negative reaction. From the tests on persons recovering from endemic typhus it appears that the agglutinins are present in the blood stream only for short periods.

The results of the tests on proved cases of endemic typhus were similar to tests made with blood of persons suspected of having endemic typhus at Gilmer and

Longview. From these localities nine samples of blood were obtained from persons several months after their illness. Five of these were negative for the Weil-Felix tests and four of them were positive in dilutions of 1 : 20 and 1 : 40. (The positive reactions in dilutions of less than 1 : 80 are not considered diagnostic of this disease.)

COMMENT

The occurrence of tropical rat mites at Dallas, Fort Worth, Henderson and Longview, Texas, show a coincidental occurrence of these parasites with proved cases of endemic typhus. The history of "insect bites" of one of the patients would seem to strengthen the hypothesis of insect or arachnid transmission of the disease.

According to Bishopp [3] the tropical rat mites occurred at Dallas just after there were migrations of large numbers of rats from the South. Since the rat mites and endemic typhus were found in this section after the migrations of large numbers of rats, one is inclined to attribute the advent of the new parasite and of endemic typhus to these migrations.

Since the report of the occurrence of tropical rat mites in Australia, it is interesting to note that small numbers of mild sporadic cases of endemic typhus have been reported by Howe [5] of Adelaide, Australia.

SUMMARY

1. Approximately 200 cases of "rat mite dermatitis" are reported from Dallas, Texas, and neighboring towns.

2. From persons having evidence of mite bites, and from their residences or places of work, mites were collected and identified as *Liponyssus bacoti* Hirst.

3. At Dallas, Fort Worth, Henderson and Longview, Texas, mites were collected from rats and were identified as *Liponyssus bacoti.*

4. At Dallas, Fort Worth, Henderson and Longview, 11 proved cases and approximately 125 cases of suspected endemic typhus are reported.

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5. Howe, quoted from Stitt, E. R.: Diagnosis and Treatment of Tropical Diseases, Philadelphia, P. Blakiston's Sons & Co., 1929.

5. From tests on persons recovering from endemic typhus it appears that agglutinins are present in the blood stream only for short periods of time.

6. The advent and coincidental occurrence of endemic typhus and the tropical rat mite in northern and eastern Texas suggest that these parasites may be vectors of the disease.

ADDENDUM.—Since July, 1930, nine proved cases of endemic typhus have been seen at Henderson and Longview, Texas. From locations suspected of being the origin of these cases we obtained tropical rat mites and rat fleas. An account of the studies with these parasites will be published in a later paper.

U. S. TREASURY DEPARTMENT
ANDREW W. MELLON, *Secretary*
PUBLIC HEALTH SERVICE
HUGH S. CUMMING, *Surgeon General*

EXPANSION OF INVESTIGATIONS ON TICK-BORNE DISEASES BY THE UNITED STATES PUBLIC HEALTH SERVICE

BY

R. R. SPENCER
Surgeon
United States Public Health Service

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EXPANSION OF INVESTIGATIONS ON TICK-BORNE DISEASES BY THE UNITED STATES PUBLIC HEALTH SERVICE[1]

By R. R. Spencer, *Surgeon, United States Public Health Service*

The recent acquisition of knowledge in the field of insect-borne diseases by workers of the United States Public Health Service brings to my mind the well-known epigram, "Knowledge is like the surface of a sphere; the larger it grows the more it comes in contact with the unknown." We are therefore permitted now to visualize new opportunities for research in medical entomology.

Before indicating what these researches might be, let us review briefly a few observations of the investigations of the Public Health Service other than those splendid contributions upon typhus and Rocky Mountain spotted fever which have been described by the preceding speakers, Doctors Dyer, Rumreich, and Badger. When all these observations are brought together and correlated they lead us inevitably to the necessity for a logical growth and expansion of our efforts in this very important subject of insect-borne diseases.

The Public Health Service has for many years conducted investigations upon Rocky Mountain spotted fever in the western United States. These investigations have been well worth while, we believe, not only because of the knowledge gained concerning Rocky Mountain spotted fever but also because of entirely unexpected observations upon other conditions.

For example, prior to 1922, tularæmia was not known to be a tick-borne disease. In that year R. R. Parker and the writer, while looking

[1] Presented at the Twenty-ninth Annual Conference of State and Territorial Health Officers with the United States Public Health Service, Washington, D. C., Apr. 28, 1931.

for spotted fever infection in wild ticks collected in the field, observed in guinea pigs, following the injection of ground-up ticks, a condition which in no way resembled spotted fever. The resemblance of the lesions in these animals to tularæmia was very striking, and when tissues and cultures were sent to Dr. Edward Francis here in Washington its identity as such was established.

As a matter of course we now know that the tick is an important, if not the most important, intermediate host responsible for the maintenance of tularæmia in nature. Experimentally, the tick is capable of holding the infection many months and can transmit the condition through the eggs to the second generation of ticks. This has not been found to be the case with deer-flies and other insects that have been used in experimentation and which are capable of transmitting tularæmia directly.

In the West human cases of tularæmia following tick bite had been occurring all the while, but had been diagnosed simply as tick fever without rash. For years past in Idaho we have found that certain physicians in the Snake River Valley had distinguished two types of tick fever—the glandular type without rash and the spotted type without glandular enlargement.

As to Rocky Mountain spotted fever investigations, it is admitted that no entirely satisfactory means for combating the disease has yet been found, although studies have been conducted from time to time for the past 30 years. However, in 1924 we developed a vaccine, or prophylactic inoculation, which has now been used for seven seasons and which we believe has a definite field of usefulness. If a steadily increasing demand for this vaccine is any indication, it is certainly the most effective weapon yet developed to use against Rocky Mountain spotted fever.

At first it was difficult to persuade people to take this vaccine, chiefly because of the unsightly material of which it is made; in the spring of 1924, when the vaccine was first prepared, no one would take it.

In 1925, on the west side of the Bitterroot River in western Montana, where our field laboratory is located, 34 people were vaccinated. All of these were among State and Public Health Service employees. In this same area we have vaccinated persons as follows:

Year	Number of persons vaccinated	Year	Number of persons vaccinated
1926	654	1929	985
1927	1, 296	1930	1, 597
1928	812	1931	[1] 2,000

[1] To date.

In this small area in western Montana the fatality rate among the nonvaccinated population has averaged 89 per cent over a period of 12 years. In six of these years it was 100 per cent. Since the use of the vaccine it has been reduced to 17 per cent among vaccinated persons. Among laboratory workers before the use of the vaccine the fatality rate was 100 per cent (6 cases, 6 deaths); with the use of the vaccine we have had 12 laboratory cases with but 1 death, and the 1 fatal case occurred in a patient who had received only one of the two usual doses of vaccine.

In Idaho, Wyoming, Colorado, Utah, eastern Montana, eastern Oregon, and eastern Washington, over 20,000 people have been vaccinated during the past five years. Only one case (nonfatal) has occurred in this group, and that one case was in an old man who had received only one dose. These data indicate that the vaccine confers complete protection against the mild type of the disease and greatly reduces the mortality against the highly fatal type. The duration of the immunity following vaccination is not long and varies considerably in different individuals. Vaccination each spring for several years appears to confer a better immunity.

In 1927 the Montana State Legislature appropriated $60,000 for the construction of a new laboratory at Hamilton in the Bitterroot Valley, primarily for the purpose of providing ample space for the manufacture of this vaccine and for further studies upon Rocky Mountain spotted fever. Part of this building was especially designed for the rearing of infected ticks on a huge scale, with a special feature designed to minimize the danger to the workers. In spite of these precautions all three of the men engaged in tick rearing have contracted Rocky Mountain spotted fever, but fortunately had only mild attacks and survived—due, we feel sure, to the fact that they had been previously protected by the vaccine.

The Public Health Service would gladly turn over the manufacture of this vaccine to any State or to any private institution engaged in the manufacture of biological products. Such activities are not the usual function of the Public Health Service, but we have here a new and unique situation. No State or firm would undertake this work for three reasons: (*a*) The manufacture of this vaccine is a dangerous procedure; (*b*) the process of manufacture is entirely different from that of any other vaccine and requires a highly trained and specialized personnel; (*c*) the cost of manufacture is high, while the amount of vaccine used each year is relatively small, and it would never be a commercially feasible undertaking. Therefore, the Public Health Service is forced to continue in the business of manufacturing this biologic product. In all the Western States in which spotted fever is endemic, the demand for the vaccine is increasing each year, and at the last session of Congress (71st) those States sponsored a bill which was introduced by Senator Walsh of Montana, and which provided that the Treasury Department be authorized to purchase from the State of Montana the laboratory at Hamilton, with its equipment. An appropriation of $75,000 was authorized for the purchase of the property and an additional sum of $75,000 for constructing and equipping, on the ground so acquired, another building, for the making of alterations to the existing laboratory, and for the construction of the necessary out-buildings. This act was approved by the President, March 4, 1931.

Plans for the new building are now being drawn, and it is hoped that work will be begun this summer. In the light of past experience we expect to be able to provide much better and much safer facilities for the routine manufacture of the vaccine and to carry on extensive investigations upon Rocky Mountain spotted fever and other tick-borne diseases. In this new building provision will be made for three complete and separate research units. Each unit is planned for the use of one investigator and an attendant, and consists of a suite of three rooms—a small office, a laboratory, and an experimental animal room. Each unit will be fully equipped, so that the investigator will have his own materials and laboratory apparatus and will not be dependent on others.

The special quarters for the rearing of infected ticks, about 200,000 each year, will be so constructed that the escape of ticks through windows will be impossible. The workers must change their clothes completely upon entering. When leaving the tick-rearing rooms they are required to place their working clothes in a hot air sterilizer, take a shower bath, and search for ticks before putting on their street clothes. These precautions are taken to prevent the men from carrying infected ticks to their families or to others with whom they come in contact. Such precautions are rather troublesome, but experience has taught that they are necessary.

Having indicated some of the observations that have been made in the past six or seven years, let me briefly outline the lines of study that will be undertaken when our new laboratory at Hamilton, Mont., is completed.

1. Continued studies upon Rocky Mountain spotted fever:
    (*a*) Ways and means of improving the potency and keeping qualities of the tick vaccine.
    (*b*) Studies to determine the causes for the various degrees of virulence encountered in nature, and the relationship between the eastern and western type of the disease.
    (*c*) Studies upon the life history and habits of the rabbit tick (*Haemaphysalis leporis-palustris*), and the rôle played by this tick in the maintenance of the disease in nature. It

should be explained that the rabbit tick transmits spotted fever from rabbit to rabbit but does not infest man.

(*d*) Clinical and epidemiological studies upon human cases. Complete studies of this kind have never been made, and in some States cases are not even reported.

(*e*) A continuation of the tick parasite studies started by the Montana State Board of Entomology. This small fly is an obligate tick parasite, and its distribution throughout the affected areas may greatly reduce the number of ticks, since all ticks parasitized invariably die.

2. With reference to studies upon tick paralysis we recognize that this condition is of little public health significance, because there are so few cases each year and because the method of prevention is known. However, it is a very obscure malady. Nothing is known of the nature of the causative agent, nor of the source from which the tick obtains it. Its study has been delayed on account of the difficulty of securing ticks known to harbor the causative agent, and the finding of a suitable experimental animal.

3. Colorado tick fever is perhaps the most interesting problem of all. So far as information is available we have here an infection that is always preceded by a history of tick bite. The seasonal occurrence is coincident with the appearance of ticks in the spring of the year, and the prodromal symptoms resemble very closely those of Rocky Mountain spotted fever. It differs from spotted fever, however, in that it is rarely, if ever, fatal, produces no rash, and the sera of cases do not give a positive Weil-Felix reaction as do the sera of Rocky Mountain spotted fever and typhus fever. Does this condition represent a mild form of Rocky Mountain spotted fever, or a distinct disease entity hitherto undescribed? We do not yet know, but it should be a relatively simple matter to determine it. Until now no serious efforts have been made to study these cases clinically, epidemiologically, or from an experimental or laboratory point of view.

Finally, I believe that it may be of interest to many of you to learn that a single species of the western tick, *Dermacentor andersoni*, transmits to man by its bite not less than four diseases, namely: Rocky Mountain spotted fever, tularaemia, tick paralysis, and Colorado tick fever. Here, we believe, is a rare opportunity for those of use who are working in this field to add considerably more to our knowledge of these diseases. In so far as tick paralysis and Colorado tick fever are concerned, we are entering a practically virgin field; and in view of what has already been accomplished, and with our new facilities, we have every reason to believe that some success will attend our efforts. At least we are undertaking these studies with a great deal of hope and enthusiasm.

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TREASURY DEPARTMENT

Public Health and Marine-Hospital Service of the United States

HYGIENIC LABORATORY.—BULLETIN No. 62

AUGUST, 1910

THE TAXONOMIC VALUE OF THE MICROSCOPIC STRUCTURE OF THE STIGMAL PLATES IN THE TICK GENUS DERMACENTOR

By

CH. WARDELL STILES

WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

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SUMMARY.

The specific determination of ticks is attended in many cases with considerable difficulty. In view of the importance of these giant mites as transmitters of disease, every newly recognized character which can be utilized in classification is of value. In the present paper the microscopic structure of the stigmal plates is shown to be a taxonomic character of considerable importance in the genus *Dermacentor*.

The species of *Dermacentor* which has been shown experimentally by King and Ricketts to act as transmitter of Rocky Mountain spotted fever in Montana is *Dermacentor andersoni*.

The tick which Salmon and Stiles (1901) considered identical with *Dermacentor reticulatus* of Europe is shown to represent a new species, *Dermacentor salmoni*.

For bibliographic references, see Stiles & Hassall, Index Catalogue of Medical and Veterinary Zoology <Bull. 39, U. S. Bureau of Animal Industry.

THE TAXONOMIC VALUE OF THE MICROSCOPIC STRUCTURE OF THE STIGMAL PLATES IN THE TICK GENUS DERMACENTOR.[a]

By Ch. Wardell Stiles, Ph. D.,

Professor of Zoology.

INTRODUCTION.

To find characters which may be readily used in distinguishing genera and species is always an interesting study for the systematist. When the group of animals in question may act as transmitters or as cause of disease, this systematic study becomes especially important, both theoretically and practically.

Since it has been shown that certain species of ticks act as transmitters of certain diseases, this group of arachnoids has been subjected to more careful study than heretofore and numerous new species have been described. To recognize these species, even when detailed diagnoses are given, as in the writings of Neumann especially, is not unattended with difficulty, and even the special student in this group is liable to fall into error in determining specimens. Every new character which can be shown to be of taxonomic value is, therefore, of practical importance at the present time, and its practical value is proportionate to its ease of application.

Salmon and Stiles (1901a, 447) indicated that the "punctation" of the stigmal plate presented a character of value in the genus *Dermacentor;* Neumann also has used this character to a slight extent, while Banks (1908), and Cooper and Robinson (1908) have adopted it in recent papers. Since the publication of the joint paper (1901a) by Salmon and Stiles, I have become more and more convinced of the value of this character, not only in *Dermacentor* but also in some other genera. With this increased conviction a second conviction has developed, namely, that with a few exceptions the determination of the North American ticks by the usual method, namely, a study with the hand lens of an uncleared, unmounted specimen, is very likely to lead the observer to erroneous conclusions.

To give an illustration: Several years ago, I became convinced that the common tick of Montana was distinct from the form which

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[a] Manuscript submitted for publication December 21, 1909.

Salmon and Stiles looked upon as *Dermacentor reticulatus* (=*D. salmoni*); Neumann considered that *D. reticulatus* of Salmon and Stiles was in reality Marx's *D. occidentalis;* specimens of the Montana tick were sent to Neumann, with the interpretation that they represented a new species and with the request to compare the Montana form with Marx's types which were then in his possession; with his usual courtesy, Neumann made the comparison and wrote that he agreed that the Montana ticks represented a new species; later, Neumann returned our government collection of ticks to Washington; he also sent four specimens of the European *D. reticulatus;* in the meantime I had been studying the American species of *Dermacentor* from the standpoint of the microscopic structure of the stigmal plate, and becoming thoroughly convinced that the Montana tick was absolutely distinct from what I found in the collection labeled *D. reticulatus* and what I had always supposed to be that species, I used for the Montana form the manuscript name *D. andersoni.*

Upon receiving the material from Neumann, this was reexamined, especially with reference to the miscroscopic structure of the stigmal plate, and this restudy resulted in some very unpleasant surprises, for instance:

(1) Neumann's four European specimens (two males and two young females) of *D. reticulatus* agree fairly well with each other in the structure of their stigmal plates; these plates are of a type very similar to that found in the American species *D. electus* seu *variabilis.* Coxæ IV of the two males show very marked variations. The palpi of one male and of one female agree fairly well in outline, but are markedly different from the palpi of the other male and the other female, while the palpi of the latter pair are of rather uniform outline. Only one specimen (a male) shows a prominent retrograde prolongation on article 2 of the palpi. One pair is not especially difficult to distinguish from the American *D. electus;* the male and female of other pair are separated from *D. electus* with somewhat greater difficulty. It seems quite clear that the American *D. electus* and the European *D. reticulatus* are exceedingly closely related. Further, both species vary so in outline of the palpi and of coxæ IV that many systematists, working on single specimens, would recognize these variations as representing several distinct species.

(2) Marx's types of *D. occidentalis*, which Neumann considered as representing a variety of the European *D. reticulatus*, are radically different from this species; they are closely allied specifically to *D. andersoni* (with which for a time I considered them identical), but they are distinct from the American form which was considered as *D. reticulatus* and which Neuman identified with *D. occidentalis.*

(3) The American form which I have always viewed as *D. reticulatus* is totally distinct from Neumann's European material of this species.

In view of this experience, it was decided to determine ticks hereafter only when the specimens could be treated with caustic and mounted in such a way as to permit the use of medium power lenses (as 8 and 4 mm.) in studying them; further, it was found that by a careful study of the stigmal plate of mounted skins there is usually but little difficulty in determining the specimens (of *Dermacentor*, at least) upon this organ alone.

The purpose of the present paper is to show the value of the stigmal plate in dividing the North American species of *Dermacentor* into four groups and in differentiating the species. A preliminary communication on this subject was published in the Proceedings of the Entomological Society of Washington, volume 9 (1–4), 1908, pages 10–11.

TECHNIQUE.

The specimens are prepared as follows: A slit is made in the caudal end of the tick, usually with a sharp knife or scissors, and in such a way as not to cut the stigmal plates; the specimen is placed in a weak caustic solution (about 2 to 5 per cent) for 12 to 96 hours, according to the condition of the material; with sharp, pointed forceps, or with a small scalpel, the entire mass of soft tissue is removed through the caudal slit; the skin is then passed through water, the alcohols, and xylol, and mounted in balsam; for pressure, a pair of cover-glass forceps, such as are in common use in bacteriological work, or a lead weight the shape of an elongated bullet, is then placed on the preparation which is now dried on a radiator, or in an oven. It is wise to examine the skin in xylol before mounting it in balsam, and during this examination legs IV are so arranged as not to cover the stigmal plates; if necessary, legs IV are removed from the skin.

Superfamily IXODOIDEA[a] Banks, 1894.

It may be well to review the classification of ticks, before passing to the genus *Dermacentor*.

Ticks represent giant mites. They belong to the superfamily *Ixodoidea* of the order *Acarina*, class *Arachnida*.

Authors are, however, not yet in entire accord relative to the general classification of the group.

The superfamily *Ixodoidea* may be divided into two families, as follows:

Scutum absent; capitulum inferior in adult, terminal in hexapod larva; claws without pulvillum; palpi cylindrical; stigmal plate between legs III and IV; sexual dimorphism slight ________________________________ *Argasidæ*

[a] For synonymy, see Salmon and Stiles, 1901a, pp. 383–384.

Scutum present; capitulum terminal in all stages; claws with pulvillum; articles 2 and 3 of palpi usually strongly excavate in long axis on median margin, article 4 small, subterminal of article 3; stigmal plate caudolateral of coxæ IV; sexual dimorphism very pronounced__________*Ixodidæ*

It is particularly the family *Ixodidæ* which interests us in the present paper.

Family IXODIDÆ[a] Murray, 1877.

FAMILY DIAGNOSIS.—*Ixodoidea* (p. 11): Scutum present. Capitulum terminal. Digit of mandibles provided with two articles; internal article with dorsal process; external article elongate, articulated with the internal article and bearing on its free border two to five teeth, which increase in size from the distal to the proximal. Palpi with articles 2 and 3 usually distinctly valvate in long axis on their median surface; article 4 very short in adult, as tactile appendage, situated in a ventro-terminal depression of article 3. Legs a little unequal, pair II shortest, pair IV longest; femur and tibia presenting pseudo-articulation near proximal end, except in pair I, where the pseudo-articulation is distal; tarsi with pulvillum. Stigmata dorso-caudad of coxæ IV. Genital pore ventro-median at height of coxæ I to III; a pair of sexual grooves extend from here caudad, more or less divergent, toward caudal margin. Sexual dimorphism very marked.

Male.—Usually smaller than female, flatter, often of less regularly oval contour, anterior pole being much narrower than posterior; dorsal shield covers entire dorsal surface or all but a marginal band; caudal margin ordinarily divided into eleven quadrangular festoons, distributed between the two stigmata, and often extending under the ventral surface. These represent in some cases marginal shields, the number and form of which are often variable.

Female.—At first flat, later may become very thick; dorsal shield confined to cephalic part of dorsum, remains comparatively small. Capitulum with two symmetrical porose areas, not found in larvæ, nymphs, or males.

TYPE-GENUS.—*Ixodes* Latreille, 1796.

This family may be divided in various ways, but authors are not yet entirely in accord relative to the details of the subdivisions.

Canestrini[b] (1890a, 491) divided the Italian genera of this family, then known to him, into three groups, as follows:

Ventral surface of male entirely covered with shields; genus *Ixodes*___*Poliopli.*
Ventral surface of male with four anal shields; genera *Hyalomma*, *Rhipicephalus*____*Tetraopli.*
Ventral surface of male without anal shields; genera *Amblyomma* (and *Aponomma*), *Dermacentor*, *Hæmaphysalis*______________________________*Anopli.*

This division is a very easy one to make, provided one has male specimens, but as it is based upon a secondary sexual character it is not entirely free from objection.

Neumann (1901a, 323), who recognized *Ixodidæ* s. str. as a subfamily, divided the genera of this group as follows:

Rostrum long; genera *Ixodes*, *Eschatocephalus*, *Aponomma*, *Amblyomma*, *Hyalomma*____*Ixodæ.*
Rostrum short; genera *Hæmaphysalis*, *Rhipicephalus*, *Dermacentor*_*Rhipicephalæ.*

[a] For synonymy, see Salmon and Stiles, 1901a, p. 414.

[b] Original paper not accessible at present. See Neumann, 1904a, p. 446.

Salmon and Stiles (1901a, 384) divided the *Ixodidæ* s. str. into two subfamilies, as follows:

Palpi short, subtriangular, not or only slightly longer than [the two together are] broad; capitulum short; cephalic margin of body emarginate for insertion of capitulum; genera *Rhipicephalus*, *Boophilus*, *Hæmaphysalis*, *Dermacentor* ---------- *Rhiphicephalinæ*.
Palpi longer than broad; capitulum long; cephalic margin of body straight or emarginate; genera *Ixodes*, *Eschatocephalus*, *Aponomma*, *Amblyomma*, *Hyalomma* ---------- *Ixodinæ*.

Since 1901 several new genera have been described.

Neumann (1904a, 447) has reverted to Canestrini's classification, with some change of names, as follows:

Ventral surface of male entirely covered with plates; anal groove surrounds anus anteriorly and is independent of genital grooves; eyes absent; rostrum elongate ---------- *Ixodeæ*.
Ventral surface of male with two adanal plates, usually accompanied by accessory plates; anal groove surrounds the anus caudally and usually joins, anteriorly, the genital grooves; eyes present; rostrum long or short. *Rhipicephaleæ*.
Ventral surface of males without adanal plates; anal groove surrounds anus caudally and usually joins, anteriorly, the genital grooves; eyes often present; rostrum long or short ---------- *Amblyommeæ*.

A later and rather extensive division of the genera in question is that proposed by Lahille (1905a, 21–23) who accepts *Ixodidæ* s. str. as a distinct family and divides the ticks as follows:

Suborder ARPAGOSTOMA [=superfamily *Ixodoidea*].

1. Capitulum inferior; scutum absent; claws without pulvillum; palpi cylindrical, nearly uniform; stigmal plates between legs III and IV; sexual dimorphism but little marked ---------- *Argasidæ*, 2.
Capitulum terminal; scutum present; claws with pulvillum; palpal articles 2 and 3 excavate on median surface; stigmal plates caudally of legs IV; sexual dimorphism very pronounced ---------- *Ixodidæ*, 3.

ARGASIDÆ.

2. Tegument chagreened; hood does not project anteriorly of body; palpi not projecting anteriorly of body; lateral borders of body thin; ventral grooves very slightly marked; eyes absent; type *Acarus reflexus* Fabricius, 1794 ---------- *Argas* Latreille, 1795.
Tegument mamillate (hemispherical elevations); hood projects anteriorly in form of a beak; palpi visible anteriorly, from above; lateral borders of body thick; ventral anal, preanal, and postanal grooves very marked; eyes present or absent; type *Argas savignyi* Audouin, 1827, *Ornithodoros* Koch, 1844.

IXODIDÆ (based on males).

3. Anal plates absent [compare *Amblyommeæ* Neumann, 1904]; eyes present or absent .... *Anopli* Canestrini, 4.
Anal plates present in pairs (4–6) [compare *Tetraapoli* Canestrini, and *Rhipicephaleæ* Neumann, 1904]; eyes distinct (ommata) .... *Artiopli*, 8.
Anal plates present in uneven numbers (as 5) [compare *Poliopli* Canestrini and *Ixodeæ* Neumann, 1904]; eyes absent (anommata) .... *Perissopli*, 10.

Anopli.[a]

4. Eyes absent (anommata) .... 5.
Eyes distinct (ommata) .... 7.
5. Article 2 of palpi drawn out laterally into sharp points; type *H. concinna* Koch, 1844 .... *Hæmaphysalis* Koch, 1844.
Article 2 of palpi not drawn out laterally into sharp points .... 6.
6. Anal groove present; type *Ixodes gervaisi* Lucas, 1847, *Aponomma* Neumann, 1899.
Anal groove absent; type *Ixodes transversalis* Lucas, 1844, *Neumanniella* Lahille.
7. Palpi longer than broad; type *Acarus cajennensis* Fabricius, 1787. *Amblyomma* Koch, 1844.
Palpi scarcely longer than broad; coxæ IV very large; type *Acarus reticulatus* Fabricius, 1796 .... *Dermacentor* Koch, 1844.

Artiopli.

8. Palpi scarcely longer than broad; dorsal surface of base of capitulum ("prosoma") hexagonal .... 9.
Palpi longer than broad; dorsal surface of base of capitulum rectangular; type *Acarus ægyptius* Linné, 1758 .... *Hyalomma* Koch, 1844.
9. Stigmal plates circular; type *Ixodes annulatus* Say, 1821 *Boophilus* Curtice, 1891.
Stigmal plates comma-shaped; type *Ixodes sanguineus* Latreille, 1804 *Rhipicephalus* Koch, 1844.

Perissopli.

10. Palpi elongate, canaliculate; type *Acarus ricinus* Linné, 1746 [1758] *Ixodes* Latreille, 1796.
Palpi not canaliculate; type *E. gracilipes* Frauenfeld *Eschatocephalus* Frauenfeld, 1853.
Palpi pyriform; (penultimate) article 3 conical; type *Hyalomma puta* Cambridge, 1879 .... *Ceratixodes* Neumann, 1902.

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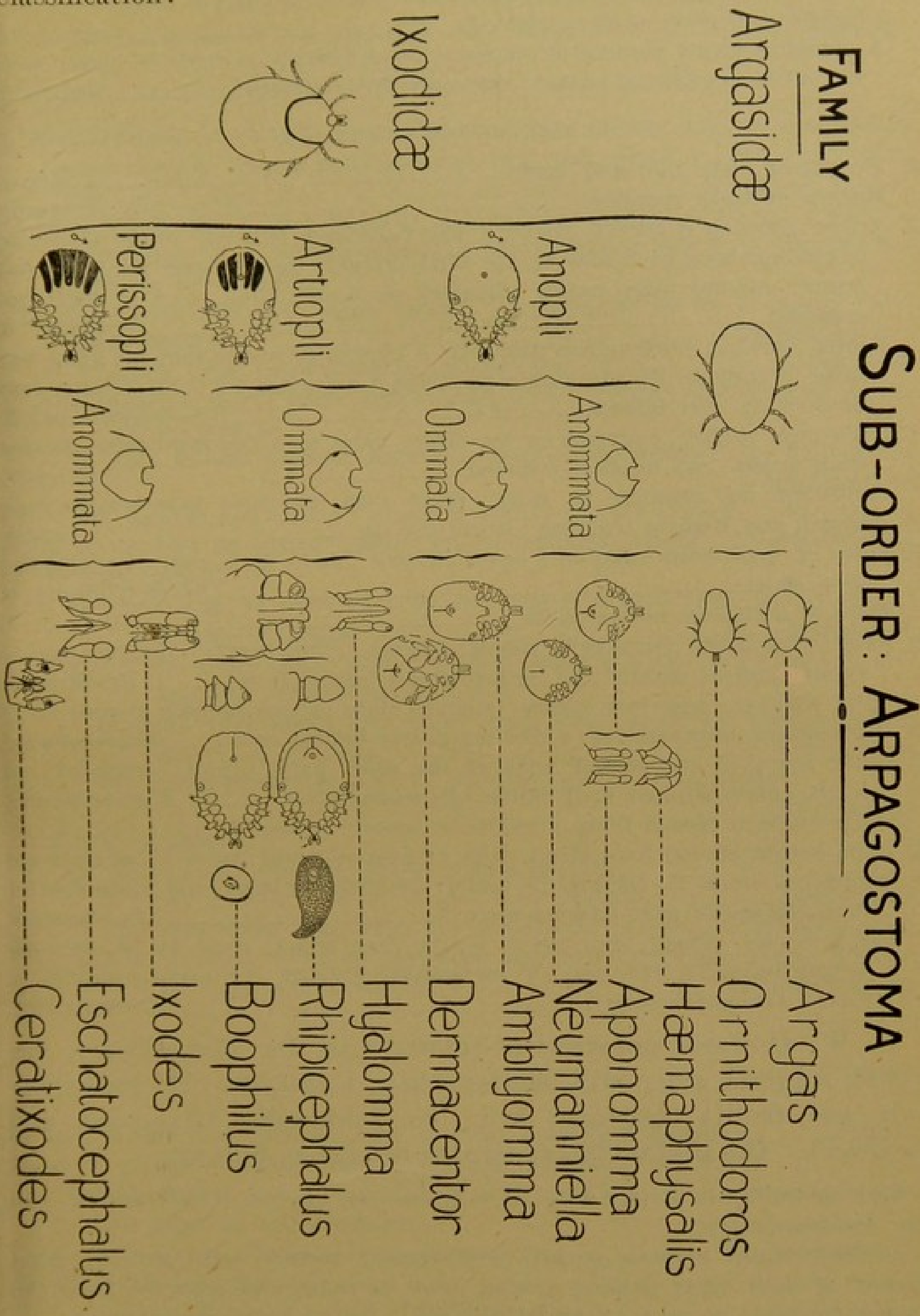
[a] Nuttall and Warburton (1908, 398) have recently established an additional genus which would fall into this group, namely:

Rhipicentor: Male resembles *Rhipicephalus* dorsally, *Dermacentor* ventrally. Basis capituli hexagonal with very prominent lateral angles. Coxa I strongly bifid and overlapping coxa II in male and female; male coxæ progressively increasing in size to pair IV, which is much the largest, pairs II–IV bifid. Adanal shields absent. Eyes present.

Type.—*Rhipicentor bicornis* Nuttall and Warburton, 1908, from North Nyassa, British Central Africa. Host unknown.

Lahille gives the following novel diagram in illustration of his classification:



That there are certain conveniences in this classification may be admitted, but, as Banks (1908, 13) has pointed out, the importance attached to secondary sexual characters hardly carries conviction with it, at least in our present knowledge of ticks. Banks himself has used still another division of the ticks as follows:

TABLE OF THE FAMILIES.

1. No corneous shield on dorsum; head hidden beneath front of body; anus near middle of venter; skin roughened ---------- *Argasidæ* 2.
   A corneous shield present on dorsum; head distinct in front of body; anus behind the middle of venter; skin only finely striated ---------- *Ixodidæ* 3.

TABLE OF THE GENERA.

2. Margin of body thin and acute ---------- *Argas*.
   Margin of body rounded ---------- *Ornithodoros*.
3. Venter showing a curved groove a short distance in front of the anus and extending back each side to the hind margin; no posterior marginal festoons; stigmal plate nearly circular; no ocelli; hind coxæ of male not enlarged ---------- (*Ixodinæ*) 4.
   Venter showing more or less distinctly a curved groove behind the anus, but none in front of it; the male with distinct marginal festoons, more or less distinct in the female ---------- (*Amblyomminæ*) 5.
4. Capitulum slightly angulate on the sides; palpi with the third joint shorter than broad, and broadly rounded ---------- *Ceratixodes*.
   Capitulum not angulate on sides; palpi with the third joint longer than broad, and slightly tapering toward the tip ---------- *Ixodes*.
5. Sides of capitulum angulate; ocelli present; male with anal plates; palpi very short ---------- (*Rhipicephalini*) 6.
   Sides of capitulum not angulate ---------- 7.
6. Palpi with acute transverse ridges; stigmal plate nearly circular; porose areas elliptical, distant; no distinct groove behind anus ---------- *Margaropus*.
   Palpi without transverse ridges; stigmal plate comma-shaped; porose areas triangular, approximate; a distinct groove behind anus ---------- *Rhipicephalus*.
7. Outer angle of the second joint of the short palpi acutely produced; no ocelli; male without anal plates (*Hæmaphysalini*) ---------- *Hæmaphysalis*.
   Outer angle of second joint of palpi not acutely produced ---------- 8.
8. Palpi longer, second joint about twice as long as broad; coxæ IV of male not enlarged; tarsi II, III, and IV plainly divided, the basal part much shorter than the apical part (*Amblyommini*) ---------- *Amblyomma*.
   Palpi shorter, second joint barely longer than broad; coxæ IV of male enlarged; tarsi II, III, and IV indistinctly divided, the parts subequal in length (*Dermacentorini*) ---------- *Dermacentor*.

C. W. Howard, government entomologist for Mozambique, has (1908, August) given still another plan of division. He recognizes only one family (*Ixodidæ*) with two subfamilies (*Argasinæ* and *Ixodinæ*). The subfamily *Ixodinæ* he divides as follows:

This subfamily is divided into three tribes, the *Ixodeæ*, *Rhipicephaleæ*, and the *Amblyom*[*m*]*eæ*.

Ixodeæ.—Males clothed on all their ventral surface with shields. Anal furrow of both sexes passing around anus in front, and separate from the genital furrows; no eyes. Rostrum elongate. Includes the genus *Ixodes*.

Rhipicephaleæ.—Males provided with one pair of anal shields, ordinarily accompanied by accessory shields. Anal furrow of both sexes passing around the anus behind, and usually joining the genital furrows in front. Eyes present. Rostrum sometimes long and sometimes short. Includes the genera *Rhipicephalus*, *Margaropus*, and *Hyalomma*.

Amblyom[*m*]*eæ*.—Males without anal shields. The anal furrow surrounding the anus behind and usually joining the genital furrows in front. Sometimes with eyes. Rostrum long or short. Includes the genera *Amblyomma*, *Aponomma*, *Neuman[n]iella*, *Rhipicentor*, *Dermacentor*, and *Hæmaphysalis*.

The various genera of this subfamily may be separated by the following key:

ADULTS.

A. Males clothed on all their ventral surface with shields; anal furrow of both sexes passing around anus in front, and not joined to the genital furrows ---------- (*Ixodeæ*), *Ixodes*.

AA. Males with small anal plates or without, but ventral surface *not covered* with plates; anal furrow passing behind anus and usually joining genital furrows, or wanting.

B. Males with two anal plates, usually accompanied by an accessory pair; eyes present ---------- (*Rhipicephaleæ*.)

C. Rostrum long; palpi elongate and valvate ---------- *Hyalomma*.

CC. Rostrum short; palpi short, broad, with an outward projection on the second article.

D. Anal groove present, stigmatic plates comma-shaped in both sexes. *Rhipicephalus*.

DD. Anal groove absent; stigmatic plates circular or oval ---------- *Margaropus*.

BB. Males with no ventral plates; eyes sometimes present ---------- (*Amblyommeæ*.)

C. Eyes present.

D. Palpi long, valvate; coxæ IV not longer in male than coxæ I to III; stigmata triangular ---------- *Amblyomma*.

DD. Palpi short, thick; coxæ IV much larger in male than coxæ I to III; stigmata comma-shaped, short.

E. Palpi very short and wider than long; coxæ IV with two long spines ---------- *Rhipicentor*.

EE. Palpi longer than wide; coxæ IV without long spines. *Dermacentor*.

CC. Eyes absent.

D. Palpi long; stigmatic plates comma-shaped.

E. Body as long as wide; anal groove present ---------- *Aponomma*.

EE. Body wider than long; anal groove not present ---------- *Neuman[n]iella*.

DD. Palpi with a sharp projection outward; stigmatic plates circular or short comma-shaped ---------- *Hæmaphysalis*.

NYMPHS.

(Key based on known Transvaal forms.)

A. Anal groove surrounds the anus in front, opening posteriorly ---------- *Ixodes*.

AA. Anal groove surrounds the anus behind, opening in front.

B. Palpi produced into a prominent lateral point ---------- *Hæmaphysalis*.

BB. Palpi more or less cylindrical.

C. Body circular in outline; as wide as long ---------- *Aponomma*.

CC. Body longer than wide.

D. Body narrower behind than in front ---------- *Margaropus*.

DD. Body as wide or wider behind than in front.

E. Shield pentagonal in outline; antero-lateral edges occupying three-quarters of the length of the shield ---------- *Rhipicephalus*.

EE. Shield cordiform in outline.

F. Eyes hemispherical ---------- *Hyalomma*.

FF. Eyes flat ---------- *Amblyomma*.

LARVA.

(Key based on known Transvaal forms.)

A. Body much longer than wide; narrowed at both extremities---------*Ixodes*.
AA. Body as long as wide, or longer than wide, but widely rounded behind.
B. Palpi produced into prominent lateral points--------------*Hæmaphysalis*.
BB. Palpi more or less cylindrical.
C. Body as wide as long; circular in outline------------------*Aponomma*.
CC. Body longer than wide.
D. Palpi very short and thick------------------------------*Margaropus*.
DD. Palpi elongate.
E. Palpi of medium length; more or less pointed at tips; dorsal shield allows a portion of the body to show along its antero-lateral edge, *Rhipicephalus*.
EE. Palpi very long; dorsal shield covers all of anterior portion of body.
F. Eyes hemispherical---------------------------------*Hyalomma*.
FF. Eyes flat-------------------------------------*Amblyomma*.

Whatever general classification may be preferred (and the foregoing summary indicates that the last word on the subject has not yet been written), the genus which interests us at present is *Dermacentor*, which presents the following characters:

Genus DERMACENTOR[a] Koch, 1844.

Generic diagnosis.—*Ixodidæ* (p. 12): Caudal margin bluntly rounded. Color of capitulum and legs usually lighter than body. Dorsum: Scutum emarginate cephalad; subscapular projection present. Eyes present, usually not very prominent. Light-colored rust usually present but variable in different specimens of same species. Punctations usually large and small. Foveolæ present. Venter: Genital pore median, more or less nearly surrounded, especially cephalad, and especially in male, with large and small, prominent punctations with hairs which probably represent sexual sense organs; situated well forward in region of coxæ I or II. Anus median, caudad of plane of coxæ IV; postanal curved groove indistinct; anal ring nearly or quite circular, inclosing two lateral labia with semicircular lateral outline and straight median border, and provided with symmetrically placed hairs. *Stigmal* plates caudo-

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[a] Part of the characters given in this diagnosis will be found to be of more than generic value, but they are inserted here because the entire group is not under discussion.

For other, shorter, diagnoses of this genus, compare the following:

Genus Dermacentor Koch.—"Venter showing indistinctly a curved groove behind the anus, from which a median line extends to margin of body. Capitulum not angulate on sides; porose areas elliptic and transverse. Palpi short and broad, the second joint barely longer than broad and with a basal projection above, but not outward. Shield usually marked with white; ocelli present. Coxa I strongly bidentate behind; coxa IV of male much larger than other coxæ, and leg IV larger than other legs. Abdomen shows festoons behind (except in distended female). No anal plates to male. Stigmal plate large, usually reniform in female, more elongate in male. Tarsi II, III, and IV indistinctly lateral of and usually smaller than coxæ IV; round to oval, but usually provided with dorso-lateral prolongations; usually somewhat dissimilar in outline in male and female; consist of three layers; external layer shows goblets, middle layer shows middle portion of goblets and in addition a large number of smaller supporting chitinous cells, which on surface view assume the form of a meshwork; inner layer shows one stem to each goblet. Capitulum: Base rather rectangular, distinctly broader than long, its postero-lateral angles prolonged caudad. Hypostome spatulate, with minute terminal denticles, followed usually by three (in adults) [four in *D. nitens*] longitudinal rows of larger denticles on each half, these followed proximally by scale-like denticles which disappear first from the median, then the middle, then the lateral row. Each palpus longer than broad, but the palpi are only slightly longer than their combined breadth; extend slightly beyond hypostome; lateral margins usually convex; median surface of articles 2 and 3 strongly excavate in long axis; article 1 small, but distinct ventrally; articles 2 and 3 much longer; article 2 broadest; article 4 small, subterminal of article 3 and provided with several bristles; margins, especially ventro-median margin of articles 1 to 3, provided with bristles directed antero-mediad. Legs: Coxæ increase in size I to IV; caudal margin of coxæ I strongly bifid in both sexes, the lateral outer spur narrower and usually longer than the median (inner) blade-like spur; spurs on coxæ II to IV become smaller, especially the median (inner), which may disappear from coxæ IV; trochanter I with dorso-distal retrograde blade-like projection or with prominent retrograde spinous spur; all articles of legs provided with spurs, or bristles or both, paired spurs or knobs on ventral margin may be very prominent but variable in different specimens of same species; tarsi I usually with curved terminal spur, which is better developed on tarsi II to IV; pulvillum extends beyond middle of terminal claws.

Male.—Without anal shields. Much smaller and flatter than gravid female. Sides diverge from scapulæ to maximum breadth usually near coxæ IV or stigmal plate, but divergence may be somewhat interrupted at eyes near legs II; caudad of stigmal plates, convergence usually very rapid. Dorsum: Scutum covers nearly or quite entire dorsum (except capitulum); punctations and hairs present. Cervical grooves more or less distinct; marginal groove usually fairly well marked, forms proximal border of 11 festoons; scutum usually reddish brown, with more or less rust; pseudoscutum usually present. Venter: More or less beset with hairs and pores, which are very noticeably more numerous near (especially anterior of) genital pore (probably sense organ to locate vulva). Genital pore usually between coxæ II; genital groove

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divided, the parts subequal in length, and a minute tooth-like claw at apex. Type: *D. reticulatus* Fabricius.—Banks, 1908, 42.

DERMACENTOR Koch, 1844.—" Des yeux. Base du rostre plus large que longue, rectangulaire à sa face dorsale. Palpes courts et épais. Péritrêmes en virgule courte. Face ventrale du mâle dépourvue d'écussons, semblable à celle de la femelle. Hanches de la première paire bidentées dans les deux sexes; celles de la quatrième, chez le mâle, notablement plus grandes que les autres. Ecusson dorsal ordinairement orné de dessins variés."—Neumann, 1897a, 360.

GENUS DERMACENTOR KOCH, 1844.—" GENERIC DIAGNOSIS.—*Ixodidæ, Rhipicephalinæ:* Eyes present. Base of capitulum rectangular, broader than long. Dorso-submedian porose plates present. Palpi short and thick. Stigmal plate comma-shaped; short. Male without anal shields. Coxæ I bidentate in both sexes; coxæ IV of male much larger than I to III. Scutum usually ornamented. TYPE-SPECIES.—*Dermacentor reticulatus* (Fabricius, 1794)."—Salmon and Stiles, 1901a, 447.

usually distinct. Stigmal plate not always of same form as in female, but shows same type of goblets. Capitulum: Internal article usually with two visor-like transverse ridges (dorsal process), their free margins directed toward body. Legs: Coxæ I to IV converge toward median line; coxæ IV much larger than others, but may present a large and a small type in one and the same species or even on same specimen; tarsi II to IV with subterminal spur.

Female.—Dorsum: Scutum usually rather prominent because of rust; cervical groove usually of hourglass-like form; eyes at lateral angles. Uncovered portion of dorsum shows punctations (circular pores) with hairs; usually also a distinct median, two submedian, and a more or less distinct marginal groove. Foveolæ caudad of scutum. Venter: Punctations (pores) and fine hairs present; genital grooves diverge more or less gradually to a point about half way between coxæ IV and anus, then more markedly to margins; median, longitudinal, postanal groove usually well marked. Vulva median, in zone of coxæ II or cephalad of this zone. Capitulum: Porose areas present, but may be of somewhat variable outline in a given species.

Type Species.—*D. reticulatus* (Fabricius, 1794) Koch, 1844, on cattle in Europe.

The specimens of *Dermacentor* now in my possession may be divided into four distinct groups according to the microscopic structure of the stigmal plates of the adult.

STRUCTURE OF THE STIGMAL PLATE.[a]

The stigmal plate is a complicated structure. It will be considered here only in so far as it is of importance in differentiating the species or groups of species.

This plate varies to some extent in the two sexes, and it varies also in the different stages of development of one and the same species.

Hexapod larva.—Several authors have mentioned the presence of a stigma caudad of each coxæ III. In the hexapod larvæ which I have examined, a similar aperture is present caudad of each coxa I and II. If the aperture caudad of coxæ III is a stigma (and this interpretation is not called into question here), then the others would seem to be stigmata also; accordingly, the hexapod larva of a number of species, at least, is provided with at least three pairs of stigmata. (See also below, p. 21, for a possible fourth pair.)

These stigmata are radically different from the stigmal plates of the adults. In the hexapod of *D. andersoni* (preserved and treated with caustic), for instance, they are small apertures, slightly broader than long, about 6 by 10 μ in superficial diameter, and 12 by 16 μ (outside diameter) in deeper focus; the aperture is provided with a

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[a] The publication of the present paper has been delayed some months. In the meantime Nuttall, Cooper, and Robinson (1908, December, 347–351) have published an article entitled "On the structure of the spiracles of a tick, *Hæmaphysalis punctata* Canestrini and Fanzazo," in which they give results for *Hæmaphysalis* similar in many respects to those described here for *Dermacentor*.

cuticular structure which is slightly differentiated from that of the skin. Both on ventral view and on optical section, these openings are provided with a pair of transverse labial structures, seen upon deeper focus, and apparently of importance in opening and closing the aperture.

A pair of organs, in structure similar to the stigmata, is found ventro-submarginal, laterally in the transverse zone of the anus. It would seem, therefore, that whatever may be the number of stigmata present in other ticks, the hexapod stage of this species (*andersoni*) apparently possesses four pairs.

Adult.—In the adult the stigmal plate is raised slightly above the body cuticle. It varies in size and in outline, the variation, so far as noticed, in the same sex of the same species being much less than the variation, so far as noticed, between the male and female of any one species, or between different species.

In order to arrive at an interpretation of the finer structure of the stigmal plate, so far as is necessary in the present paper, it will be best to take the species formerly considered the American D. *reticulatus*. Banks (1907, 608) has identified this species with *D. albipictus* Packard, with which he also makes *D. variegatus* synonymous. Neumann identifies this form with *D. occidentalis*. It is further interesting to note that there is a specimen of tick labeled "*D. albipictus*" in the United States National Museum which is identical with *D. electus*. The citation of this confusion is not to be interpreted as even an indirect criticism of my colleagues, Neumann and Banks, but as illustrating the difficulties which are encountered in tick determination and as showing how these difficulties may be overcome, at least in part, by the method here described.

I shall recognize the species under consideration as a new species, *Dermacentor salmoni* (see p. 55).

If a transverse section of the stigmal plate (fig. 34) is prepared, or if the plate is mounted so as to show in profile, it will be seen that the plate is composed of three layers, which may be called the external, the middle, and the internal. The differences in these layers are caused by differences in the component parts. Certain large chitinous gobletlike structures are observed. The stem of the goblet is in the internal layer; the rim and the upper portion of the goblet occupy the external layer; the rest of the goblet occupies the middle layer, and is supported by smaller chitinous structures of circular to elongate form. These goblets vary in form in different species, but seem to be fairly constant in each species. Thus in *D. salmoni* the rim of the goblet presents a very broad diameter; in *D. electus* the goblet is very narrow; *D. occidentalis* and *D. andersoni* stand about midway between *D. salmoni* and *D. electus* in respect to this character.

Surface views of the plate naturally vary according to the size of the goblets, and it is this variation which I find to be so useful in differentiating the species in question.

In surface views of *D. salmoni* the three layers described for transverse section can be easily recognized (fig. 32). We notice a superficial layer of very large rings, corresponding to the rim of the goblets; focusing down to the internal layer, we find that for each large ring there is a small circle present, representing a cross section of the stem of the goblet; thus the rings in the external layer of the plate agree in number with the small circles of the internal layer; focusing to the middle layer, it is noticed that there is a somewhat funnel-shaped structure, corresponding to the lower portion of the bowl of the goblet, and the spaces between these funnels are occupied by numerous structures more or less ringlike in section, representing cross sections of the circular to elongate bodies mentioned for the transverse sections of the plate.

In *D. electus*, the rings of the external layer are very small, delicate, very numerous, but often difficult to see (figs. 3, 5); focussing to the internal layer, however, the circles (stems) are seen to be very distinct and very numerous, so that the plate exhibits quite a characteristic appearance; the funnel, so prominent in the middle layer of *D. salmoni*, is not seen on surface view, so that this layer also, in *D. electus*, presents an entirely different appearance.

In *D. andersoni*, the rings (figs. 9, 10) of the external layer stand (in reference to size) between those of *D. salmoni* and *D. electus;* the funnel of the middle layer is present, but not large; the circles of the internal layer are distinct, but less striking than in the case of *D. electus*.

In *D. nitens*, the stigmal plate (figs. 40–43) is very striking. The rings of the external layer are few in number (8 to 20), and relatively large, but they show great variation in size on any one plate and their number may vary on the right and left plates of one individual; the circles of the internal layer are not very distinct; the circles of the middle layer are distinct.

The following table gives the measurements in μ of the goblets observed in a limited number of specimens of the species discussed in this paper.

	Diameters of goblets.				Surface measurements of goblets.			
	Males.		Females.		Males.		Females.	
	Longest.	Shortest.	Longest.	Shortest.	Largest.	Smallest.	Largest.	Smallest.
Reticulatus group:								
D. reticulatus	19	5	16	5	19×14	7×7	17×15	7×6
D. electus	19	5	18	5	19×15	6×5	18×18	6×6
Andersoni group:								
D. occidentalis	40	13	39	15	40×30	17×14	39×30	19×15
D. andersoni	40	5	40	12	37×28	5×5	38×25	14×12
D. venustus	43	12	43	10	43×29	16×15	30×24	12×10
D. parumapertus	.....	.....	25	7	.....	.....	18×16	10×9
D. p. marginatus	32	13	30	7	25×20	17×16	30×22	10×9
Salmoni group:								
D. nigrolineatus	53	15	52	17	51×35	25×15	52×40	28×22
D. salmoni	73	26	85	26	70×45	40×30	85×58	39×26
D. variegatus	59	15	49	8	55×36	24×15	49×27	15×8
Nitens group:								
D. nitens	88	43	115	78	85×75	51×51	114×80	89×79

The aperture (macula) of the stigmal plate is of some use in determining the species, but the "chamber" into which this aperture leads is of greater value.

This chamber may be relatively small, as in *D. andersoni* (figs. 9, 10), or it may be very large, as in *D. parumapertus marginatus* (figs. 17–19).

With this general introduction in mind, we may pass to certain species of *Dermacentor*. As work in groups of parasites other than ticks has prevented me from keeping thoroughly informed on the recent extensive literature on the *Ixodoidea*, the following account should not be interpreted as representing a revision of the species of *Dermacentor*, but simply as a contribution to their microscopic anatomy.

Banks (1908, 42–51) recognizes the following North Américan species of this genus: *D. bifurcatus*, *D. albipictus*, *D. parumapertus*, *D. parumapertus marginatus*, *D. venustus*, *D. occidentalis*, *D. variabilis*, and *D. nitens*. These forms he distinguishes by the following key:

TABLE OF SPECIES.

1. Females .... 2.
   Males .... 8.
2. Stigmal plate nearly circular, with from 10 to 20 very large more or less isolated granulations; shield without distinct punctures; color dark red-brown, without markings .... *nitens*.
   Stigmal plate with many much smaller, more crowded granulations; shield distinctly punctured, and usually with some pale markings .... 3.
3. Stigmal plate about as broad as long; with short and broad dorsal prolongation, and covered with many very minute granules, scarcely visible as such; shield plainly longer than broad, and much streaked with white .... *variabilis*.
   Stigmal plate with much larger granules, at least near the peritreme .... 4.
4. Stigmal plate without distinct dorsal prolongation; shield plainly longer than broad .... 5.
   Stigmal plate with a more or less distinct dorsal prolongation .... 6.

5. Shield mostly white, with brown streaks and spots; porose areas close together .... *albipictus.*
Shield dark red-brown, with very little white; porose areas rather widely separated .... *nigrolineatus.*
6. Shield mostly white, about as broad as long .... 7.
Shield without white, or but little, plainly a little longer than broad; porose areas but little longer than broad, and well separated .. *parumapertus.*
7. Porose areas very small; stigmal plate with rather wide dorsal prolongation .... *occidentalis.*
Porose areas larger; stigmal plate with a more narrow dorsal prolongation *venustus.*
8. Stigmal plate with from 4 to 10 very large isolated granules; dorsum without white marks; only eight impressed lines behind .... *nitens.*
Stigmal plate with many smaller, more crowded granules; twelve impressed lines behind .... 9.
9. Stigmal plate about as broad behind as long, with dorsal prolongation, the granulations extremely minute; dorsum marked with white streaks and spots .... *variabilis.*
Stigmal plate usually plainly longer than broad; the granulations much larger .... 10.
10. Stigmal plate without distinct apical prolongation; the sides of the body more nearly parallel .... 11.
Stigmal plate with distinct apical prolongation; sides of body more divergent .... 12.
11. Dorsum mostly white, with brown streaks and spots in a pattern; hind angles of the capitulum but little produced; coxa IV about one-half as long as broad on base; large species .... *albipictus.*
Dorsum red-brown, with black lines, no white; hind angles of capitulum much prolonged; coxa IV not twice as broad on base as long; species of moderate size .... *nigrolineatus.*
12. Dorsum with few, if any, white spots; coxa IV about as long as broad at base; hind angles of capitulum moderately produced .... *parumapertus.*
Dorsum largely white, or much spotted with white .... 13.
13. Stigmal plate more attenuate behind; coxa IV about one-half as long as broad at base; hind angles of capitulum moderately produced .... *venustus.*
Stigmal plate less attenuate behind; coxa IV not twice as broad on base as long; hind angles of capitulum much produced .... *occidentalis.*

It will be noticed that Banks has utilized the "granulations" (goblets) of the stigmal plates in a manner somewhat similar to the way Salmon and Stiles (1901a) used them. He has also placed considerable stress on the size of coxæ IV. Further, the rust and the prolongations of the stigmal plate are used in his keys.

In the present paper, greater stress will be placed upon the goblets (granulations); the rust and the stigmal prolongations may be utilized, but with reserve; the size of coxæ IV will not be given much prominence, as in my experience this is subject to extreme variation and has too frequently misled me.

D. bifurcatus from a wild cat, in Texas, is not at my disposal.

D. albipictus as interpreted by Banks represents at least two species, namely, *D. variegatus* [=*albipictus*] and *D. salmoni.*

D. parumapertus is undoubtedly a good species, but my material is not sufficient to permit as careful a study as I should wish.

D. parumapertus marginatus is present in my material.

D. venustus as interpreted by Banks contains two species, *D. venustus* of Texas and *D. andersoni* of Montana.

D. occidentalis is a good species.

D. nigrolineatus is closely allied to *D. salmoni*, but is a distinct species.

D. variabilis seu *electus* presents certain variations which may possibly prove to be of subspecific or possibly even of specific value.

D. nitens is so distinct from the other species that the probability is present that it will eventually be taken as basis for a distinct subgenus.

The following key may be utilized to distinguish the species discussed in the present paper:

KEY TO CERTAIN SPECIES OF DERMACENTOR.

1\. Adults with four longitudinal rows of large denticles on each half of hypostome; stigmal plate nearly circular, without dorso-lateral prolongation, goblets very large, attaining 43 to 115 μ in diameter; not over 40 per plate, each surrounded by an elevated row of regularly arranged supporting cells; white rust wanting; base of capitulum distinctly broader than long, its postero-lateral angles prolonged slightly, if at all; coxæ I with short spurs; trochanter I with small dorso-terminal blade; (Nitens group) ---------------------------------- *D. nitens, p.* 63.

Male: Stigmal plate slightly longer than broad, with 4 to 11 goblets; genital pore surrounded by numerous punctations and hairs, a double transverse row immediately caudad of pore.

Female: Stigmal plate nearly circular, with 6 to 20 goblets; genital pore (? apparently with fewer hairs than in male).

Adults with three longitudinal rows of large denticles on each half of hypostome; goblets small, medium, or large, always more than 40 per plate; whitish rust usually present ---------------------------------- 2.

2\. Dorso-lateral prolongation of stigmal plate small or absent; plates of adults distinctly longer than broad; goblets large, usually 30 to 85 μ in diameter, appearing as very coarse punctations on untreated specimens, but on specimens treated with caustic they appear very distinct in outline; base of capitulum distinctly (usually about twice) broader than long, the postero-lateral angles distinctly prolonged caudad; spurs of coxæ I long, lateral spur slightly longer than median; trochanter I with dorso-terminal spur ---------------------------------- *Salmoni* group, 8.

Dorso-lateral prolongation of stigmal plate distinct; body of plate distinctly longer than broad; goblets of medium size, usually 17.5 to 35 or 40 μ in diameter, appearing as medium sized punctations on untreated specimens, but on specimens treated with caustic they appear very distinct in outline, which is not usually circular; base of capitulum usually less than twice as broad as long, the postero-lateral angles always distinctly prolonged caudad ---------------------------------- *Andersoni* group, 4.

Dorso-lateral prolongation of stigmal plate distinct; goblets small, rarely exceeding 17.6 μ, occasionally reaching 19 μ in diameter; on untreated specimens they appear as very fine granulations, and on specimens treated with caustic they may be difficult to see, but their large number can be determined from the prominent stems of the goblets; surface of outline of goblets distinctly circular; base of capitulum usually less than twice as broad as long, the postero-lateral angles distinctly prolonged caudad; spurs of coxæ I long---------------------*Reticulatus* group, 3.

RETICULATUS GROUP.

3\. Article 2 of palpi with dorso-lateral retrograde spur, sometimes very prominent; palpi with tendency to angular sides; trochanter I with tendency to distinct dorso-terminal retrograde spur; stigmal plate with tendency to distinct elongation, especially in male, with more or less distinctly terminal prolongation, and with rather broad margin free of goblets; type locality Europe--------------------------------*D. reticulatus*, p. 28.

Male: Plate long and narrow, goblets about 375 per plate, 5 to 19 μ in diameter; genital pore surrounded by numerous large and small punctations.

Female: Plate not so long as in male, relatively broader; goblets about 200 per plate, 5 to 16 μ in diameter; genital pore surrounded by large and numerous smaller punctations.

Article 2 of palpi with generally not very prominent dorso-median retrograde prolongation; palpi with tendency to convex sides; trochanter I with rather indistinct spur, often almost resembling a blade; stigmal plate with decided tendency to broadness, especially in female, with tendency to subterminal prolongation, and with much narrower or no margin free of goblets; goblets may attain 535 in number and 5 to 19 μ in diameter; type locality, United States----------------------------*D. electus*, p. 29.

Male: Plate much shorter than in *D. reticulatus*, and with smaller aperture; aperture smaller than in female *electus;* about 535 goblets per plate, 5 to 19 μ in diameter; genital pore with large and small punctations.

Female: Plate usually extremely broad, with large aperture, and decidedly subterminal prolongation; about 450 goblets per plate, 5 to 18 μ in diameter; genital pore with large and smaller punctations.

ANDERSONI GROUP.

4\. Trochanter I with distinct dorso-subterminal retrograde, sharp, digitate spur; postero-lateral angles of capitulum pronouncedly prolonged caudad, 112 to 160 μ long; goblets attain 13 to 40 μ in diameter; type locality, California---------------------------------------*D. occidentalis*, p. 32.

Male: Stigmal plate elongate, small, with about 65 goblets, which attain 13 to 40 μ in diameter.

Female: Stigmal plate much broader, with about 70 goblets, which attain 15 to 39 μ in diameter.

Trochanter I with dorso-subterminal blade; postero-lateral angles of capitulum with rather short prolongations:

Male -- 5.

Female-- 6.

5. Stigmal plate small, prolongation forming very obtuse angle with plate; goblets about 45 per plate, scattered, not covering entire plate, not angular, but nearly circular; goblets attain 44 in number, 13 to 32 μ in diameter; coxæ I with unusually short spurs, the inner considerably shorter than outer; scutum with very little rust; small species, type locality, Arizona ---------------------------- *D. parumapertus marginatus*, p. 48.

Stigmal plate twice as large; broad prolongation, forming rounded, somewhat obtuse angle with plate; goblets about 75 per plate, scattered, those near aperture somewhat elongate, those in prolongation more circular, may attain 12 to 43 μ in diameter; coxæ I with longer spurs, inner slightly shorter than outer; scutum with considerable rust; type locality, Texas -- *D. venustus*, p. 43.

Stigmal plate still larger; prolongation shows decided tendency to form right angle; goblets, about 157 per plate, attain 5 to 32 or 40 μ in diameter, tendency to angularity; coxæ I with long spurs, inner slightly shorter than outer; scutum with considerable rust; type locality, Bitter Root Valley, Arizona ---------------------------------- *D. andersoni*, p. 36.

6. Stigmal plate small, its chamber relatively unusually large, occupying nearly entire body of plate; a portion of dorsal margin without goblets or supporting cells; goblets around aperture with unusual tendency to circular outline; about 90 goblets per plate; prolongation with few goblets; scutum with little rust; coxæ I with short spurs, the inner distinctly shorter than the outer:

D. parumapertus: Type form from Lakeside, Cal., requires further study; apparently dorsal margin of plate narrow, about 90 goblets of 7 to 25 μ diameter, prolongation shows tendency to form very acute angle, little rust in scutum -- p. 46.

D. parumapertus marginatus: Broad triangular dorsal margin of plate without goblets; goblets 73 to 99 in number, 7 to 30 μ in diameter, prolongation shows tendency to form acute angle; very little rust on scutum, chiefly present near margin; type locality Arizona ---------------- p. 48.

Stigmal plate larger, chamber relatively smaller, does not occupy nearly all of body of plate; very little if any of dorsal margin free of supporting cells; goblets around aperture show decided tendency to angularity; scutum with considerable rust; coxæ I with long spines, inner slightly shorter than outer -- 7.

7. About 105 goblets per plate, attain 10 to 43 μ in diameter, apparently absent from marginal band; requires further study; type locality Texas.

D. venustus, p. 43.

About 120 goblets per plate, attain 12 to 32 or 40 μ in diameter, absent from narrow marginal band; prolongation shows decided tendency to form an acute angle with plate; type locality Bitter Root Valley, Montana.

D. andersoni, p. 36.

SALMONI GROUP.

8. Goblets may exceed 100 in number, are crowded together, and attain 15 to 59 μ in diameter; aperture equatorial; body elongate, quite pilose, rust present; capitulum and coxæ I large; type locality North America.

D. variegatus, p. 60.

Male: Pseudoscutum distinct; goblets attain 126 in number, 15 to 59 μ in diameter.

Female: Scutum large, 1.7 to 2.1 mm. long; goblets attain 108 in number, 8 to 49 μ in diameter.

Goblets do not exceed 90 in number ------------------------------------ 9.

9. Goblets 51 to 79 in number, and 26 to 85 μ in diameter; aperture usually equatorial; body not so elongate and pilose as in *variegatus*, rust present; capitulum and coxæ I smaller than in *variegatus;* stigmal plate rather irregular in outline; type locality Oklahoma__________*D. salmoni*, p. 55.

Male: Pseudoscutum not distinct; goblets 51 to 56 in number, 26 to 73 μ in diameter.

Female: Scutum large, 1.3 to 2 mm. long; goblets attain 71 to 79 in number, 26 to 85 μ in diameter.

Goblets about 70 in number, 15 to 53 μ in diameter; small species, quite pilose but without rust; capitulum and coxæ I small; type locality Adirondacks, N. Y________________________________*D. nigrolineatus*, p. 51.

Male: Pseudoscutum very indistinct or absent; stigmal plate elongate with preequatorial aperture; goblets about 69 in number, 15 to 53 μ in diameter.

Female: Scutum small, 1.1 to 1.4 mm. long; stigmal plate irregularly circular; goblets 66 to 103 in number, 17 to 52 μ in diameter.

RETICULATUS GROUP.

Dermacentor reticulatus and *D. electus* [=*D. variabilis* (Say) Banks] show small goblet cells of very nearly the same size, rarely exceeding, in the cases I have thus far measured, 17.6 μ in diameter. On account of their small diameter they are not prominent, and hence they can be easily overlooked, but if a lower focus is taken the stems of the goblets (in the inner layer) come prominently into view.

DERMACENTOR RETICULATUS (Fabricius, 1794) Koch, 1844.

(Figs. 1, 2, 49, 50, 71, 82, 83, 101, 102, 120, 121.)

1794: *Acarus reticulatus* Fabricius, 1794a, 428 (host ? ; Europe).

1844: *Dermacentor reticulatus* (Fabricius, 1794) Koch, 1844a, 235.—Neumann, 1901a, 340 (names *Bos taurus* as type host; France).—Salmon and Stiles, 1901a, 448–452 *in part only* (namely, exclusive of American specimens and of figs. 61, 169–177).

The four specimens here taken as *D. reticulatus* are accepted as such on basis of determination by Neumann. They bear the number U. S. B. A. I. 3904, were collected in France, and represent two males and two females.

One male has a very prominent dorsal retrograde spinous prolongation on the second palpal article (fig. 49), but this is very much less evident on one female, and is not evident on the other male and female. The palpi of the male with the retrograde prolongation are very pronouncedly swollen laterally and one female agrees in this character; the other male and the other female have palpi which are much narrower. Either these palpal characters would therefore appear to be of less value than has heretofore been assumed, or ultimate investigations may show that two species are still confused in the European *D. reticulatus;* the pair without the retrograde spine is strongly suggestive of *D. electus.*

The stigmal plates are shown in figure 1 (male) and figure 2 (female).

It will be noticed that these plates are not identical in outline. That of the male is much more elongate than that of the female. They agree, however, in certain important characters, namely: The goblets present approximately the same relative distribution, being closer together near the aperture, but somewhat more separated and decidedly smaller near the periphery. Numerous (215 to 378) goblets are present, and these attain a maximum diameter of 19 μ, but the peripheral goblets may be as small as 7 μ.

The longest diameter of the male plate is 848 μ; the greatest breadth 480 μ. The length of the female plate is 656 μ; its breadth is 464 μ.

If it should eventually develop that the present *D. reticulatus* of Europe contains two species, the name should be confined to forms with stigmal plates as here described and with a prominent dorsal retrograde spinous prolongation on the second palpal article.

Neumann has designated *Bos taurus* as type host and France as type locality for this species.

DERMACENTOR VARIABILIS (Say, 1821) Bank, 1907=DERMACENTOR ELECTUS Koch, 1844.

(Figs. 3–6, 51, 52, 72, 84, 85, 103, 104, 122, 123.)

1821: *Ixodes variabilis* Say, 1821, 77.
1844: *Dermacentor electus* Koch, 1844a, 235 (type locality, Pennsylvania); 1847a, 109, pl. 22, figs. 83–84.
1907: *Dermacentor variabilis* (Say, 1821) Banks, 1907, 608; 1908, 49–50, pl. 7, figs. 3–4, 6, 8, pl. 10, figs. 3–4.

As basis of this species I have taken a series of specimens determined as *D. electus* by Neumann. Some of these were determined independently as *D. electus* by myself and agree with the form which Salmon and Stiles (1901a, 455–456, figs. 186–214) published under this name.

Banks (1907, 608; 1908, 49–50) makes this species identical with Say's *Ixodes variabilis* 1821, and he adopts the name *D. variabilis*. Banks informs me that this identification is based upon comparison of descriptions, not upon comparison of types. Personally I have formed no opinion as yet upon the correctness of this synonymy. The form which I here discuss is *D. electus;* if Banks is correct in his view, Say's specific name takes priority.

The stigmal plates of *D. electus* [=*D. variabilis* (Say) Banks] are very similar, in respect to the size of the goblets, to those of *D. reticulatus*, although the distribution of the goblets is somewhat different, and the outline of the plates also presents marked differences.

The male plate is not so pronouncedly elongate as the male plate of *D. reticulatus* and in the female plate the "comma" is more equatorial while in the female *D. reticulatus* it is nearly terminal.

It will be noticed in figures 3 and 4, of the male plate, that the tail of the "comma" is nearly terminal.

Comparing the plates of *D. electus* with those of *D. reticulatus*, it will be noticed that the goblets are more numerous, and more generally distributed in the former and extend quite to the periphery of the plate, while in *D. reticulatus* they do not attain the periphery. In some specimens of *D. electus*, considerable variation was found in respect to this point.

In *D. electus*, the goblets are 455 to 536 in number, may attain 16 μ or even 19 μ in diameter. It is, however, often quite difficult to see the upper portion of the goblets (figs. 3 and 5) although it is very easy to see the lower stems (fig. 4) which naturally give a clear idea of the distribution; these stems may attain 5 to 6 μ or even 8 μ in diameter.

The chamber under the breathing pore is relatively small, elongate, and near the ventro-median margin of the plate. The plates may attain 608 to 672 μ long by 420 μ broad in the male, and 512 to 752 μ long by 480 to 640 μ broad in the female.

In connection with the foregoing observations the following specimens have been examined:

U. S. B. A. I. 2131, from skin. Examined by Neumann in connection with his revision of ticks and recognized as *D. electus*.

U. S. B. A. I. 2156, collected by Cooper Curtice and determined by him as *D. americanus;* reexamined by Chapman and determined as *D. electus*.

U. S. B. A. I. 2157, collected by Dr. B. G. Wilder, from *Canis familiaris* at Siasconset, Nantucket, Mass., July, 1889; determined by Neumann as *D. americanus* [= *electus*].

U. S. B. A. I. 2158, collected by Hassall, July 12, 1892, from *Canis familiaris;* determined by Neumann, February 4, 1897, as *D. americanus* [= *electus*].

U. S. B. A. I. 3011, collected in 1898 from *Bos taurus*, at St. Joseph, Mo.; determined 1901 by Stiles as *D. electus*.

U. S. B. A. I. 3150, collected May 25, 1899, by Mrs. R. E. Miller, from *Canis familiaris*, at Joppa, Md.; determined 1899 by Stiles and Hassall as *D. americanus* [= *electus*].

U. S. B. A. I. 3205. Stigmal plate of unusual outline.

U. S. B. A. I. 3233, collected in 1901 by W. S. D. Haines, from *Canis familiaris*, at Joppa, Md.; determined 1901 by Stiles as *D. electus*.

U. S. B. A. I. 3403, collected May, 1902, by Ephriam Cutter, from *Canis familiaris*, at West Falmouth, Buzzards Bay, Mass.; determined 1902 by Stiles as *D. electus*.

U. S. B. A. I. 3518, collected July 3, 1903, by Dr. J. R. Mohler, from *Canis familiaris*, at Washington, D. C.; determined July 3, 1903, by Ransom as D. *electus*.

U. S. B. A. I. 3529, collected August, 1903, by J. S. Jackson, from *Bos taurus*, at San Luis Obispo, Cal.; determined by Ransom as *D. electus*.

U. S. B. A. I. 4037 (from 2126), collected October, 1890, by Cooper Curtice, from *Bos taurus*, at Albany, Tex.; determined by Neumann as *D. electus*.

U. S. B. A. I. 4138, collected from *Bos taurus* in Maryland; determined June 15, 1905, as *D. electus*.
U. S. B. A. I. 4360, collected from wild cat, California.

The following specimens bear numbers of the U. S. P. H. & M. H. S.:

U. S. P. H. & M. H. S. 9746, female belonging to U. S. Nat. Mus. (old number 2381), from (? S. C.) Birdslee, Gainsville, Ohio, July 5, 1883; determined January 4, 1906, by Stiles as *D. electus*.
U. S. P. H. & M. H. S. 9758, female belonging to U. S. Nat. Mus. (old number 5760); determined by Stiles as *D. electus*.
U. S. P. H. & M. H. S. 9773, male belonging to U. S. Nat. Mus. (no number); collected in Virginia, June 12, 1881.
U. S. P. H. & M. H. S. 9781, male belonging to U. S. Nat. Mus.; original label reads "506, swept from grass, Coney Island, L. I., J. L. Zabriskie, 27. V. 1891; *Ixodes albipictus* Pack.;" the determination was apparently made by Ashmead; redetermined *D. electus* by Stiles.
U. S. P. H. & M. H. S. 9920, collected August 17, 1905, by S. Goes, from *Canis familiaris*, at Gurley, Tex.; determined by Stiles.
U. S. P. H. & M. H. S. 10624, locality and host unknown.

The following specimens are from Marx Collection (now in the U. S. Nat. Mus.); they were determined by Marx, and later redetermined by Neumann as *D. electus* or *D. americanus:*

Marx 123, from Mexico.
Marx 124, host *Canis familiaris;* Nantucket.
Marx 125, host panther; Florida.
Marx 126, host *Canis familiaris;* D. C.
Marx 127, host *Canis familiaris;* D. C.
Marx 128, host *Canis familiaris;* one specimen, from Labrador. So far as can be judged from unmounted material, the determination seems to be correct.
Marx 130. Minnesota. Same as preceding number.
Marx 131. Alabama. Ditto.
Marx 132. Alognakig, Alaska. Ditto.
Marx 133. Host *Canis familiaris;* Nantucket.
Marx 134. Host *Equus caballus;* Kansas.
Marx 136. San Jacinto, Cal.
Marx 140. Host and locality not given. Examined by Neumann, but apparently not by Marx.
Marx 141. Ditto.

As already indicated, the foregoing specimens present considerable variation in certain characters, and it is by no means excluded that the American *D. electus* will eventually be subdivided into several distinct species or subspecies. Our material does not contain a sufficient number of specimens from any one given locality to enable us to conclude safely whether the variations noticed are individual or specific.

ANDERSONI GROUP.

We now pass to a group in which the goblets are of medium size, usually varying from about 17.6 to 35 μ or 40 μ in diameter.

DERMACENTOR OCCIDENTALIS Marx, 1892.

(Figs. 7, 8, 53, 54, 73, 86, 87, 105, 106, 124, 125.)

1892: *Dermacentor occidentalis* Marx in Curtice, 1892g, 226 (on *Bos taurus;* California), 234 (on cattle, deer, dog, and man); 1892i, 237.—Banks, 1907, 608; 1908, 47–48, pl. 8, figs. 1–2.—Morgan, 1899a, 134.—Neumann, 1897a, 365 (as syn. of *D. reticulatus*); 1905d, 235 (var. of *D. reticulatus*).—Railliet, 1893a, 714.—Salmon and Stiles, 1901a, 449 (syn. of *D. reticulatus*).

1905: *D. reticulatus occidentalis* (Marx, 1892) Neumann, 1895d, 235–236.

Not: *D. occidentalis* of Montana, mentioned in connection with Rocky Mountain Spotted Fever.

SPECIFIC DIAGNOSIS.—*Dermacentor* (p. 18): ♂ and young ♀: Caudal margin nearly semicircular. Color (alcohol specimens) light to dark reddish-brown, except for rust on scutum; capitulum and legs lighter. Dorsum: Eyes not prominent. Scutum with whitish rust (alcohol specimens) punctations large and small. Venter: Genital pore surrounded by numerous hairs (♂) which are much less prominent and less numerous in female than in female of *D. andersoni.* Anal ring circular or slightly broader than long, diameters vary between 192 and 272 μ. Stigmal plates with prominent dorso-lateral prolongation, which shows a tendency to form at the caudal margin of the plate a broadly rounded obtuse angle in the male and an acute angle in the female; aperture elongate, relatively not quite so long as in *D. andersoni;* goblets of medium size, attain about 32 μ, exceptionally 40 μ, in diameter, are closely set, but may be not so closely set as in *D. andersoni*, and occupy nearly entire surface except margin and distal portion of prolongation; meshes of middle layer about 9 μ in diameter; stem of goblets about 5 to 6 μ in diameter. Capitulum: Posterolateral projections of base long and prominent, giving to posterior margin (especially of male) a prominently concave line. External article, see male. Hypostome, each half with a number of minute subterminal denticles, followed by three rows of larger denticles, followed proximally by smaller scale-like denticles. Palpi, lateral margins somewhat convex, but for part of the distance nearly straight; four to five strong bristles on ventro-median margin of article 1; article 3 not distinctly triangular dorsally, may even appear rather quadrangular; few bristles on concave margin of dorso-terminal portion, terminal bristles present; an indication of a dorso-retrograde prolongation at posteromedian angle of article 2. Legs: Lateral (outer) spur of coxæ I longer than the median (inner) spur; trochanter I with strong and very prominent sharp retrograde spur; spurs or knobs on ventral margins of femur IV, tibia III–IV, and protarsus IV, variable in different specimens, see male; tarsi I with very small terminal spur.

Male.—Length, 3.68 to 4.5 mm. (exclusive of hind legs); greatest breadth, 2.0 to 2.56 mm. Body, oval; unmounted specimens attain 0.8 to 0.86 mm. broad at scapulæ, specimens mounted under pressure may measure up to 0.88 mm. at this point; the sides diverge from here until they reach their maximum diameter at coxæ IV to anterior margin of stigmal plate, where they vary from 2.0 to 2.56 mm. in unmounted specimens. Dorsum: Scutum covers nearly or quite entire dorsum (except capitulum); scapulæ project 0.20 to 0.32 mm. from border of excavation; cervical grooves much more distinct anteriorly than posteriorly; marginal groove rather indistinct; scutum reddish brown, nearly covered with thin rust; pseudoscutum distinct but not very prominent, extending about 0.40 of length of scutum in median line; red spots not so prominent (alcohol specimens) as in *D. andersoni*, and rather variable, the most prominent are: (a) Four short spots arranged radially or nearly so, from caudal margin of pseudoscutum; (b) two spots back of these; (c) a narrow elongate median and two shorter somewhat elongate submedian spots; (d) the forked spot somewhat indistinct, may also be nil; dorso-marginal spots very variable, several may be seen each side or they may be very indistinct; the rust on the eleven distinct postero-marginal festoons exceedingly variable; numerous small and a few larger punctations present; minute hairs issue from many of these punctations. Foveolæ a short distance caudal of pseudoscutum, dorsal of or near median margin of coxæ IV, and measuring 48 to 64 μ or even 80 μ in diameter; in one case, one foveola was divided into two. Venter: Ventral surface sparsely beset with hairs which, with the circular pores through which they pass, are noticeably more numerous around the genital pore. Genital pore between coxæ II; genital groove distinct. Stigmal plate 0.320 to 0.512 mm. long (through the aperture); 0.256 to 0.440 mm. broad (including prolongation); 0.40 to 0.56 mm. from antero-median margin to tip of prolongation; goblets may attain about 65 in number and 13 to 40 μ in diameter. Capitulum: 0.46 to 0.688 mm. long; base 0.40 to 0.528 mm. broad, and 0.224 to 0.30 mm. from posterior margin to anterior margin of portion over palpi; postero-lateral prolongations 112 to 160 μ in length, rather sharp. Mandibles 0.768 to 0.832 mm. long; digit 112 to 128 μ long; external article with proximally, rather large recurved tooth, a small subapical tooth, and an exceedingly small, almost invisible apical tooth; dorsal process of internal article elongate transversely with two visor-like transverse ridges, similar to *D. andersoni*. Hypostome with seven to eight large denticles in each row. Palpi 0.40 to 0.432 mm. long, each palpus 208 to 272 μ in maximum breadth; article 2 with four to five bristles on ventro-median edge; article 3 with one to two bristles on ventro-median edge. Legs: Coxæ IV present two types; they may be relatively short or long; tibia III, and femur, tibia, and protarsus IV provided with a double row of three prominent ventral knobs or spurs, especially large on tibia IV; femur IV also with a small additional ventral pair of spurs; tarsi I with terminal recurved spur, variable, may be practically nil, or may be rather well developed; tarsi II to IV with subterminal spur, variable in different specimens.

Young female.—Length 4.0 to 4.25 (exclusive of hind legs: with hind legs extended may attain 5.5 mm.); greatest breadth 2.37 mm. Body elongate oval; unmounted specimens 0.91 to 0.99 mm. broad at scapulæ, specimens mounted under pressure may measure up to (?) at this point; the sides diverge from here to a maximum breadth about at coxæ IV to stigmal plate. Dorsum: Scutum covers 0.40 to 0.46 of length of body (exclusive of head); 1.31 to 1.56 mm. long in median line; 1.5 to 1.7 mm. broad at lateral angles; quite prominent because of its whitish rust; scapulæ project about 0.22 to 0.28 mm. from border of excavation, which is somewhat convex cephalad; from shoulders, the sides of scutum diverge in distinctly curved convex lines to lateral angles, then converge rapidly in nearly straight lines to the rounded postero-lateral angles, when they converge more rapidly, and form a bluntly rounded posterior angle. Cervical grooves decidedly deeper anteriorly than posteriorly, each forming mediad the concave side of an hourglass, but inclining to a curved rather than a straight line; because of the depth of these grooves anteriorly the antero-median field is very prominent and rather raised; the distal diverging portion may be paralleled laterally by an indistinct dark line; rust not so thick in antero-median field as elsewhere, and absent from a portion of the margin caudad of lateral angles. Eyes convex, distinct, but not prominent, at lateral angles; translucent in cleared specimens. Uncovered portion of dorsum shows numerous finer punctuations (circular pores) with minute hairs and fewer coarser punctations (circular pores); also a distinct median, two submedian grooves, and distinct marginal groove limiting the 11 postero-marginal festoons. Foveolæ 72μ in diameter, a short distance caudad of scutum. Venter: Punctations and fine hairs present; genital grooves diverge gradually but regularly to a point about half way between coxæ IV and anus, then more markedly to margins; median postanal groove distinct. Stigmal plate 0.36 to 0.384 mm. long (measured through aperture; one specimen); breadth (including prolongation) about the same; goblets may attain about 70 in number, and 15 to 39μ in diameter. Vulva between coxæ II. Capitulum: 0.656 to 0.72 mm. long; base 0.576 to 0.656 mm. broad, and 0.23 to 0.27 mm. from posterior margin to anterior margin of portion over palpi; postero-lateral prolongations 112μ long (one specimen), bluntly pointed; porose areas do not meet in median line. Mandibles ?; external article apparently as in male; dorsal process of internal article apparently as in *D. andersoni*. Smaller anterior denticles of hypostome confined to smaller area than in male; eight to ten large denticles in each row; proximal denticles not so small as in male. Palpi 0.528 to 0.560 mm. long; 208 to 272 mm. broad; article 2 with six, article 3 with two to three bristles on ventro-median edge. Legs: Coxæ I to IV diverge slightly from median line; knobs and spurs on tibia III, and on femur, tibia, and protarsus IV not so well developed as in male; tarsi I with very small terminal spur which may be almost nil; tarsi II to IV with terminal spur, also with small ventral knobs.

Replete female.—One specimen, partially replete. Length, 6.5 mm.; maximum breadth, 4 mm.; legs I lateral of scutum. Venter: Vulva has shifted slightly forward of coxæ II. Legs: Coxæ farther apart than in young female, due to repletion.

TYPE.—Marx 119, U. S. Nat. Mus.

HOSTS.—Deer, cattle, dogs, and man; California.

Curtice (1892g, 226, 234) gives, in regard to this tick, the following statements:

P. 226: "*Dermacentor occidentalis* Marx in MSS., the cattle tick of California. This cattle tick is like *D. americanus* [=*electus*], but is somewhat smaller; the head shield of the female is decidedly whiter, the shield of the male being nearly white with small symmetrically situated dark spots toward either side."

P. 234: "*Dermacentor occidentalis* Marx, MS. This California species, the one ordinarily found on deer, cattle, and dogs, was quite annoying to me during the past season. They get on one while passing through the chaparal and arriving at the base of the hair insidiously insert their beak into the skin."

Later, Curtice (1892i, 237) merely mentions "*D. occidentalis* Marx, the western deer tick," as having been taken on cattle.

Morgan (1899, 134) refers to "the deer tick (perhaps *Dermacentor occidentalis*)" as being recognized as distinct by hunters in Louisiana. A legitimate doubt may arise as to whether the Californian species occurs in Louisiana.

Neumann (1897a, 365), on basis of an examination of males and females, collected "sur le Daim" in California, and labeled by Marx as *D. occidentalis*, considered this form identical with *D. reticulatus* of Europe. Later, Neumann (1905d, 235–236) reexamined these specimens and recognized them as a subspecies, *D. reticulatus occidentalis*. Through error he identified with this form the American

D. reticulatus of Salmon and Stiles. He gives the following characters for Marx's specimens:

Base of rostrum a little broader, with posterior angles very much prolonged backward. Hypostome with six rows of denticles. Various prominences of the palpi slightly pronounced. Granulations (here=goblets) of the peritremes (=stigmal plates) much more apparent. Coxæ II–IV with longer spine.

Male.—Coxæ IV sometimes prolonged caudad to the anus.

Female.—Dorsal shield relatively longer. Porose areas smaller.

California and Tennessee. On *Cariacus canadensis* (Briss.), *Bos taurus* L., and *Equus caballus* L.

Banks (1907, 608) lists *D. occidentalis* as a distinct species, but gives no anatomical details. Later, however (1908, 47–48), he gives the following specific description:

Male.—Red-brown, with many waxy-white markings, often with a waxy bloom, sometimes almost wholly white, but there is a red-brown near the eyes, on the festoons, and several submedian spots; moreover, the white is broken by the many red-brown punctures; legs pale reddish brown, marked with white above. Capitulum rather narrow, and the hind angles prolonged into very prominent spines; palpi very short, not as long as the width of the capitulum; dorsum not much more than one and one-half times as long as broad, with many punctures, but mostly small; lateral furrows distinct and long, twelve indented lines behind. Legs of moderate size, tarsus IV with two very distinct teeth below and one less prominent, teeth on other joints distinct; coxæ armed as usual; coxæ IV about one and one-half as wide at base as long. Stigmal plate elongate, with a broad, turned-up tip, almost truncate; large granulations on the main part, small ones on the tip.

Length of male, 3 to 3.5 mm.

Female.—Shield red-brown, mostly covered with white, red-brown near eyes and in the middle region, and the white broken up by the many brown dots at punctures; capitulum and legs red-brown, latter white at tips of joints, and generally paler above than below; abdomen dark red-brown. Capitulum rather small, and hind angles prominent, and the porose areas very small and rather close together. Shield about as broad as long, broadest before middle, and rather pointed behind, with many small punctures and some larger, but not nearly as many large ones as in *D. parumapertus*. Legs rather small, coxæ armed as usual. Stigmal plate with a broad dorsal prolongation, with large granulations in the main part, and minute ones on the prolongation.

Length of female shield, 1.5 mm.

Nearly all specimens come from California—Occidental, San Diego, Goose Lake, Siskiyou County, Santa Clara County, Humboldt County; some taken from deer.

Closely related to *D. venustus*, but with a more narrow capitulum, and with a broader prolongation to stigmal plate, in the male by shorter hind coxæ and in the female by smaller porose areas. Taken together, I think these characters indicate its distinctness from *D. venustus*.

In Marx's material I find one bottle (Marx 119) of specimens labeled *D. occidentalis*, from Occidental, California; this I assume is the material upon which he based the name, hence this would be the type material.

A microscopic examination of the stigmal plate shows that this tick is different not only from *D. reticulatus* of Europe but also from the American *D. reticulatus* of Salmon and Stiles (=*D. salmoni*).

Fig. 7 shows the male plate, with a pronounced dorso-lateral prolongation. The length of the plate, through the aperture, is 384 μ; the breadth, including the prolongation, 320 μ. The goblets are 67 in number, of medium size, attaining about 32 μ in diameter, rather closely packed together so that they have a tendency to lose their circular form for an angular outline. The aperture of the plate is relatively small when compared with *D. andersoni*.

The following material, which has been taken as basis for the specific diagnosis given in the foregoing, has been examined:

Marx 115. Host ?; Kern County, Cal., determined by Marx as *D. occidentalis*; determined by Neumann as *D. reticulatus occidentalis*.

Marx 116. Host deer; ditto; ditto.

Marx 117. Host ?; Santa Rosa, Cal.; ditto; ditto.

Marx 118. Host ?; California; ditto; ditto.

Marx 119. Host ?; Occidental, Cal.; ditto; ditto.

B. A. I. 2155. Host California deer; collected by Cooper Curtice; determined by Marx as *D. occidentalis*.

B. A. I. 3209. Host *Bos taurus*; Grand Island, Nebr.; collected by Hake & Co.; determined by Stiles in 1901 as *D. electus*. A male *D. occidentalis* mounted on slide with a female of another species.

B. A. I. 3512. Host *Bos taurus*; San Luis Obispo, Cal.; collected by G. F. Foulkner, June 2, 1903; determined by Ransom as *D. reticulatus*; redetermined by Stiles as *D. occidentalis*.

B. A. I. 3590. Host *Bos taurus*; San Luis Obispo, Cal.; collected by J. S. Jackson, February, 1904; determined by Ransom as *D. reticulatus*; redetermined by Stiles, 1909, as *D. occidentalis*.

U. S. P. H. & M. H. S. 9769. Host and locality unknown. Specimen came from the U. S. N. M. and bore the number 1348. To judge from the trochanter, this is *D. occidentalis*, but the capitulum and shape of the stigmal plate give rise to some doubt on this point.

For some months I considered this form identical with *D. andersoni*, and it is due to this fact that *D. occidentalis* has been quoted in medical literature as the species involved in transmitting Rocky Mountain spotted fever. As is shown in the present paper, however, the two forms are specifically distinct.

DERMACENTOR ANDERSONI Stiles, (1905) 1908.

(Figs. 9–13, 44–48, 55, 56, 74, 88, 89, 107, 108, 126, 127.

1905: *Dermacentor andersoni* Stiles, 1905g, 22, 24 (Bitter Root Valley, Montana); 1908m, 949.

1905: *Dermacentor occidentalis* of all writings on "Rocky Mountain Spotted Fever" as Ashburn, Craig, and Ricketts.

1908: *Dermacentor venustus* Marx [in part only], of Banks, 1908, 46–47.

Specific diagnosis.—*Dermacentor* (p. 18): ♂, young and replete ♀: Caudal margin nearly or quite semicircular. Color grayish to red to deep reddish brown, or even nearly black (♀), except scutum; capitulum and legs lighter. Dorsum: Eyes not very prominent. Scutum well provided with whitish to greenish white rust, which varies considerably in different specimens; punctations large and small. Venter: Genital pore surrounded by numerous hairs. Anal ring nearly or quite circular, 0.27 to 0.35 mm. in diameter. Stigmal plates with prominent dorso-lateral prolongation, which shows a tendency to form at the caudal margin of the plate a right angle in the male and an acute angle in the female; aperture (pore, macula) and chamber large, elongate; goblets of medium size, usually from 17.5 to 32 μ in diameter, but may vary between 5 and 40 μ in diameter, are closely set and occupy nearly entire surface of plate except margin and terminal portion of elongation; meshes of middle layer about 9 μ in diameter; stem of goblets about 4.5 μ in diameter. Capitulum: Postero-lateral projections of base short. External article with a proximal, very large recurved tooth, a subapical smaller tooth, and a very small apical tooth. Hypostome, each half with a number of small subterminal denticles, followed by three rows of strong denticles, followed proximally by smaller denticles. Palpi, lateral margin convex, article 1 provided with four to five strong bristles on ventro-median margin; article 3 rather triangular dorsally, bluntly rounded distally, with several bristles on the concave margin of dorso-terminal portion and one or two terminal bristles; dorso-retrograde prolongation of article 2 (so prominent in *D. reticulatus*) nil, but one may be indicated on the postero-median angle. Legs: Lateral (outer) spur of coxæ I longer than the median (inner) spur; trochanter I provided with retrograde curved blade; terminal recurved spur not very well developed on tarsi I.

Male.—Length, 4 mm. (exclusive of hind legs; with legs outstretched, about 5 mm.); greatest breadth, 2.5 mm. Body oval, sides may be somewhat straighter than those of *D. salmoni*, more like those of *D. variegatus;* unmounted specimens 0.88 mm. broad at scapulæ (shoulders), specimens mounted under pressure measure up to 1.12 mm. at this point; the sides diverge from here till they reach their maximum divergence at coxæ IV, where the breadth may vary from 2.25 to 2.5 mm. in unmounted specimens to 2.9 or even 3.25 mm. in specimens mounted under pressure. Dorsum: Scutum covers entire dorsum (except capitulum); scapulæ project 0.27 to 0.30 mm. from border of excavation; cervical and marginal grooves distinct, cervical groove deeper anteriorly than posteriorly; scutum deep reddish brown, nearly covered with rust; pseudoscutum rather prominent, extending about 0.37 of length of scutum in median line; the most prominent red spots (namely, not covered with rust) back of pseudoscutum are: (*a*) Four elongate spots arranged in a semicircle and running radially, or nearly so, from caudal margin of the pseudoscutum; (*b*) two elongate to reniform spots back of these, one on each side of scutum; (*c*) an elongated median spot and two shorter, elongate, submedian spots corresponding to the same spots in *D. variegatus;* (*d*) but the forked spot usually so prominent in *D. salmoni* and *D. variegatus* is usually either exceedingly indistinct or absent; only a portion of the lateral margin of the scutum is white, and usually three or four small dark spots may be seen on each side; the rust on the eleven distinct postero-marginal festoons is quite variable, in some specimens rather profuse, in others very slight; numerous punctations of 8 to 32 μ in diameter, and a number of 64 μ or more in diameter, of less regular outline; very short, microscopic, whitish hairs issue from the center of at least some of the larger punctations. Foveolæ a short distance caudad of pseudoscutum, near antero-median corner of coxæ IV, and measuring about 80 μ in diameter. Venter: Surface sparsely beset with hairs, which, with the circular pores through which they pass, are noticeably more numerous around the genital pore. Genital pore between coxæ II. Stigmal plates 0.416 to 0.640 mm. long (through the aperture); breadth of plate (including prolongation), 0.480 to 0.656 mm.; goblets may attain 157 in number and 5 to 40 μ in diameter. Capitulum: 0.70 to 0.80 mm. long; base 0.528 to 0.72 mm. in breadth, and 0.288 to 0.352 mm. from posterior margin to anterior margin of portion over palpi; postero-lateral prolongations short, about 48 to 64 μ in length, rather blunt. Mandibles (cheliceræ) 0.928 to 1.072 mm. long; digit 96 to 104 μ long; dorsal process of internal article elongate transversely and forming two transverse ridge-like edges directed toward the body, to some extent resembling the visors of two caps. Hypostome with seven to nine large denticles in each row. Palpi 480 to 640 μ long, each palpus 272 to 320 μ in maximum breadth; article 2 with six to seven bristles on ventro-median edge; article 3 with two to three bristles on ventro-median edge. Legs: Coxæ I to IV with curved mesial margin; coxæ IV present two types which grade into each other, and the two may even be found in one specimen; they may be relatively short or exceedingly long; ventral margins of legs bear spurs, especially femur and tibia IV; tarsi II to IV with large subterminal recurved spur.

Female.—Dorsum: Scutum 1.56 to 1.62 mm. long in median line; 1.4 to 1.9 mm. broad at lateral angles; very prominent because of its whitish color; scapulæ project 0.256 to 0.352 mm. from border of excavation; from shoulders, the sides of scutum diverge in a rather irregular line to the lateral angles, then converge in nearly straight lines to the postero-lateral angles, when they suddenly change direction, converging much more rapidly, and forming a bluntly rounded posterior angle. Cervical grooves rather well developed, each forming an obtuse angle, at its equator, toward the median line, thus forming an hourglass like outline, deeper anteriorly than posteriorly; the distal, diverging portion of the hourglass is paralled each side by a more or less well developed dark line; eyes at lateral angles; large punctations somewhat more prominent antero-laterally; rust not so thick in antero-median field. Uncovered portion of margins as elsewhere, and absent from lateral angles. Uncovered portion of dorsum shows coarser and finer, also irregularly shaped punctations, a distinct median and two submedian grooves, and distinct marginal groove limiting the eleven postero-marginal festoons. Foveolæ 0.096 to 0.112 mm. in diameter, a short distance caudad of scutum. Venter: Punctations and fine hairs present; genital grooves run subparallel caudad, diverging slightly to a point about halfway between coxæ IV and anus, whence they diverge markedly toward lateral margin; median post-anal groove distinct in unmounted specimens. Stigmal plate 0.5 to 0.528 mm. long (through aperture); breadth (including prolongation) about the same; goblets may attain 120 in number and 12 to 32, occasionally 40 μ in diameter. Capitulum: 0.672 to 0.848 mm. long; base 0.60 to 0.736 mm. broad, 0. 24 to 0.288 mm. long from posterior margin to anterior margin of portion over the palpi; postero-lateral prolongation 16 to 32 μ, bluntly rounded; porose areas nearly meet in median line. Mandibles 0.96 to 1.118 mm. long; digit 96 to 128 μ long; dorsal process of internal article elongated somewhat transversely, with two pointed teeth. Smaller anterior denticles of hypostome confined to smaller area than in male; seven to nine or ten large denticles in each row. Palpi 0.544 to 0.672 mm. long by 0.256 to 0.32 mm. broad; article 2 with four to six strong bristles and article 3 with one to three bristles on ventro-median edge. Legs: Coxæ diverge II to IV; lateral (outer) spur of coxæ I may attain 320 μ in length; ventral margins of legs, especially femur and tibia IV, bear spurs or knobs or both; tarsi II to IV with two ventral chitinous knobs, showing some variation in different individuals.

Young female.—This seems to be the form most commonly found. Length 4.5 to 5 mm. (exclusive of hind legs; with hind legs extended may attain 6.5 to 7 mm.); greatest breadth 2.3 to 2.6 mm. Body oval, rather similar to male.

but not quite so flat; unmounted specimens 0.712 to 1.0 mm. broad at scapulæ, specimens mounted under pressure may attain 0.875 to 1.062 mm. at this point; the sides diverge from here to a maximum breadth (2.312 to 2.6 mm. in unmounted and 2.31 to 3.18 mm. in specimens mounted under pressure) about at stigmal plate. Dorsum: Scutum covers about 0.43 of length of body (exclusive of head); eyes not very distinct in unmounted specimens, more distinct as translucent spot with radial structure in mounted, cleared specimens. Venter: Vulva between coxæ II.

Replete female.—May attain 16 mm. long by 9.5 mm. broad by 6 mm. thick. Form varies with degree of repletion; legs I are lateral of scutum so that anterior margin may reach 2.37 mm. in breadth; from here body increases rapidly in breadth, reaching a maximum in region of coxæ III to IV; a slight constriction is common near stigmal plates, from which point the breadth rapidly decreases. Dorsum: Eyes somewhat more distinct than in young female, owing to their more prominent position due to change in form of body. Venter: Vulva may shift to intercoxal space of legs I to II; a radial submedian groove may appear each side between anal and genital groove; otherwise similar to young female except for proportions due to greater repletion. Legs: Coxæ much farther apart than in young female, due to repletion.

Hexapod larva.—On several occasions replete female specimens were allowed to oviposit, and the eggs were allowed to hatch. Length of larva may attain 0.656 mm.; greatest breadth 0.316 mm.; the caudal portion of the body is broader than the anterior. Scutum 0.224 mm. long, scarcely emarginate anteriorly; a small light, but slightly indistinct, spot (apparently the eye) is visible at the lateral angle, and back of this the scutum rounds off very abruptly; accordingly, the scutum is entirely different from that of the adults. Cuticle of the body, except where covered by heavier chitinous structures, is provided with wrinkles, like striations, of slightly irregular course, but for the greater part running transversely. Posterior margin with nine distinct, and two less distinct festoons, each of which, except the median, bears both dorsally and ventrally, a small hair directed postero-mediad. Hairs are present also on other portions of the body and are arranged more or less symmetrically. Capitulum is decidedly *Rhipicephalus*-like in appearance, 176 μ broad, and its base is drawn out each side into a sharp lateral angle; postero-lateral prolongations (compare adults) are lacking, the proximal margin being straight and even. Mandibles 176 to 200 μ long; digit 22μ; external article with two distinct teeth, the anterior smaller, and the posterior larger; dorsal process of internal article difficult to analyze, apparently elongated transversely, and possessing two (or three??) teeth. Hypostome spatulate, each half with two longitudinal rows of distinct denticles, five to six in each row; proximally of these, there are several indistinct denticles. Palpi may or may not extend beyond hypostome; when straightened under pressure, however, they are slightly longer than hypostome; maximum breadth 44 μ; article one very small, scarcely visible; article two measures about 44 to 66 μ long, and bears several stout serrate bristles; one bristle is situated near distal end on ventro-median edge; one near proximal end on lateral border; one on dorso-median border near the middle of the article; and one dorsally near proximal end; article three measures 44 to 52 μ long, and bears several bristles, the most prominent of which are: one proximal, ventrally; one lateral, and two near the distal end; article four extends directly ventrad in a subterminal depression of article three, and bears about seven or more longer and shorter terminal bristles. Coxæ increase in size and are slightly divergent from I to III; coxæ I have a strong ventral spur directed caudad, and three prominent bristles, one of which is anterior and terminal, one on the median border, and one ventral near lateral border; the ventral spur of coxæ II to III is smaller than that of coxæ I; anterior and posterior lateral bristles on coxæ II and III corresponding to those of coxæ I, but the median bristle appears to be wanting; ventrally, on the body, there is a pair of bristles between the postero-median corners of coxæ I, II, and III. Four pairs of small stigmata are present, one stigmal opening being situated latero-caudad of each of coxæ I, one caudad of each of coxæ II and III, and one pair on transverse anal zone. The articles of the legs are well provided with bristles, rather symmetrically arranged, but no spurs are present. Pulvillum extends to about the middle of the claws. Anal ring 44 μ in diameter, and enclosing two lateral labia, each with a post-equatorial bristle.

Type.—U. S. P. H. & M. H. S. 9467.

HOSTS.—Man (*Homo sapiens*), cattle (*Bos taurus*), horses (*Equus caballus*) dogs (*Canis familiaris*), rabbit (*Lepus* sp.), and apparently the ground squirrel or gopher (*Citellus columbianus*), and an undetermined species of squirrel.

GEOGRAPHICAL DISTRIBUTION.—Montana, Washington State, Colorado, and (?) Idaho.

This species has passed through a varied and confusing history. Its variation is such that I have changed my opinion upon it at least a dozen times; in 1905 I determined it is as a new species, *D. andersoni*, but later in correspondence with various writers I suppressed the species in favor of *D. occidentalis*, thus adopting a determination made by Curtice some years ago. Marx confused the species with *D. americanus* (=*electus*). Very recently Banks (1908, 47) has identified it with *D. venustus* of Texas.

I have now been able to examine a large series of specimens and am persuaded that the recognition of a new species was justified. After finding certain characters, it now seems strange how it was possible to confuse it with other forms, yet in this confusion *D. andersoni* has simply repeated the history of many other species.

D. andersoni as described here is the common tick of the Bitter Root Valley, Montana, and is the form which has been collected by authors who have worked on Rocky Mountain Spotted Fever in that region. In all literature on that disease, this is apparently the tick [a] referred to under the name *Dermacentor occidentalis*.

In connection with the foregoing discussion I have compared the following specimens in the collection of the U. S. P. H. & M. H. S.:

9465. Host *Lepus* sp., at Polaris, Mont.; collected by Dr. F. M. Poindexter in 1904.
9466. From Victor, Mont.; collected by Dr. J. J. Buckley, May 28, 1904.
9467. Host *Equus caballus*, at Woodman, Mont.; collected by Mr. John Mills, May, 1904.
9468. From Polaris, Mont.; collected by Dr. F. M. Poindexter, 1904.
9470. From Missoula, Mont.; collected by Prof. M. J. Elrod, May 4, 1904.
9471. Host *Homo*, at Missoula, Mont.; May 10, 1904.
9472. From River View, Fork Valley, Mont.; collected by E. S. Hall.

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[a] I assume full responsibility for the erroneous use of the name *D. occidentalis* in medical literature, but have no apologies to make for the confusion, for it was made at a time when the two species could not be distinguished satisfactorily.

9473. Host *Homo*, in Montana; collected by Doctor Gates, April 30, 1904.
9474. From Woodman and Lo Lo, Mont.; collected by Mr. McGrath.
9475. Near Lo Lo, Mont.; collected by Mr. John Mills.
9476. Host *Homo*, at Missoula; collected by Dr. J. J. Buckley, May 12, 1904.
9477. From River View, Fork Valley, Mont.; collected by E. S. Hall, May, 1904.
9478. Host *Homo*, in foot hills south of Hamilton, Mont.; May, 1904.
9479. Host *Homo*, at Nimrod, Mont.; collected by Doctor Spottswood, May 16, 1904.
9480. Host ?, at Red Lodge, Mont.; collected by Mrs. J. Flaherty, May, 1904.
9481. From Foy's Lake, near Kalispell, Mont.; May, 1904.
9482. Host *Homo*, near Hamilton, Mont.; collected by Doctor McGrath, April and May, 1904.
9483. From Grantsdale, Mont.; collected by A. L. Holt, May, 1904.
9484. From Missoula, Mont.; collected by Mrs. C. W. Stiles.
9485. Host *Homo*, at Missoula, Mont.: collected by Doctor Spottswood, May 9, 1904.
9486. Host *Homo*, at Missoula, Mont.; collected by Doctor Spottswood, April 22, 1904.
9487. Host *Bos taurus*, near Hamilton, Mont.; collected by Doctor Tuttle, May 22, 1904.
9488. Host *Homo*, at Lo Lo, Mont.; collected by Doctor Gwinn.
9489. From Trail Creek, Mont.; May 23, 1904.
9490. Host *Homo*, at Missoula, Mont.; collected by Doctor Pixley, May, 1904.
9491. From Polaris, Mont.; collected by Miss Emma Saltine, May, 1904.
9492. Host *Homo*, at Missoula, Mont.; collected by Stiles, May 10–15, 1904.
9493. Host *Homo*, at Missoula, Mont.; collected by Dr. J. J. Buckley, May, 1904.
9494. Ditto.
9495. From Fort Logan, Mont.; collected by Max Sarter.
9496. Host *Equus caballus*, near Jefferson, Mont.; May, 1904.
9497. From Missoula, Mont.; collected by Prof. M. J. Elrod.
9499. Host *Bos taurus* at Alhambra, Mont.; collected by Mrs. H. F. Staph, May, 1904.
9500. Host *Homo*, near Helena, Mont.; collected by Dr. T. D. Tuttle, May 22, 1904.
9501. From Watson, Mont.; May, 1904.
9502. Host *Equus caballus*, at Livingston, Mont.; collected by Doctor Tuttle, May, 1904.
9503. From Lo Lo, Mont.; collected by John Mills.
9504. Bitter Root Valley, Mont.; collected by Doctor Spottswood.
9505. Host *Bos taurus*, at Livingston, Mont., May, 1904.
9506. From Grantsdale, Mont.; collected by A. L. Holt, May, 1904.
9507. Host *Equus caballus*, at Grants Creek, near Missoula, Mont.; collected by Dr. J. J. Buckley, May 9, 1904.
9508. Host *Equus caballus*, at Nelson Gulch, near Helena, Mont.; collected by Dr. T. D. Tuttle, May, 1904.
9509. Host *Homo*, at Grantsdale, Mont.; collected by A. L. Holt.
9510. Host *Equus caballus*, near Helena, Mont.; collected by Dr. T. D. Tuttle.
9511. Host *Homo*, at Helena, Mont.; collected by Dr. T. D. Tuttle, May, 1904.
9512. Host *Equus caballus*, near Florence, Mont.; collected by Ashburn and Stiles, May 19, 1904.
9513. From Dillon, Mont.; collected by Mr. Riley.
9517. From Fort Missoula, Mont.; collected by Ashburn and Stiles, May, 1904.
9518. Host *Bos taurus*, at Livingston, Mont.; collected by Dr. T. D. Tuttle, May, 1904.

9551. Hexapod larva, host *Citellus columbianus*. This is apparently the hexapod larva of *D. andersoni*.

9557. Ditto.

9589. From Montana, June, 1904.

9742. From Montana. In collection of Army Medical Museum.

9755. Belongs to U. S. National Museum, with two labels "24" and "25;" locality and host not given; belongs to *andersoni* group, perhaps to *D. andersoni*.

9760. Collected at Elko, Nev., by Mr. Whickham; belongs to *andersoni* group, possibly to *andersoni*.

9761. Collected by E. A. Bush, San Jose, Cal., August 2, 1887. Apparently *D. andersoni*, but not exactly typical specimen.

9768. From Utah. Material poor; belongs to *andersoni* group; if a *D. andersoni* it is not very typical.

9782. From U. S. National Museum, with label "*Dermacentor occidentalis* n. sp. Curtice, Easton, Wash. K." This is not *D. occidentalis*, but is closely related to, possibly identical with, *D. andersoni*.

10429. From Utah, collected by Alf. A. Robinson, 1908. Possibly represents a distinct species; it belongs to the *andersoni* group, but appears not to be a typical *D. andersoni*.

10018. Host *Equus caballus*, at Missoula; collected by Doctor King.

Marx 135. Host?; Glenwood Springs, Colo.; determined by Marx as *Dermacentor americanus* (= *electus*); determined by Neumann as *D. electus*. Shows exceedingly slight differences from the Montana forms of *andersoni*, but I do not feel justified on present material in describing it as distinct, although it is not impossible that examination of extensive material might reveal distinct differences

B. A. I. 3400: Host *Homo*, Wyoming; determined by Stiles in 1902 as *D. reticulatus*.

B. A. I. 2424: Host *Bos taurus;* Eagleville, Cal.; collected by C. H. Blemer, 1896; determined by Stiles and Hassall as *D. americanus;* redetermined by Stiles, 1909, as *D.? andersoni*.

The stigmal plates of this species, as found in the Bitter Root Valley, Montana, present the following characters:

The male plate (fig. 9) is similar to the female plate in general structure, but in the male the prolongation is at right angles to a plane drawn through the aperture, while in the female the prolongation forms an acute angle with that plane; 157 goblets are present.

Figure 10 shows the female plate of P. H. & M. H. S. 9503, taken at Lo Lo, Bitter Root Valley, not far from the point where the type (9467) was collected. The plate has a pronounced dorso-lateral subterminal prolongation. The aperture is relatively long. The plate measures 544 μ long, through the aperture, by 528 μ broad, including the prolongation. The goblets, 120 in number, occupy nearly the entire surface of the plate, except at the margins and near the end of the prolongation. On a very superficial focus these goblets come close together, and as a result they have a tendency to change their more or less circular outline for an angular outline; upon lowering the focus very slightly the appearance given in figure 9 is obtained.

The goblets are of medium size, may attain 32 or even 36 μ in diameter; the stems in the inner layer are seen more distinctly near the periphery than near the aperture.

DERMACENTOR VENUSTUS Marx, 1897.

(Figs. 14, 15, 57, 75, 90, 109.)

1897: *Dermacentor venustus* Marx in Neumann, 1897a, 365 (from Texas and New Mexico, not described) as syn. of *D. reticulatus* (Fabr.); 1901a, 345 (as a syn. of *D. reticulatus*).—Banks, 1908, 46–47 (in part only).—Salmon and Stiles, 1901a, 449 (as syn. of *D. reticulatus*).—Stiles, 1908m, 949.

Specific diagnosis.—*Dermacentor* (p. 18): ♂ and young ♀: Caudal margin about semicircular, anus nearer caudal than lateral margins. Color (alcohol specimens) dark reddish brown, except for rust on scutum; capitulum and legs lighter. Dorsum: Eyes not prominent. Scutum with a fair amount of whitish rust; punctations large and small. Venter: Genital pore of male surrounded by a number of punctations. Anal ring circular, prominent, 0.3 mm. in diameter. Stigmal plates with prominent dorso-lateral prolongation, the caudal margin of which forms with the plane of the aperture, a broadly rounded obtuse angle in the male and a right (?) angle in the female; aperture and chamber prominent; goblets medium size, attain about 10 to 43 μ, usually 24 to 40 μ in diameter, not thickly set in male, concentrated around aperture, more separated on prolongation (♂), attain 75 (♂) in number; meshes of middle layer 8 to 12 μ. Capitulum: Postero-lateral projections of base 64 μ long. External article (♂) with two teeth, one not very large proximal and one very small apical. Hypostome, each half with a number of minute subterminal denticles, followed by three rows of large denticles, followed by a number of scale-like denticles. Palpi, dorso-median margins convex; article 3 not distinctly triangular dorsally, appears somewhat quadrangular; a few subterminal bristles on median concave margin of dorsal portion of article 3. Legs: Lateral (outer) spur of coxæ I very slightly longer than the median spur; trochanter I ———; spurs or knobs on ventral margin of legs may be very prominent; tarsi I ———, tarsi II–IV ———; pulvillum ———.

Male.—Length 4.9 to 6.0 mm. long (exclusive of hind legs; with legs extended may attain 6.5 to 7.3 mm.); greatest breadth 2.93 to 3.75 mm. Body elongate oval; unmounted specimens attain 1.0 mm. broad at scapulæ, a specimen mounted under pressure measures 0.96 mm. at this point; the sides diverge from there in a slightly curved line to the broadest portion at coxæ IV, the curve being slightly interrupted at the eyes; the sides then converge rapidly. Dorsum: Scutum covers entire dorsum (except capitulum) or a slight marginal border may be uncovered; scapulæ project 0.24 to 0.48 mm. from rounded anterior border of excavation; cervical grooves very short, not very deep, only the usual cephalic portion being evident; marginal groove may be well marked; scutum reddish brown, with comparatively small, but fair, amount of whitish rust, and on account of small amount, the usual reddish spots are indistinct; pseudoscutum may be fairly well marked, though it is not prominent, extending about 0.40 of length of scutum in median line; small and large punctations present, the larger especially prominent. Foveolæ 80 μ in diameter, over coxæ IV. Venter: Surface with not unusually numerous hairs and punctations, but especially numerous near genital pore. Genital pore between coxæ II; genital groove present. Stigmal plate 0.48 mm. long (through aperture); breadth (including prolongation) 0.56 mm.; goblets may attain 75 in number and 12 to 43 μ in diameter. Capitulum: 0.896 mm. long; base 0.56 mm. broad, 0.32 mm. from posterior margin to anterior margin over palpi; postero-lateral prolongations 64 μ, blunt. Mandibles 0.88 mm. long; digit 128 μ long; dorsal process of internal article elongate transversely, with two visor-like ridges. Hypostome with seven to eight large denticles in each row. Palpi 480 μ long, each palpus 272 μ in maximum breadth; article 1 with five ventro-median bristles; article 2 with five such bristles; article 3 with (?) two such bristles. Legs: Coxæ I to IV with rather rounded mesial margin; coxæ IV quite large; ventral margins, especially of femur, tibia, and protarsus IV, with well developed spurs; at least tibiæ IV (others could not be studied) with large subterminal recurved spur.

Female.[a]—Dorsum: Scutum 1.52 mm. long in median line; 1.79 mm. broad at lateral angles; rather prominent because of its whitish rust; scapulæ project(?)——; from shoulders the sides diverge in a convex line to lateral angles, then they converge in nearly a straight line to postero-lateral angles, when they converge more rapidly to form a bluntly rounded caudal angle. Cervical grooves very prominent, hour-glass shaped, deeper cephalad than caudad; eyes rather prominent, at lateral angles; large and small punctations present, the larger especially prominent in lateral fields; rust not so thick in antero-median field as elsewhere. Uncovered portion of dorsum with not very prominent hairs and punctations, a median and two submedian grooves present, marginal groove and postero-lateral festoons not very prominent. Foveolæ a short distance caudad of scutum, about 64 μ in diameter. Venter: Punctations and hairs not prominent; genital grooves diverge gradually to a point about halfway between coxæ IV and anus, then they diverge markedly toward lateral margin; median postanal groove distinct. Stigmal plate with prominent dorso-lateral prolongation which is at nearly right angle to a line drawn through the rather elongate aperture; about 105 goblets are present, attaining 10 to 30, even 43 μ in diameter. Capitulum: Something over 0.576 mm. long; base 0.672 mm. broad; porose areas rather deep, do not meet in median line, diverge anteriorly. Mandibles (?); digit (?); dorsal process of internal article (?). Smaller denticles on hypostome rather numerous; eight or nine large teeth in each row. Palpi (?); article 1 apparently with four, article 2 with five, article 3 with three ventro-median bristles. Legs: Coxæ diverge I to IV; spurs or knobs (?).

Young female.—Length 5.3 mm. (exclusive of hind legs); greatest breadth 3.3 mm. Body rather oval; unmounted specimen measures 1.0 mm. broad at scapulæ; the sides diverge from here in a convex line (slightly interrupted between legs I and II) to a maximum breadth at the stigmal plates. Dorsum: Scutum covers about 0.32 of the length of the body (exclusive of capitulum); eyes rather large and distinct. Venter: Vulva between coxæ II.

TYPE.—Marx 122, in U. S. National Museum.

HOST.—Sheep (Ovis aries) in Texas.

In the Marx collection I find three bottles containing ticks which Marx determined as *Dermacentor venustus*, namely:

Marx 120. Host (?)———; Las Cruces, N. Mex., one male; determined by Marx as *D. venustus;* determined by Neumann as *D. reticulatus occidentalis.* This is a member of the *andersoni* group, but it is not *D. occidentalis.* It may be *venustus*, but as there is only one specimen, which can not be mounted, I reserve judgment.

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[a] Only one specimen, which could not be mounted.

Marx 121. Host Mountain goat; Soldier, Idaho; one male determined by Marx as *D. venustus;* determined by Neumann as *D. reticulatus occidentalis.* Not being able to mount this, as it is a single specimen, I hesitate to make a definite determination; but it is not *D. occidentalis;* it bears a striking resemblance to *D. andersoni*, so far as can be seen on unmounted material.

Marx 122. Host *Ovis aries;* Texas; three males, one young female; determined by Marx as *D. venustus;* determined by Neumann as *D. reticulatus occidentalis.* This lot, I assume, is type of *D. venustus.*

Microscopic examination of the stigmal plates shows that they are quite distinct from *D. reticulatus*, but very closely related to *D. parumapertus* and *D. occidentalis.*

Figure 14 shows the plate of the male, which is seen to have a pronounced dorsal prolongation. The aperture is broad, but not very long, and lies slightly antero-mediad of the center of the body of the plate. The goblets are of medium size, circular to elongate, and attaining a diameter of 48 by 28 μ. They may attain 75 in number and are somewhat scattered; the goblets near the aperture are larger, those nearer the periphery are smaller and more scattered, those in the prolongation are smallest and the most scattered. The longitudinal diameter of the plate is 480 μ, the transverse diameter (including prolongation) is 544 μ.

The specific description of *D. venustus* as given by Banks is influenced by the fact that he includes *D. andersoni* in this species.

Mr. Banks (1908) has examined the types and drawings of *D. andersoni*, my drawings of Marx's *D. venustus*, and also Marx's original material, and apparently Marx's manuscript of *D. venustus.* He considered *venustus* and *andersoni* specifically identical and has published them as such under the name *D. venustus*, although he does not refer to the name *D. andersoni.* He says:

Specimens come from various places in the West; Olympia, Yakima, Klikitat Valley, and Grand Coulee, Wash.; Fort Collins and Boulder, Colo.; Pecos and Las Cruces, N. Mex.; Bozeman, Mont.; Bridger Basin, Utah; Soldier, Idaho; and Texas (on sheep).

This species is quite common in the Northwest. It has been included in *D. occidentalis* by Neumann, but was separated out by Doctor Marx in manuscript under the name I have adopted. It is larger than *D. occidentalis*, with more red and less white in the coloring, and differs in many minor points of structure, as size of porose areas, size of hind coxæ in male, etc. This is the species supposed to be concerned in the transmission of spotted fever in Montana.

Bank's description of *D. venustus* is based largely, and his drawings exclusively, on material which is in reality *D. andersoni.* This combination of circumstances gives rise to some complication. My interpretation of the best way to solve the difficulties is this: Marx's material and Marx's name are, as admitted by Banks, a part of *D. venustus* as described under Marx's manuscript name *D. venustus*, which is adopted by Banks, although Banks writes "n. sp." after this name. I can not assume that the type specimens of this *D. venustus* can be other than the Marx material, for any such assumption would necessarily carry with it a corollary that Banks had examined the unpublished manuscript and drawings of two personal friends (one deceased) and had taken advantage of these circumstances. It will be noticed that he did not mention the museum number of the type specimen of *D. venustus* as construed by him, and the most natural assumption is that it is to be found in Marx's material. Further, this interpretation preserves two specific names now published for their respective species.

If it were to be construed that the type of the species *D. venustus* as interpreted by Banks were not in Marx's material, then the type of *D. andersoni* examined by Banks would come up for consideration. To interpret this as type would produce confusion, and seems not only unnecessary but perhaps unwarranted. The only remaining possibility would be that the type of *D. venustus* is to be found in Banks's specimens (other than what he examined in my laboratory), but it is found impossible to follow this side of the question further, as it would be a reflection upon my friend Banks and would not simplify matters. If any person should be inclined to differ with me in this interpretation, it may be recalled that it is clear that the material of Banks's *D. venustus* would under any other interpretation include three distinct sets of type material, and it is equally clear that Marx's type material is the oldest.

The entire question at issue contains elements which are not covered in detail by the International Code.

DERMACENTOR PARUMAPERTUS Neumann, 1901.

(Fig. 16.)

1901: *Dermacentor parumapertus* Neumann, 1901a, 267–268 (host unknown, at Lakeside, Cal.).—Banks, 1907, 608; 1908, 45–46, pl. 8, figs. 8, 10.

1905: *Dermacentor electus parumapertus* (Neumann, 1901) Neumann, 1905d, 236.

The specific diagnosis as given by Neumann is as follows:

Male.—Unknown.

Female.—Body oval, swollen, slightly broader anteriorly, sides subrectilinear, 9 mm. long, 5.5 mm. broad. Color deep chestnut-brown. Shield oval, slightly longer (1.5 mm. long) than broad, contour slightly sinuous back of eyes; eyes flat, blackish, large, near equator of shield; cervical grooves very broad, being confounded with lateral grooves; punctations numerous, unequal, the larger occupying especially the grooves and forming two longitudinal series on the median field; color deep chestnut-brown. Dorsal and ventral surfaces smooth, with numerous fine punctations. Vulva very small, very anterior, in plane of second intercoxal space. Anus very small, toward posterior third; no anal groove.

Peritremes (stigmal plates) very small (340 μ), oval, with a short retrodorsal prolongation. Rostrum small, 0.7 mm.; base short, at least twice as broad as long, rectangular, posterior angles slightly salient; porose areas small, deep, oval, subparallel. Hypostome spatulate, slightly rounded at extremity, with three rows of seven to nine teeth each side. Palpi thin, sides parallel; article 2 one and one-half times as long as article 3. Legs medium. Coxæ I divided into two short spines, the median thicker; a small spine at postero-external angles of coxæ II–IV. Tarsi progressively attenuated, terminated by a short spine.

Banks (1908, 45–46) restudied this form, which he describes as follows:

DERMACENTOR PARUMAPERTUS Neumann.

Male.—Dark red-brown, legs a trifle paler, no white markings, except sometimes a few small spots, and a minute white spot at tips of some joints of the legs. Capitulum moderately broad, hind angles only very slightly produced; palpi very short, not as long as width of capitulum; dorsum one and two-thirds times as long as broad, with many scattered, deep, but not very large punctures, submarginal furrow very distinct on the sides, less so behind; twelve impressed lines near posterior margin. Coxæ spined as usual, hind coxæ barely wider on base than long, legs rather short, hind pair not so much larger than the others, and the teeth below small and indistinct. Stigmal plate elongate, attenuate behind, the fore part around peritreme with large granules, a few down on the narrow portion, which is covered with smaller granules.

Length of male, 2.8 mm.

Female.—Shield and capitulum dark red-brown or almost black, without marks; abdomen blackish; legs red-brown, a faint white mark at tips of some of the joints. Capitulum moderately broad, hind angles distinctly prolonged behind, porose areas rather small, nearly circular, and well separated; palpi as long as width of capitulum. Shield plainly a little longer than broad, with many deep punctures; those in the depressed area each side especially large and numerous, almost confluent. Legs rather small and short; coxæ armed as usual. Stigmal plate small, with a distinct, although short and broad, dorsal prolongation; most of the surface with rather large granules, but those on the prolongation very small.

Length of female shield, 1.1 mm.

Specimens are from Lakeside, Cal. (also Neumann's type in the Marx collection), taken on man, and in a chicken house.

Distinguished from other forms most readily by lack of white on shield, by porose areas, and stigmal plate. After describing this species, Neumann later made it a variety of *D. electus* (*variabilis*), but it differs in many important characters from that species, and the granulations of the stigmal plate are much larger.

DERMACENTOR PARUMAPERTUS var. MARGINATUS.

This form agrees in general with the true *D. parumapertus*, but differs in several minor points. The posterior border of the female shield is margined with white; the porose areas are larger and rather closer together; the lateral lobes of the shield have fewer punctures, and the shield is more contracted behind the eyes; the stigmal plate of the female has a narrower dorsal prolongation, and the inner margin is more convex; the posterior angles of the capitulum are less prominent. Otherwise it is very similar to the type.

Several specimens from Mesa City, Ariz., from a jack rabbit (Cordley).

My material, apparently the type specimen, does not permit a detailed study.

A microscopic examination of the stigmal plates of the type specimens (Marx 143) shows that this form is quite distinct from *D. electus* and that it is closely related to *D. venustus* and *D. andersoni*. The slide of the type is not especially good, but certain features can be clearly recognized.

Figure 16 represents the stigmal plate of the female. It will be noticed that the plate is relatively small, the aperture, *and especially the chamber*, relatively very large; a prominent dorso-lateral prolongation is present; and the goblets are rather numerous (90) and of medium size, 7 to 25 μ in diameter. One of the most prominent features is the convexity of the surface, especially near the aperture. This convexity gives to the plate an appearance which is quite different from that noticed in the other species, where it may be relatively flat, or even concave. Two other characters of the plate are quite prominent: The goblets are unusually circular in outline and arranged rather regularly near the aperture; further, on the proximal border of the dorso-lateral prolongation there is a prominent, solid, broad margin, free of goblets or other similar structures.

Very closely allied to *D. parumapertus* is the following form:

DERMACENTOR PARUMAPERTUS MARGINATUS Banks, 1908.

(Figs. 17–19, 58, 59, 76, 91, 92, 110, 111, 128.)

1908: *Dermacentor parumapertus marginatus* Banks, 1908, 46, pl. 8, fig. 6 (host, Jack rabbit [probably *Lepus eremicus*]; Mesa City, Ariz.).

Banks has recognized as a subspecies of *D. parumapertus* a form taken from the Jack rabbit in Arizona. Owing to paucity of material of the type form, I am not altogether clear at present as to the relations of the two ticks in question. The following description is based upon material which is evidently Banks' *D. p. marginatus:*

Subspecific diagnosis.—*Dermacentor* (p. 18): ♂ and ♀: Caudal margin practically semicircular, but anus nearer caudal than lateral margins, except in replete female. Color reddish brown, very little rust present (alcohol specimens); capitulum about the same color, but legs lighter. Dorsum: Eyes not very prominent, but quite distinct in mounted specimens. Scutum with only a slight amount of rust; large punctations much more prominent than the smaller. Venter: Genital pore surrounded by numerous large and small punctations, especially in male. Anal ring circular, 224 to 230 μ in diameter. Stigmal plates with prominent, broad, dorso-lateral prolongation; goblets of medium size, 7 to 32 μ in diameter, attain 44 to 99 in number, unusually circular, concentrated around aperture, but scattered on prolongation which forms caudally an obtuse angle in the male and an acute angle in the female; meshes of middle layer vary in diameter. Capitulum: Postero-lateral prolongations of base short. Hypostome, each half with a number of minute terminal and subterminal denticles, followed by three rows of larger denticles, followed by scales. Palpi, lateral margins convex; median dorsal margin prominently convex. Legs: The lateral (outer) spur of coxæ I distinctly longer than the median which is quite short; trochanter I with a dorso-terminal retrograde blade, similar to *D. andersoni;* ventral knobs not well developed; tarsi I with poorly developed terminal spur.

Male.—Length 2.8 to 3.187 mm. (exclusive of hind legs; with hind legs extended may attain 4.18 mm.); greatest breadth 1.68 to 1.81 mm. Body rather triangular; unmounted specimens attain 0.64 to 0.688 mm. broad at scapulæ; specimens mounted under pressure may attain 0.75 mm. at this point; the sides diverge from here in almost a straight line until they reach their maximum diameter. Dorsum: Scutum covers nearly or quite entire dorsum (except capitulum); scapulæ project 0.08 to 0.16 mm. from border of excavation, which is rather convex cephalad; cervical grooves deep and prominent anteriorly; marginal groove distinct; scutum dark reddish brown, very little rust present (alcohol specimens); pseudoscutum very indistinct; numerous fine punctations and hairs present; also large punctations, which are unusually prominent, and more apparent in marginal field than elsewhere; eyes well marked at coxæ II. Foveolæ just back of plane of anterior margin of coxæ IV, 64 μ in diameter. Venter: Ventral surface with coarse and fine punctations and large and small hairs, especially numerous near genital pore; four longitudinal rows of large hairs especially prominent arranged near median and lateral margins of coxæ. Genital pore between coxæ II; genital groove distinct. Stigmal plate rather small and rather similar to *D. occidentalis;* 0.256 to 0.288 mm. long (through relatively large aperture); 0.32 to 0.40 mm. broad (including long slender dorsolateral prolongation); attaining 0.488 mm. when measured from antero-median margin to tip of prolongation; goblets may attain 44 in number, 13 to 32 μ in diameter, rather concentrated around aperture, fewer and more scattered on prolongation. Capitulum: 0.56 to 0.6 mm. long; base 0.432 to 0.512 mm. broad by 0.192 mm. from posterior margin to anterior margin over palpi; posterolateral angles project 32 to 40 μ, rather blunt. Mandibles 0.7 to 0.8 mm. long; digit 88 μ long; external article with large proximal and smaller distal tooth, the usual minute apical tooth not visible (absent?); dorsal process of internal article not very prominent, elongate transversely in two visor-like ridges. Hypostome with minute subterminal denticles, followed by three rows of six to eight large denticles, followed by scale-like denticles disappearing median to lateral. Palpi 0.368 to 0.4 mm. long; each palpus about 144 to 200 μ in maximum breadth; article 1 small, with two bristles, article 2 with four bristles, article 3 with two bristles. Legs: Coxæ IV rather large, may attain plane of caudal margin of stigmal plates; ventral knobs not well developed; tarsi I with poorly developed terminal spur; tarsi II–IV with poorly developed subterminal and not very well developed terminal spur.

Female.—Dorsum: Scutum 1.23 to 1.37 mm. long in median line; 1.5 to 1.6 mm. broad at lateral angles; distinct despite small amount of rust present (alcohol specimens); scapulæ project 160 to 270 μ from anterior margin; from shoulders the sides of scutum diverge in a very convex line to lateral angles, from here they converge in a line (which may be slightly concave) to the blunt postero-lateral angles, then they converge more rapidly forming a bluntly rounded caudal margin; in general the outline appears oval. Cervical grooves very distinct, broad caudally, forming an hourglass. Eyes at lateral angles, not prominent under a hand lens, but may appear light, more prominent, and rather salient under the microscope. Some fine punctations present; larger punctations quite prominent. Rust appears on postero-lateral margins. Uncovered portion of dorsum with numerous not very prominent punctations and hairs; also a distinct median and two submedian grooves, marginal groove not very prominent. Venter: Fine and coarse punctations (cuticular rings with hairs) present; one row of hairs especially prominent each side, lateral of lateral spine of coxæ; genital grooves diverge slightly to a point about half way between coxæ IV and anus, whence they diverge markedly toward lateral margin; median postanal groove present. Stigmal plates 0.384 to 0.4 mm. long (through unusually large aperture and chamber); 0.352 to 0.384 mm. broad, including prominent projection; goblets 73 to 99 in number, 7 to 30 μ in diameter. Capitulum: 0.83 to 0.94 mm. long; base 0.656 to 0.72 mm. broad, 0.24 to 0.27 mm. from posterior margin to anterior margin over palpi; postero-lateral angles short, 16 to 48 μ, bluntly rounded. Porose areas nearly circular to rather oval, do not meet in median line. Mandibles attain 1.12 mm. long; digit 128 μ long; external article with three teeth, proximal large, subapical smaller, apical very small; dorsal process of internal article apparently with two prongs. Hypostome with smaller terminal denticles, followed by three rows of large denticles, ten to twelve in each row, disappearing median to lateral. Each palpus attains 0.59 to 0.64 mm. long, by 0.256 mm. broad; article 1 triangular to nearly quadrangular ventrally, with four ventro-median bristles; article 2 much longer than broad, with five ventro-median bristles; article 3 nearly quadrangular dorsally, with two to three ventro-median bristles; article 4 small, ventro-subterminal of article 3 and with several bristles. Coxæ II to IV diverge; median spur on coxæ I unusually short when compared with lateral spur, which attains 160 μ in length and shows a tendency to curve laterad; tarsi I with very poorly developed terminal spur; spur on tarsi II to IV slender, not very prominent.

Young female.—Length 3.375 to 3.875 mm. long (exclusive of hind legs; with hind legs extended attains 5.0 to 5.3 mm.); greatest breadth 2.0 to 2.625 mm. Body elongate oval to broad oval; unmounted specimens 0.8 to 0.88 mm. broad at scapulæ; the sides diverge from here in a markedly convex line (which is slightly interrupted between legs I and II) to their maximum, when they converge rapidly, forming a bluntly rounded caudal margin. Dorsum: Scutum covers 0.43 to 0.50 of length of body (exclusive of head); postero-marginal festoons evident but not unusually prominent. Foveolæ a short distance caudad of scutum, 64 to 112 μ in diameter. Venter: Vulva between coxæ II. Anus nearer caudal than lateral margins.

Replete female.—May attain 10.3 mm. long by 7 mm. broad by 5 mm. thick. Form oval. Legs I lateral of scutum so that anterior margin of body (back of head) seems almost straight and attains 1.84 mm. in breadth; from here body increases rapidly in breadth to its maximum in the region of coxæ IV; no constriction visible at stigmal plate; caudal end very bluntly rounded. Dorsum: Eyes slightly more distant than in young female, owing to their more prominent position, due to change in form of body. Scutum with rust at margins as in young female. Median and submedian grooves visible as lines, and a pair of broken grooves (indicated as lines) lateral of submedian grooves. Venter: Vulva has shifted to anterior of plane of coxæ II. Genital groove still distinct, postanal groove appears merely as a line. Legs: Coxæ much farther apart, due to repletion.

TYPE.—Collection, Banks, Washington, D. C.

Of this form I have seen the following specimens:

Marx 137. Host, Jack rabbit; Fort Bowie, Ariz.; determined by Neumann as *Dermacentor electus.*

Marx 139. Host, Jack rabbit; Fort Bowie, Ariz.; determined by Neumann as *Dermacentor electus.*

? Marx 142. Host and locality ?; determined by Neumann as *Dermacentor electus.* This is a member of the *andersoni* group, and is probably the same as 137, but the material is not very favorable for identification.

B. A. I. 3415. Host, *Lepus campestris;* Deming, N. Mex.; collected by A. H. Wallace; determined by Stiles in 1902 as *D. reticulatus.*

Marx 129. Host (?), Elko, Mont.; determined by Marx as *D. americanus;* determined by Neumann as *D. electus;* two gravid females, not especially favorable for determination; clearly belonging to *andersoni* group, and apparently to *D. parumapertus marginatus.*

Figures 17 to 19 show the male and female plates of a tick which Neumann considered *D. electus.* Microscopic examination of the plates, however, shows that we are dealing with specimens of the *Andersoni* group, for the goblets are of medium size. In the male (fig. 17) the plate resembles that of the male *D. venustus* and *D. occidentalis* to some extent; in the female, the plate reminds one strongly of that of *D. parumapertus.* The convexity of the plate, the arrangement and the circular form of the goblets, the very large aperture and chamber, and the very broad anterior margin (*m*) of the prolongation clearly distinguish this form from all others forms discussed in this paper, with the possible exception of *D. parumapertus.* It is desirable to study a number of specimens of the latter in order to decide upon the relation which these two forms bear to each other.

SALMONI GROUP.

We may next pass to three species (*D. nigrolineatus*, *D. salmoni*, and *D. variegatus* Neumann [= *D. albipictus* Packard, teste Banks], which by means of their stigmal plates can be easily distinguished from all other species of *Dermacentor* discussed in this paper; it is more difficult to distinguish *salmoni* from *variegatus* by this means, but the latter is very pilose and of different outline from *salmoni.*

The goblets in these species are large, namely, usually 30 to 85 μ in diameter, and hence relatively few (56–126) in number when compared with the *reticulatus* group.

DERMACENTOR NIGROLINEATUS (Packard 1869) Banks, 1907.

(Figs. 20–25, 60–64, 77, 78, 93, 94, 112, 113, 129, 130.)

1869: *Ixodes nigrolineatus* Packard, 1869b, 66 (on *Cervus virginianus*, Northern New York).

1907: *Dermacentor nigrolineatus* (Packard, 1869) Banks, 1907, 608.

Specific diagnosis.—*Dermacentor* (p. 18): ♂ and young ♀: Caudal margin semicircular. Color (alcohol specimens) dirty yellow to reddish brown; capitulum and legs may be either lighter or darker than body and scutum. Dorsum: Eyes rather distinct, salient in female, less prominent in male. Scutum without rust, punctations small, with short hairs. Venter: Genital pore surrounded by hairs (♂) which are much less numerous and less prominent in female; entire cuticle quite pilose, much like *D. variegatus.* Anal ring nearly circular, slightly broader than long, transverse diameter (mounted specimens) about 252 μ, sagittal diameter 240 μ. Stigmal plates without any dorso-lateral prolongation; aperture relatively small, preequatorial in male, less distinctly so in female; goblets rather large, 15 to 53 μ in diameter, more numerous in postequatorial than in preequatorial portion. Capitulum: Postero-lateral projections prominent, about 80 μ long. Hypostome, each half with a number of minute subterminal denticles, followed proximally by three rows of six to eight large denticles, followed by several smaller scale-like denticles. Palpi, both lateral and median margins convex; two to three bristles on ventro-median margin of article 1; three to five on same margin of article 2; two to three on same margin of article 3; article 3 rather triangular, in dorsal view, its distal margin somewhat rounded; dorso-retrograde prolongation at postero-median angle of article 2 may be indicated, but is insignificant if present. Legs: Lateral (outer) spur on coxæ I somewhat narrower than median (inner) spur, but of about same length; trochanter I with prominent sharp retrograde spine-like distal spur; ventral margins of femur IV, tibia III–IV and protarsus IV may bear slight spurs or knobs, but these if present are not at all prominent; tarsi I with small terminal spur.

Male.—Length, 3.36 to 4.0 mm. long (exclusive of hind legs); greatest breadth, 1.99 to 2.5 mm. Body oval; unmounted specimens attain 0.88 mm. broad at scapulæ; the sides diverge from here until they reach their maximum breadth at coxæ IV or at stigmal plates. Dorsum: Scutum covers nearly entire dorsum (except capitulum and caudal margin); scapulæ project about 0.208 mm. from border of excavation; cervical grooves not prominent, more distinct anteriorly than posteriorly; marginal groove not distinct, except at sides in some specimens; scutum dirty yellow to brownish, without rust; pseudoscutum very indistinct (one specimen) or absent; eleven postero-marginal festoons, the median may be distinctly narrower than the others; numerous minute punctations with short hairs present. Foveolæ near median margin of coxæ IV, may attain 64 to 80 μ in diameter. Venter: Ventral surface thickly beset with hairs. Genital pore between coxæ II; genital groove distinct, diverging rapidly caudad of coxæ IV. Stigmal plate 0.455 to 0.546 mm. long, 0.224 to 0.336 mm. broad; goblets about 68 in number and 15 to 53 μ in diameter. Capitulum: Small, may attain about 0.504 mm. in length; base 0.464 to 0.48 mm. broad, 0.20 mm. long from posterior margin to anterior margin of portion over palpi; postero-lateral prolongations about 80 μ long. Mandibles about 0.656 to 0.704 mm. long; digit attains 120 μ in length; external article with rather large recurved proximal tooth (smaller subapical tooth not observed), and very minute apical tooth; dorsal process of internal article elongate transversely with two visor-like transverse ridges. Hypostome with six to eight large denticles in each row. Palpi 0.320 to 0.368 mm. long, each palpus attains 0.184 to 0.224 mm. in maximum breadth; article 2 with four, article 3 with two to three bristles on ventro-median edge. Legs: Coxæ, lateral spurs of II to IV prominent, median spurs of II to IV small or absent; tibia III and femur, tibia, and protarsus IV with or without slightly developed knobs or spurs; tarsi I with small or fairly well developed terminal spur, tarsi II to III with subterminal and terminal spurs, tarsi IV apparently with terminal spur only.

Young female.[a]—Length 5 to 6.6 mm. (exclusive of hind legs); greatest breadth 3 to 3.3 (unmounted) to 4.99 mm. (mounted). Body rather elongate oval; unmounted specimens attain about 0.80 to 0.96 mm. broad at scapulæ, specimens mounted under pressure attained only a slightly greater breadth, 0.992 mm.; the sides diverge from here to a maximum breadth about at coxæ III to IV, then they may run nearly parallel for a short distance or converge at first gradually, then more rapidly to bluntly rounded caudal margin. Dorsum: Scutum covers nearly 0.32 of body length (one specimen) (exclusive of capitu-

[a] Specimens poorly preserved as to form.

lum); 1.12 to 1.44 mm. long in median line; 0.992 to 1.312 mm. broad at lateral angles; rust absent; scapulæ project 0.176 mm. from border of excavation; from shoulders, the sides of the scutum curve (convexity laterad) to the lateral angles, then converge with somewhat sigmoid course to more or less pointed posterior angle. Cervical grooves distinctly deeper cephalad than caudad, each forming mediad the concave side of an hourglass. Punctations small, with fine hairs, but in unmounted material a few large punctations also are seen. Eyes rather salient, at lateral angles, very dark in unmounted, translucent in cleared specimen. Uncovered portion of dorsum shows numerous fine punctations (circular pores) with fine hairs; also several longitudinal grooves (which can not be safely interpreted because of shrunken condition of specimens). Foveolæ 32 μ in diameter, between coxæ IV. Venter: Punctations and fine hairs present, but not so numerous as in male; genital grooves diverge gradually, then form curve (convexity mediad) caudad of zone of coxæ IV, then diverge rapidly latero-caudad; median postanal groove apparently present (material poor). Stigmal plate relatively much broader and shorter than in male, 392 μ long by 308 to 378 μ broad; goblets attain about 103 in number, usually 24 to 52 by 24 to 40 μ in diameter, extremes 17 and 52 μ. Vulva in zone between coxæ I and II. Capitulum (only one good specimen): About 0.72 mm. long; base 0.592 mm. broad, and 0.282 mm. long from posterior margin to anterior margin of portion over palpi; postero-lateral angles 48 to 64 μ long, rather blunt; porose areas broad, do not meet in median line. Mandibles about 0.88 mm. long; digit 120 μ long; external article with large proximal recurved tooth, smaller subapical and very small apical tooth; dorsal process of internal article with two teeth. Hypostome with numerous minute subterminal denticles, followed by three rows of larger denticles on each half, ten or more in each row, disappearing first from median, then intermediate, lastly from external row. Palpi 0.416 to 0.464 mm. long; each palpus may reach a maximum of 0.192 to 0.224 mm. in breadth; article 2 may have five, article 3 may have three bristles on ventro-median margin. Legs: Coxæ I to IV diverge gradually away from median line; coxæ I and trochanter I about as in male; knobs or spurs on tibia III, femur, tibia, and protarsus IV not prominent; tarsi I with fairly well developed terminal spur; tarsi II to IV with terminal spur and two small subterminal knobs.

Replete female.—Not seen.

Nymphal skin.—Stigmal plate with 14 goblets (fig. 25).

TYPE.—Museum of Comparative Zoology, Cambridge, Mass.

HOSTS.—Deer (New York, Wisconsin, Texas), *Equus caballus* (Oklahoma, Tennessee).

The specific diagnosis as given by Banks (1908, 48–49) reads as follows:

Male.—Rather pale red-brown, no white markings, but the black cæcal marks show through in most specimens as several irregular lines behind; legs more yellow-brown. Capitulum small and narrow, its posterior angles produced into long spines; palpi very small and stout. Dorsum slender, about one and two-thirds times as long as broad; middle anterior region smooth and shining, sides and behind densely punctured, and with many short hairs; lateral furrows not very distinct, twelve impressed lines behind, but the festoons are not as obvious as usual. Legs rather short, coxæ with usual spines, coxa IV but little wider at base than long; stigmal plate large, elliptical, without dorsal prolongation, and covered with many large granules.

Length of male, 3.5 mm.

Female.—Shield red-brown, without marks; legs similar; abdomen dark red-brown. Capitulum scarcely twice as broad as long; hind angles distinctly prolonged behind; porose areas large, oval, and distinctly separated; palpi small and short, not as long as width of capitulum. Shield plainly longer than broad, broadest much before the middle, tapering and almost pointed behind, with very few punctures. Legs small and short, the tarsi very short; coxæ with the usual spines, that on IV no longer than on III. Stigmal plate elliptical, of same shape as in male, no dorsal prolongation, and covered with many large granules.

Length of female shield, 1.2 mm.

Through the kindness of Mr. Nathan Banks I have been able to examine a male tick (U. S. P. H. & M. H. S. 10592) determined by him as *Dermacentor nigrolineatus*, host and locality not stated. This measures 3.46 mm. long by 1.99 mm. in greatest breadth.

The two stigmal plates (fig. 20) measure, respectively, 0.455 mm. long by 0.280 mm. broad, and 0.511 mm. long by 0.224 mm. broad. The outline of the plate is quite regular, without any indication of a dorso-lateral prolongation. There are 69 goblets present; these are circular to oval, 32 to 40 μ in diameter, and are more numerous in the postequatorial portion of the plate. The macula or pore is in the preequatorial portion of the plate.

Of other characters, the following may be mentioned:

The base of the capitulum (fig. 60) is 0.448 mm. broad; the postero-lateral angles project about 96 μ; the palpi are about 320 μ. Trochanter I has a well-developed sharp dorso-distal retrograde spur. The venter is thickly beset with hairs, and hairs and pores are numerous around the male genital pore.

A male of U. S. P. H. & M. H. S. 9992 (mounted) appears to be specifically identical with Banks's specimen. It was collected in New York. According to our catalogue record it was determined by Banks as *D. variegatus.*

It measures 3.36 mm. long by 2.33 mm. broad; the stigmal plates measure 0.518 by 0.322 and 0.546 by 0.336 mm.

There is a single female specimen of 9992. Unfortunately it is damaged. Its scutum (fig. 78) measures 1.34 mm. long; the stigmal plates are less elongate than in the male; they measure 0.392 by 0.308 mm. and 0.392 by 0.378 mm. There are 66 goblets present, which measure 22 to 42 μ in diameter. The injured body measures (mounted) 6.6 mm. long by 4.99 mm. broad, without the capitulum, which is lost.

B. A. I. No. 4288 contains three female ticks collected from *Equus caballus* in Davidson County, Tenn., by J. C. Drake, January 11, 1906. Two unmounted specimens measure 5.75 to 7.5 mm. long. One mounted specimen measured shows a scutum 1.46 mm. long. The stigmal plates measure 0.490 by 0.420 and 0.490 by 0.399 mm. On one plate there are 103 goblets measuring 24 to 52 μ in diameter. The plates agree fairly well with those of 9992, but as seen from the measurements they are somewhat larger. In absence of male specimens the specific determination is at present provisional, but I believe the specimens are specifically identical with 9992.

B. A. I. 4363, collected by W. B. Lincoln, January 18, 1906, at Bellaire, from *Equus caballus* (the host came from Oklahoma), agrees fairly will with Banks's specimen of *D. nigrolineatus*. A stigmal plate of a (nymp?) of 4363 is shown in figure 25.

Although the material at hand is not in very good condition, the characters given in the specific diagnosis could be recognized.

Salmon's Dermacentor—DERMACENTOR SALMONI new species.

(Figs. 26–36, 65, 66, 79, 95, 96, 114, 115, 131, 132.)

1901: *Dermacentor reticulatus* (Fabricius) of Salmon and Stiles, 1901a, 448–452, figs. 61, 169–177 [North American specimens only].—Banks, 1907, 608 (as syn. of *D. albipictus*); 1908, 55.—Hunter and Hooker, 1907, November 2, 50.

1910: *D. salmoni* Stiles, 1910, 55, figs. 26–36a, 65, 66, 79, 95, 96, 114, 115, 131, 132 (type host *Bos taurus*, in Oklahoma; type U. S. P. H. & M. H. S. 3191).

Specific diagnosis.—*Dermacentor* (p. 18): ♂, young and replete ♀: Caudal margin very bluntly rounded, anus nearer caudal than lateral margin. Color exceedingly variable, very light to very dark [when alive, No. 3179 changed color while being drawn, see figs. 169–172 of Salmon and Stiles, 1901a]. Dorsum: Eyes rather distinct. Scutum well provided with rust; punctations large and small. Venter: Genital pore surrounded by numerous hairs, especially in male. Anal ring nearly circular; in specimens mounted under pressure, 224 to 368 μ in longitudinal by 288 to 385 μ in transverse diameter. Stigmal plates with or without dorso-lateral prolongations; aperture (macula) rather elongate, not strikingly large; goblets about 50 to 100 in number, 26 to 85 μ in diameter, closely set and occupy nearly entire surface [these goblets correspond to the large wart-like punctations shown in figs. 176–177 of Salmon and Stiles, 1901a]; slightly deeper focus shows a finer structure of somewhat reticulate appearance, represented by the middle layer [and corresponding to the finer punctations in figs. 176–177 of Salmon and Stiles, 1901a]; in some parts of the plate, especially near the margin, these fine circles are visible at the same focus which shows the goblets, especially when the plate is slightly curved; the meshes vary in size and shape but may attain 8.8 to 17.6 μ in diameter; the deeper pores (stems of goblets) are about 8.8 μ in diameter; as focus is raised, these circular canals assume a conpressed, slit-like outline. Capitulum: Postero-lateral projections short. External article apparently with either two or three teeth, the terminal tooth exceedingly minute, and apparently sometimes lacking, at least not visible, the subterminal tooth larger, proximal tooth largest. Hypostome, each half with small subterminal denticles, followed by three rows of strong denticles, followed proximally by smaller scale-like denticles. Palpi, article 1 triangular to nearly quadrangular ventrally, with two to four ventro-median marginal bristles; article 2 with four to eight such bristles; article 3 slightly broader than long, its apex very blunt so that the article may appear almost quadrangular; a few subterminal and terminal bristles present; dorso-retrograde prolongation indicated on postero-median margin. Legs: The lateral spur on coxæ I may be slightly longer than the median spur; lateral spur of coxæ II–IV unusually sharp; trochanter I with dorso-distal rather prominent retrograde spur; terminal spur on tarsi I–IV usually well developed.

Male.—Length 4.1 to 5.7 mm. long (exclusive of hind legs); greatest breadth 2.3 to 3.6 mm., near stigmal plate. Body rather oval, sides (unmounted) decidedly convex; 0.96 to 1.12 mm. broad at scapulæ. Dorsum: Scutum covers entire dorsum (except capitulum); scapulæ project 0.16 to 0.32 mm. from border of excavation; cervical and marginal grooves distinct; pseudoscutum not at all prominent; scutum deep reddish brown, usually concealed for the most part by a silver white metallic rust with rose and green tinges; when rust is pronounced, there remain a number of reddish to brown spots more or less symmetrically placed; the most prominent are: (a) Four elongate spots arranged in a semicircle or nearly so and running longitudinally; (b′) two elongate lateral spots posterior of these, one on each side; (b^2) a dark median spot between, on same plane as b′ and covering foveolæ; (c) an elongate median spot and two elongate submedian spots; (d) the forked spot may be very prominent; several dark spots may be present in the postero-lateral festoons; numerous punctations present, with hairs. Marginal groove rather distinct. Foveolæ about at equator, and measuring 64 to 112 μ in diameter. Venter: Ventral surface with hairs and punctations which are noticeably more numerous around genital pore. Genital pore between coxæ II. Stigmal plates 0.518 to 0.714 mm. long by 0.294 to 0.406 mm. broad; goblets may attain 61 in number and 26 to 73 μ in diameter. Capitulum: Length, 0.480 to 0.640 mm. dorsally, 0.80 to 0.896 mm. ventrally; base, 0.48 to 0.576 mm. broad, only about half as long; postero-lateral projections may attain 112 μ long. Mandibles: 0.896 to 1.056 mm. long; digit, 120 μ; dorsal process of internal article elongated transversely, with two well-developed visor-like ridges. Hypostome with numerous subterminal minute denticles which extend an unusual distance proximally in median line; about seven to eight large denticles in each row, followed by scale-like denticles. Each palpus 400 to 576 μ long, 224 to 320 μ broad; article 1 nearly quadrangular, with two to four ventro-median bristles; article 2 with five to six, article 3 with three to four bristles on ventro-median margin. Legs: Coxæ IV large, of two types, the caudal margin may extend to plane of caudal margin of stigmal plate.

Female.—Dorsum: Scutum 1.32 to 2.03 mm. long in median line; 1.376 to 1.84 mm. broad at lateral angles; decidedly emarginate anteriorly; scapulæ project about 0.24 to 0.352 mm. from border of emargination; breadth of scutum at shoulders (unmounted) 1.0 to 1.28 mm.; from shoulders, the sides of the scutum diverge in a somewhat irregularly curved or in a nearly straight line to the lateral angles, then converge in a straight or irregular line to the blunt postero-lateral angles, when they change direction, converging more rapidly to the bluntly rounded posterior angle; the postero-lateral angle may be effaced. Cervical grooves may be rather pronounced, diverging anteriorly and posteriorly from a transverse plane passing through the eyes; they are rather deep anteriorly, shallow and broad posteriorly; they divide scutum into three distinct longitudinal areas; surface of scutum provided with a number of more or less uniformly distributed fine punctations, each bearing a short bristle or hair; on slightly deeper focus they show also a number of larger structures composed of more or less circular spots, apparently forming the insertion of muscle fibers. Eyes light or dark, rather prominent, at lateral angles; rust well distributed, but absent at lateral angles and in grooves; rust may also be absent from a portion of median line and from a divergent line laterally of each posterior branch of cervical groove. Uncovered portion of dorsum shows coarser and finer punctations, with hairs, a distinct median and two submedian furrows; short furrows may appear antero-laterally of submedian furrows; marginal furrow not distinct. Foveolæ round to oval, 64 to 144 μ in diameter. Venter: Punctations and fine hairs present, genital grooves run convex (laterad) caudally to a point slightly caudad of plane of coxæ IV, then they diverge toward the lateral margin; median postanal groove distinct in unmounted specimens. Stigmal plates 0.539 to 0.840 mm. long; 0.416 to 0.602 mm. broad; dorso-lateral projections short or absent; goblets attain about 70 in number and 26 to 85 μ in diameter. Capitulum: 0.608 to 0.768 mm. long (dorsally); base 0.608 to 0.704 mm. broad; 230 to 320 μ long from posterior margin to plane over palpi; dorso-lateral angles not very prominent, project 48 to 80 μ, blunt; porose areas deep, distinct and round, but in one specimen they meet in median line. Mandibles attain 0.8 to 1.13 mm. in length, digit 128 to 144 μ; dorsal process apparently bidentate, with base near terminal extremity. Smaller anterior denticles of hypostome confined to smaller area than in male, may be nearly absent; seven to ten large denticles in each longitudinal row, continued proximally by scales; first transverse row of large denticles may be somewhat irregular and may show four teeth. Palpi 0.448 to 0.608 mm. long by 0.240 to 0.324 mm. broad; dorsal retrograde projections small; article 2 about as broad as long; article 3 broader than long; its apex blunt so that it appears almost quadrangular dorsally; article 1 triangular ventrally, with three to four bristles; article 2 with four to eight bristles; article 3 with two to three bristles. Legs: Coxæ diverge I to IV; lateral spine of coxæ I may attain 256 μ long; ventral margin of protarsus and tarsus II, femur, tibia, protarsus and tarsus III, and tibia, protarsus, and tarsus IV may have small knobs.

Replete female.—May attain 17 mm. long by 12 mm. broad. Form varies with degree of repletion; legs I are lateral of scutum; from here body increases rapidly in breadth, reaching a maximum at about coxæ IV; there may be a constriction at plane of the feveolæ or at stigmata; posterior margin is very bluntly rounded, so that anus may be nearer posterior than lateral margin. (See Salmon and Stiles, 1901a, figs. 171–172). Foveolæ slightly preequatorial. Color is exceedingly variable; live specimens may change color while under observation, especially if background is changed; live specimens may be whitish to creamy color to a greenish or brown; alcohol specimens may be greenish to brown or even black. Dorsum: Dorsal surface may show two prominent longitudinal grooves, diverging slightly caudad and interrupted just caudad of foveolæ; a median groove extending from near foveolæ about to anus. Venter: Vulva may shift slightly forward of coxæ II or even to plane of spines on coxæ I; genital and anal grooves prominent. Legs: Coxæ I–IV diverge markedly.

Nymph.—A nymphal skin, about 4.5 mm. long, shows a stigmal plate 192 by 152 μ, with 17 goblets.

TYPE.—B. A. I. 3179.

HOSTS.—Horse (*Equus caballus*) in Tennessee; cattle (*Bos taurus*) in Oklahoma; collected also in Montana, and (?) Oregon.

Salmon and Stiles (1901a, 448–452, figs. 61, 169–177) confused with *Dermacentor reticulatus* of Europe certain American ticks which prove, from a study of the stigmal plates, to be distinct from the European form.

B. A. I. 2998 (see fig. 176 of Salmon and Stiles, 1901a) consists of five mounted specimens, one male, four females, none in very good condition. They were taken from *Bos taurus;* locality unknown; determined by Banks in 1898 as *D. 5-striatus;* determined by Stiles in 1901 as *D. reticulatus.* The stigmal plates are quite distinct from those of *D. variegatus* and of *D. nigrolineatus*. They present the following measurements in mm.:

Stigmal plates.	Body.	Size of scutum.	Breadth of base of capitulum.	Remarks.
Male: 0.714 × 0.490	....	....	....	
Female: 0.658 × 0.420; 0.616 × 0.420	ca. 12 × 10	(?)	0.576	Mounted, pressed.
Female: 0.658 × 0.504	ca. 10 × 8	1.68 long.	.784	Do.
Female: 0.623 × 0.448	6.6 × 4.86	1.456 × 1.376	.640	Do.
Female: 0.539 × ——; 0.574 × 0.364	ca. 11 × 7	1.328 × 1.42	.688	Do.

There is a very slight tendency, both in the male and in the female, to the formation of a dorso-lateral projection. The goblets (fig. 27) may attain 79 in number and 32 to 80 μ in diameter. The trochanter has a dorso-distal retrograde spur.

U. S. P. H. & M. H. S. 9724 contains two specimens (one male, one female), collected in Montana by Maj. P. M. Ashburn, U. S. Army; host is not given (horse ?); they possess certain striking resemblances to 2998, yet certain differences are noticed. Whether these differences are of specific value or individual variations can not be determined at present because of paucity of material. The following are the measurements in mm.:

Stigmal plates.	Body.	Size of scutum.	Breadth of base of capitulum.	Remarks.
Male: 0.518 × 0.378; 0.518 × 0.378	4.129 × 2.331	....	0.480	Mounted, pressed.
Female: 0.644 × 0.476; 0.644 × 0.476	4.928 × 2.797	1.84 × 1.84	.688	Do.

The striking difference to be noticed is the regularity of outline of the male plate as compared with that of 2998; the female plate agrees more closely with that of 2998. In number the goblets are 54 to 58 in the male and 51 to 55 in the female and 30 to 85 μ in size. Figures 28–34 show the two pairs of stigmal plates from two specimens and indicate that we have here a species which may exhibit considerable variation.

B. A. I. 3179 (compare figs. 169–172 of Salmon and Stiles, 1901a) contains four mounted specimens of fragments of three females; they were collected from *Bos taurus* in Oklahoma by W. F. Cantalow; determined by Stiles in 1901 as *D. reticulatus*. They appear to agree with 2998. The measurements, in millimeters, are as follows:

Stigmal plates.	Body.	Size of scutum.	Breadth of capitulum.	Remarks.
Female: 0.672×0.560; 0.686×0.560	....	2.03×1.76	0.752	Mounted, pressed.
Female: 0.616×0.518; 0.630×0.518	ca. 6×5	....	....	Do.
Female: \$0.840×——; \$0.800×0.608	ca. 8×6	....	....	Do.

This material is not very satisfactory, but, despite the large stigmal plate in one specimen, it is impossible at present for me to distinguish between these ticks and 2998. Figure 26, from this material, shows 78 goblets, 26 to 65 μ in diameter.

B. A. I. 3206 contains two mounted and twelve unmounted females, collected by Doctor Steddom from *Equus caballus* at Nashville, Tenn., February 27, 1901. Here again the general agreement of the plates with 2998 is very striking, despite certain pronounced differences. Still, as the plates on the two sides on single mounted specimens vary one from the other, it does not seem altogether justified to consider the form distinct from 2998. The millimeter measurements of the mounted specimens are as follows:

Stigmal plates.	Body.	Length of scutum.	Breadth of capitulum.	Remarks.
Female: 0.616×0.504; 0.616× ——.	ca. 14×12			Mounted, pressed.
Female: 0.630×0.462.				Do.

The goblets are about 71 in number and vary from 28 to 48 μ in diameter. A gravid, unmounted female attains about 17 mm. in length by 12 mm. in breadth.

U. S. P. H. & M. H. S. 10003, collected by Dr. E. C. Stevenson, contains four males and one female presenting the following measurements in mm.:

Stigmal plates.	Body.	Size of scutum.	Breadth of capitulum.	Remarks.
Male: 0.588×0.336.	5.43×3.19		0.576	Mounted, pressed.
Male: 0.602×0.322; 0.602×0.280.	5.46×3.26		.576	Do.
Male: 0.638×0.364; 0.700×0.294.	5.72×3.66		.640	Do.
Male: 0.700×0.350; 0.672×0.406.	5.66×2.79		.608	Do.
Female: 0.560×0.420; 0.560×0.420.	5.06×3.19	1.696×1.680	.768	Do.

These specimens present very marked variations among themselves and when compared with the other specimens listed here. The female plate agrees fairly well with 2998, but the male plates are quite different, being of a much more elongate pattern. Figure 36 shows a plate with 61 goblets measuring 30 to 60 μ in diameter. The variation in form and size of coxæ IV of the males is very striking.

The following specimens have been examined:

B. A. I. 2998. Host *Bos taurus;* loc. ? ; 1898; determined by Banks, 1898, as *Dermacentor 5-striatus;* determined by Stiles, 1901, as *D. reticulatus.*

B. A. I. 3179. Host *Bos taurus;* Oklahoma; collected by W. F. Cantalow; determined by Stiles, 1901, as *D. reticulatus.*

B. A. I. 3026. Host *Equus caballus;* Nashville, Tenn.; collected by Steddom, February 27, 1901.

U. S. P. H. & M. H. S. 9724. Host— ? ———; Montana; collected by Maj. P. M. Ashburn, U. S. Army.

U. S. P. H. & M. H. S. 9756. Male and female from U. S. National Museum; bears the label "*Ixodes oregonensis*," but without further data.

U. S. P. H. & M. H. S. 9769. Belongs to U. S. National Museum, original No. 1348; no further data.

U. S. P. H. & M. H. S. 10003. Received from Dr. E. C. Stevenson.

In the specimens just listed, we evidently have *dermacentors* which agree very closely in respect to their goblets, scuta, and base of capitulum. The outline of the stigmal plate varies exceedingly, its size moderately. In order to determine whether these variations are individuar or specific, it is desirable to have a large number of specimens taken from one host animal. At present, despite the variations mentioned, I do not feel justified in separating the forms into distinct species, although it seems very possible that 10003 may eventually be separated out as a distinct systematic unit.

The original determination of *D. reticulatus* for this species was based upon specimens found in the collection of the Bureau of Animal Industry. Later, they were recognized as distinct. Banks (1907, 608), on basis of the figure Salmon and Stiles (1901a, fig. 177) published of the stigmal plate identified the form with *D. variegatus*= *D. albipictus*, but in this he has been led into error.

DERMACENTOR ALBIPICTUS Packard, 1869 seu VARIEGATUS Marx, 1897.

(Figs. 37–39, 67, 68, 80, 97, 98, 116, 117, 133.)

1868: *The Moose Tick* Hays and Packard, 1868, December, 559, fig. 1a–e (on the Moose; Nova Scotia).

1869: *Dermacentor albipictus* Packard, 1869, 662–663; 1869, 365–366.

1897: *D. variegatus* Marx and Neumann, in Neumann, 1897a, 367–370, 383, figs. 22–24 (type locality U. S. A.).—Salmon and Stiles, 1901a, 452–454, figs. 178–185.

Banks (1907, 608) has identified *D. variegatus* with *D. albipictus*. He tells me that he has examined the type of both and that there is no question regarding their identity. On his authority they are here accepted as synonymous. He also considers "*D. reticulatus*" of Salmon and Stiles as belonging to the same species, but as will be shown in this paper I can not concur with him in this view.

The specimens used as basis for the present discussion of *D. albipictus* are *D. variegatus*.

SPECIFIC DIAGNOSIS.—*Dermacentor* (p. 18): ♂ and young ♀: Caudal margin very blunt, anus being nearer posterior than lateral margin. Color red to deep reddish brown, except for rust; capitulum and legs lighter. Dorsum: Eyes not very prominent. Scutum prominently emarginate cephalad; rather well provided with whitish rust, which varies considerably in different specimens; punctations and hairs numerous. Venter: Genital pore surrounded by numerous hairs, especially in male. Anal ring nearly circular, 320 μ long by 368 μ broad. Stigmal plates may be about as large as female coxæ IV; with or without short dorso-lateral prolongation; aperture rather prominent; goblets large, rather irregular in outline, 108 to 126 in number, 8 to 59 μ in diameter, closely set and occupy nearly or quite entire surface (see also Salmon and Stiles, 1901a, figs. 184, 185); meshes of middle layer about 8 μ in diameter; stem of goblets about 8 μ in diameter, circular on lower focus, but compressed, slit-like on higher focus. Capitulum: Postero-lateral projections of base 80 to 124 μ long, blunt. External article with three teeth, the proximal tooth large, next distal tooth smaller, disal tooth apical and often scarcely visible. Hypostome, each half with an unusually large number of small subterminal denticles, followed by three rows of strong denticles, followed proximally by small scale-like denticles. Palpi, article 1 nearly quadrangular ventrally, provided with four to five ventro-marginal bristles; article 3 slightly broader than long, its apex somewhat rounded, a few dorso-terminal and terminal bristles; dorso-retrograde prolongations of article 2 indicated on postero-median margin. Legs: The lateral spur of coxæ I slightly longer than the median; lateral spurs of coxæ II–IV unusually sharp; trochanter I with a dorso-distal rather prominent retrograde spine; terminal recurved spur on tarsi I–IV well developed.

Male.—Length 6.5 mm. (exclusive of hind legs; with hind legs outstretched, about 8 mm.); greatest breadth 4.3 mm. Body subtriangular; unmounted specimens 1.12 mm. broad at scapulæ, specimens mounted under pressure may measure up to 1.2 mm. at this point; the sides diverge from here in nearly a straight or in a curved line until they reach their maximum divergence about at stigmal plate. Dorsum: Scutum covers entire dorsum (except capitulum); scapulæ project 0.40 to 0.48 mm. from border of excavation; cervical groove very deep anteriorly, marginal groove distinct; scutum deep reddish brown, well provided with rust; pseudoscutum usually quite prominent, extending about 0.35 of length of scutum in median line; the most prominent red spots back of pseudoscutum are: (a) Four elongate spots arranged radially or nearly so from caudal margin of pseudoscutum; (b) two elongate spots back of these, one on each side of the scutum; (c) an elongate median and two elongate submedian spots; (d) forked spot very prominent; spots also present on postero-lateral margins; numerous minute punctations and some slightly larger punctations, with hairs present. Foveolæ about in equator of scutum and measuring 96 μ in diameter. Venter: Ventral surface finely punctate with numerous minute white hairs, noticeably more numerous and larger punctations around genital pore. Genital pore between coxæ II. Stigmal plates 0.688 to 0.848 mm. long (through the aperture); breadth of plate (including prolongation when present) 0.48 to 0.683 mm.; goblets attain 126 in number and 15 to 59 μ in diameter. Capitulum: 0.700 to 0.816 mm.; base 0.688 to 0.80 mm. broad, and 0.368 mm. long from posterior margin to anterior margin over palpi; postero-lateral projections rounded, 128 μ long. Mandibles 1.1 to 1.2 mm. long; digit 185 μ; dorsal process of internal article elongate transversely in two nearly parallel ridges like two visors of a cap. Hypostome with six to eight large denticles in each row. Palpi 0.56 to 0.672 mm. long, each palpus 0.32 to 0.352 mm. in maximum breadth; shorter than in female, especially article 2; article 2 with six to seven ventro-median bristles; article 3 with three to four ventro-median bristles. Legs: Coxæ IV large, the caudal margin attaining plane of caudal margin of stigmal plate, the median margins nearly parallel for some distance; ventral spurs or knobs may be present on tarsus I, protarsus and tibia II, and especially on femur, tibia, protarsus, and tarsus IV; tarsi II to IV with subterminal spur.

Female.—Dorsum: Scutum 1.776 to 2.128 mm. long in median line; 1.8 to 1.9 mm. broad at lateral angles; very prominent because of size and rust; scapulæ project about 0.468 mm. from border of excavation; from shoulders sides of scutum diverge in rather strongly convex line to lateral angles, then converge in straight or somewhat convex line to postero-lateral angles, then they converge more rapidly to the bluntly rounded posterior angle. Cervical grooves diverge anteriorly and posteriorly from plane passing through the eyes, deeper anteriorly, not especially broad posteriorly; eyes at lateral angles; punctations fine and numerous; color light brown with thin white rust of slightly metallic effect and leaving exposed a median longitudinal band, the cervical grooves, a small band laterally of posterior branch of grooves, and a distinct brown spot median of eyes. Uncovered portion of dorsum shows numerous punctations with hairs, a distinct median, two submedian, and well marked marginal grooves; additional grooves may appear between submedian and marginal grooves. Foveolæ round to oval, 128 to 144 μ in diameter, a short distance caudad of scutum. Venter: Numerous punctations and fine hairs present; genital grooves run subparallel to a point about midway between coxæ IV and anus, whence they diverge markedly toward lateral margin. Stigmal plates 0.736 to 0.784 mm. long by 0.64 to 0.70 mm. broad; goblets 8 to 49 μ in diameter, may attain 108 (in nymph 14) in number. Capitulum: 0.8 to 1 mm. long; base 0.768 to 0.8 mm. broad; 0.288 mm. long from posterior margin to anterior margin over palpi; postero-lateral prolongations 80 μ; porose areas deep, roundish to rather oval, diverging anteriorly. Mandibles attain 1.28 to 1.42 mm. long; digit 180 μ long; internal apophysis (dorsal process) distinctly tridentate, the median tooth shortest. Smaller anterior denticles of hypostome numerous; nine to ten large denticles in each row. Palpi may attain 0.768 mm. ventrally, by 256 to 320 μ broad, not extending laterally of base of capitulum; article 2 longer than broad; dorso-retrograde projection small; article 3 slightly broader than long, its apex rounded; article 1 with seven ventro-median bristles; article 2 and with nine ventro-median bristles; article 3 with three ventro-median bristles. Legs: Coxæ diverge II to IV; lateral spine of coxæ IV may attain 320 μ long; ventral margin of tibia and tarsus II, femur, tibia, protarsus and tarsus III, and tarsus IV may have small knobs.

Young female.—Length 5.5 to 6 mm. (exclusive of hind legs; with hind legs extended may attain 8 mm.); greatest breadth 3 mm. Body rather subtriangular, depressed, sides may be nearly straight and nearly parallel for some distance; unmounted specimens 1.28 mm. broad at scapulæ, specimens mounted under pressure may attain 1.28 mm. at this point; the sides diverge from here to the maximum breadth about at coxæ IV or at stigmal plate. Dorsum: Scutum covers about 0.40 of length of body (exclusive of head); eyes distinct but not prominent. Venter: Vulva between coxæ II.

Replete female.—May attain 17 mm. long by 10 mm. broad. Form varies with degree of repletion.

Nymph.—Length 5 to 6 mm.; breadth 3 to 3.5 mm.; sides nearly parallel; both ends bluntly rounded; anus nearer lateral than posterior margin. Goblets about 14 in number.

TYPE.—Type-specimen of *D. albipictus* is, teste Banks, in the Museum of Comparative Zoology.

HOSTS.—Moose, wapiti, and beaver.

The stigmal plate in this species was figured by Salmon and Stiles (1901a, figs. 184–185) from specimens not treated with caustic, and the fact was pointed out that it was coarsely punctate. From the new point of view, these coarse punctations represent the goblets.

The first reference to the moose tick appears to be the following:

The moose tick.—On the 13th of April a pair of young moose were brought through New York on their way to Europe. They were raised in Nova Scotia, and being very tame, were allowed to run at large. The cow moose would ramble off in the woods, and while there had become infested with ticks; the bull had escaped contact with these insects. When the cow arrived in New York her sides and back were almost covered with adult ticks. The insects were removed, very much to the relief of the animal, and the ticks were placed in a bottle without food or water. On the 1st of May they commenced to lay eggs, and continued to do so until the 25th of June, when they died. The eggs are forced out in large masses. On the 3d of July, the day after I sent the drawings to you, the entire mass of eggs seemed to hatch out at once, the shell opening like a clam, and releasing a six-legged insect.—W. J. Hays.

[The specimens sent us by Mr. Hays are very interesting, as showing that the young tick has only three pairs of legs instead of four, which all adult spiders and mites (*Arachnida*) possess. This is a strong argument for the supposition that the *Arachnids* form an order in the class of insects and not an independent class. Figure 1 e represents the adult tick, drawn by Mr. Hays. The six-footed young has enormous legs, and the head is separated from the hind body, where in the adult it is sunken in the thorax; d, shows the claws, with a broad sucking disk beneath, enabling it to adhere to objects. On the right is a magnified drawing of the mouth parts of the young; a, is the labium, armed with hooks; b, the maxillæ, probably, also armed with powerful hooks; and c, the mandibles. Thus armed, the young tick buries itself in the flesh of its victim.—Eds.]—Amer. Nat., v. 2 (10), 1868, p. 559.

Packard (1869, September, 365; 1869, 662–663) republished the figures, but added no details except that "the opening of the oviduct is just behind the head, between the anterior pair of feet, so that the eggs appear as if ejected from the mouth."

The specimens taken as basis for the present study are:

B. A. I. 3172. Host Wapiti or moose; Blue Mountain, New Hampshire; determined by Stiles and Hassall, 1899, as *D. variegatus*.

Banks has examined specimens from Adirondack Mountains, New York; Michigan, Nebraska, Montana, Idaho, Nevada, and Washington State.

NITENS GROUP.

DERMACENTOR NITENS Neumann, 1897.

(Figs. 40–43, 69, 70, 81, 99, 100, 118, 119, 134.)

1897: *Dermacentor nitens* Neumann, 1897a, 376–378, fig. 28 (on *Equus caballus;* Jamaica, also Santo Domingo).—Banks, 1908, 50–51, pl. 7, figs. 7, 10; (Jamaica, Santo Domingo, Texas, Haiti).—Salmon and Stiles, 1901a, 455, figs. 215–218 (*Equus caballus;* Porto Rico).

The peculiar structure of the stigmal plates of this species was noticed by Neumann. In the present paper it will be sufficient to show illustrations from the new point of view of the goblets (see figs. 40 to 43).

In a male specimen examined the goblets were five in number and varied from 43 to 88 μ in diameter. In a female, the goblets were six in number and varied from 78 to 115 μ in diameter.

Banks (1908, p. 51) reports this species from Jamaica, Santo Domingo, Haiti, Texas, and Arizona.

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LIST OF HYGIENIC LABORATORY BULLETINS OF THE PUBLIC HEALTH AND MARINE-HOSPITAL SERVICE.

The Hygienic Laboratory was established in New York, at the Marine Hospital on Staten Island, August, 1887. It was transferred to Washington, with quarters in the Butler Building, June 11, 1891, and a new laboratory building, located in Washington, was authorized by act of Congress, March 3, 1901.

The following *bulletins* [Bulls. Nos. 1-7, 1900 to 1902, Hyg. Lab., U. S. Mar. Hosp. Serv., Wash.] have been issued:

*No. 1.—Preliminary note on the viability of the *Bacillus pestis*. By M. J. Rosenau.

No. 2.—Formalin disinfection of baggage without apparatus. By M. J. Rosenau.

*No. 3.—Sulphur dioxid as a germicidal agent. By H. D. Geddings.

*No. 4.—Viability of the *Bacillus pestis*. By M. J. Rosenau.

No. 5.—An investigation of a pathogenic microbe (*B. typhi murium* Danyz) applied to the destruction of rats. By M. J. Rosenau.

*No. 6.—Disinfection against mosquitoes with formaldehyd and sulphur dioxid. By M. J. Rosenau.

No. 7.—Laboratory technique: Ring test for indol, by S. B. Grubbs and Edward Francis; Collodium sacs, by S. B. Grubbs and Edward Francis; Microphotography with simple apparatus, by H. B. Parker.

By act of Congress approved July 1, 1902, the name of the "United States Marine-Hospital Service" was changed to the "Public Health and Marine-Hospital Service of the United States," and three new divisions were added to the Hygienic Laboratory.

Since the change of name of the Service the bulletins of the Hygienic Laboratory have been continued in the same numerical order, as follows:

*No. 8.—Laboratory course in pathology and bacteriology. By M. J. Rosenau. (Revised edition, March, 1904.)

*No. 9.—Presence of tetanus in commercial gelatin. By John F. Anderson.

No. 10.—Report upon the prevalence and geographic distribution of hookworm disease (uncinariasis or anchylostomiasis) in the United States. By Ch. Wardell Stiles.

*No. 11.—An experimental investigation of Trypanosoma lewisi. By Edward Francis.

*No. 12.—The bacteriological impurities of vaccine virus; an experimental study. By M. J. Rosenau.

*No. 13.—A statistical study of the intestinal parasites of 500 white male patients at the United States Government Hospital for the Insane; by Philip E. Garrison, Brayton H. Ransom, and Earle C. Stevenson. A parasitic roundworm (*Agamomermis culicis* n. g., n. sp.) in American mosquitoes (*Culex sollicitans*); by Ch. Wardell Stiles. The type species of the cestode genus *Hymenolepis*; by Ch. Wardell Stiles.

No. 14.—Spotted fever (tick fever) of the Rocky Mountains; a new disease. By John F. Anderson.

No. 15.—Inefficiency of ferrous sulphate as an antiseptic and germicide. By Allan J. McLaughlin.

*No. 16.—The antiseptic and germicidal properties of glycerin. By M. J. Rosenau.

*No. 17.—Illustrated key to the trematode parasites of man. By Ch. Wardell Stiles.

*No. 18.—An account of the tapeworms of the genus *Hymenolepis* parasitic in man, including reports of several new cases of the dwarf tapeworm (*H. nana*) in the United States. By Brayton H. Ransom.

*No. 19.—A method for inoculating animals with precise amounts. By M. J. Rosenau.

*No. 20.—A zoological investigation into the cause, transmission, and source of Rocky Mountain "spotted fever." By Ch. Wardell Stiles.

No. 21.—The immunity unit for standardizing diphtheria antitoxin (based on Ehrlich's normal serum). Official standard prepared under the act approved July 1, 1902. By M. J. Rosenau.

*No. 22.—Chloride of zinc as a deodorant, antiseptic, and germicide. By T. B. McClintic.

*No. 23.—Changes in the Pharmacopœia of the United States of America. Eighth Decennial Revision. By Reid Hunt and Murray Galt Motter.

No. 24.—The International Code of Zoological Nomenclature as applied to medicine. By Ch. Wardell Stiles.

No. 25.—Illustrated key to the cestode parasites of man. By Ch. Wardell Stiles.

No. 26.—On the stability of the oxidases and their conduct toward various reagents. The conduct of phenolphthalein in the animal organism. A test for saccharin, and a simple method of distinguishing between cumarin and vanillin. The toxicity of ozone and other oxidizing agents to lipase. The influence of chemical constitution on the lipolytic hydrolysis of ethereal salts. By J. H. Kastle.

No. 27.—The limitations of formaldehyde gas as a disinfectant with special reference to car sanitation. By Thomas B. McClintic.

*No. 28.—A statistical study of the prevalence of intestinal worms in man. By Ch. Wardell Stiles and Philip E. Garrison.

*No. 29.—A study of the cause of sudden death following the injection of horse serum. By M. J. Rosenau and John F. Anderson.

No. 30.—I. Maternal transmission of immunity to diphtheria toxine. II. Maternal transmission of immunity to diphtheria toxine and hypersusceptibility to horse serum in the same animal. By John F. Anderson.

No. 31.—Variations in the peroxidase activity of the blood in health and disease. By Joseph H. Kastle and Harold L. Amoss.

No. 32.—A stomach lesion in guinea pigs caused by diphtheria toxine and its bearing upon experimental gastric ulcer. By M. J. Rosenau and John F. Anderson.

No. 33.—Studies in experimental alcoholism. By Reid Hunt.

No. 34.—I. *Agamofilaria georgiana* n. sp., an apparently new roundworm parasite from the ankle of a negress. II. The zoological characters of the roundworm genus *Filaria* Mueller, 1787. III. Three new American cases of infection of man with horse-hair worms (species *Paragordius varius*), with summary of all cases reported to date. By Ch. Wardell Stiles.

*No. 35.—Report on the origin and prevalence of typhoid fever in the District of Columbia. By M. J. Rosenau, L. L. Lumsden, and Joseph H. Kastle. (Including articles contributed by Ch. Wardell Stiles, Joseph Goldberger, and A. M. Stimson.)

No. 36.—Further studies upon hypersusceptibility and immunity. By M. J. Rosenau and John F. Anderson.

No. 37.—Index-catalogue of medical and veterinary zoology. Subjects: Trematoda and trematode diseases. By Ch. Wardell Stiles and Albert Hassall.

No. 38.—The influence of antitoxin upon post-diphtheritic paralysis. By M. J. Rosenau and John F. Anderson.

No. 39.—The antiseptic and germicidal properties of solutions of formaldehyde and their action upon toxines. By John F. Anderson.

No. 40.—1. The occurrence of a proliferating cestode larva (*Sparganum proliferum*) in man in Florida, by Ch. Wardell Stiles. 2. A reexamination of the type specimen of *Filaria restiformis* Leidy, 1880=*Agamomermis restiformis*, by Ch. Wardell Stiles. 3. Observations on two new parasitic trematode worms: *Homalogaster philippinensis* n. sp., *Agamodistomum nanus* n. sp., by Ch. Wardell Stiles and Joseph Goldberger. 4. A reexamination of the original specimen of *Tænia saginata abietina* (Weinland, 1858), by Ch. Wardell Stiles and Joseph Goldberger.

*No. 41.—Milk and its relation to the public health. By various authors.

No. 42.—The thermal death points of pathogenic micro-organisms in milk. By M. J. Rosenau.

No. 43.—The standardization of tetanus antitoxin (an American unit established under authority of the act of July 1, 1902). By M. J. Rosenau and John F. Anderson.

No. 44.—Report No. 2 on the origin and prevalence of typhoid fever in the District of Columbia, 1907. By M. J. Rosenau, L. L. Lumsden, and Joseph H. Kastle.

No. 45.—Further studies upon anaphylaxis. By M. J. Rosenau and John F. Anderson.

No. 46—*Hepatozoon perniciosum* (n. g. n. sp.); a hæmogregarine pathogenic for white rats; with a description of the sexual cycle in the intermediate host, a mite (*Lelaps echidninus*). By W. W. Miller.

No. 47.—Studies on Thyroid.—I. The relation of Iodine to the Physiological Activity of Thyroid Preparations. By Reid Hunt and Atherton Seidell.

No. 48.—The Physiological Standardization of Digitalis. By Charles Wallis Edmunds and Worth Hale.

No. 49.—Digest of comments on the United States Pharmacopœia. Eighth decennial revision for the period ending December 31, 1905. By Murray Galt Motter and Martin I. Wilbert.

No. 50.—Further studies upon the phenomenon of anaphylaxis. By M. J. Rosenau and John F. Anderson.

No 51.—Chemical tests for blood. By J. H. Kastle.

No. 52.—Report No. 3 on the origin and prevalence of typhoid fever in the District of Columbia (1908). By M. J. Rosenau, L. L. Lumsden, and Joseph H. Kastle.

No. 53.—The influence of certain drugs upon the toxicity of acetanilide and antipyrine. By Worth Hale.

No. 54.—The fixing power of alkaloids on volatile acids and its application to the estimation of alkaloids with the aid of phenolphthalein or by the Volhard method. By Elias Elvove.

No. 55.—Quantitative pharmacological studies—adrenalin and adrenalin-like bodies. By W. H. Schultz.

No. 56.—Milk and its relation to the public health. [Revised edition.] By various authors.

No. 57—I. The presence of tubercle bacilli in the circulating blood in clinical and experimental tuberculosis. By John F. Anderson. II. The viability of the tubercle bacillus. By M. J Rosenau.

No. 58.—Digest of comments on the Pharmacopœia of the United States of America (eighth decennial revision) and the National Formulary for the period ending December 31, 1906. By Murray Galt Motter and Martin I. Wilbert.

No. 59.—The oxidases and other oxygen catalysts concerned in biological oxidations. By Joseph Hoeing Kastle.

No. 60.—A study of the anatomy of *Watsonius* (n. g.) *watsoni* of man, and of 19 allied species of mammalian trematode worms of the superfamily *Paramphistomoidea*. By Ch. Wardell Stiles and Joseph Goldberger.

No. 61.—Quantitative pharmacological studies: Relative physiological activity of some commercial solutions of epinephrin. By W. H. Schultz.

No. 62.—The taxonomic value of the microscopic structure of the stigmal plates in the tick genus *Dermacentor*. By Ch. Wardell Stiles.

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○

B reticulatus ♂

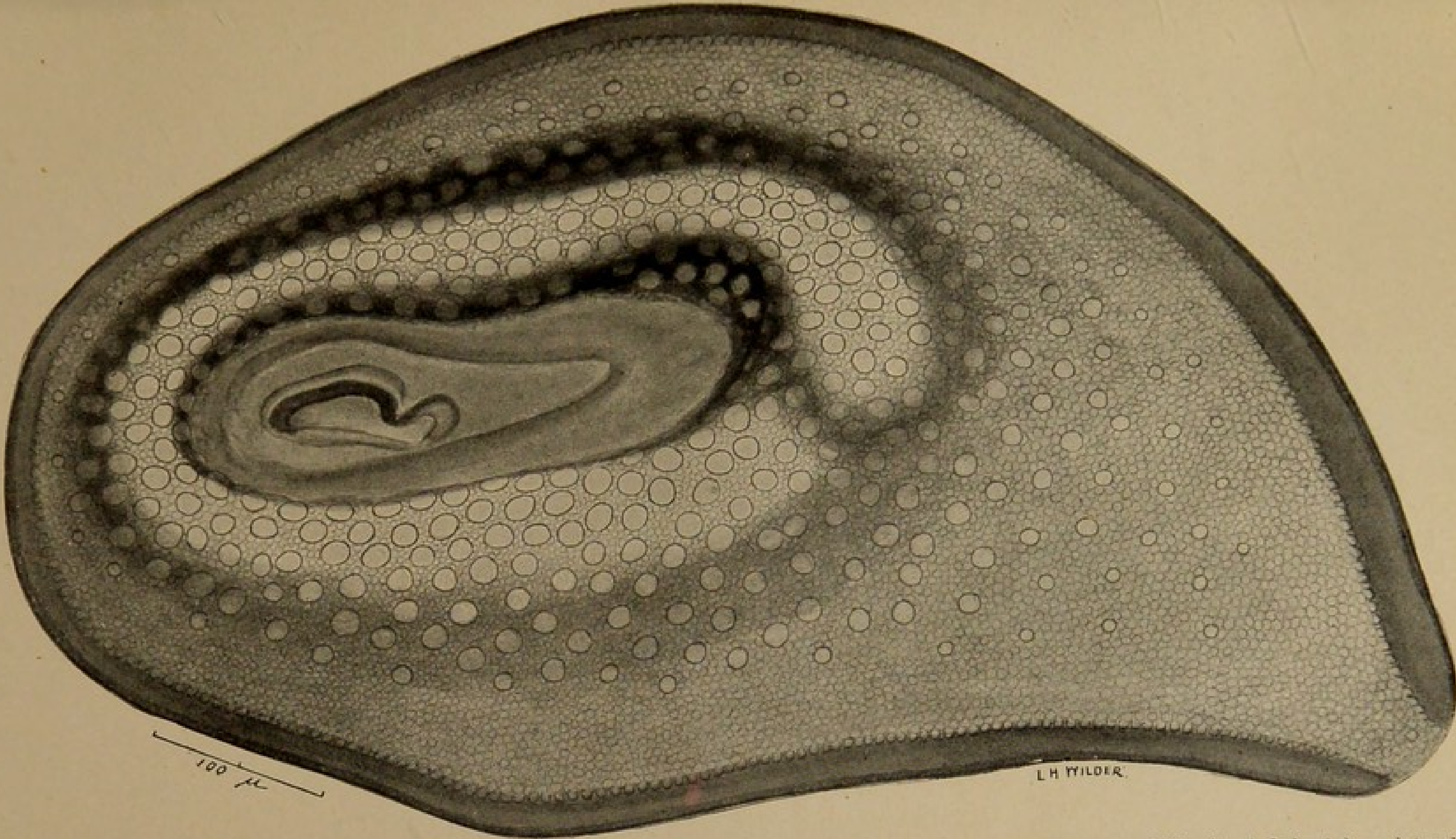


FIG. 1.—Stigmal plate of male of *Dermacentor reticulatus* of France. Notice the elongate form of the plate, with the caudally situated short dorso-lateral prolongation; the aperture is elongate, cephalad, and mediad of the center; the outline of the relatively large chamber under the aperture is seen; the goblets are numerous (378) and are much more thickly set near the aperture than near the periphery; toward the prolongation the goblets become sparse and smaller; the middle layer is visible as composed of very numerous circles which form a mesh work; upon examination with a hand lens the goblets appear as fine punctations, while at the periphery the circles of the middle layer may appear as excessively minute punctations. Greatly enlarged. Original. B. A. I. 3904.

D. reticulatus ♀

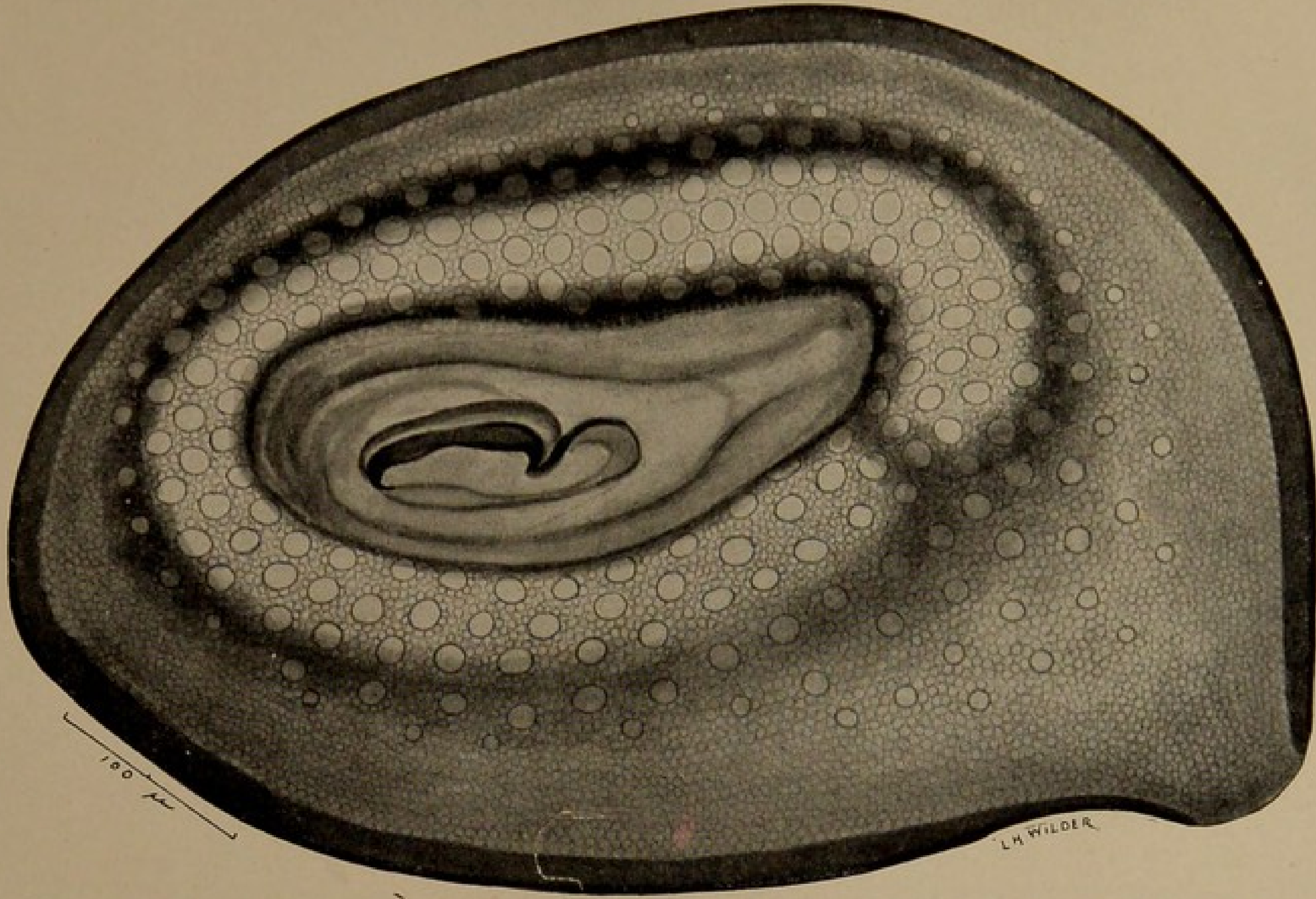


FIG. 2.—Stigmal plate of female of *D. reticulatus*. Notice that this is relatively less elongate than the male plate, but otherwise of the same general structure. Goblets are 215 in number. Greatly enlarged. Original. B. A. I. 3904.

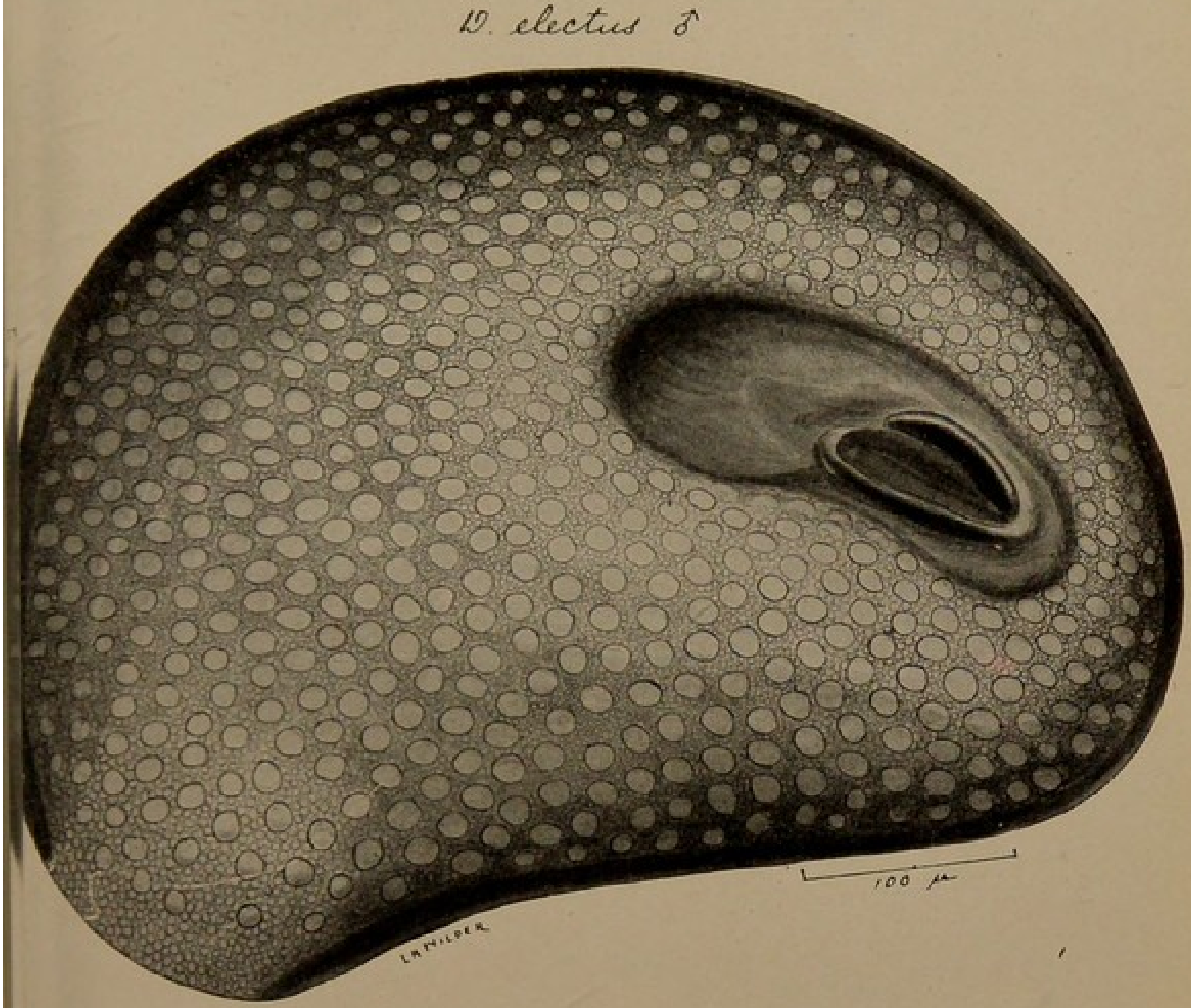


FIG. 3.—Surface view of stigmal plate of male *D. electus* [*D. variabilis*]. Notice the location of the aperture near the ventro-median-anterior margin; the plate is not so elongate as that of *D. reticulatus* and the dorso-lateral prolongation is subterminal; the goblets are 536 in number, rather evenly distributed; the circles of the middle layer are visible. Greatly enlarged. Original. U. S. P. H. & M. H. S. 9920.

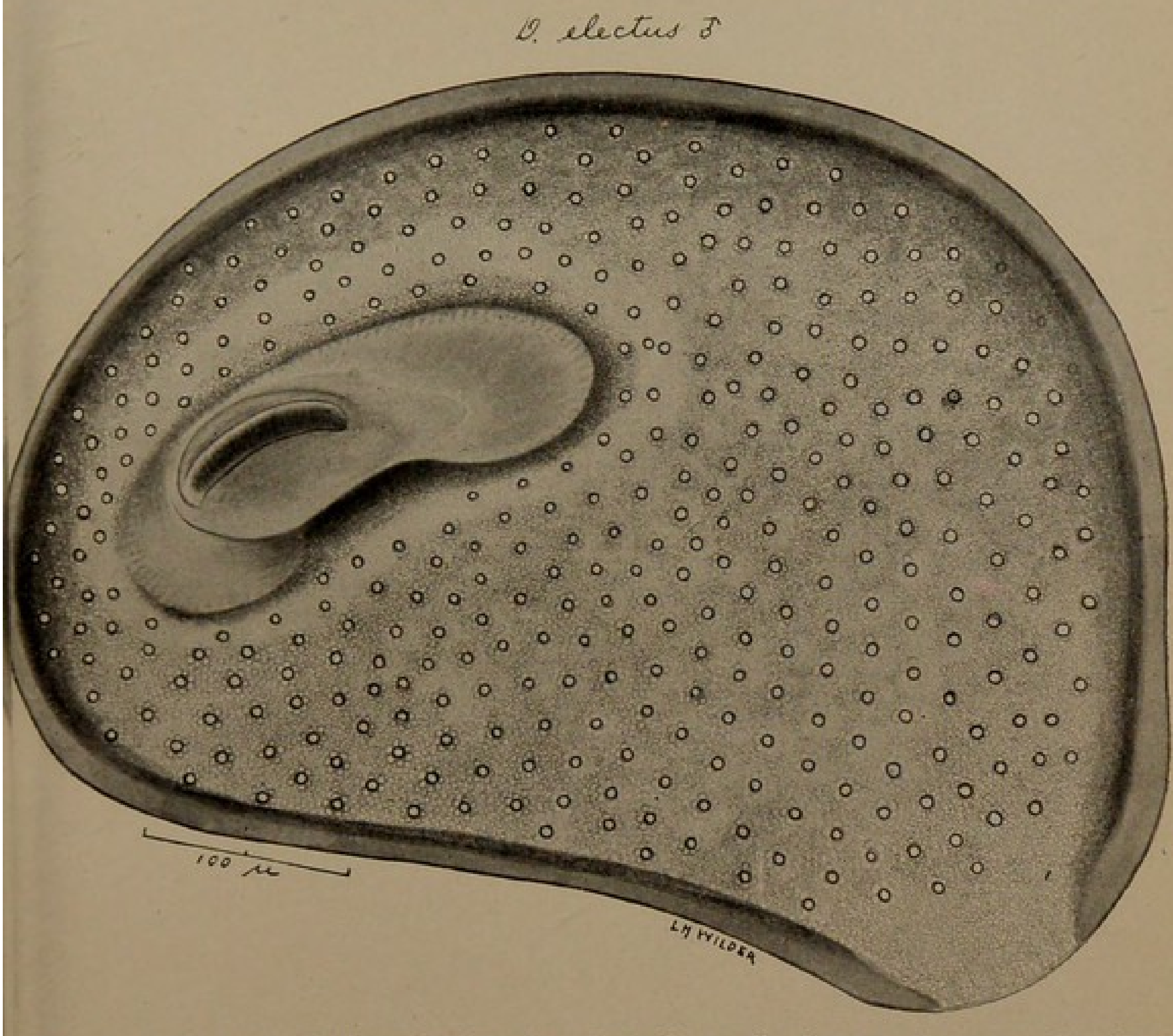


FIG. 4.—Deep focus of plate, showing the relatively small, elongate chamber under the aperture and the numerous circles (goblet stems) of the inner layer. Greatly enlarged. Original. U. S. P. H. & M. H. S. 9920.

D. electus ♀

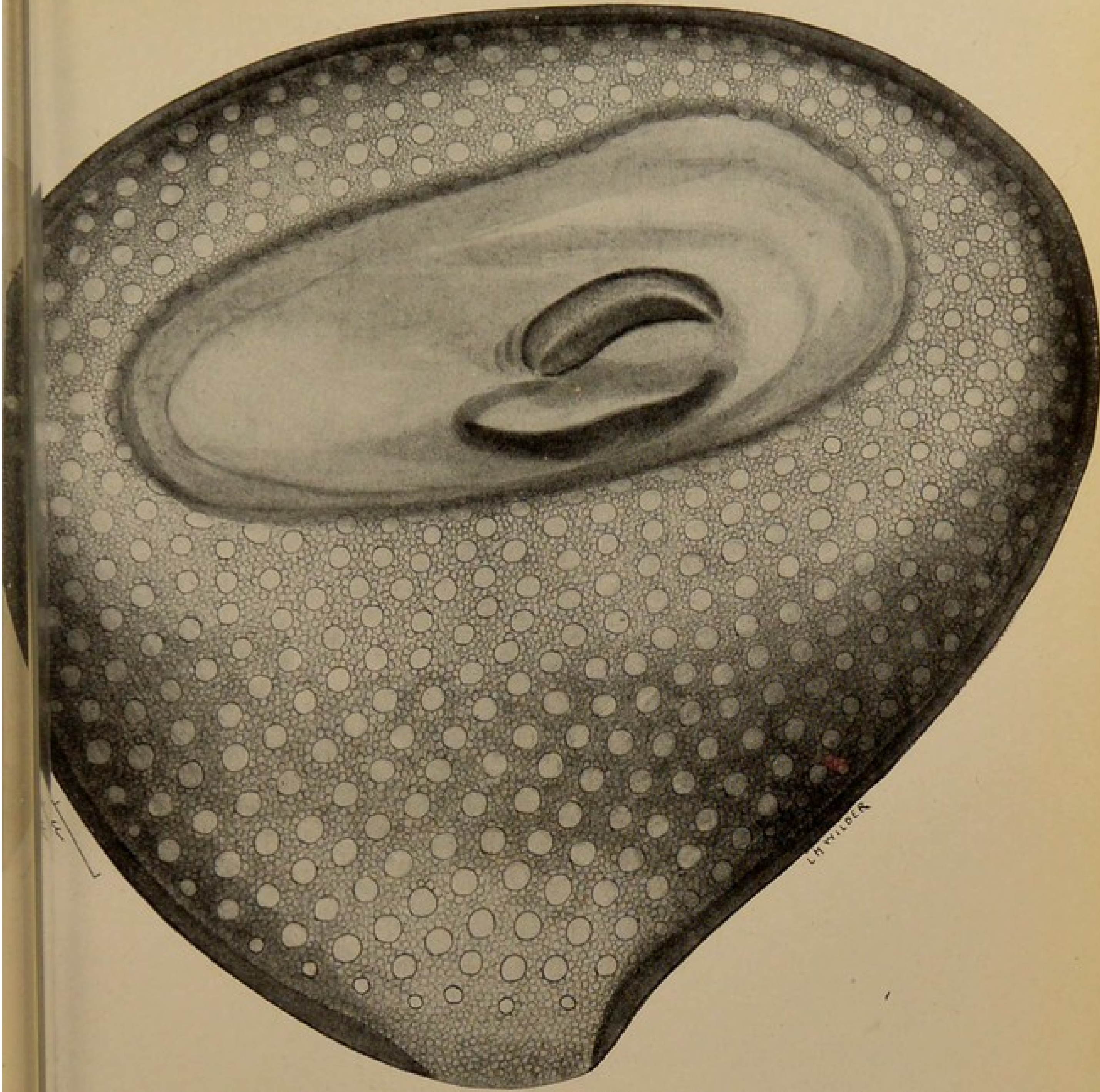


Fig —Female stigmal plate of *D. electus* seu *variabilis*. Notice that this plate is much broader than that of the male; 455 s are present, and the chamber is much larger; the dorso-lateral prolongation is just caudad of the equator. G y enlarged. Original. B. A. I. 3150.

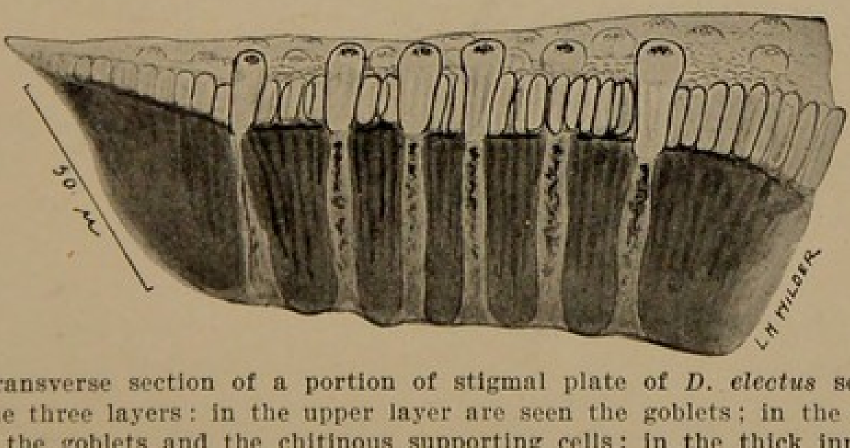


Fig. 6.—Transverse section of a portion of stigmal plate of *D. electus* seu *variabilis*. Notice the three layers: in the upper layer are seen the goblets; in the middle layer are seen the goblets and the chitinous supporting cells; in the thick inner layer are seen the stems of the goblets. Greatly enlarged. Original.

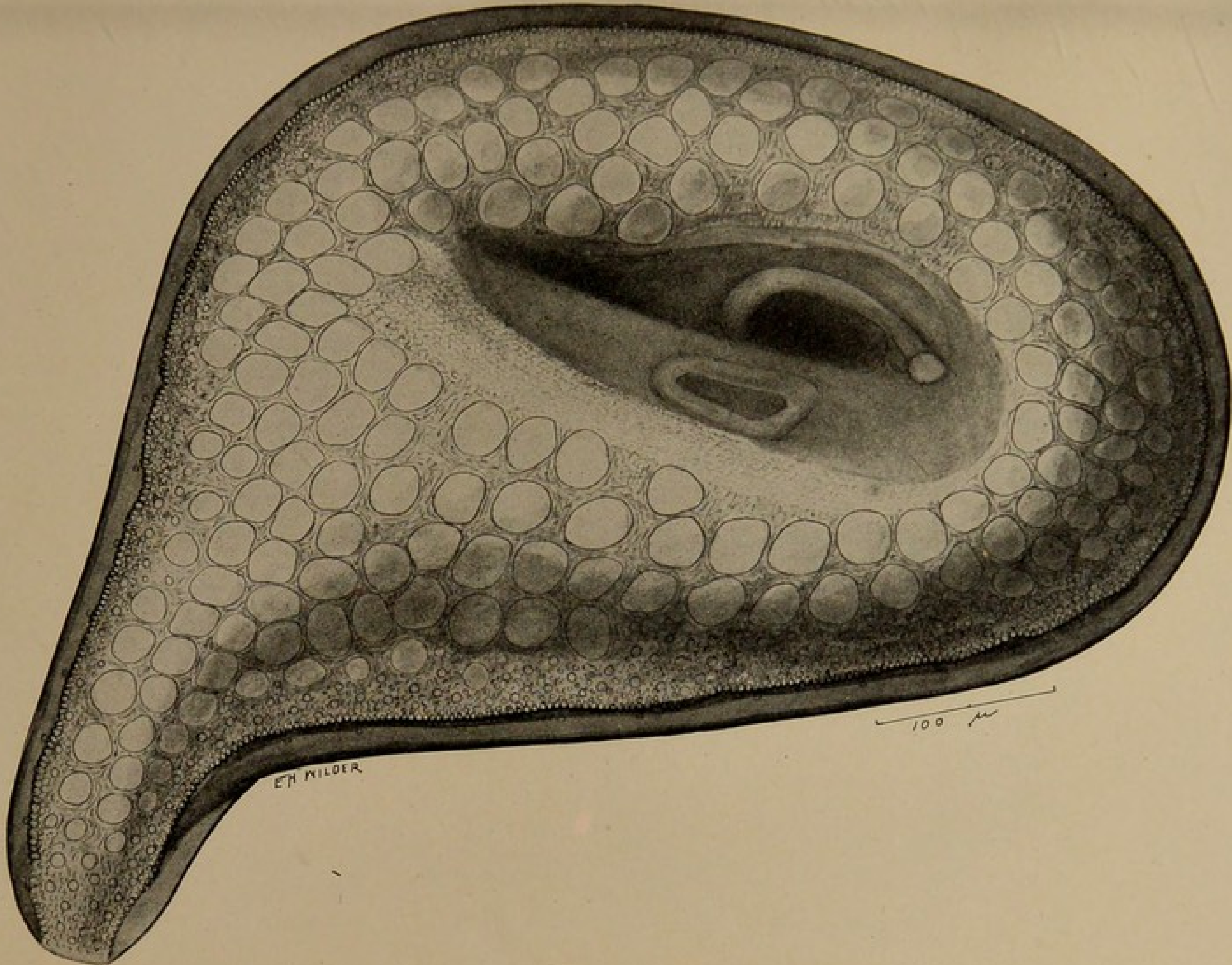


FIG. 9.—Stigmal plate of male *D. andersoni*. Notice the relatively large aperture and chamber and the prominent dorsolateral prolongation which forms a right angle at the caudal margin; the goblets are numerous (157) and evenly distributed, but are absent from the margin; the middle layer is visible. Greatly enlarged. Original. U. S. P. H. & M. H. S. 9466.

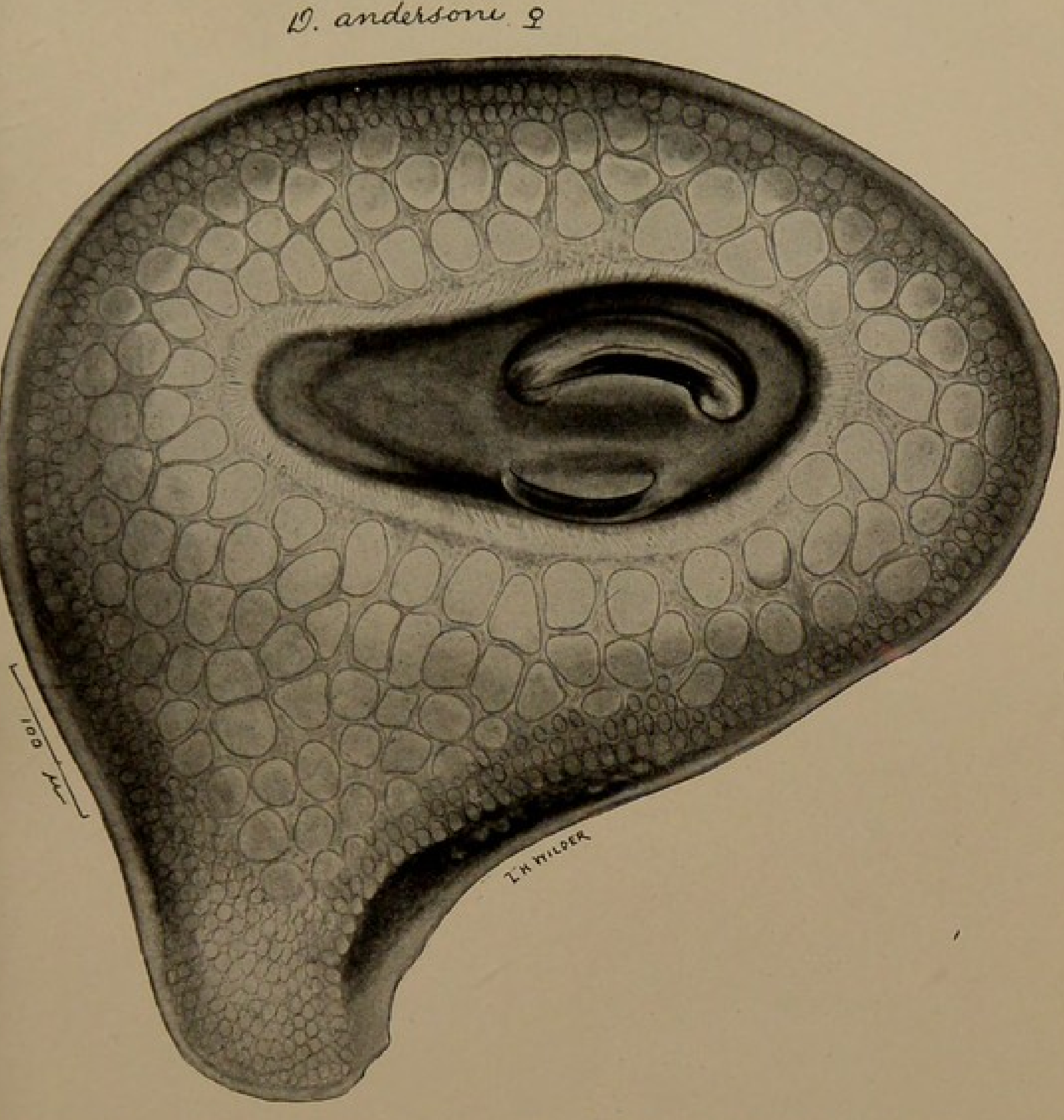


FIG. 10.—Stigmal plate of female *D. andersoni*. Notice the acute angle formed by the dorso-lateral prolongation; the anterior margin of the prolongation is broader than the caudal margin; 120 goblets are present. Greatly enlarged. Original. U. S. P. H. & M. H. S. 9503.

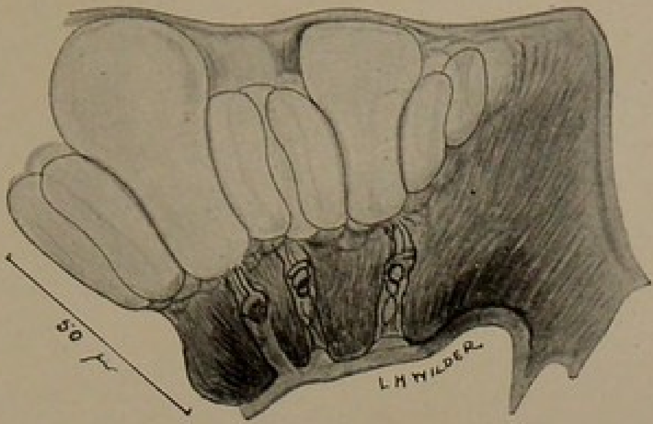


FIG. 11.—Section of a stigmal plate of *D. andersoni*. Greatly enlarged. Original.

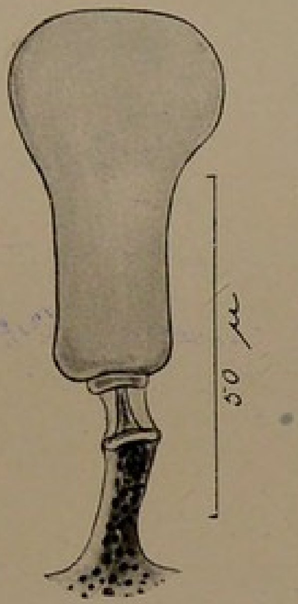


FIG. 12.—An isolated goblet of same. Greatly enlarged. Original.

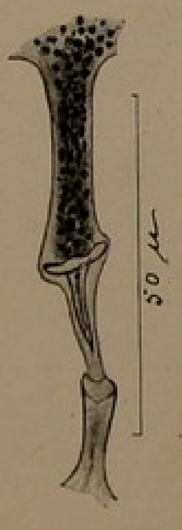


FIG. 13.—An isolated hair near margin of stigmal plate. Greatly enlarged. Original.

D. venustus ♂

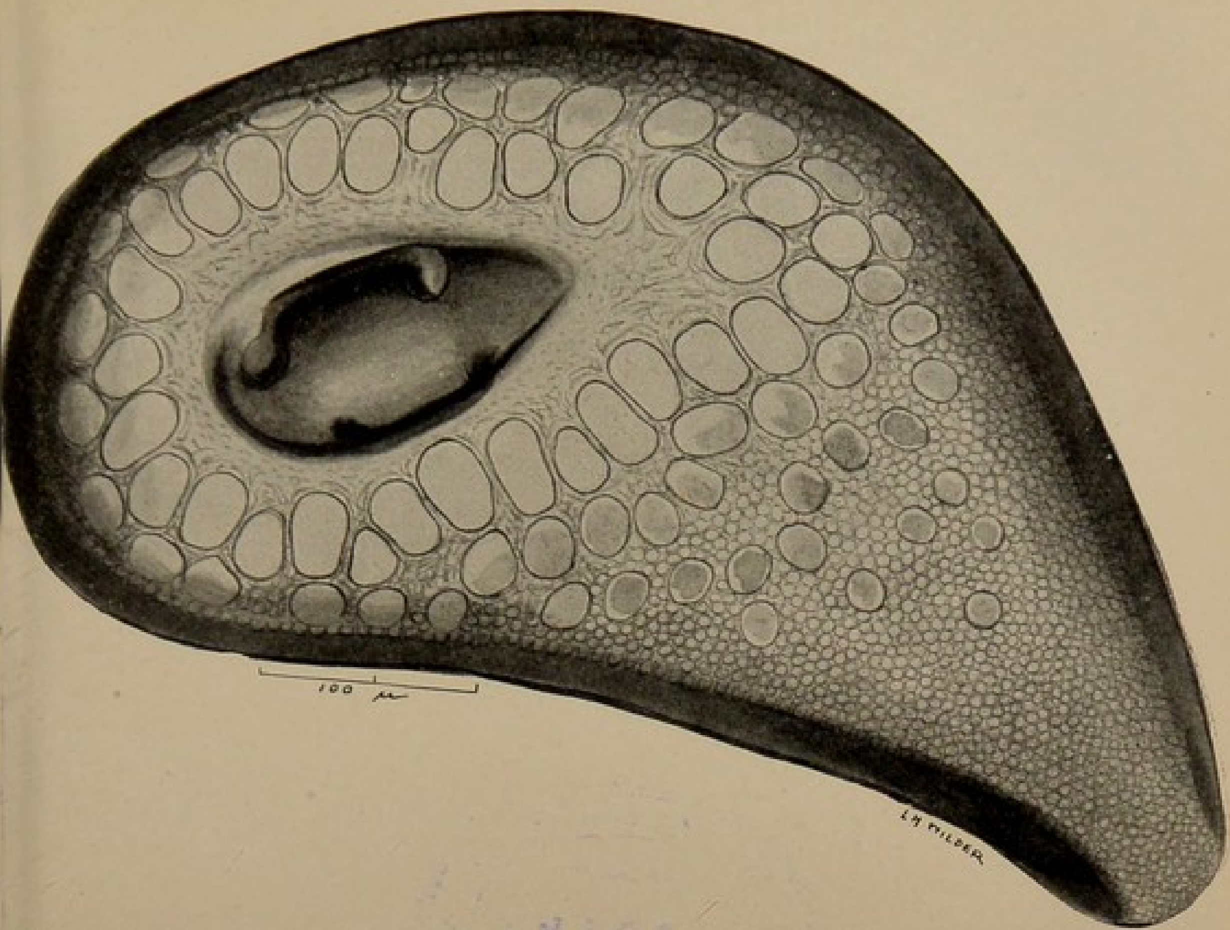


FIG. 14.—Stigmal plate of male *D. venustus*. Notice the broad aperture, the prominent terminal prolongation, and the scattered goblets; the middle layer also is visible. Greatly enlarged. Original. Marx 122.

D. venustus ♀

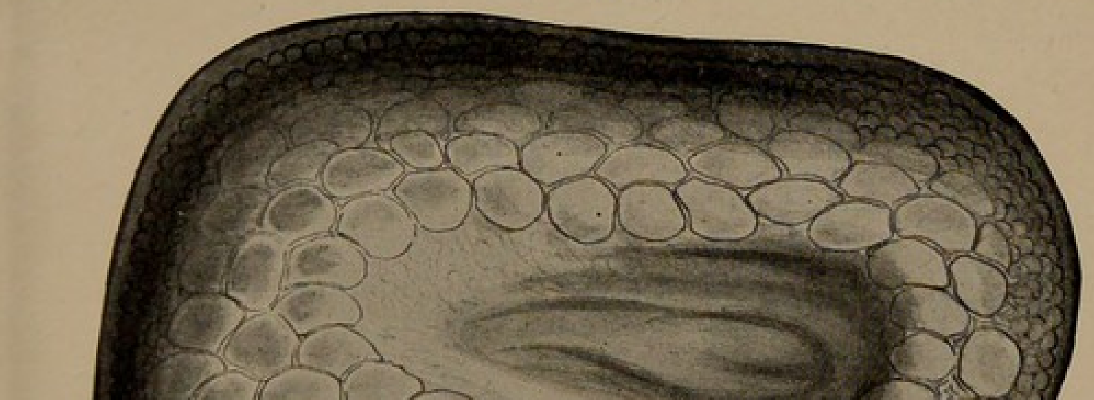


FIG. 15.—Stigmal plate of female *D. venustus*. As this was drawn from an unmounted specimen, it may not be absolutely so exact a representation as is the plate of the male. Greatly enlarged. Original. Marx 122.

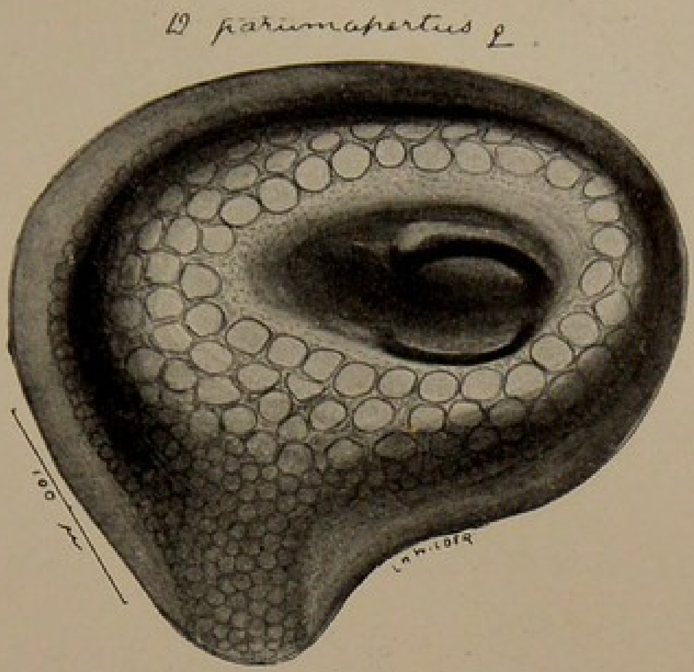


FIG. 16.—Stigmal plate of female *D. parumapertus*. Notice the convexity of the plate, the prolongation which forms an acute angle at the caudal margin of the plate, the concentration of the goblets around the aperture, and note also the unusually large chamber. Greatly enlarged. Original. Marx 143.

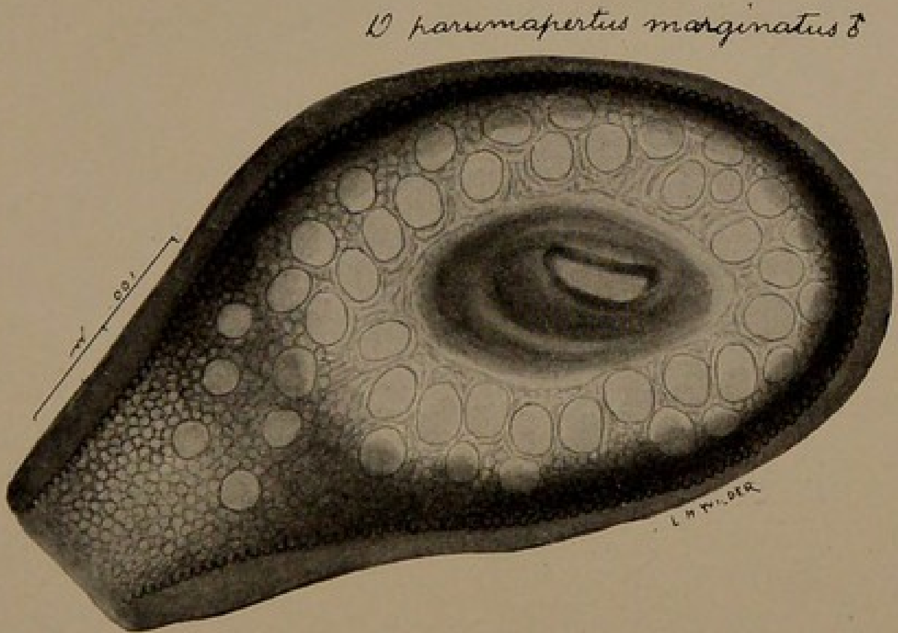
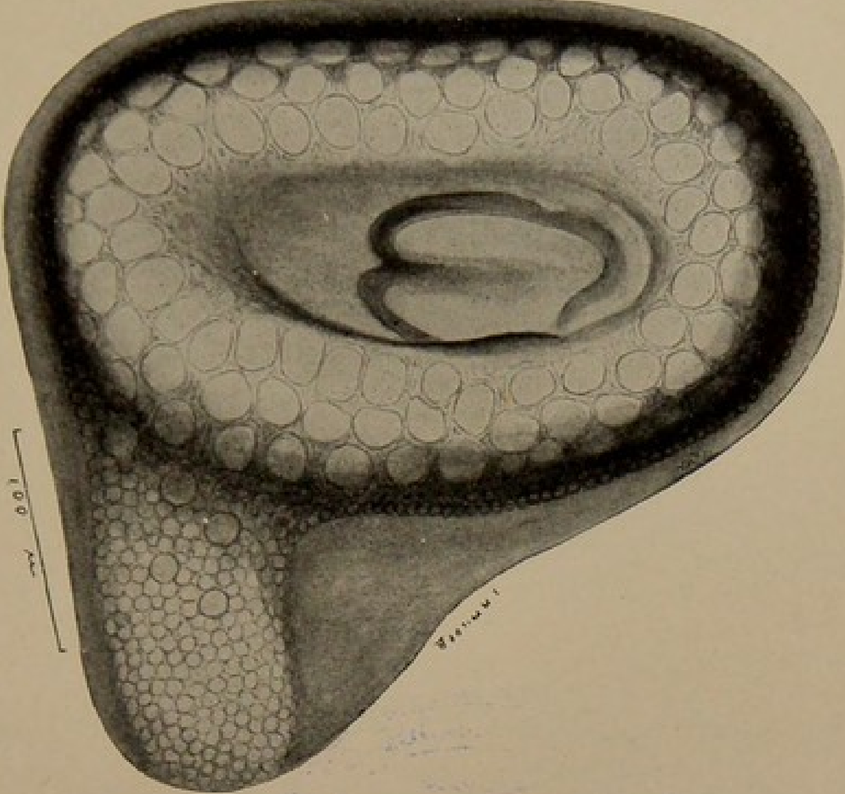
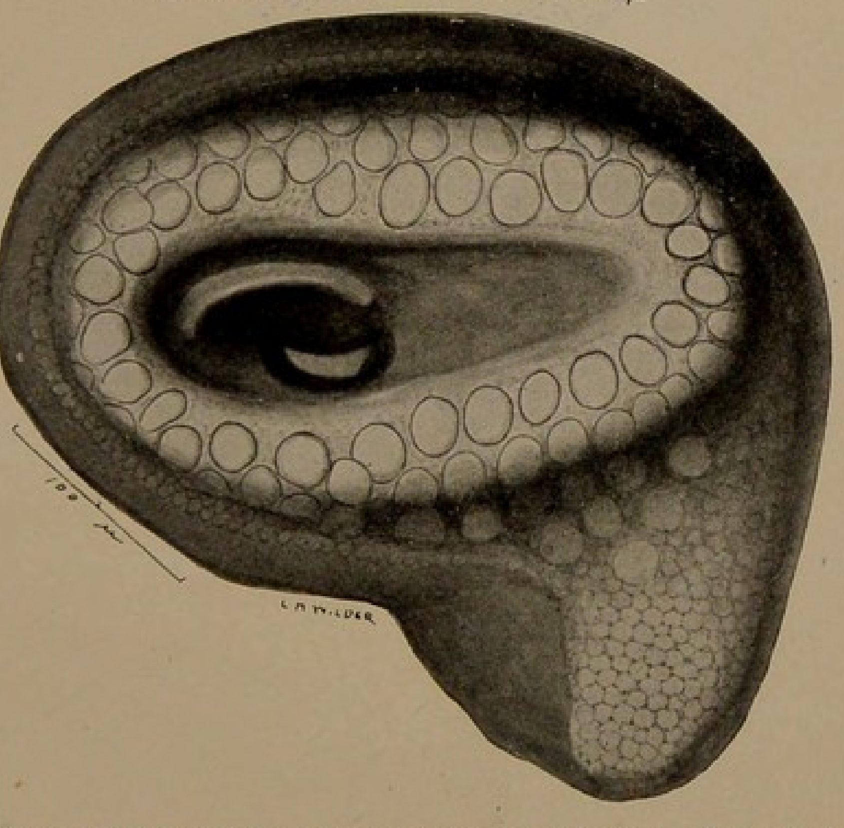


FIG. 17.—Stigmal plate of male *D. parumapertus marginatus*. Notice the prominent prolongation [broken at end], the unusually large chamber, the convexity of the plate, and the arrangement of the goblets. Greatly enlarged. Original. Marx 137.

D. parumapertus marginatus ♀



D. parumapertus marginatus ♀



FIGS. 18–19.—Plates of two female *D. parumapertus marginatus*. Notice the acute angle formed by the prolongation, the enormous aperture and chamber, the circular goblets, the convexity of the plate, and the broad anterior margin of the prolongation. Greatly enlarged. Original. Marx 137 and B.A.I.3415.

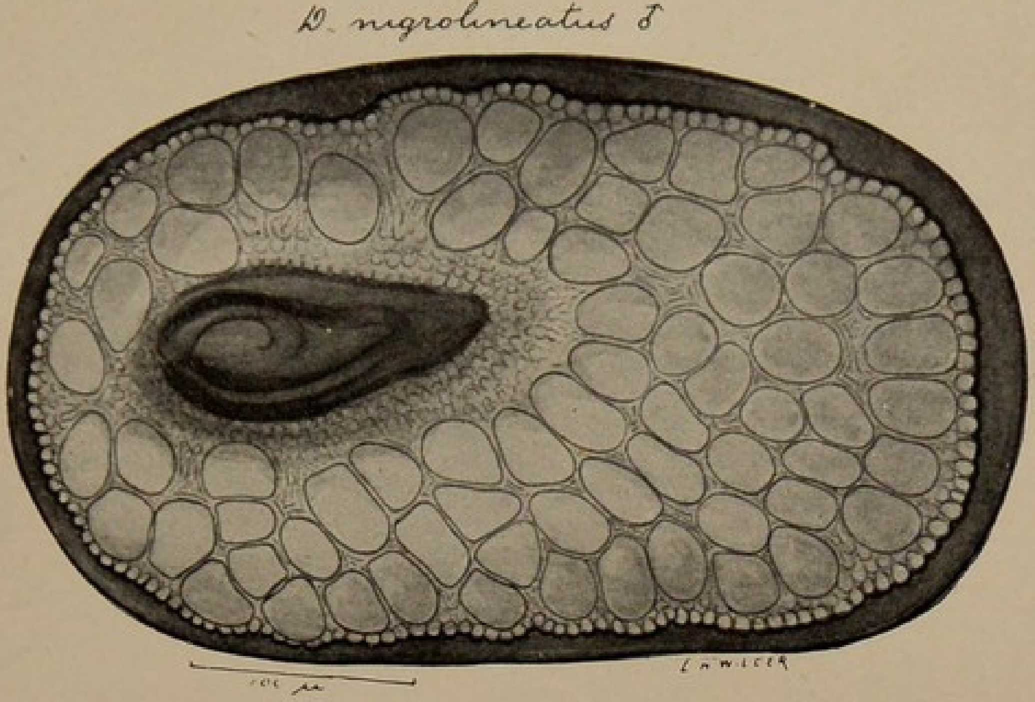


FIG. 20.—Stigmal plate of male tick determined by Banks as *D. nigrolineatus*. Notice the preequatorial position of the aperture, the arrangement of the goblets, and the absence of a dorso-lateral prolongation. Enlarged. Original. U. S. P. H. & M. H. S. 10592.

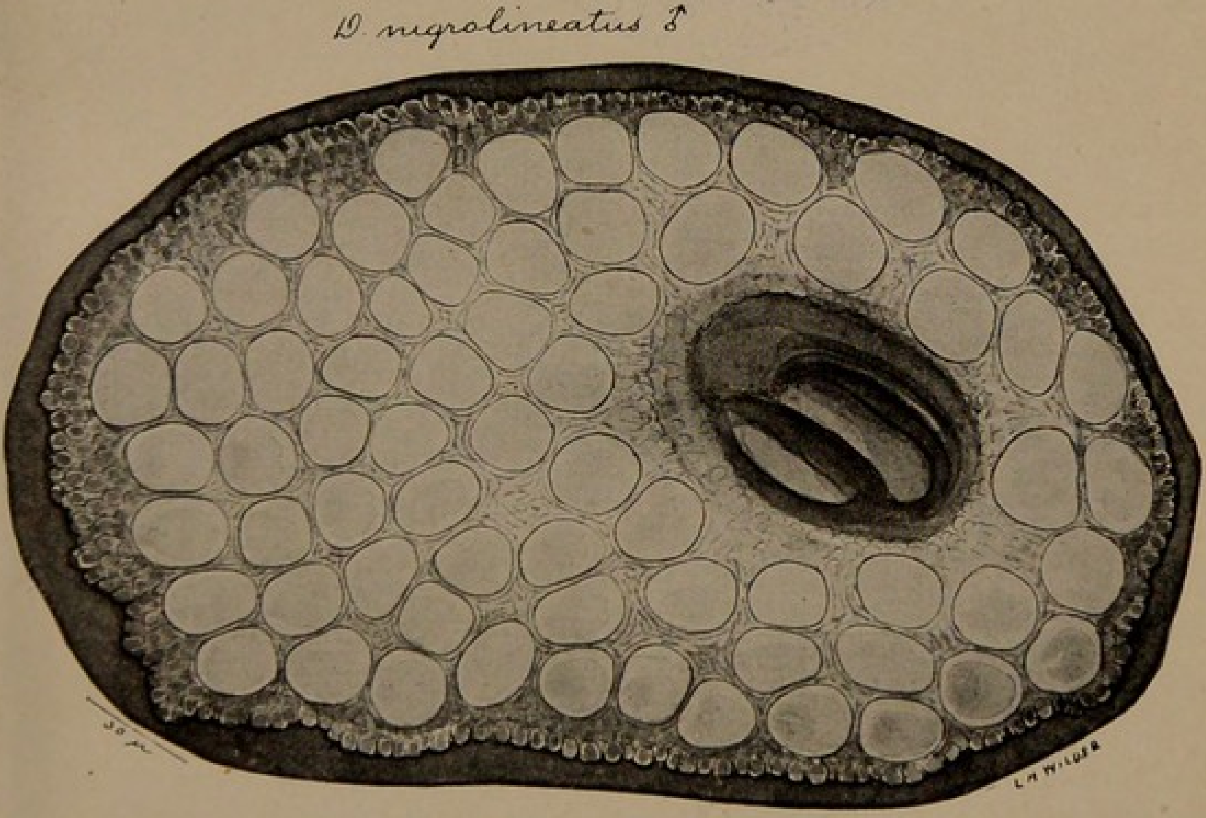


FIG. 21.—Stigmal plate of male *D. nigrolineatus* from Oklahoma. Enlarged. Original. B. A. I. 4363.

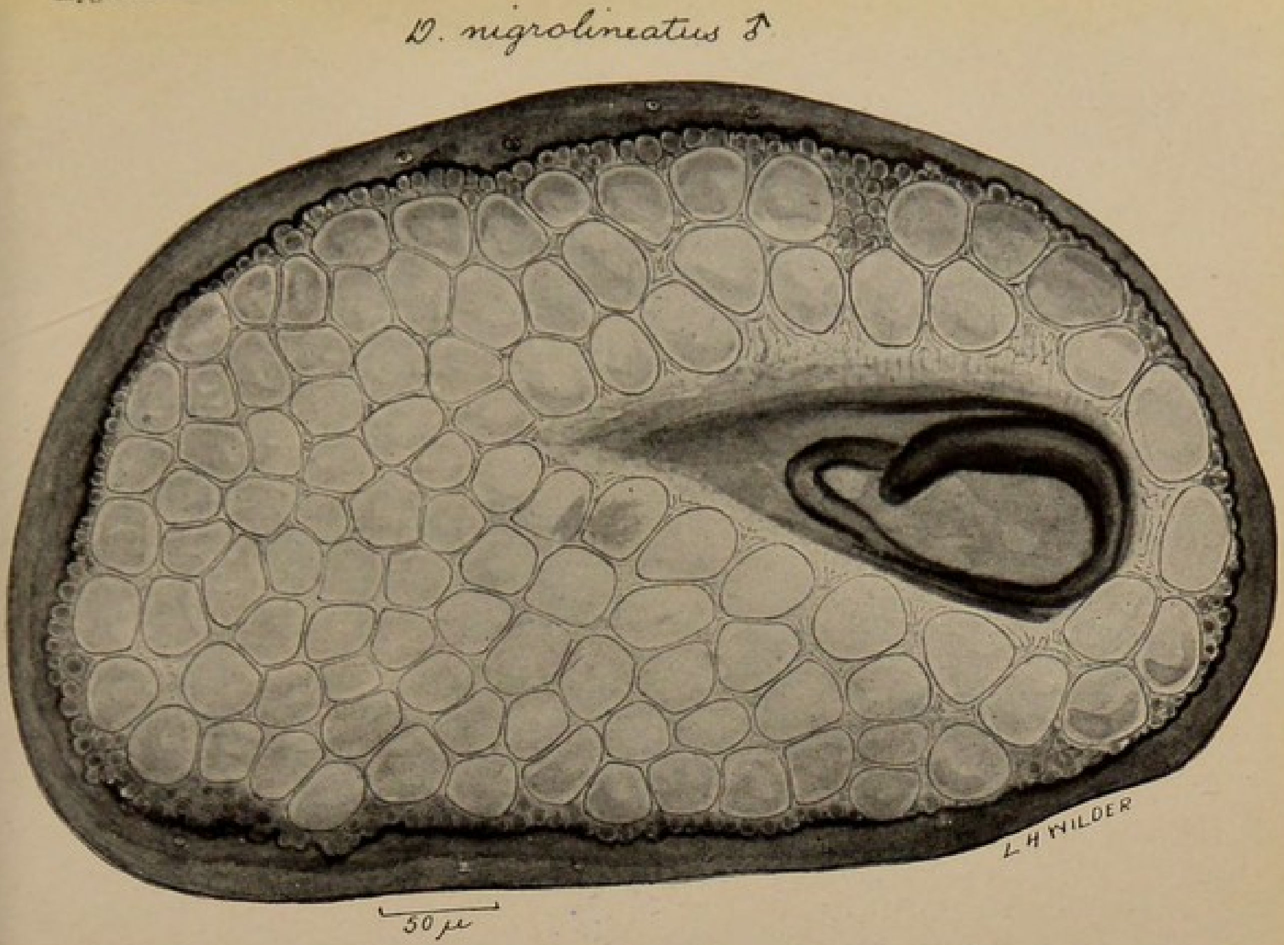


FIG. 22.—Stigmal plate of male *D. nigrolineatus* from New York. Enlarged. Original. U. S. P. H. & M. H. S. 9992.

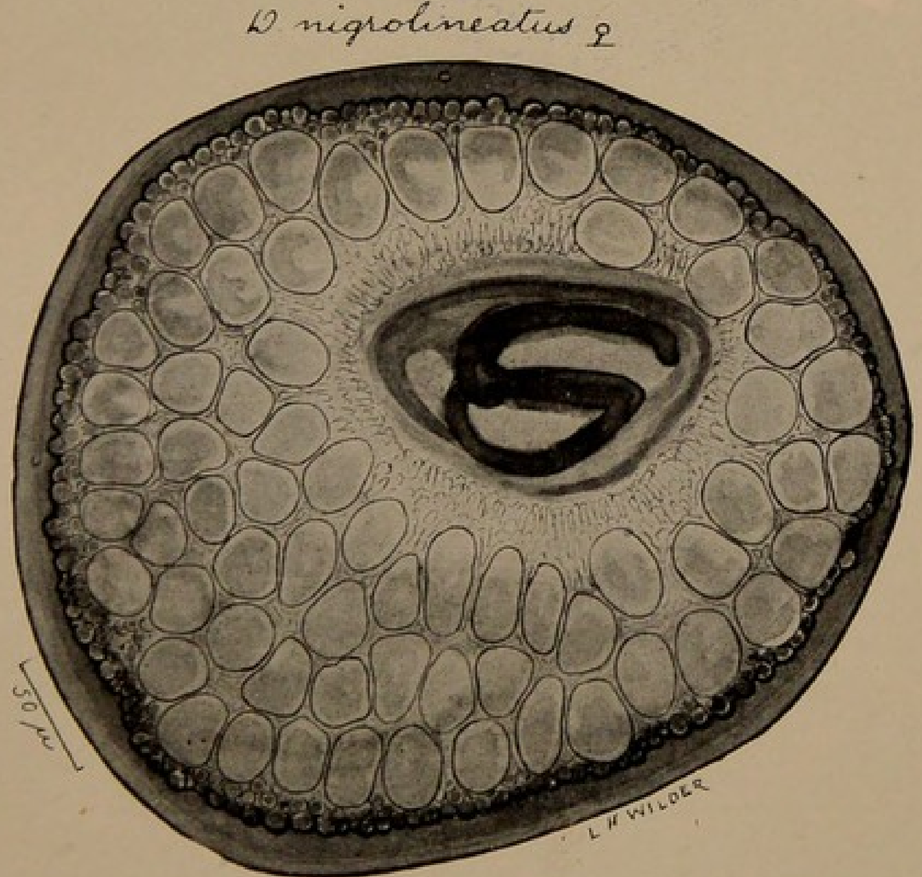


FIG. 23.—Stigmal plate of female *D. nigrolineatus* from New York. Enlarged. Original. U. S. P. H. & M. H. S. 9992.

D nigrolineatus ♀

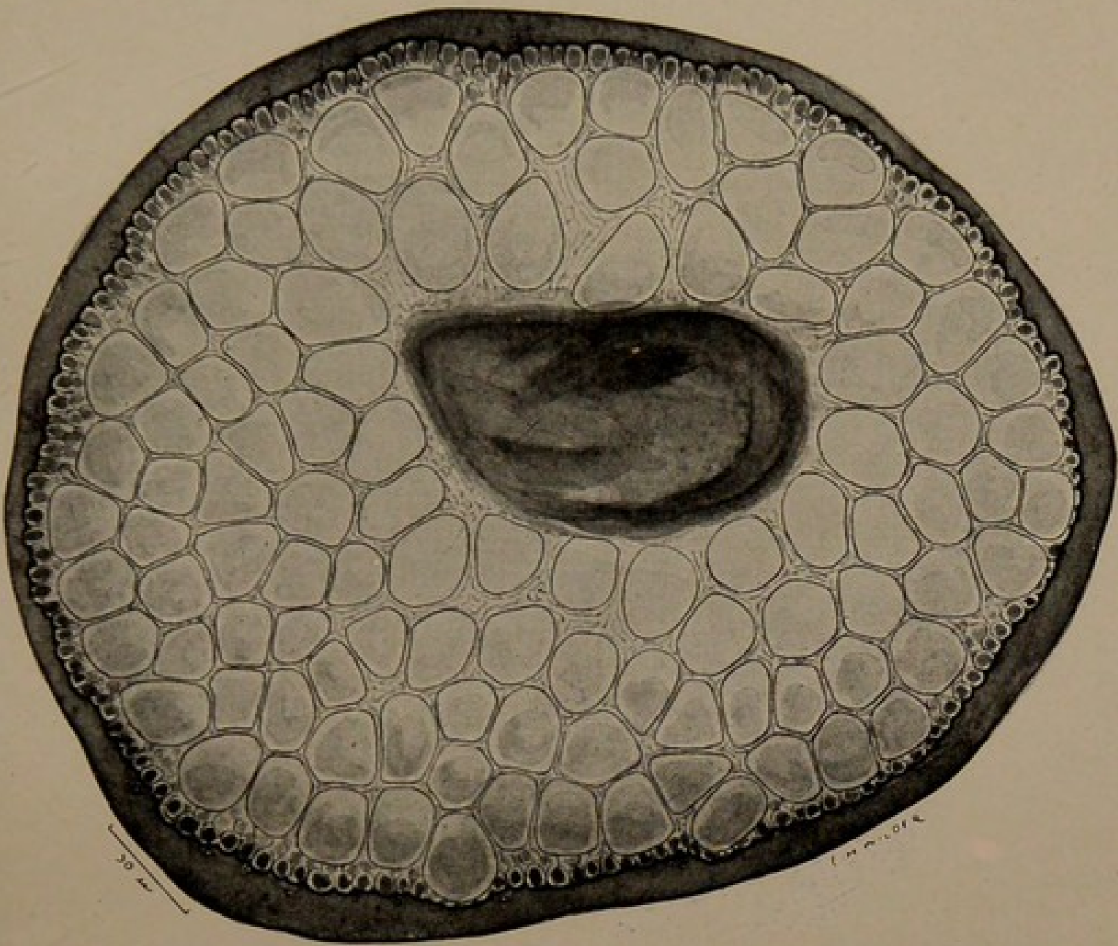


FIG. 24.—Stigmal plate of female *D. nigrolineatus* from Tennessee. Enlarged. Original.
B. A. I. 4288.

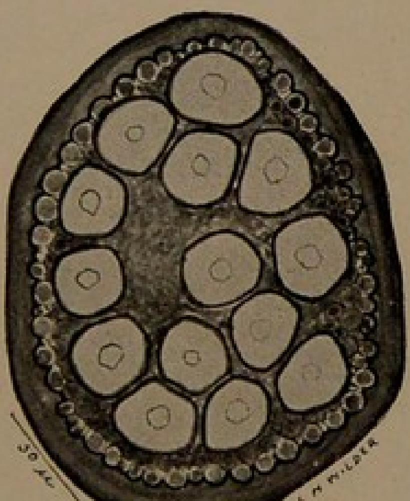


FIG. 25.—Stigmal plate of nymph *D. nigrolineatus* from Oklahoma. Enlarged. Original.
B. A. I. 4363.

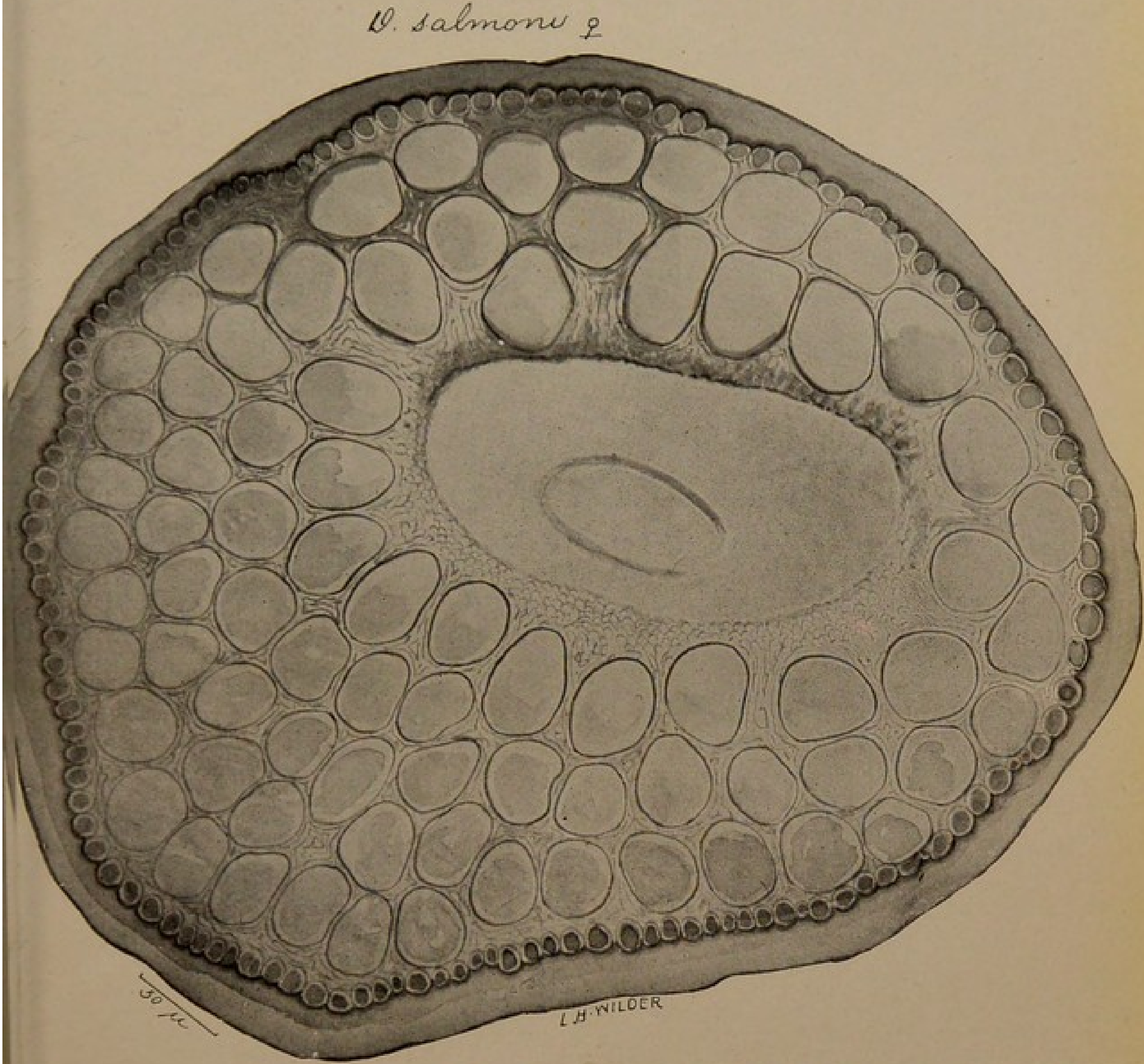


FIG. 26.—Stigmal plate of female *D. salmoni* (type) from *Bos taurus*, Oklahoma. Enlarged. Original. B. A. I. 3179.

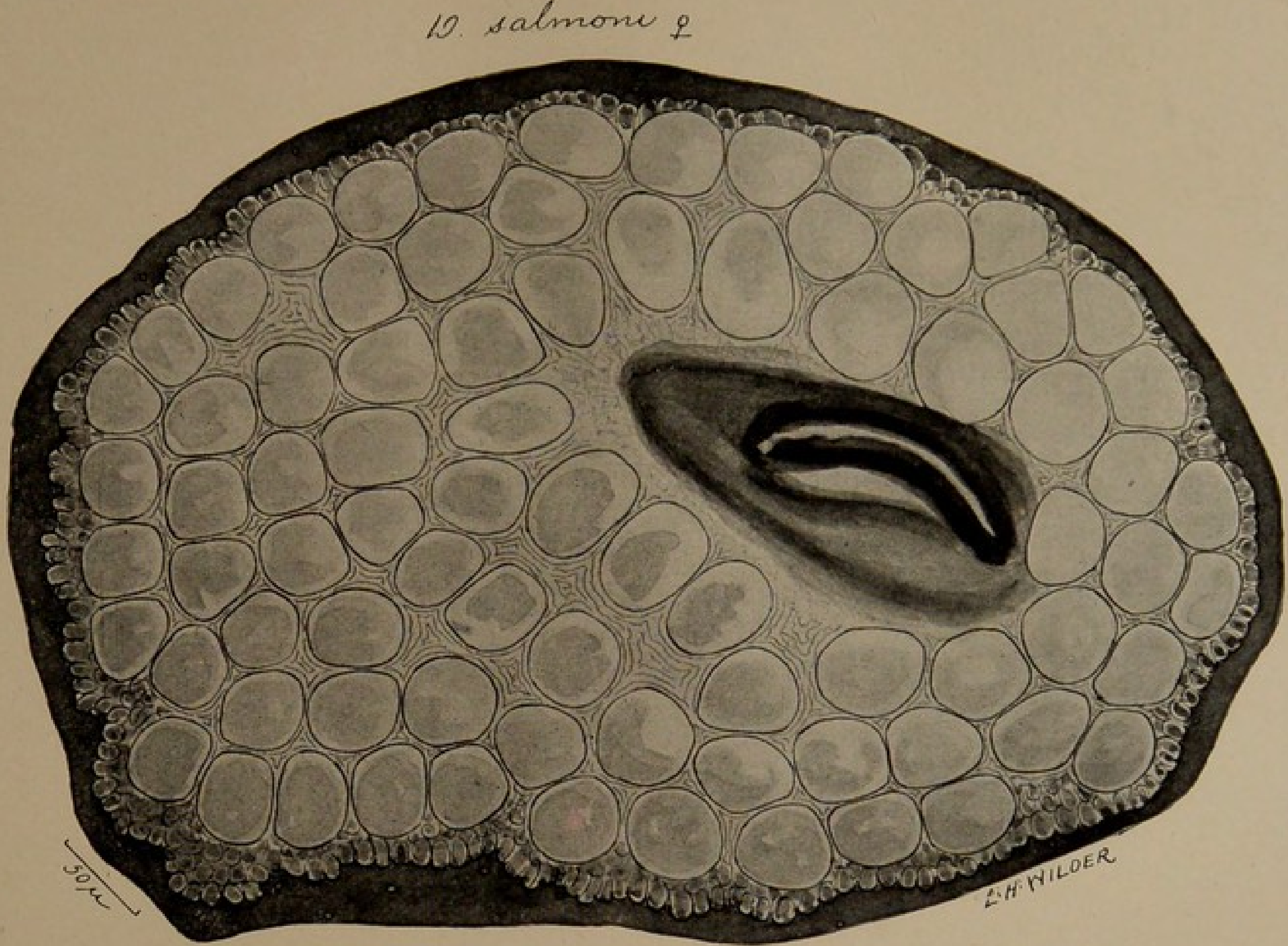
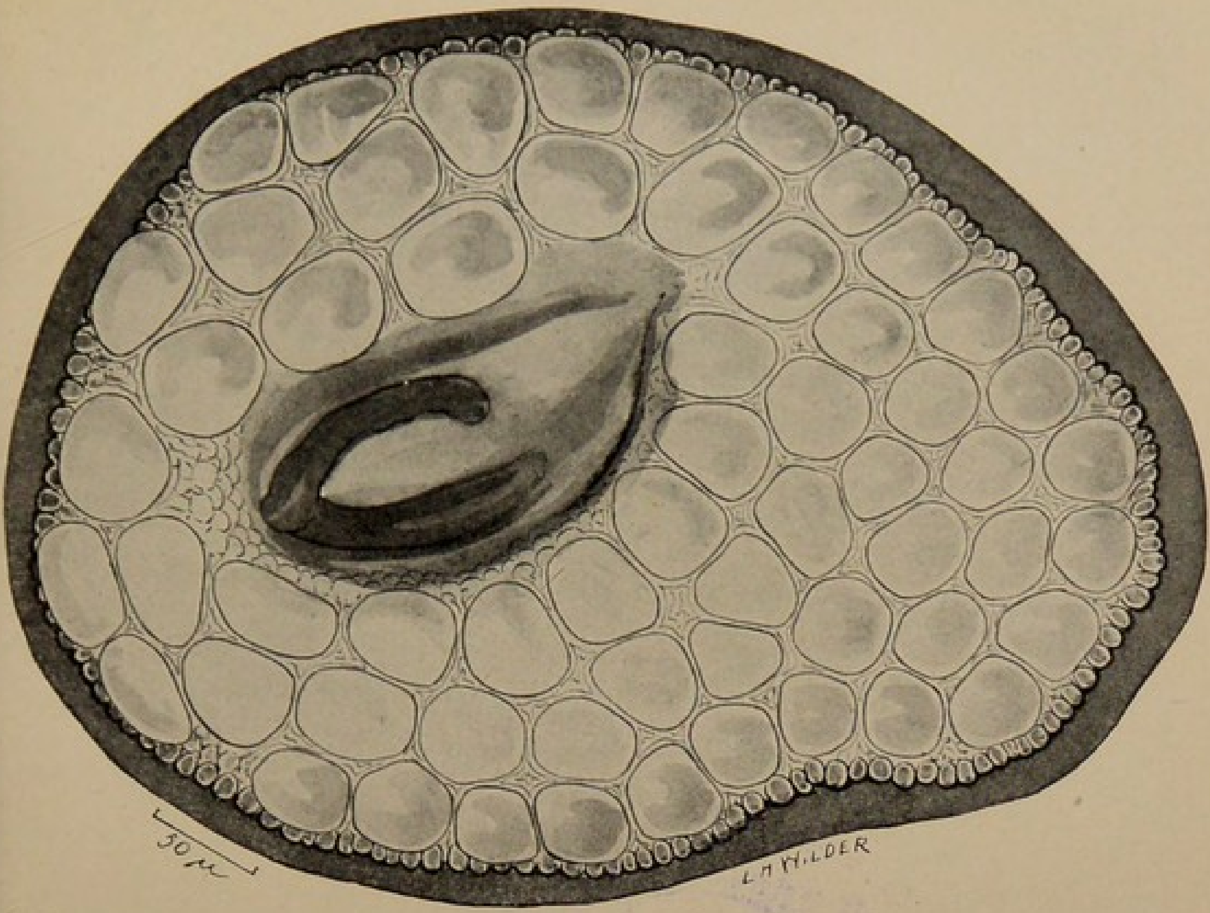
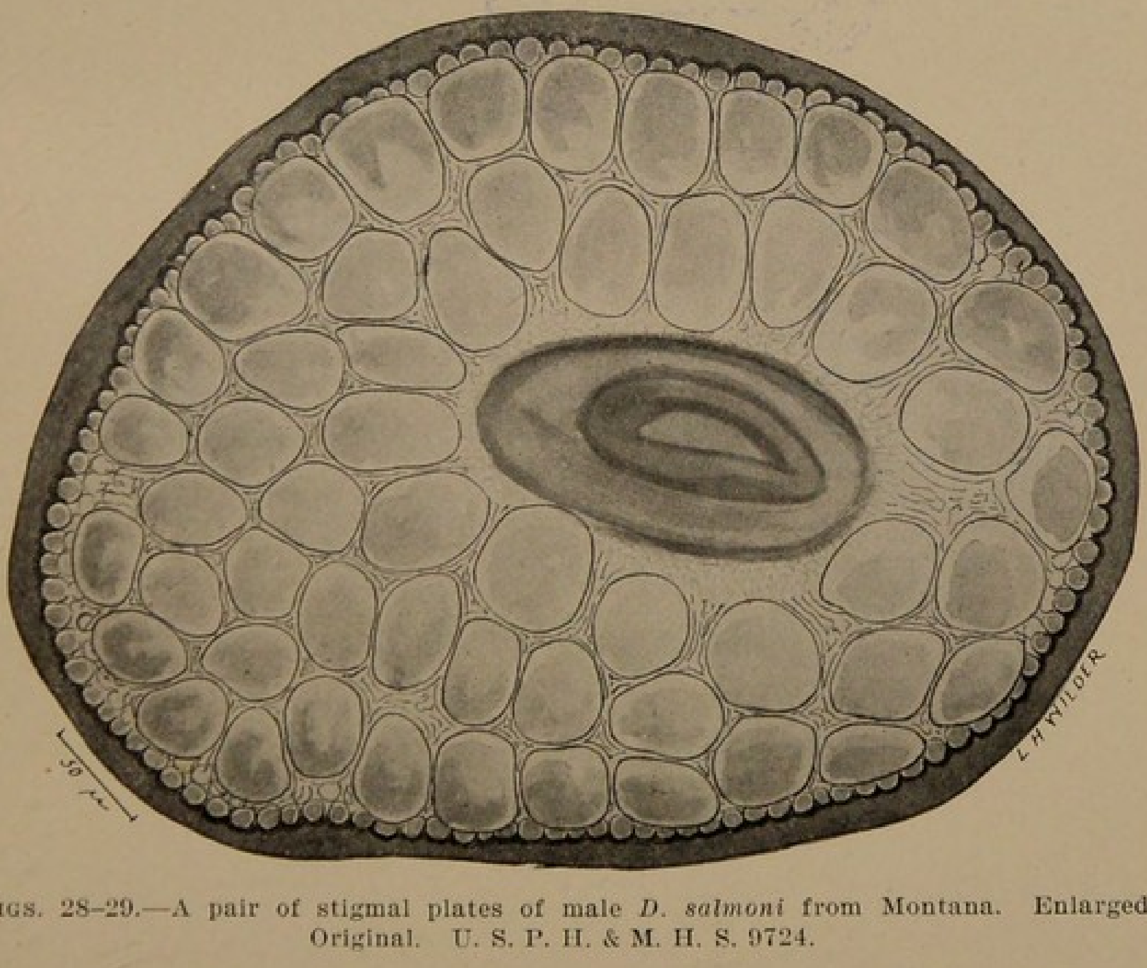


FIG. 27.—Stigmal plate of female *D. salmoni*. Enlarged. Original. B. A. I. 2998.

D. salmoni ♂



D. salmoni ♂



FIGS. 28–29.—A pair of stigmal plates of male *D. salmoni* from Montana. Enlarged. Original. U. S. P. H. & M. H. S. 9724.

D. salmoni ♀

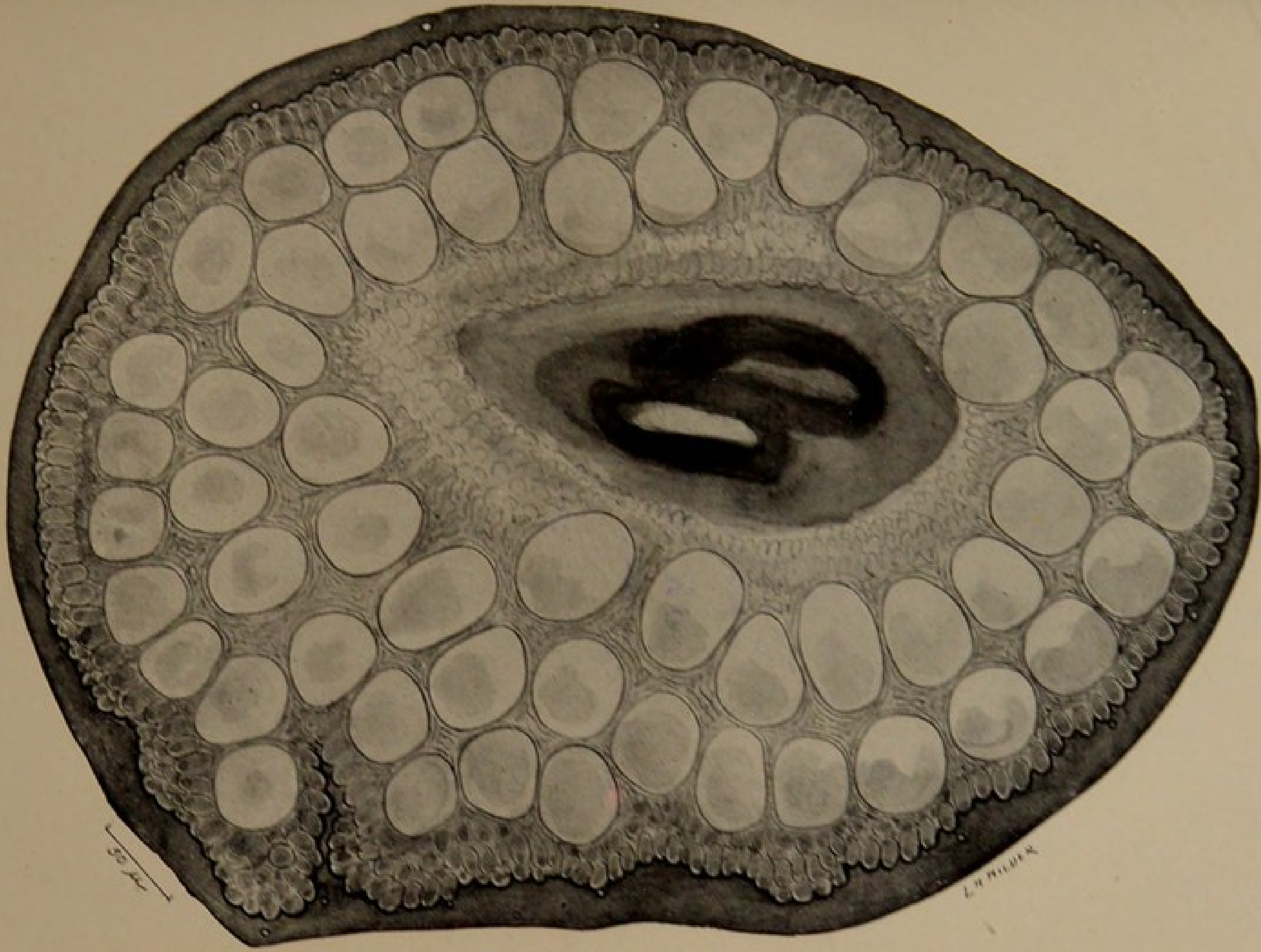


FIG. 30-31.—A pair of stigmal plates of female *D. salmoni* from Montana. Enlarged. Original. U. S. P. H. & M. H. S. 9721.

D. salmoni ♀

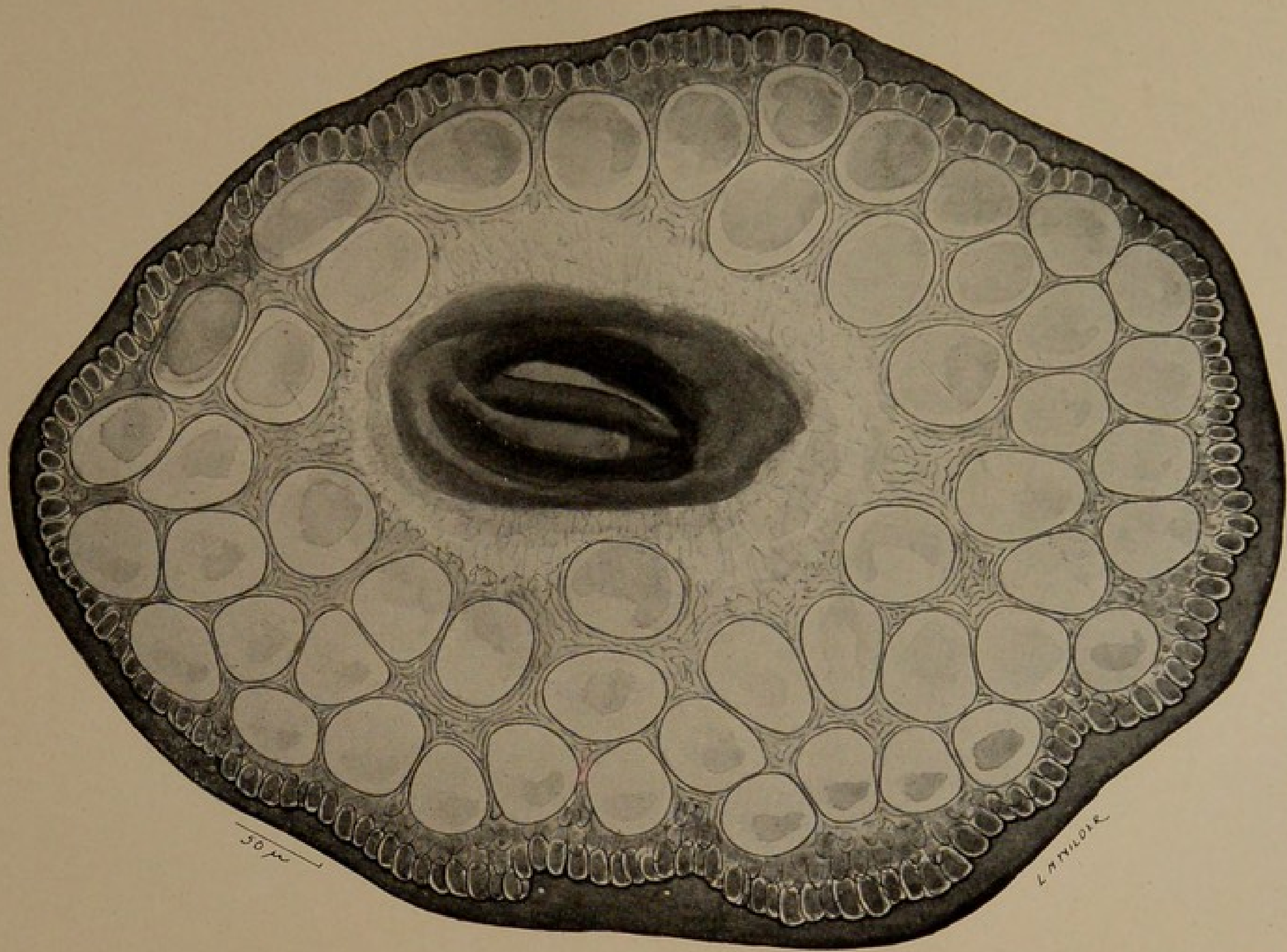


FIG. 30-31.—A pair of stigmal plates of female *D. salmoni* from Montana. Enlarged. Original. U. S. P. H. & M. H. S. 9724.

D salmoni ♀

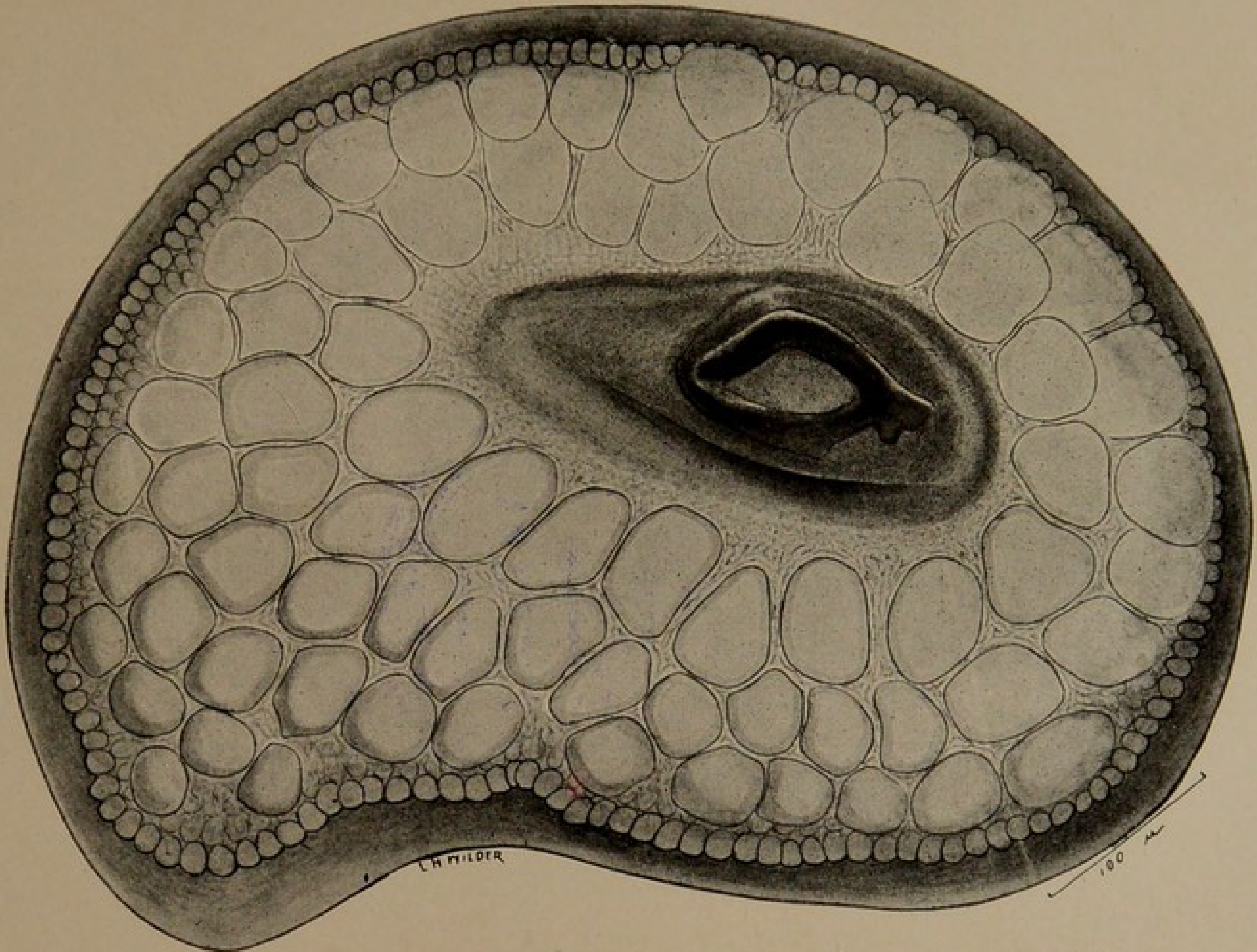


FIG. 32.—Stigmal plate of female *D. salmoni* from Tennessee. Enlarged. Original. B. A. I. 3206.

D. salmoni ♀

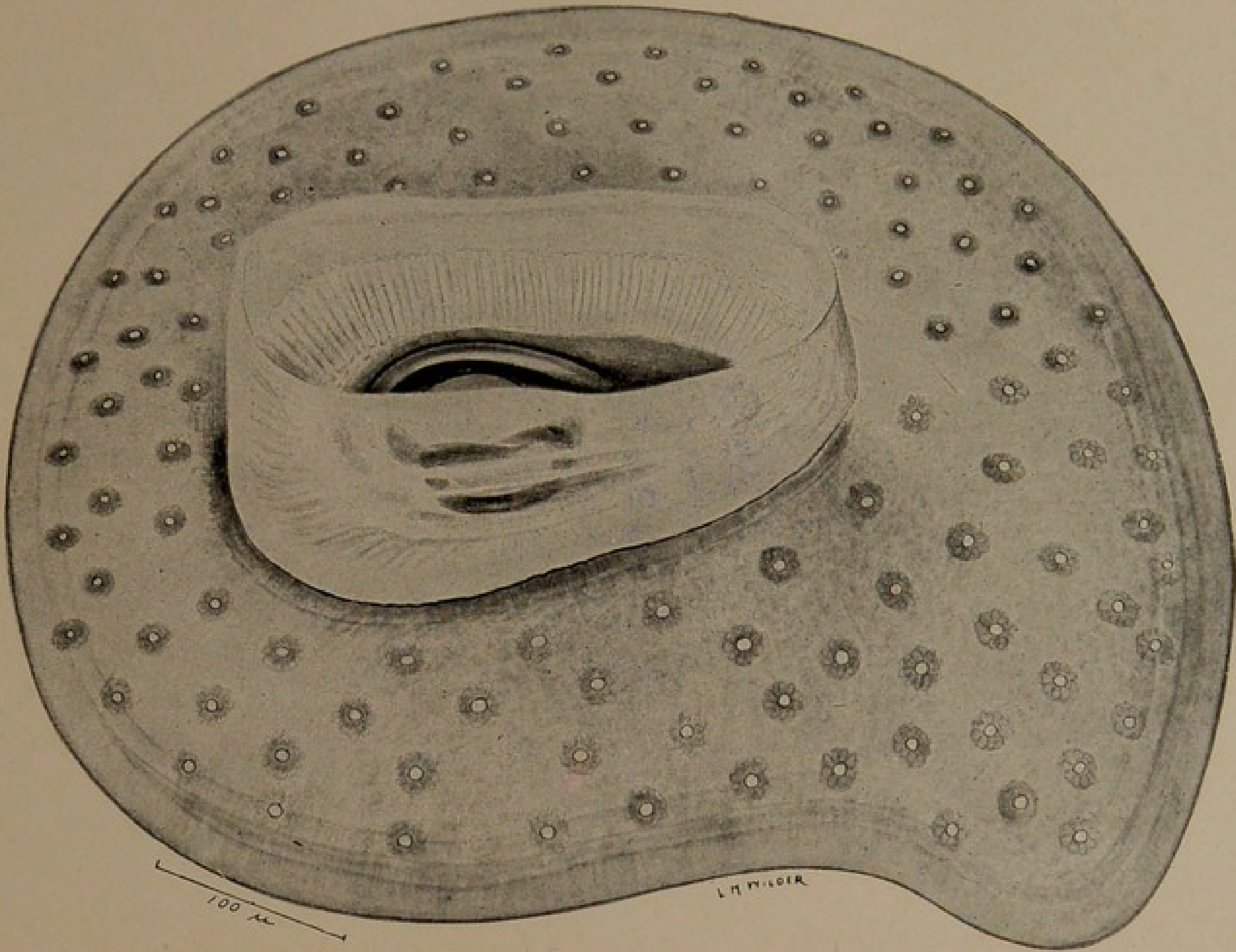


FIG. 33.—Obverse view of plate shown in figure 32.

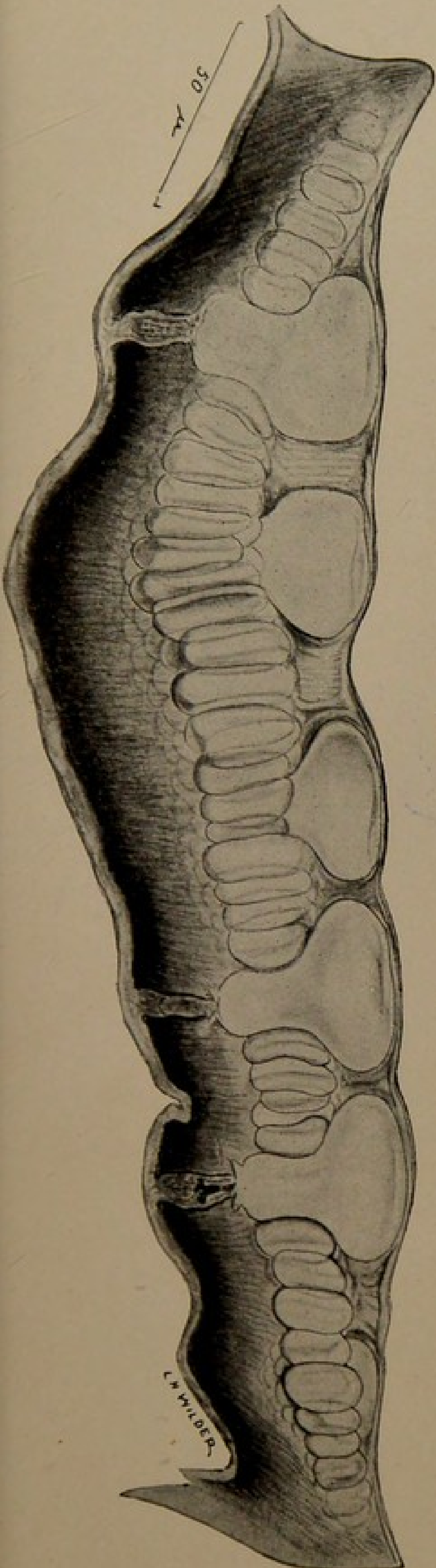


FIG. 34a.—Section of stigmal plate of *D. salmoni* from Tennessee. Greatly enlarged. Original. B. A. I. 3206.

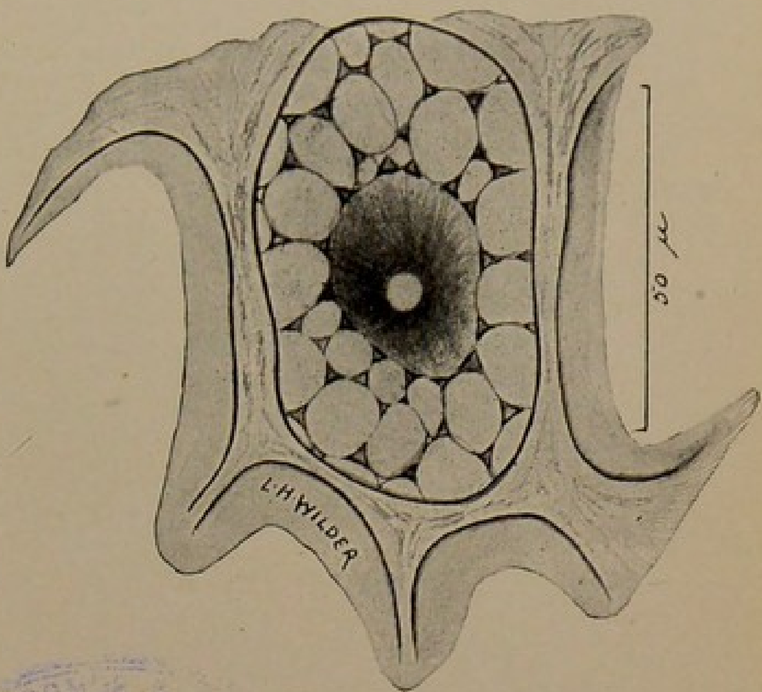


FIG. 34b.—View of a goblet of *D. salmoni*, at deep focus to show the supporting cells and the stem of the goblet. Greatly enlarged. Original. B. A. I. 3206.

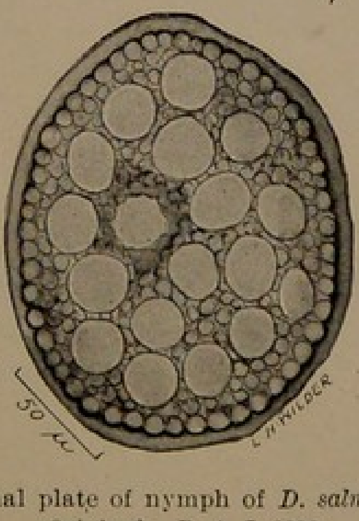


FIG. 35.—Stigmal plate of nymph of *D. salmoni*. Enlarged. Original. B. A. I. 3206.

D. salmoni ♂

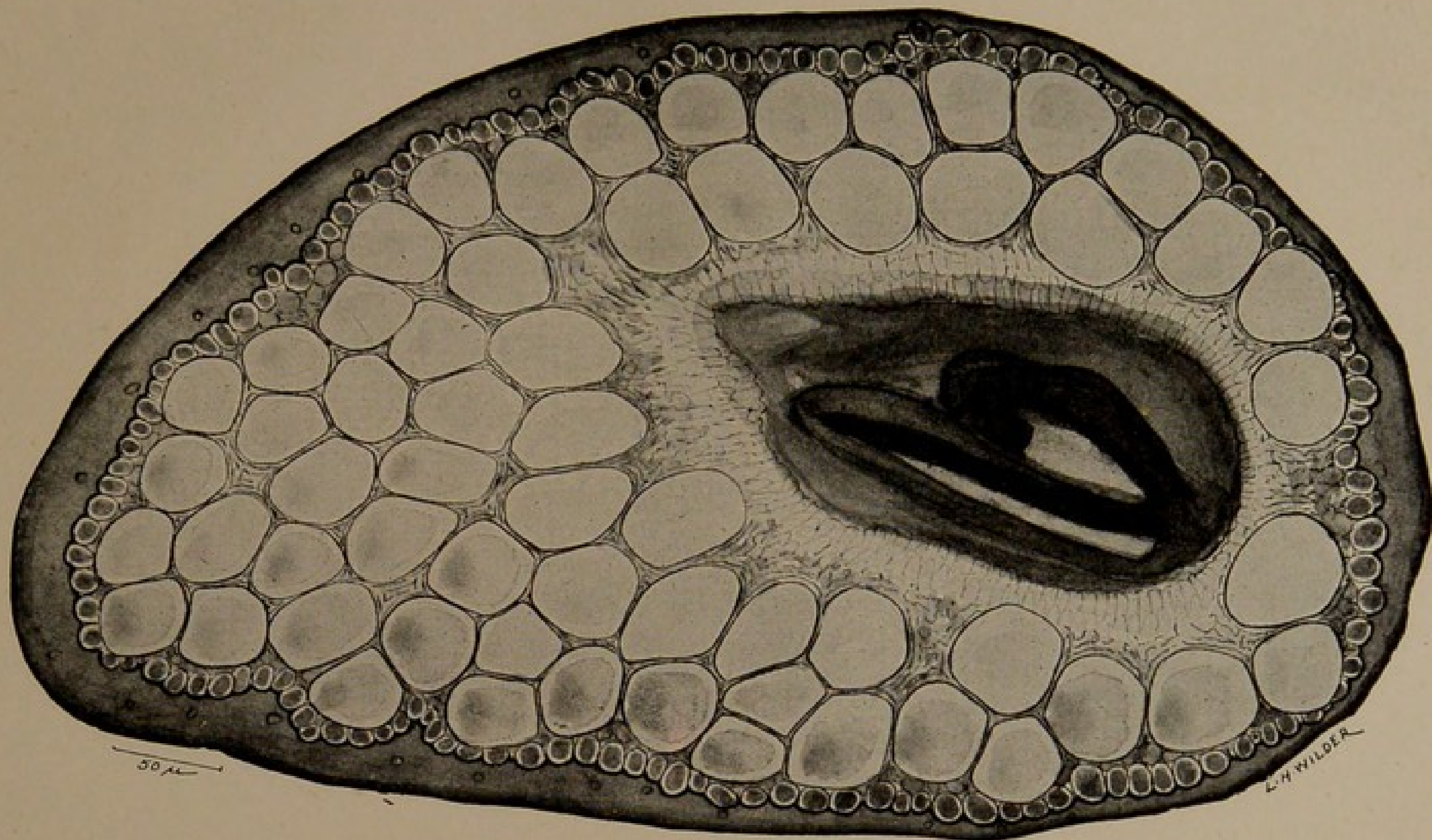


FIG. 36.—Stigmal plate of male *D. salmoni*. Enlarged. Original. U. S. P. H. & M. H. S. 10003.

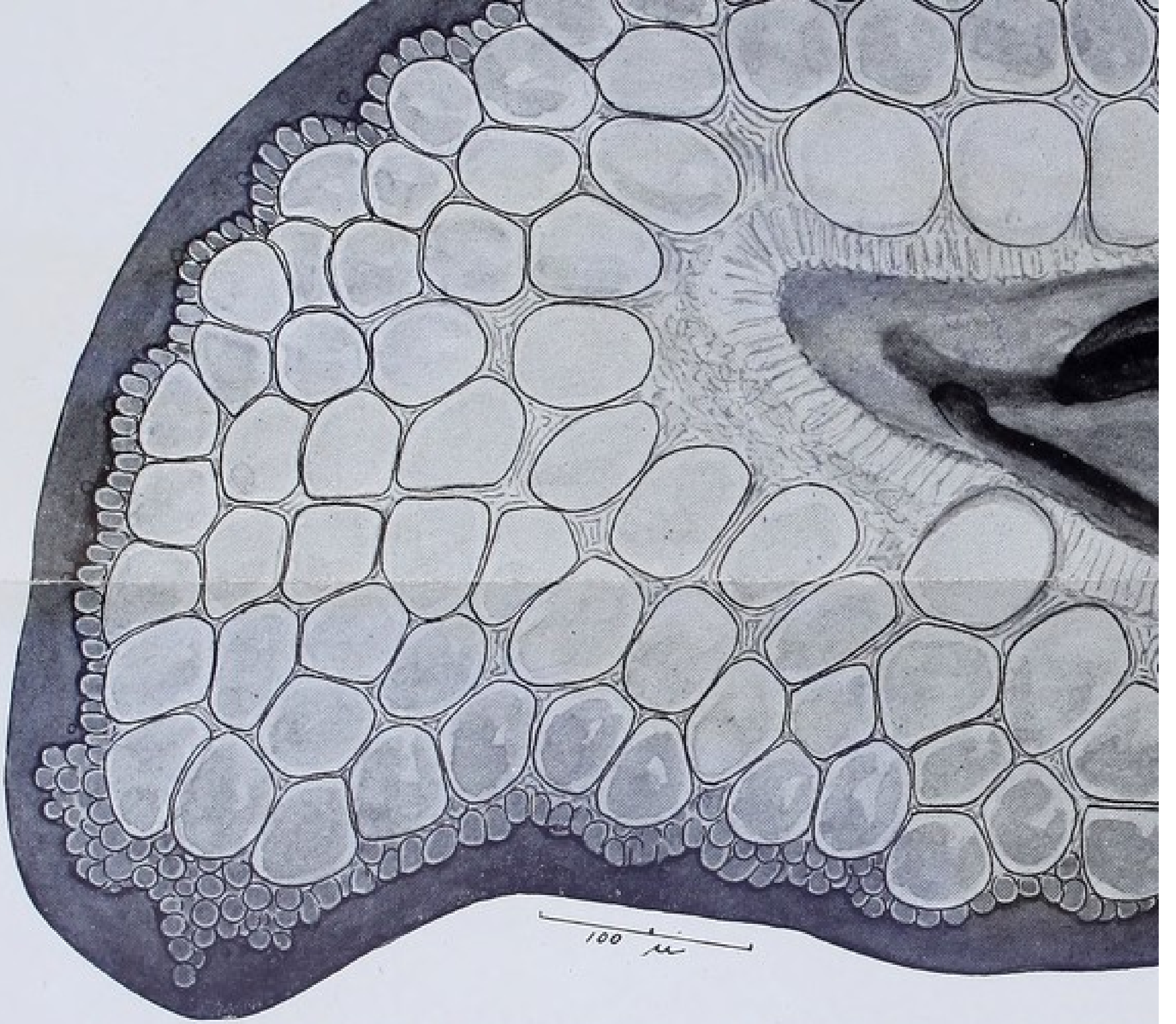


Fig. 37.—Stigmal plate of male *D. albipictus* seu *variegatus*. Notice the prolongation, and the larg

FIG. 38.—Stigmal plate of female *D. albipictus* seu *variegatus*. Enlarged. Origin

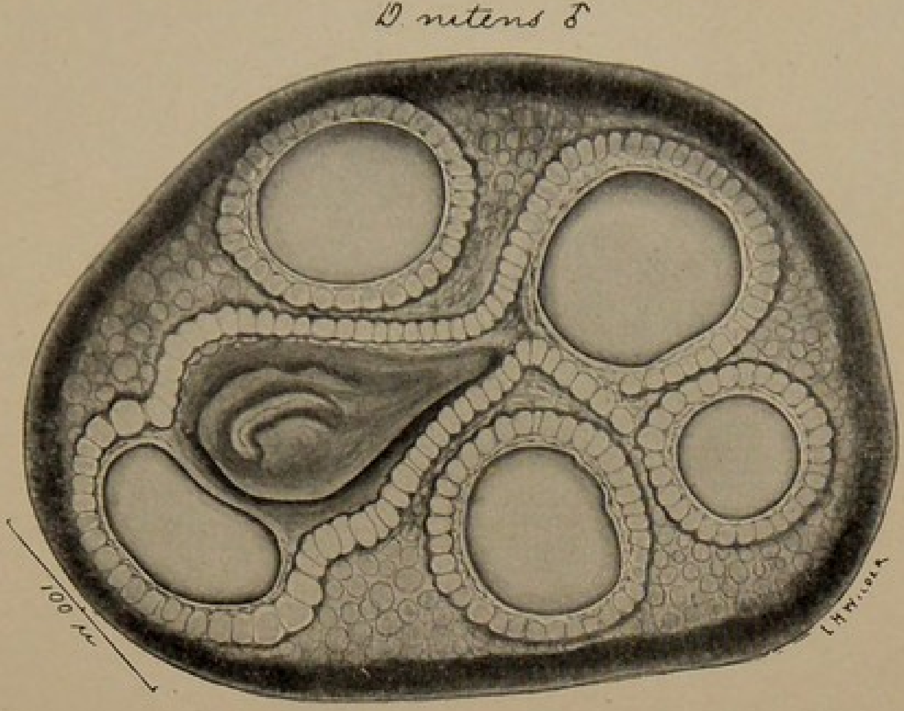


FIG. 41.—The same at lower focus.

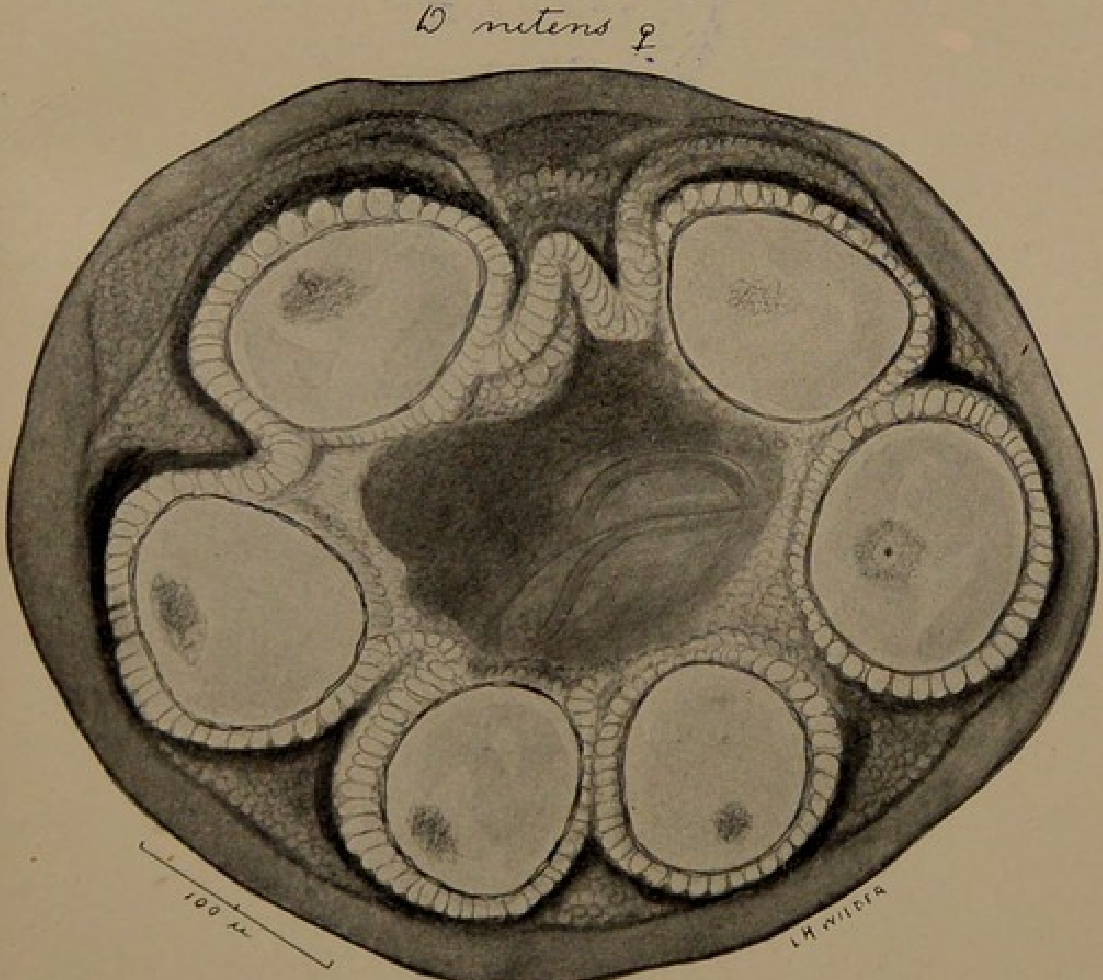


FIG. 42.—Stigmal plate of female *D. nitens* from Jamaica. Enlarged. Original. U. S. P. H. & M. H. S. 9991.

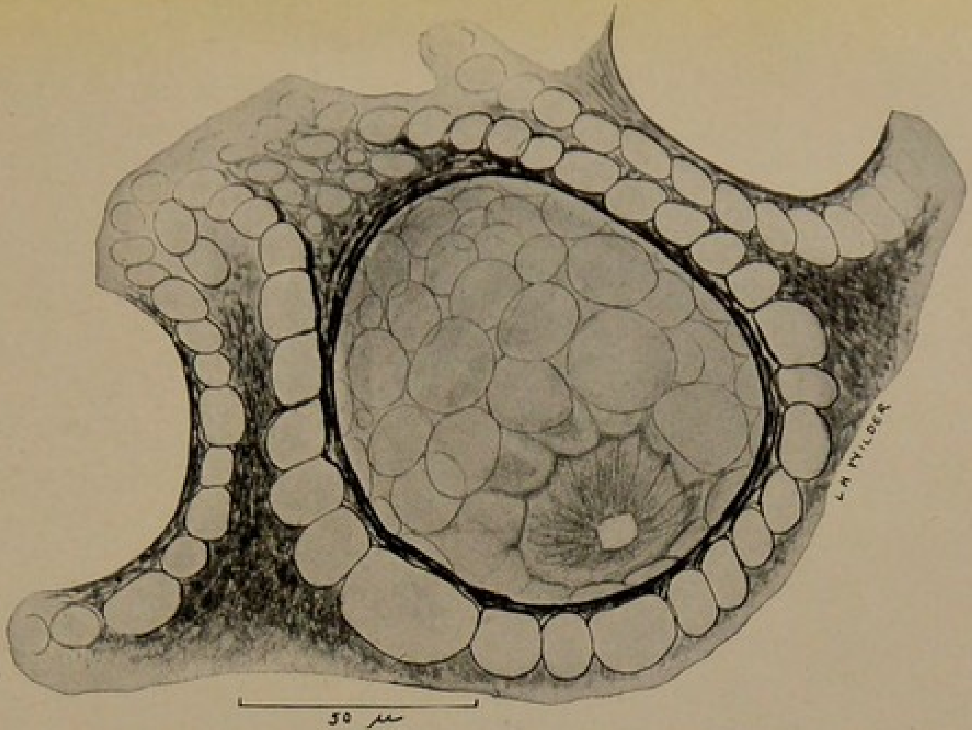


FIG. 43.—A goblet very greatly enlarged, showing also the supporting cells and the stem of the goblet. Greatly enlarged. Original. U. S. P. H. & M. H. S. 9908

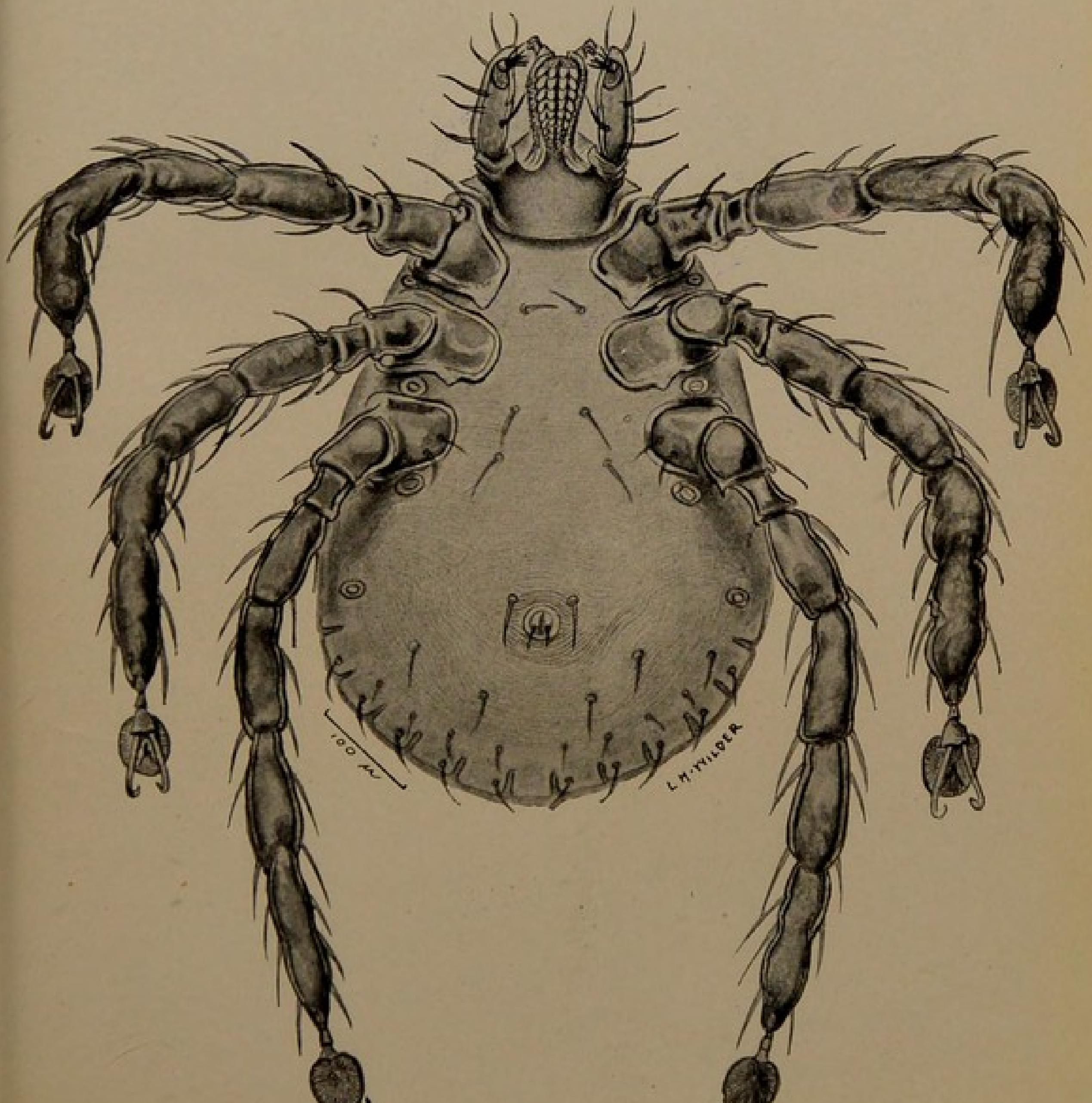


FIG. 48.

Fig. 44. Ventral view.

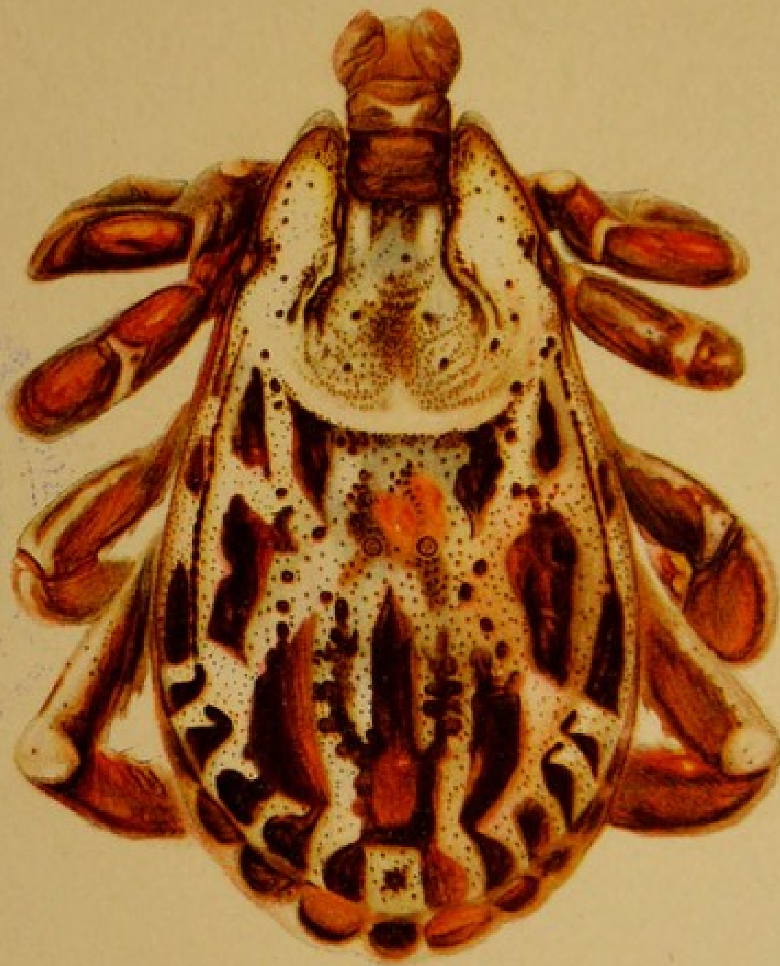


Fig. 45. Dorsal view.

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Dermacentor andersoni.

Fig. 46. Dorsal view.

Fig. 47. Ventral view.

L. H. Wilder

Dermacentor andersoni.

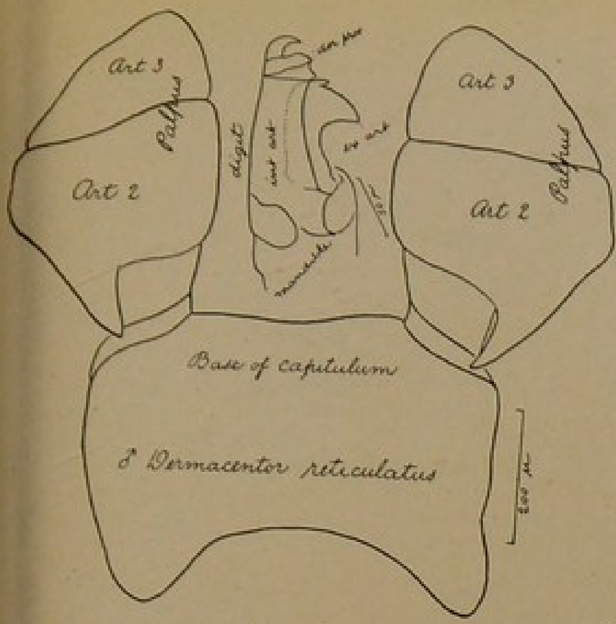

Fig. 49.

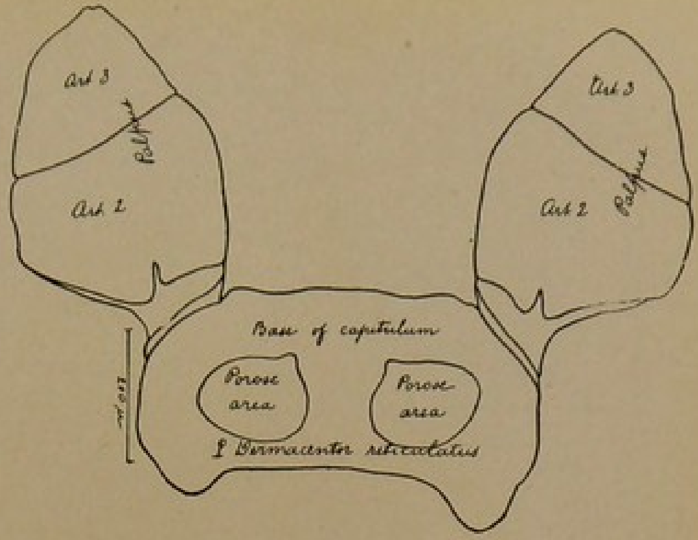

Fig. 50.

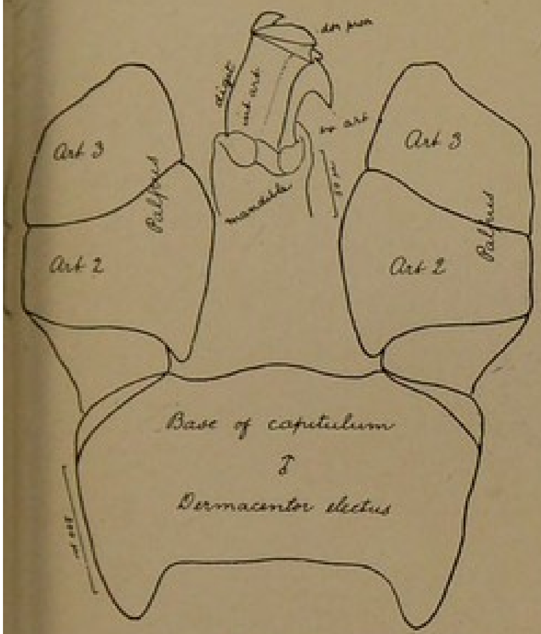

Fig. 51.

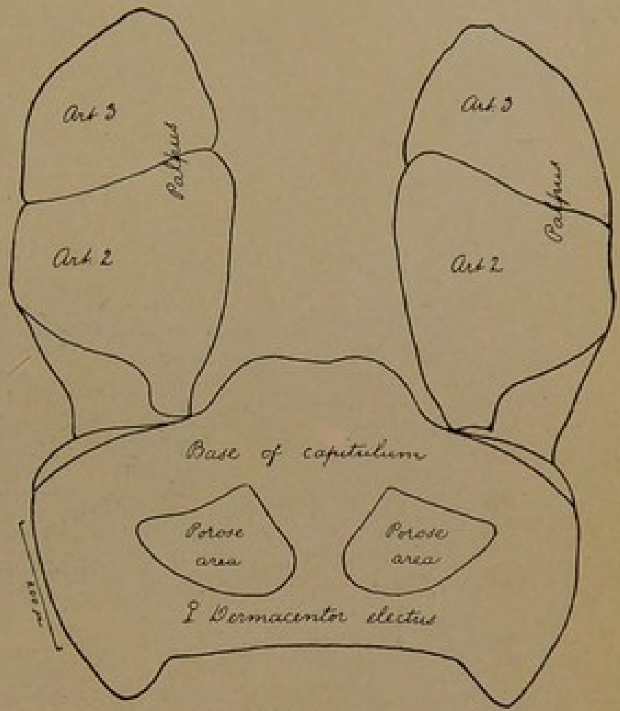

Fig. 52.

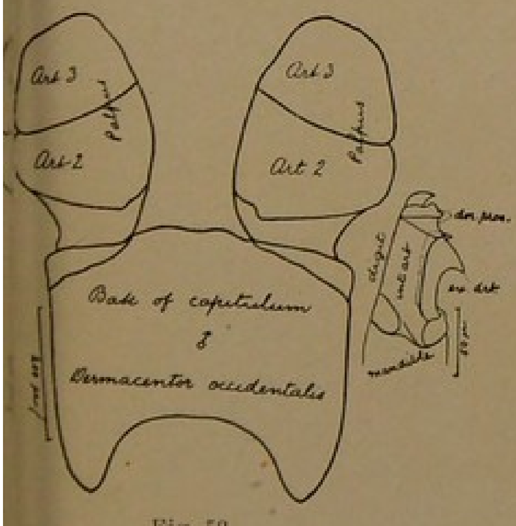

Fig. 53.

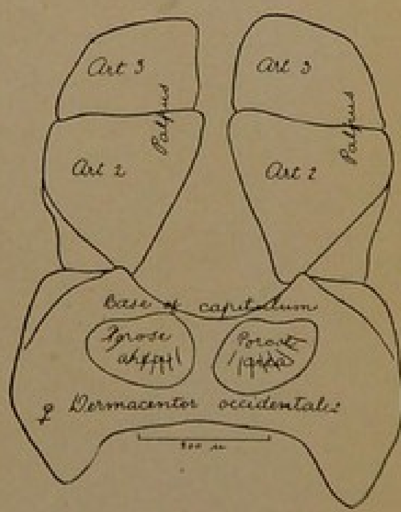

Fig. 54.

L. H. Wilder, Del.

Figs. 49–54.—OUTLINES OF CAPITULUM AND DIGIT OF DERMACENTOR.

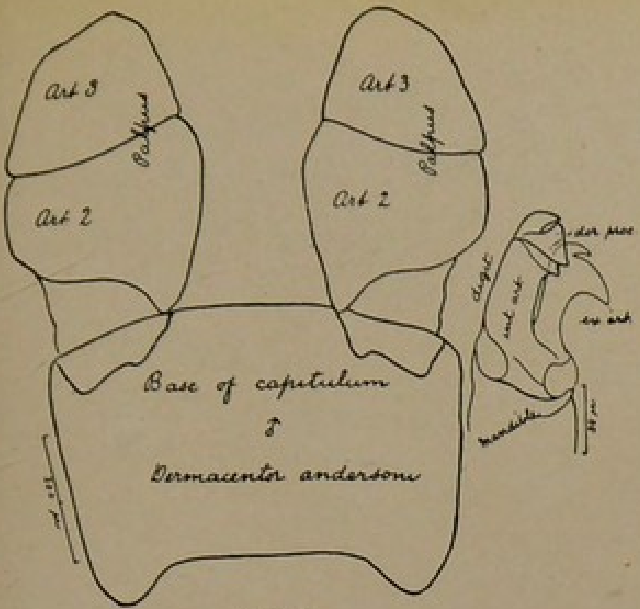

Fig. 55.

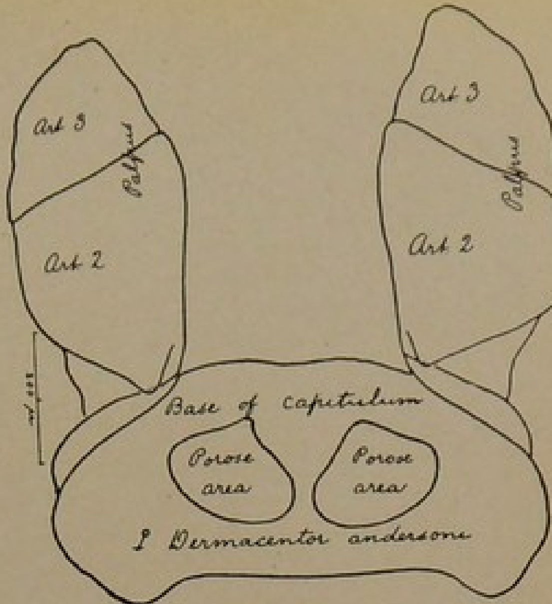

Fig. 56.

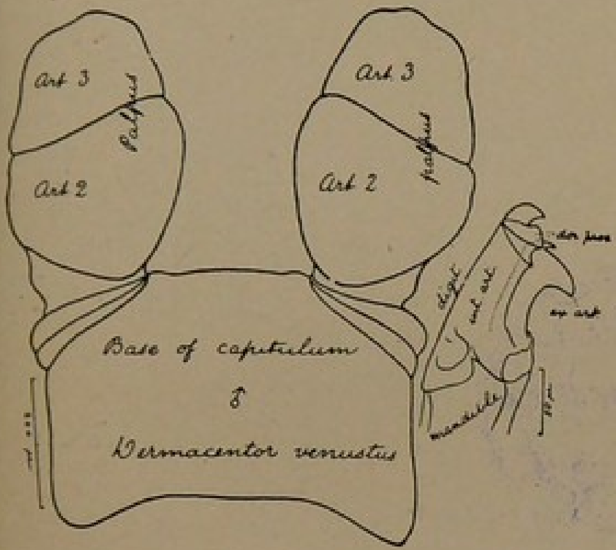

Fig. 57.

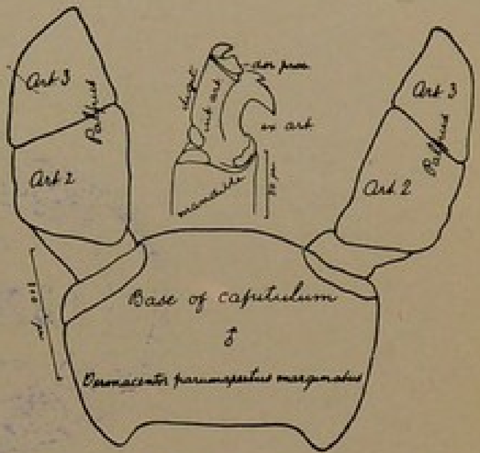

Fig. 58.

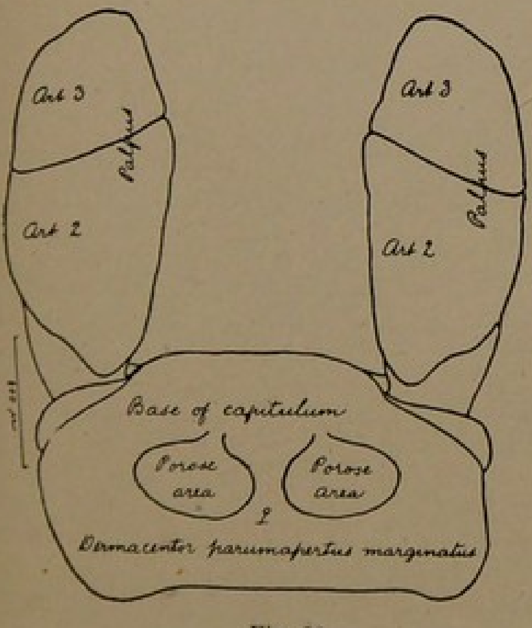

Fig. 59.

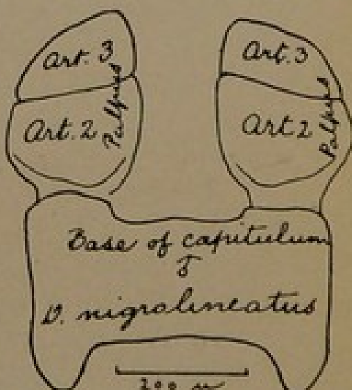

Fig. 60.

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Figs. 55–60.—OUTLINES OF CAPITULUM AND DIGIT OF DERMACENTOR.

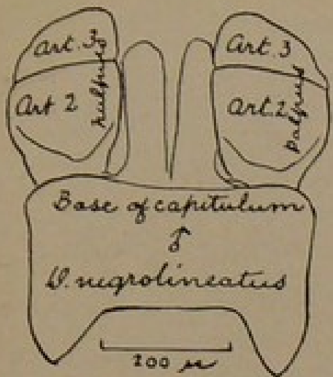


Fig. 61.

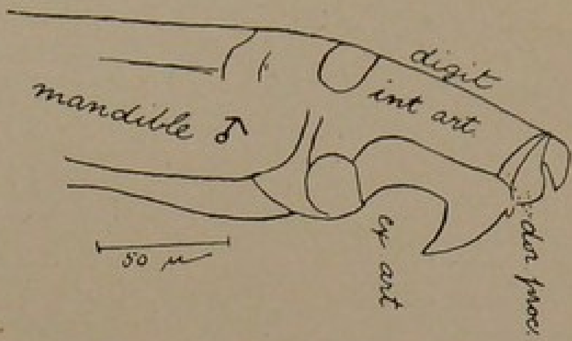


Fig. 62.

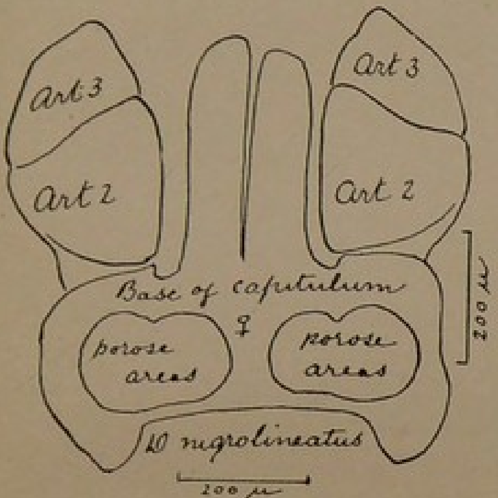
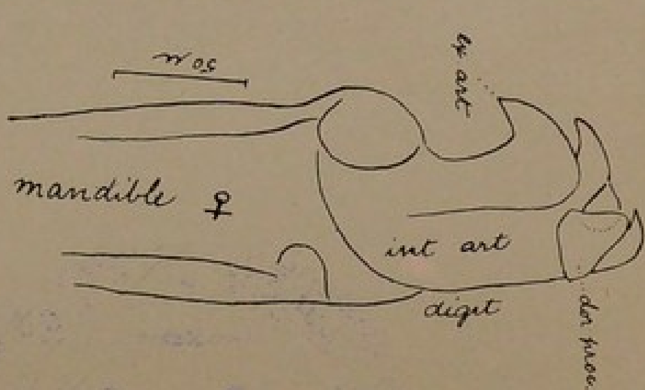


Fig. 63.



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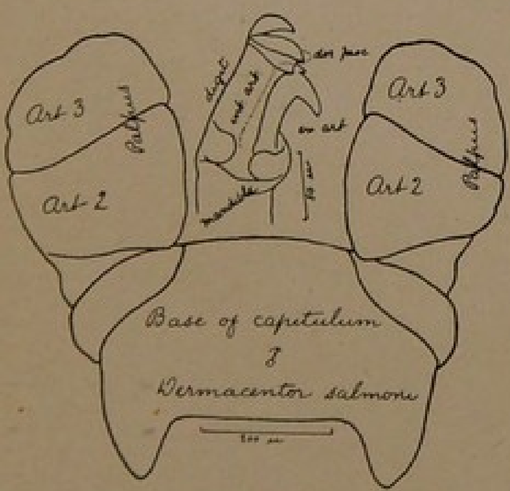

Fig. 65.

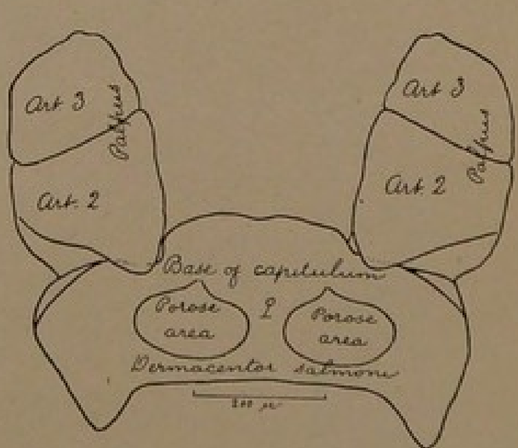

Fig. 66.

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Figs. 61-66.—OUTLINES OF CAPITULUM AND DIGIT OF DERMACENTOR.

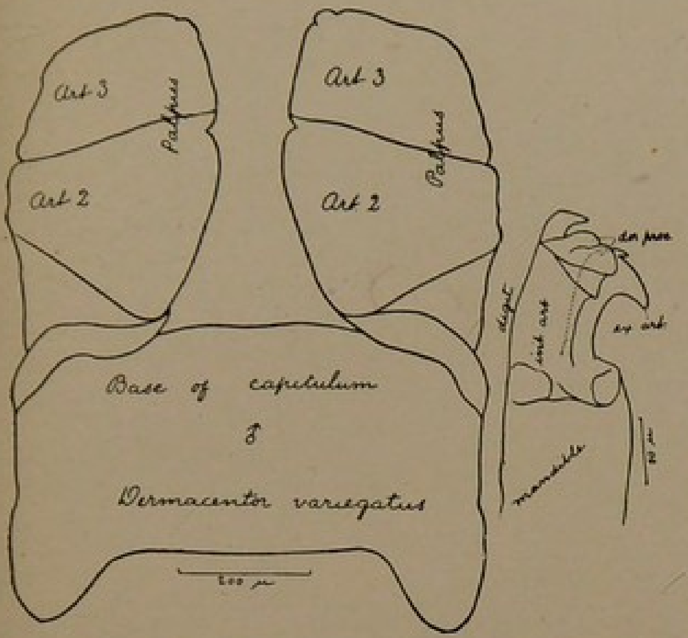
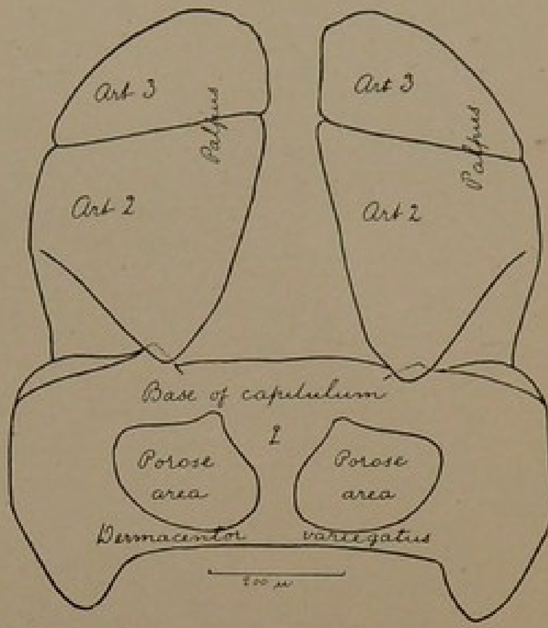


Fig. 67.



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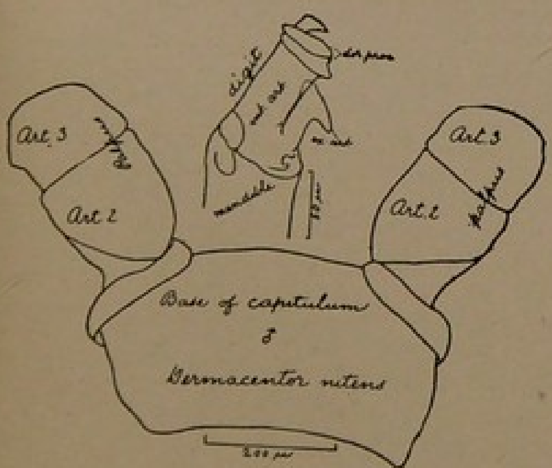

Fig. 69.

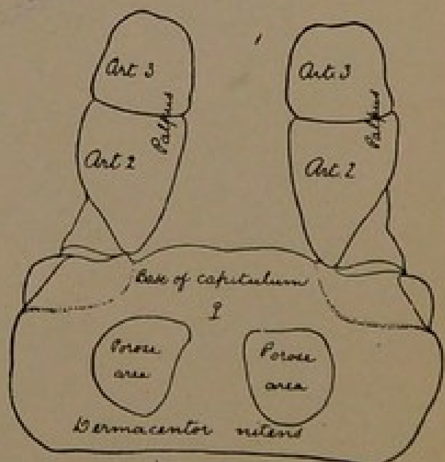

Fig. 70.

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Figs. 67–70.—OUTLINES OF CAPITULUM AND DIGIT OF DERMACENTOR.

Fig. 71.

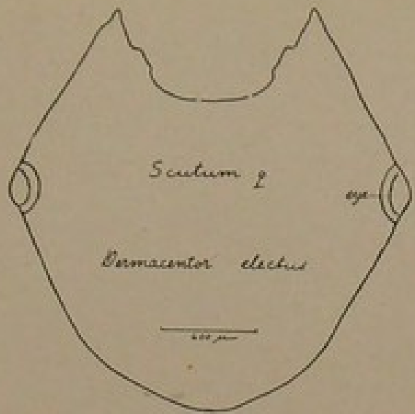
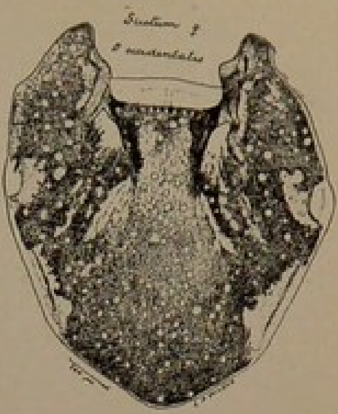


Fig. 72.



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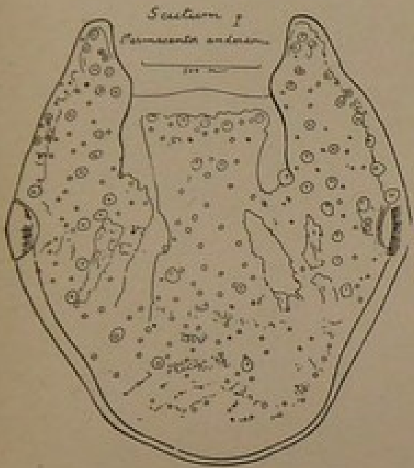

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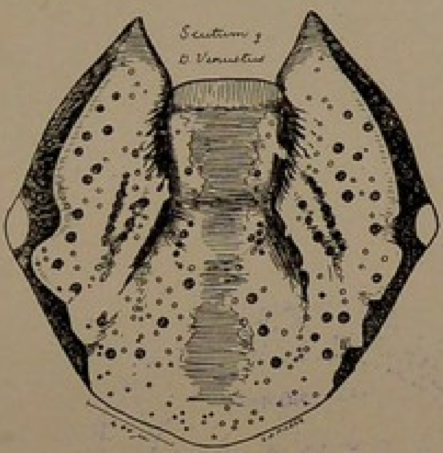

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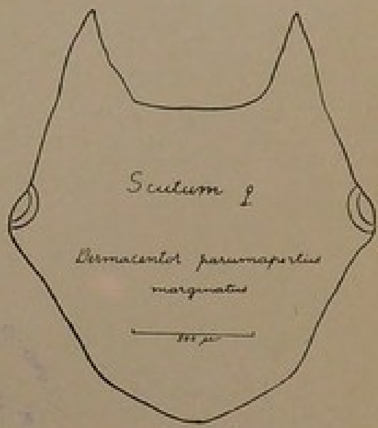

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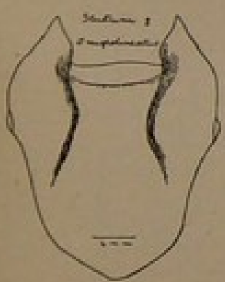

Fig. 77.

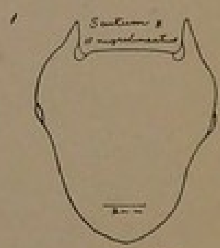

Fig. 78.

Fig. 79.

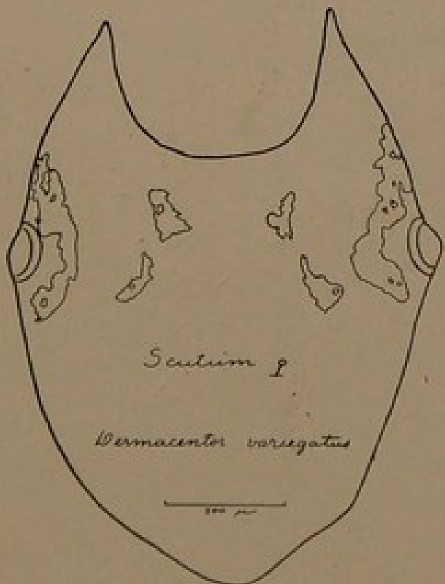

Fig. 80.

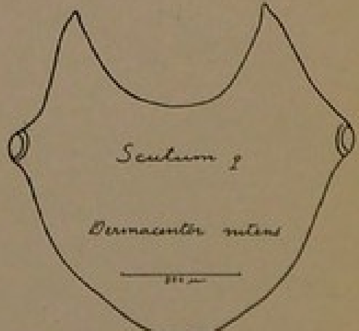

Fig. 81.

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Figs. 71–81.—SCUTUM OF FEMALE OF DERMACENTOR.

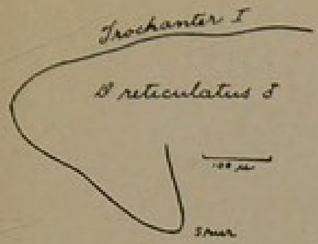


Fig. 82.

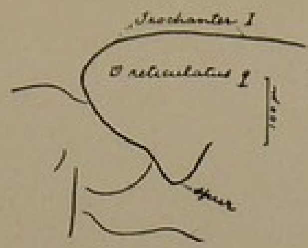


Fig. 83.

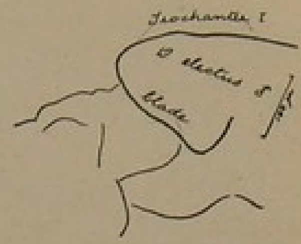
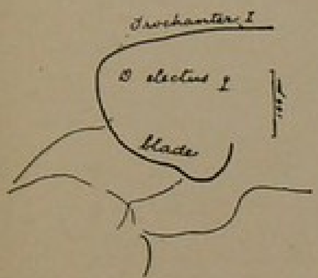


Fig. 84.



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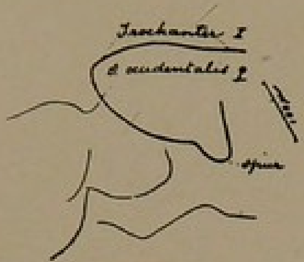

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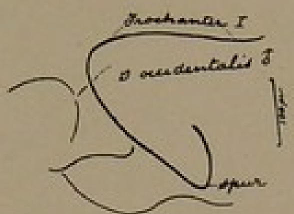


Fig. 87.

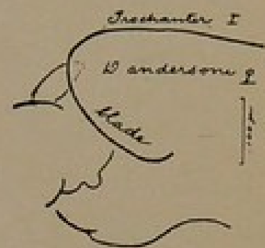


Fig. 88.

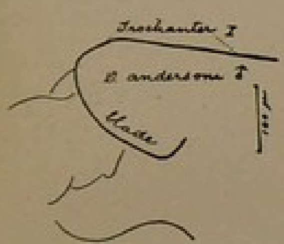


Fig. 89.

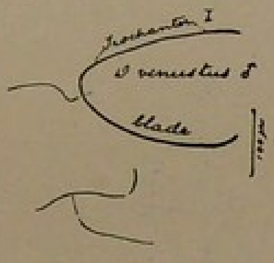


Fig. 90.

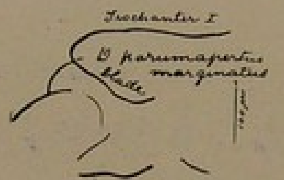
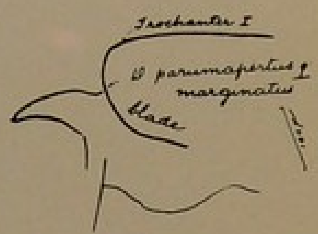


Fig. 91.



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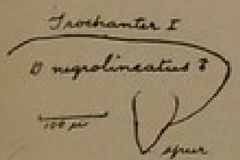

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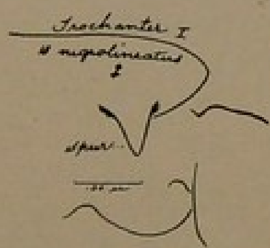

Fig. 94.

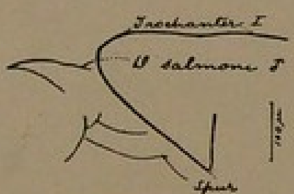

Fig. 95.

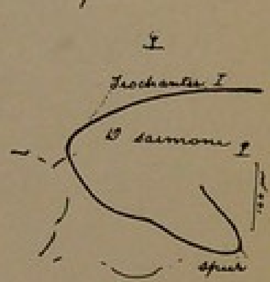

Fig. 96.

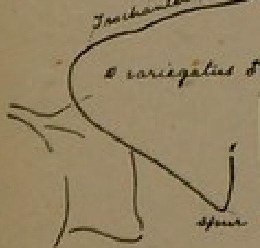

Fig. 97.

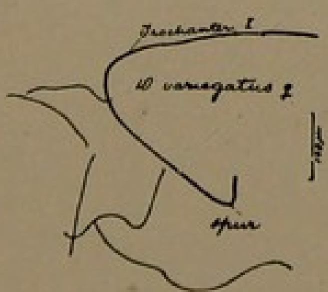

Fig. 98.

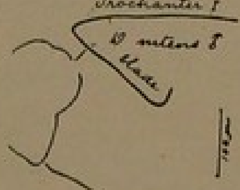

Fig. 99.

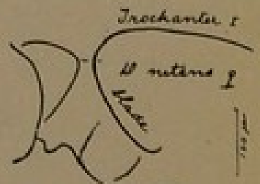

Fig. 100.

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Figs. 82–100.—DORSAL VIEW OF TERMINAL PORTION OF TROCHANTER I OF DERMACENTOR.

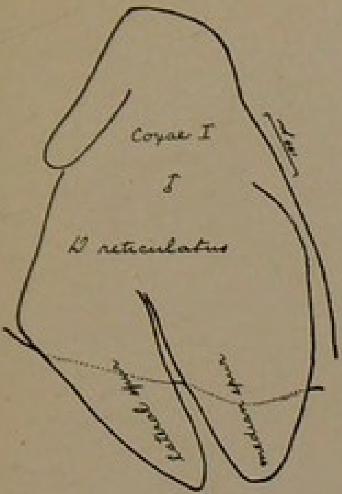


Fig. 101.

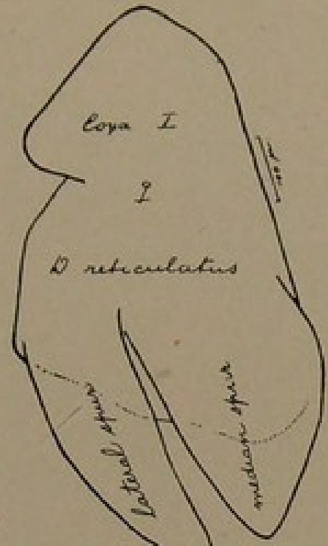


Fig. 102.

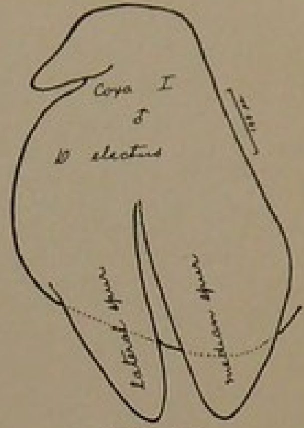


Fig. 103.

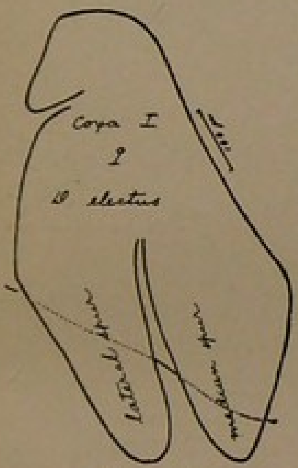
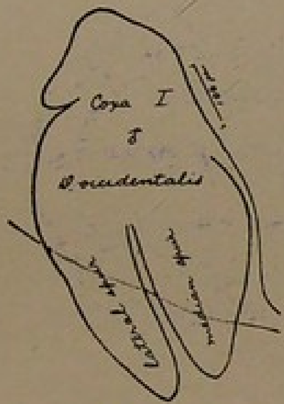


Fig. 104.



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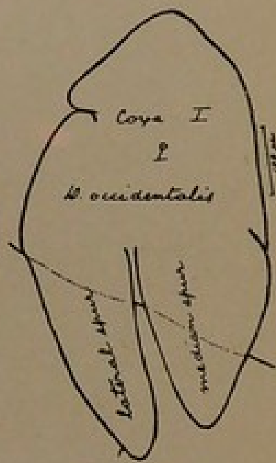

Fig. 106.

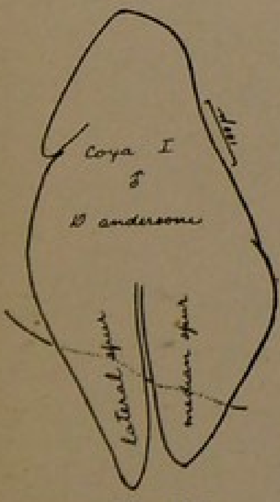

Fig. 107.

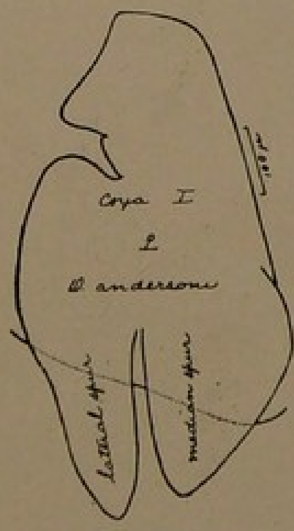

Fig. 108.

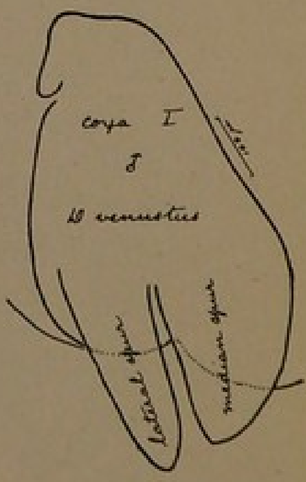

Fig. 109.

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Figs. 101–109.—COXA I OF DERMACENTOR.

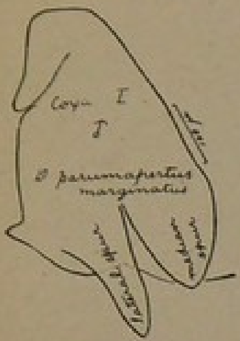


Fig. 110.

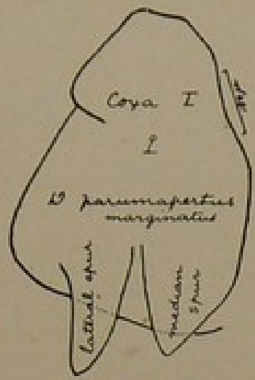


Fig. 111.

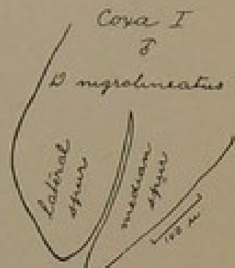


Fig. 112.

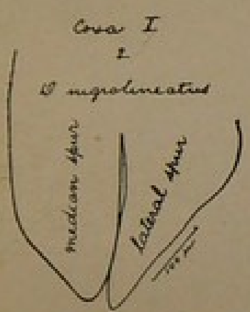
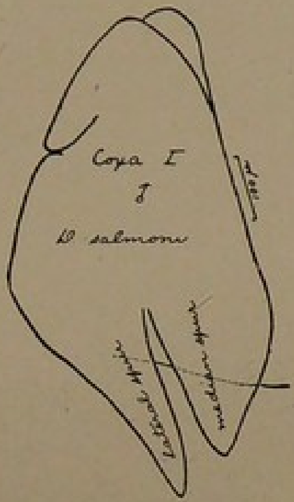


Fig. 113.



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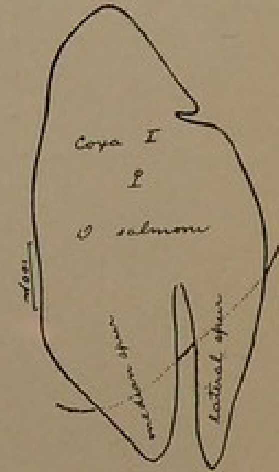

Fig. 115.

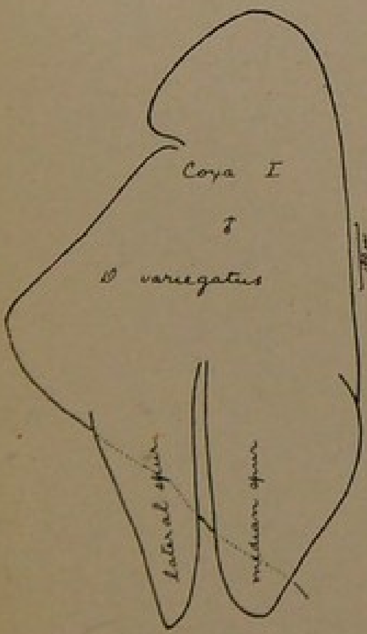

Fig. 116.

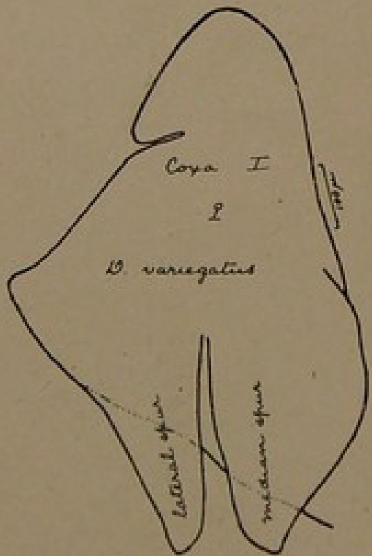

Fig. 117.

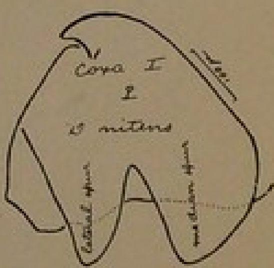

Fig. 118.

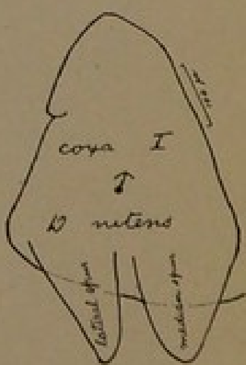

Fig. 119.

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Figs. 110-119.—COXA I OF DERMACENTOR.

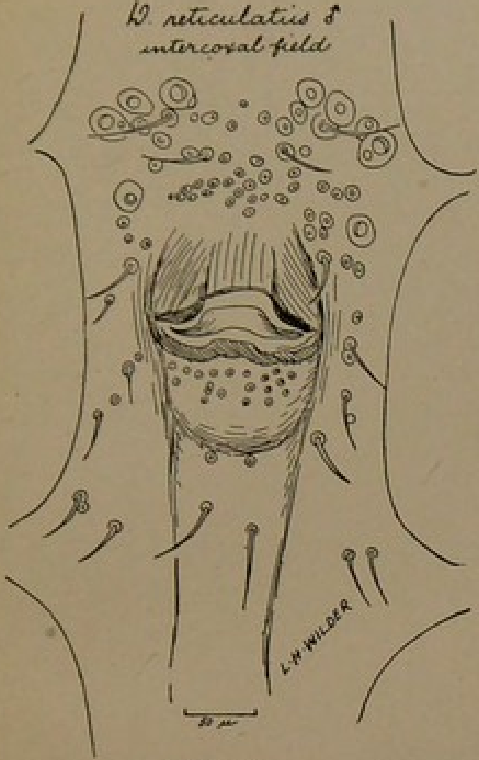

Fig. 120.

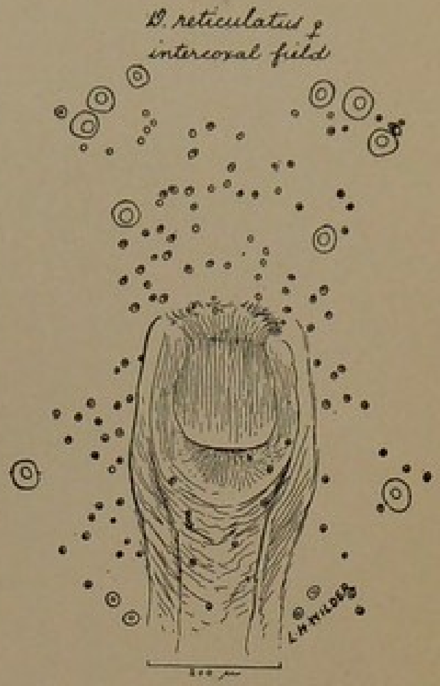

Fig. 121.

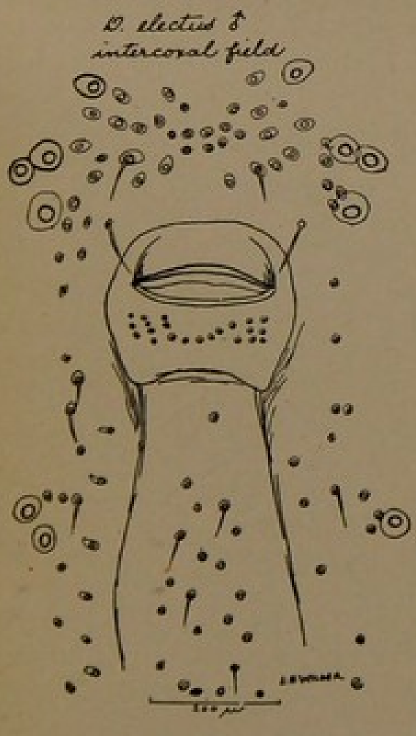

Fig. 122.

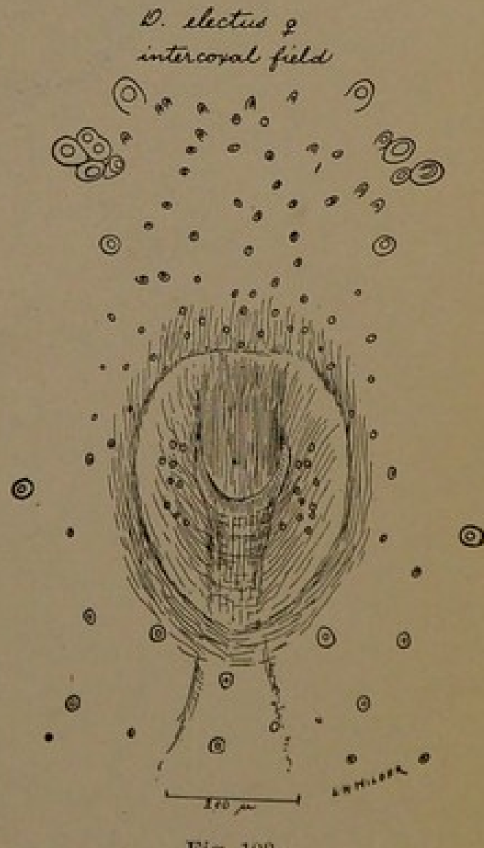

Fig. 123.

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Figs. 120–123.—INTERCOXAL FIELDS OF DERMACENTOR.

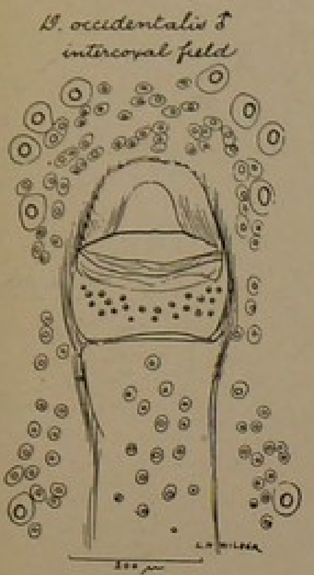

Fig. 124.

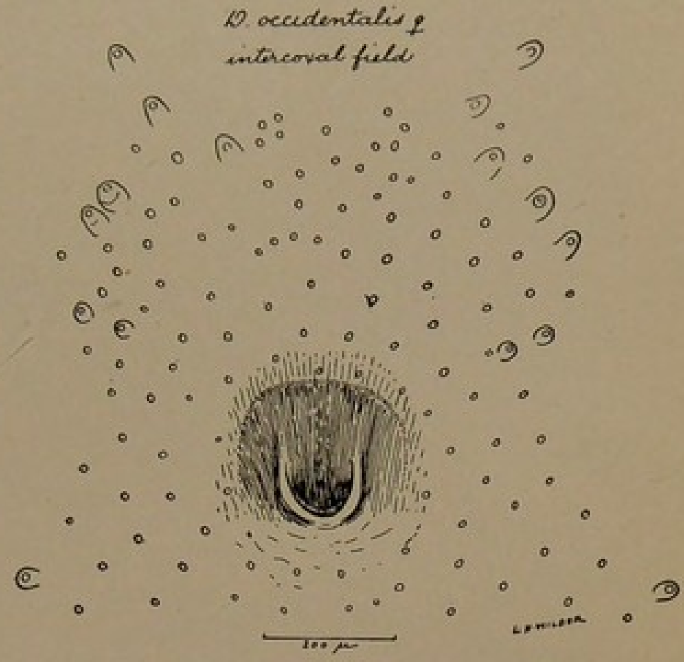

Fig. 125.

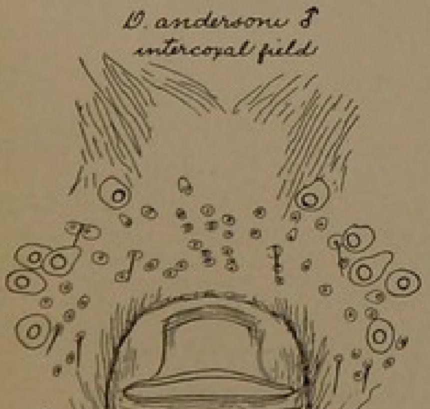

Fig. 126.

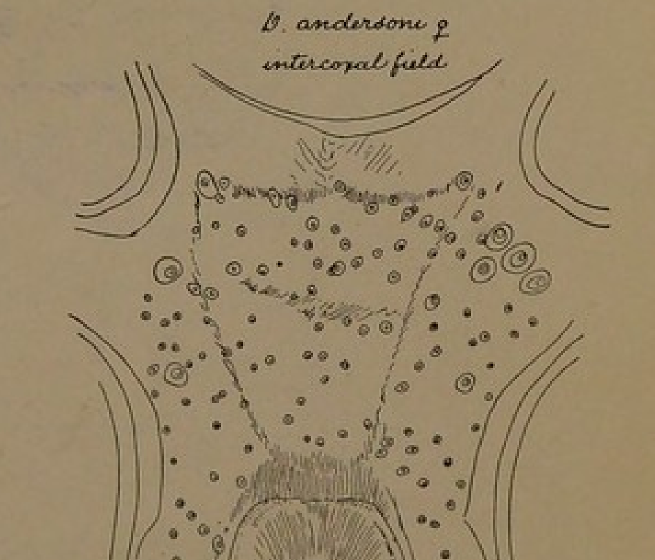

Fig. 127.

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Figs. 124-127.—INTERCOXAL FIELDS OF DERMACENTOR.

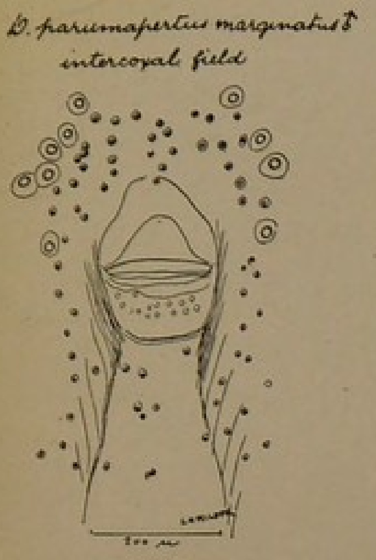

Fig. 128.

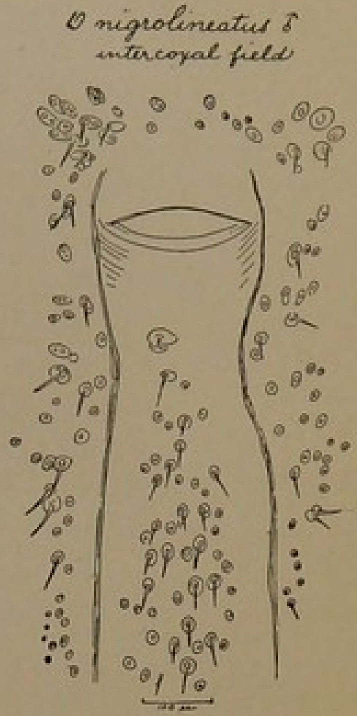

Fig. 129.

Fig. 130.

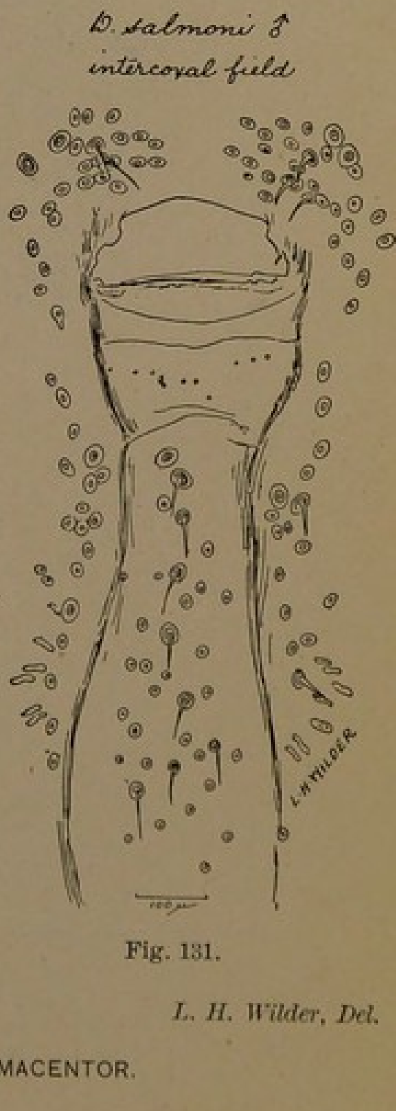

Fig. 131.

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Figs. 128–131.—INTERCOXAL FIELDS OF DERMACENTOR.

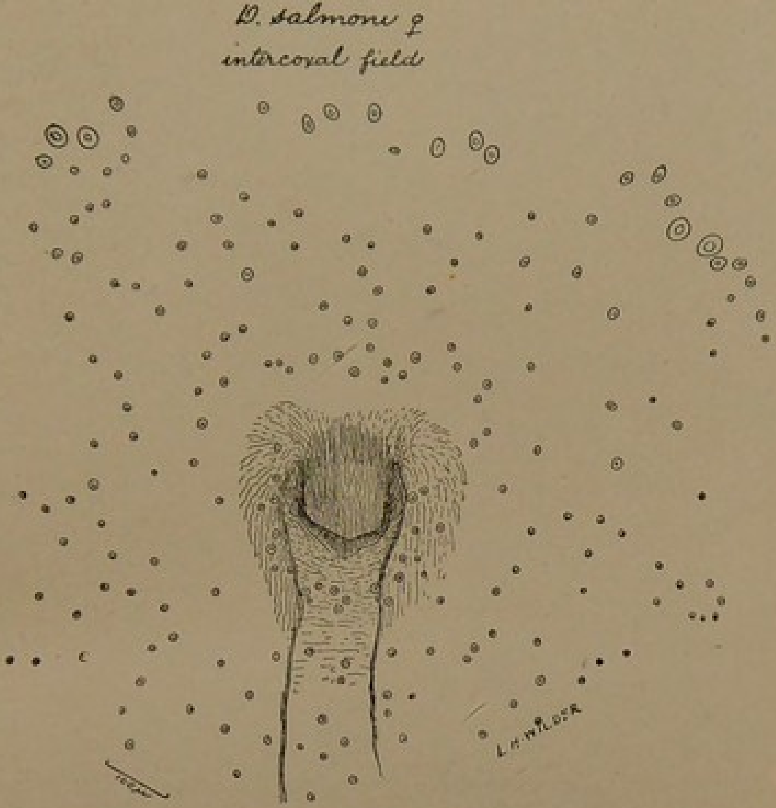

Fig. 132.

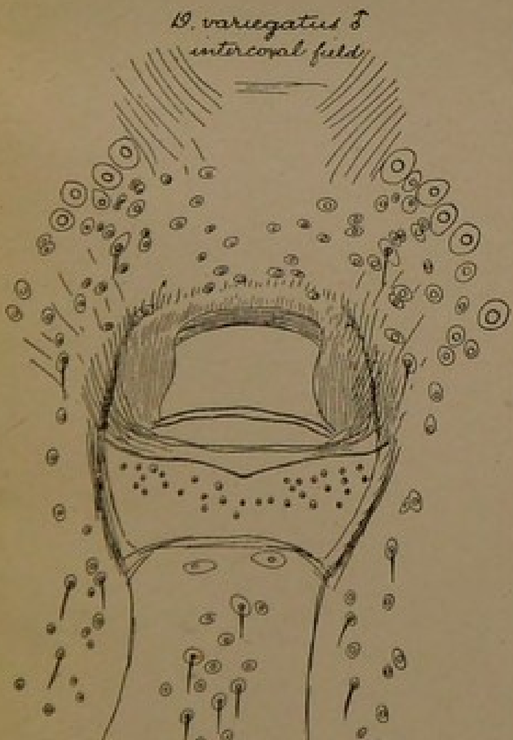

Fig. 133.

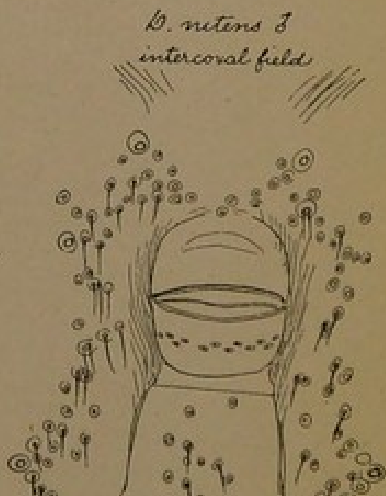

Fig. 134.

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Figs. 132–134.—INTERCOXAL FIELDS OF DERMACENTOR.