Notes on the proportion of the sexes in dogs / by Walter Heape.

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Notes on the Proportion of the Sexes in Dogs.

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Introduction.

In the following paper I have confined myself to the facts presented by the records I have collected.

I do not propose here to enter into a detailed argument regarding the causes which influence the proportion of the sexes produced by various animals, but would preface my remarks with a very brief general statement of certain aspects of that problem, as they appear to me.

For generations it has been believed that the sex of an embryo is determined by extraneous forces exerted during the development of the embryo.

The subject has always excited great interest among breeders and there is a huge literature dealing with it. I have myself noted titles of over 600 papers and books in which a great variety of causes have been urged as influencing the sex of the offspring and numerous theories published on methods to be adopted in order to regulate the proportion of the sexes which are born.

A very large section of this mass of literature has been written on the assumption that sex is determined during embryonic life, that it can be and is normally determined in accordance with conditions which affect the growing embryo. But it seems clear, as I will show below, that both the ovum and the spermatozoan are themselves sexual, that the *latest*

moment at which the sex of the offspring can be determined is the time of fertilisation, and that no influence exerted subsequently can alter that sex.

If these statements be true therefore, it follows that all this portion of the literature may be disregarded from the point of view from which it was written; at the same time it appears to me to be of considerable value from another point of view and well worthy of attention.

The most recent writers on the subject claim that the sex of the generative products is governed by the laws of heredity, and, so far as I understand, the effect of extraneous influences on the sex of the progeny is wholly denied by them.

I find reason myself to believe, that while each ovum and spermatozoan in the generative glands contains within itself sex, which is probably determined by the laws of heredity, that the proportion of those male and female ova and spermatozoa which are developed and set free from the generative glands may be regulated by selective action, exerted in accordance with the resultant of a variety of extraneous forces. If this be true the proportion of living male and female ova and spermatozoa which are freed from the generative glands, and the proportion of the sexes of the offspring which result therefrom, will thus be influenced. It is this aspect of the problem with which I specially deal in the following paper; and it is in this connection that I find the literature, referred to above, of interest.

The very existence of sex demands that ova and spermatozoa or both should be themselves sexual, i.e. male, female, or hermaphrodite.

Recent researches by Wilson (*Journ. Exp. Zool.* vol. 3, 1906) demonstrate that the spermatozoa examined by him are histologically differentiated into two groups and it appears not improbable that these groups are male and female. If this be so, although histological evidence is wanting, there is no *prima facie* reason why ova should not be similarly differentiated, and the power some females possess to produce parthenogenetically in some cases functional males, in others functional females, points emphatically to that conclusion.

In this relation the research of Doncaster "on the maturation of the unfertilised egg and the fate of the polar bodies in the Tenthredinidae" (*Quart. Journ. of Mic. Sci.*, vol. 49, 1906) regarding the product of conjugation of certain portions of the divided polar bodies in parthenogenetic eggs, is of great interest, and is strongly suggestive, to my mind, that the ovum, in all animals, is capable of determining the sex of the progeny.

Apart from this latter point, to which I will refer below, it may I think be assumed that what is true for the spermatozoa

is at least true for the ova, and that both contain within themselves definite sexual characteristics.

Now regarding the product of these generative elements.

An animal is not necessarily purely male or female; on the contrary, notwithstanding the evidence adduced by Punnett, for instance ("Sex determination in Hydatina with some remarks on Parthenogenesis," *Proc. Roy. Soc.*, vol. 78, 1906) which seems to me probably capable of other interpretation, I will venture to maintain there is no such thing as a pure male or female animal, but that all contain a dominant and recessive sex, except those hermaphrodites in which both sexes are equally represented.

The appearance of recessive male characteristics in adult dominant females and of recessive female characteristics in adult dominant males, among unisexual animals, is of undoubted occurrence and not only from a structural point of view. I suggest therefore that this fact, together with various known examples of more pronounced dual sexuality; such as, for instance, the ability possessed by the male sexual gland of certain unisexual animals, under certain conditions, to produce ova (Potts "The modification of the sexual characters of the Hermit crab caused by the parasite Peltogaster," *Quart. Journ. of Mic. Sci.*, vol. 50, 1906); and the normal production of true hermaphrodites; is proof that all animals contain the elements of both sexes in some degree.

I should perhaps here point out that Potts' results do not show that the sex of the animal is changed by the parasite, but rather that the recessive sex present in the animal is thus stimulated. The structural modifications which accompany the changes in the generative glands indicate the close correlation of primary and secondary sexual characteristics.

In this relation the experiments of Bordage (quoted by Castle "The Heredity of Sex," *Bull. Mus. Comp. Zool. Harvard*, vol. 40, 1903) are of interest; they show that cutting back the apex of a young male plant of Carica pupaya just before the appearance of the male flower, may result in the growth of two branches from below the cut which bear female flowers and fruit. Also the observations of Strasburger (*Biolog. Centralblatt*, 1900) on the effect of rust fungus on the female flowers of Lychnis dioica, resulting in the development of stamens normally reduced to rudiments; and those of Meehan on the "Relation of heat to the sexes of flowers" (*Proc. Acad. Nat. Sci. Philadelphia*, 1882—1884), may be similarly interpreted. These observations are all indicative of the result of stimulation of the recessive sex, either directly, or indirectly on account of the functional degeneration of the dominant sex.

Much evidence advanced by Castle (*loc. cit.*) is of great interest in reference to this portion of the subject, and I regret that the

necessary brevity of this preliminary communication prevents me from analysing more fully his painstaking paper.

The assumption of male characteristics in old females and of female characteristics in old males is common knowledge and is evident not only in structural modifications but in modified mental traits. It would seem as if the recessive sex is here asserting itself, either on account of atrophy or hypertrophy of the dominant sex, either from exhaustion resulting from a long and active sexual life in paired individuals, or from a want of sexual exercise in unpaired individuals.

There are many examples of the existence of structural rudiments of the recessive sex, such as the clitoris of the female, the oviduct and mammæ in the male; while the occurrence of both structural *and* functional characteristics of the recessive sex in many unisexual animals from birth, is also well known, e.g. in the Pipe fish (Gudger "The breeding habits and the segmentation of the egg of the Pipe fish, Siphostoma Floridæ," *Proc. U.S. Nat. Hist. Mus.*, vol. 29, 1905), and there seems to me ample evidence for the conclusion that there is no such thing as a pure male or female.

From these premises it must be concluded, in order to fulfil the required conditions, that a male ovum is fertilised by a female spermatozoan and, *vice versa*, a female ovum by a male spermatozoan in all animals other than those produced parthenogenetically.

But if it is true that the adult animal is never purely male or female it may be argued that the sexual products are similarly constituted. In that case an ovum or a spermatozoan contains dominant male or female characteristics as the case may be, and recessive characteristics of the opposite sex. (Conf. Castle, *loc. cit.*)

In such case the possibility of infinite gradations of sexual differentiation in an individual would be vastly increased and, from the point of view of heredity, such complex conditions carry with them factors of the greatest importance.

For instance, the sexual selection which is undoubtedly, though unconsciously, exercised by civilised peoples, renders it probable that the recurrence in a nation, at long intervals of time (as suggested by Weininger "Sex and Character," 1906), of an increased or reduced proportion of so called effeminate men or of masculine women, or of the ebb and flow of a number of national characteristics intimately associated with the predominance of characteristics peculiar to one or the other sex (such as the desire for war, national hysteria, social sexual problems, &c.), may thus be accounted for. Weininger ably maintains, and it seems clear, that national characteristics of this nature are definitely correlated with the sum of dominant sexuality which exists at any one time.

Again it may be argued that, if both spermatozoan and ovum contain both male and female sexual elements, the dominant and recessive sex in the offspring would be assured even if an ovum was fertilised by a spermatozoan of the same dominant sex. This is no doubt true, but in that case it must be assumed that the individual resulting from such union would produce sexual products of only one dominant sex.

Such is manifestly not the case and I conclude that, so far as this argument is concerned, the probable existence of a dominant and recessive sex in both ovum and spermatozoan does not affect the question, but that it is essential that an ovum in which one sex is dominant should be fertilised by a spermatozoan in which the opposite sex is dominant.

These will be referred to below as male and female ova and spermatozoa.

Whether the sex of the embryo is determined by the ovum or by the spermatozoan is another matter. In the case of hermaphrodites it would appear that each of the sexual elements have equal power, but where the sexes are differentiated one or the other of the generative products must have a determining power.

In this latter case it may be held that a fight for supremacy takes place on the union of each spermatozoan with an ovum and that the dominant sex of the embryo is determined by the most powerful of the two.

But on this assumption the sex of the ovum and spermatozoan must, as a rule, be supposed to be of more or less equal power, and Mendelian laws indicate the certainty that in such case a far larger proportion of hermaphrodites would be produced than actually occur.

This appears to me sufficient reason for assuming that, in unisexual animals, either the ovum or the spermatozoan has a predominating influence, but which of the two is dominant I know of no conclusive evidence to show.

There is a mass of literature dealing with this aspect of the problem from a statistical point of view, one portion of it indicating marked influence of the male, the other no less marked influence of the female parent. I will not attempt an exhaustive analysis of these statistics here. They deal chiefly with the human species and with domesticated animals and are, for the most part, open to the objection that they are based only on living progeny and disregard those which are still-born or die young; for this reason they are not satisfactory for our purpose, but at the same time much may be learned from them.

Doncaster's and Castle's works show, it is true, that certain parthenogenetic ova give rise to male and others to female embryos and that in this case the power of determining the sex is contained

in the ovum; but the advent of a spermatozoan may upset all that and the sex of the sperm may always dominate that of the ovum. According to Castle (p. 199) there is some evidence of this among Rotifers, in which eggs under unfavourable conditions which form two polar bodies, develope parthenogenetically into males or if fertilised become "winter eggs" and produce parthenogenetic females. In this case the female element in the sperm would appear to dominate the male element in the ovum. But there are exceptions and the evidence does not appear to me to be at all conclusive since we are dealing with eggs capable of parthenogenetic development, and there are wide possibilities of differentiation in such eggs which are also capable of fertilisation. For instance, according to Punnett (*l. c.*) fertilisation of arrenotokous females is only possible a few hours after hatching.

Again, Bateson and Punnett's interpretation of their studies on Poultry (*Report to the Evolution Committee, Royal Society*, Pt. II., 1905) leads them to infer that sometimes the ovum and at others the sperm is responsible for sexual differentiation.

Thus it may be that for certain species of animals, or for certain individuals, the sex of the embryo is derived from the ovum while for others it is derived from the sperm, and that is as far as present evidence permits us to go.

But even if that be so, if the two are necessarily of opposite sex, the sex of the ovum has a regular relation to the sex of the embryo just as surely as if it conferred its own sex, and for the purpose of my future argument this is all it is necessary to assume.

On this assumption a female parent producing ova of one sex only will give birth to embryos of one sex, unless the male parent possesses no spermatozoa of the opposite sex wherewith to fertilise it, in which case the union will be barren. Düsing ("Die Regulierung des Geschlechtsverhältnisses bei der Vermehrung der Menschen, Tiere, und Pflanzen," *Jena Zeitschr.*, vol. 17, 1884) claimed that the statistical results he obtained from a study of the mating of thoroughbred horses, indicated the dominant influence of the male parent on the sex of the offspring. Any sire that usually produces spermatozoa of one sex only can be fertile, as a rule, only with mares which produce ova of the other sex, and to such an extent he determines the proportion of the sexes of the offspring for which he is responsible; but where sperm of both sexes is uniformly produced, the sire must be fertile with all mares producing ova, and, as only one ovum is produced by each mare, the responsibility for the sex of the offspring then lies solely with the female parent.

I think it will be found that a very large proportion of the evidence adduced to show the preponderating influence of the

male parent on the sex of the offspring may thus be explained; while statistically the father might be shown to be responsible, physiologically the mother controls the governing influence.

Normally it may be assumed that both sexes of ova and spermatozoa are present in the ovary and testis. Among most viviparous animals, however, but few ova ripen at one time, in many of them only a single one is dehisced; the necessities attending gestation having led to specialisation in this respect. On the other hand, having regard to the enormous numbers of spermatozoa produced per ovum fertilised, it seems that specialisation to the same extent has not occurred in the male and that both sexes of spermatozoa are as a rule presented; thus it follows that in these animals, as a rule, the sex of the embryo is solely determined by the mother, no matter whether that sex is derived from the ovum or the sperm.

Concerning the proportion of the sexes produced; it may well be that, in those females which shed all their ova the proportion of the sexes of these ova and, if they are fertilised, the proportion of the sexes of the young so produced, will be governed by Mendelian laws. But amongst animals which only produce during their life a small proportion of the ova contained in the ovary, in which from time to time, owing probably to a great variety of circumstances, a considerable number of these ovarian ova degenerate and are absorbed, the proportion of the sexes of the ova produced is surely directly dependent upon the causes which induce the degeneration of some and the ripening of other ovarian ova.

There can be little doubt that the proportion of the sexes produced by various species of animals, and by varieties of those species, is to some extent a racial characteristic; but from a study of the evidence before me I am induced to maintain that such proportion may be very largely influenced by a great variety of causes which exert their influence upon the male or female ovarian ova, causing one or the other to develope and ripen or to degenerate as the case may be. The same may be true for the testes of the male, but of this I have no evidence.

A study of the rabbit's ovary shows that two kinds of degeneration prevail, the one affecting first the follicle and subsequently the ovum, the other first the ovum and subsequently the follicle. I have interpreted the latter to mean that the ovum is unable to assimilate the nutriment offered to it, while the former, I judge, is evidence that, for some reason or other, either one or more ova develope at the expense of the others, or the nutriment available is insufficient for the maintenance of all the ova at that time ("Ovulation and degeneration of ova in the Rabbit," *Proc. Roy. Soc.*, vol. B. 76, 1905).

Although the causes which induce the degeneration of ova have not been surely demonstrated, I think it may unhesitatingly be accepted that nutrition plays a very important part therein; but whether it exerts a selective action as regards sex, whether it affects the proportion of male or female ova which ripen, there is, so far as I know, no conclusive evidence. On this subject of nutrition and sex there is again a large literature which it is impossible to present fairly here. Most of it is written to show that the sex of the embryo can be governed by the nutriment supplied to the mother during gestation and with this section, for reasons already stated, we have nothing to do; for the rest, almost all of it is based upon the supposed effects produced by the quantitative supply of nutriment presented to the mother.

There is much confusion about the whole of this section of the subject. For instance, in support of the view, very generally held, that more nutriment is required for the production of females than for males; it is argued that, as the adult female has greater capacity for storing nutriment than the adult male, this fact is evidence that more nourishment is required for her production. I think it is clear that the viviparous female has, broadly speaking, greater powers of storing nutriment than is possessed by the male. Her maternal functions require such special capacity and, though I will not give data here, I will add, there is conclusive evidence to my mind that she possesses it. But if it is so, that is no evidence that the ovum from which she is derived requires more nourishment for its development.

Again, the greater difficulty experienced in rearing male than female children is attributed by some observers to the better nourished condition in which girls are born; and many have argued, in one form or another, this is clear evidence that the mother needs an extra supply of nourishment to enable her to produce a girl. So far as this latter point is concerned perhaps the greater mortality among male infants is otherwise to be explained. But however this may be the point at issue is not affected thereby, for if nutriment has any effect at all upon the proportion of the sexes produced, it must be exerted on the ovum in the ovary; that is to say it is the capacity of the mother to supply the ovary with nutriment which must be taken into consideration. Now it does not at all follow that a female with exceptional powers of assimilating and of storing nutriment, or that a mother especially capable of producing well-nourished offspring, gives birth to an excess of females; indeed my own experiments indicate that the reverse, in many cases, is true. At the same time there are records of experiments which may, in my opinion, be interpreted to show that nutrition has a selective action on ovarian ova; it is on these lines I have myself been

working, not without success; and I hold that either quantitatively or, more probably, qualitatively this is true.

Of the various other agencies which it is claimed affect the proportion of the sexes born, such as in-breeding, cross-breeding, age, climate, temperature, &c.; such power as they have, and I think there is sufficient evidence to show they are potent agencies, must be exercised either as a selective agent on the ova and spermatozoa, while within the generative glands of the parents, or as a purely destructive agent on the freed products of these glands. As selective agents these forces may act directly on the ovarian ova or indirectly affect them by modifying the vitality of the whole generative gland, making it thus more or less capable of assimilating the nutriment with which it is supplied. By these means ova requiring an excess of, or a certain quality of nutriment, will have their needs supplied or they will degenerate; those most easily brought to maturity will ripen while others will fail to do so; the special vitality of some ova will cause them to thrive, certainly at the expense of and probably on, their less active neighbours.

The variation which exists in the physiological capacities of the adult male and female is surely represented in the sexual ovum. The marked difference in the death rate of males and females during famines, for instance (Lewis McIver, *Madras Census Report*, 1881, vol. 1, 1883), may well be reproduced among male and female ova in the ovary when that organ is subjected to homologous conditions; and such conditions may certainly be brought about in consequence of the active participation of one or other or many of the extraneous forces already alluded to.

Thus, so far as this portion of the subject is concerned I am disposed to maintain:

(1) that through the medium of nutrition supplied to the ovary, either by the quantity or by the quality of that nutrition, either by its direct effect upon the ovarian ova or by its indirect effect, a variation in the proportion of the sexes of the ova produced, and therefore of the young born, is effected in all animals in which the ripening of the ovarian ova is subject to selective action;

(2) that when no selective action occurs in the ovary the proportion of the sexes of ovarian ova produced is governed by laws of heredity.

With this very brief outline of my interpretation of the evidence before me regarding this section of a most intricate subject I must here content myself.

In the following pages are treated various breeds of dogs and indications are given of the exercise of certain forces which appear to affect to some extent the proportion of the sexes produced.

I am not aware that this has hitherto been done; the figures given are I think not without value and will, I hope, be thought worthy of record.

The Proportion of the Sexes in Dogs.

Darwin, in his *Descent of Man* (vol. 1, p. 304, 1871) records information he had obtained regarding the proportion of the sexes in Greyhounds. From 1857 to 1868, 6878 births were recorded, the proportion of males being 110·1 per 100 females.

The figures submitted to him showed very considerable fluctuation during different years, the extremes being in 1864, when 95·3 males were produced per 100 females, and in 1867, when the proportion of males was 116·3.

Further he states that several great breeders of dogs are unanimously of opinion that females are *produced* in excess.

Some years ago I collected statistics on this subject and in view of the opinion of the breeders above mentioned and of the interest now aroused in the sex problem it appears to me advisable to record the results obtained..

The figures Darwin published were those of births of a single breed of dogs recorded in the *Field*. But a dog-breeder does not necessarily keep all the offspring produced in a litter, there may be more produced than the mother can rear with advantage, in which case one or more puppies may be destroyed; or there may be weakly members of the litter which the breeder will certainly destroy; or there may be some puppies born dead.

Clearly then the proportions he arrived at were not necessarily the proportions of the sexes actually borne by dogs of this breed, and were certainly not so unless the foregoing sources of error were eliminated.

If it is true, as is suggested, that females are valued less than males, in case puppies are destroyed on account of the large size of a litter it would be the bitch puppies which would be so destroyed, and this custom might account for the opinion that females are produced in excess. On the other hand among human beings the mortality of young males is greater than that of young females; if the same rule obtains for dogs therefore it is to be expected that among weakly members of a litter, which are destroyed, males would predominate and Darwin's figures would be below and not above the average for males produced.

Again the proportion of the sexes in Greyhounds may be different from those in other breeds of dogs; there may be a racial variation in the proportion of the sexes produced; and in view of the application of Mendelian laws this fact would appear to be worthy of attention.

With regard to the records now presented. First, I have checked the figures supplied to Darwin by collecting the returns entered in volumes 7 to 11 of the *Greyhound Stud Book* for the years 1886—1892. Secondly, I have tabulated the returns for all breeds of dogs published in the *Stock Keeper*, *Kennel Register* for the years 1889—1891. Thirdly, I have abstracted the returns published in the *Stock Keeper* for particular breeds of dogs, for those years. Fourthly, I have collected information from certain breeders who keep accurate records, of the number of males and females actually born in a variety of breeds of dogs; and, as some of these latter records extend over a considerable period and give the results of the mating of individual dogs and individual bitches, year after year, I have been enabled to record the tendency of these individuals to produce a marked proportion of offspring of one or the other sex.

The Greyhound Stud Book.

Records from the *Greyhound Stud Book*, vols. 7 (1888) to 11 (1892) are summarised in Table I. The animals registered during that time are tabulated under the year in which they are born.

TABLE I.

Greyhound Stud Book. Registered births per year, 1886—1892.

Year	1886	1887	1888	1889	1890	1891	1892
Dogs	777	2278	1935	1923	1781	940	40
Bitches	666	1880	1628	1666	1475	813	36
Total	1443	4158	3563	3589	3256	1753	76
Dogs per 100 bitches	116·6	121·17	118·86	115·43	120·74	115·62	111·1

As the Table indicates, pups are not always registered the first or even the second year after they are born and for that reason the records for the years 1886, 1891, and 1892, in the Table, include only a part of the animals which have already been or eventually will be recorded for those years.

Probably, for the same reason, the records for 1890 are also incomplete, but judging from the totals obtained for 1887—1889,

but few remain to be added to that year's total and the results for the four years 1887—1890 may be taken as typical.

The proportion of dogs for these four years varies between 115·43 and 121·17, an average of 119·07; while if all the animals registered are included in the calculation the average works out at 118·5, as against 110·1 given by Darwin, a difference of 8·4 in favour of dog pups.

In Table II, the numbers are given in accordance with the month of birth, and, roughly, of the month of conception.

TABLE II.

Greyhound Stud Book. —*Registered births per month for years* 1886—1892.

Month of birth	Dogs	Bitches	Total	Dogs per 100 bitches	Extreme variation during years 1887—1890. Dogs per 100 bitches	Difference	Mean of variation during years 1887—1890. Dogs per 100 bitches	Month of conception
Jan.	1031	805	1836	128·07	123—134	11	128·5	Nov.
Feb.	988	867	1855	113·96	95—127	32	111·0	Dec.
Mar.	1280	1127	2407	113·57	107—117	10	112·0	Jan.
Apr.	1610	1378	2988	116·84	111—127	16	119·0	Feb.
May	1685	1414	3099	119·16	111—124	13	117·5	Mar.
June	1326	1155	2481	114·8	112—121	9	116·5	Apr.
July	938	761	1699	123·26	95—130	35	112·5	May
Aug.	432	363	795	119·0	93—149	56	121·0	June
Sept.	202	182	384	110·99	96—130	34	113·0	July
Oct.	94	65	159	144·61	115—187	72	151·0	Aug.
Nov.	45	25	70	180·0	133—200	67	166·5	Sept.
Dec.	43	22	65	195·45	171—500	329	335·5	Oct.
Totals	9674	8164	17838	118·5	115—121	6	118·0	

According to Stonehenge (*The dog in health and disease*, 1887) the best time of year for breeding is from April to September, the cold of winter being unfavourable for the development of young puppies; but for sporting reasons Greyhounds are usually bred earlier in the year, because their age is reckoned from the 1st January and the earlier they are born the better chance they have in competition with their fellows of the same year. Thus, this Table shows that the four months, March to June, are the months during which most births are recorded and,

roughly, November to May is the time of year when conception usually takes place.

From March to June, when births are most frequent, the proportion of dogs per 100 bitches is remarkably constant, varying from 113·57 to 119·16, a difference of 5·59, the average being 116·29; whereas from July to February, when births are less frequent, there is a much wider variation, namely from 110·99 (September) to 195·45 (December), a difference of 84·46, the average being 122·1 dogs per 100 bitches.

In only three of these months, viz. August (119·0), September (110·99), and February (113·96) is the proportion of dogs lower than that recorded for any of the months, March to June; in all other months the proportion of dogs is higher, especially in the four winter months from October to January, when the proportion ranges from 144·61 to 195·45, the average being 132·27 dogs per 100 bitches.

The column in Table II showing the extremes of variation for the years 1887—1890 indicates a very similar result. The lowest proportion of dogs recorded for the four months March to June varies from 107 to 112, a difference of 5, while the highest proportion varies from 117 to 127, a difference of 10. From July to February, however, the lowest figures range from 93 to 171, the highest figures from 127 to 500.

In the same way the differences range from 9 to 16 from March to June, and from 11 to 329 from July to February, while the greatest differences occur during the winter months, October to December, when the highest proportion of dogs is born.

The mean of the variation during the years 1887—1890 shows this result more markedly. In this column it is seen that in all months from February to July less than 120 dogs per 100 bitches are registered, while in all from August to January, with the single exception of September, the proportion of dogs is more than 120.

An examination in detail of my figures shows that throughout each year, month by month, there is almost invariably a marked preponderance of dogs recorded. The only months in which bitches predominate occur irregularly as follows: July, 1888, 95 dogs; February, 1889, 95; August, 1889, 93; September, 1890, 96 per 100 bitches; while in a series of years there is no month which shows a preponderance of bitches.

Again, while the annual total invariably shows a higher proportion of dogs than bitches there is no year in which this is markedly the case, the extreme variation of the totals for 1887—1890 being 6.

The year in which only 115 dogs were recorded was in 1889, when the proportion of dogs fell especially low in both February and August of that year.

Although below I shall show that accurate records of the sex of puppies *born* prove that, in a variety of breeds, a still higher proportion of dogs is produced than is recorded in these tables, I think it is nevertheless justifiable to conclude that the figures now dealt with are not widely misleading and that they demonstrate sufficiently clearly the broad conclusions I have drawn from them, namely:

In spite of the fact that it must be assumed all births are not recorded, the marked increase in the proportion of dogs registered as born in the winter months is very striking, and I am of opinion it may be assumed that conception during the six months June to November, and especially during the last four of these months, August to November, is more highly favourable to the production of male than of female Greyhounds under the conditions of breeding now practised.

The fact that the preponderance of births of dogs over bitches is greater at one time of the year than at another, and that an excessive preponderance of male births is associated with a low birth rate, during the winter months, is worthy of notice in its relation to the normal breeding time of these animals, i.e. to the time when the generative organs are in their most active condition, and therefore in relation to the view that the sex of the ova produced is governed by selective action.

The Stock Keeper, Kennel Register.

The records contained in the *Kennel Register* are open to the same objection which has been admitted for the *Greyhound Stud Book*, namely, that all pups born are not necessarily registered; but, as a comparison of these returns with breeders' Schedule returns (given below) will show, the objection is certainly not a weighty one in this case. I have, therefore, abstracted details for a series of breeds, of which there are sufficient entries, for the years 1889—1891, Table IV, and also added the annual totals of every entry made for all breeds for those years, Table V. The returns in Table IV have been classified into Large dogs and Terriers, and it is seen that while the dogs born per 100 bitches among Terriers is 113, among Large dogs it rises to 117·51. At the same time it is shown that whereas among Terriers the pups per litter work out at an average of 5·4, among Large dogs the litters are considerably bigger and average 7·5 pups. The class of dog with the highest fertility per litter thus appears to produce the largest proportion of dog pups.

The results obtained for the Large dogs are dominated by Collies, St Bernards, and Spaniels; those for Terriers by Bull, Irish, and Fox Terriers; to test this point further I have isolated these breeds, with the following results:

TABLE III.

Stock Keeper, Kennel Register, 1889—1891.

Breeds	Dogs	Bitches	Total	Dogs per 100 bitches	Litters	Pups per litter
Collies..... St Bernards.. Spaniels	5040	4290	9330	117·48	1247	7·48
Bull Terriers Irish Terriers Fox Terriers.	2216	1986	4202	111·58	752	5·59

The difference is 5·9 and, from these figures, it seems permissible to conclude that the largest number of dog pups is obtained amongst the largest litters.

It is true that individual entries such as, for instance, English White Terriers, Black and Tan Toy Terriers, &c., and Bulldogs, do not conform to this conclusion, but in each of these isolated cases we are dealing with very small numbers and for that reason a detailed comparison is not justified. As a class distinction the comparison I have made is, I think, justifiable and I may add that the figures given below, derived from the Schedules sent to breeders, in which an accurate record of each litter is given, bear out this conclusion, though the difference is less, being 2·63.

Taking each breed individually there is some evidence that the production of a high percentage of males is associated with in-breeding. Many breeders hold a strong opinion that this is the case; I have not sufficient evidence here to show the fact, but there are some indications of its probability.

Concerning fertility, it is remarkable that the average number of pups per litter is so closely in accord with the actual size of the breed of dog concerned (Table IV). From Bloodhounds to Toy Terriers there is an almost regular correlation between size and fertility per litter.

In the absence of assurance that all pups born are registered, one is naturally disposed to imagine it is possible that a larger proportion of pups are destroyed among small breeds than among large breeds of dogs, that the relation shown here is an artificial one due to the necessity of reducing the strain of motherhood

TABLE IV.

Stock Keeper, Kennel Register, 1889—1891.

Breed	Dogs	Bitches	Total	Dogs per 100 bitches	Litters	Pups per litter
Bloodhounds	90	71	161	126·76	16	10·06
Setters.....	81	84	165	96·43	19	8·68
St Bernards.....	923	804	1727	114·8	208	8·53
Newfoundlands.....	193	162	355	119·13	42	8·45
Retrievers	78	62	140	125·8	18	7·7
Mastiffs	171	159	330	107·55	43	7·67
Collies & Sheep dogs	3671	3106	6777	118·19	917	7·39
Spaniels	446	380	826	117·37	122	6·77
Bulldogs.....	279	220	499	126·82	79	6·32
Totals for large breeds	5932	5048	10980	117·51	1464	7·5
Airedale Terriers ...	114	95	209	120·0	31	6·74
Bull Terriers	375	329	704	113·98	111	6·34
Irish Terriers	1209	1114	2323	108·53	379	6·13
Bedlington Terriers.	100	104	204	96·15	35	5·83
Scotch Terriers	224	195	419	114·87	76	5·51
Dandie-dinmont do.	158	137	295	115·33	56	5·3
Black & tan, and Manchester do. ...	184	165	349	111·51	74	4·72
Welsh Terriers	21	21	42	100·0	9	4·6
Fox Terriers	632	543	1175	116·39	262	4·48
English white do. ...	106	78	184	135·9	42	4·38
Black & tan Toy, Yorkshire, & Skye Terriers	196	156	352	125·64	83	4·24
Totals for Terriers...	3319	2937	6256	113·0	1158	5·4
Totals for all breeds	9251	7985	17236	115·85	2622	6·57

among small dogs. But this is not so; the details given below, of Schedule returns, show a similar relation between size and fertility. The figures there given are not identical with those we are now considering but the difference, on the whole, is not an increase in the pups per litter of small breeds, it is a decrease in the case of large breeds; a difference which may be accounted for to some extent by the very much smaller numbers there dealt with (individual variation), but probably chiefly to the fact that the bulk of the Schedule returns deal with animals which are especially finely bred.

From a comparison of the whole of my figures I am tempted to suggest that, if dealt with in greater numbers, returns of all breeds of dogs would show the rate of fertility coincident with the degree of specialisation from the parent type.

It is possible there is correlation between the size of the mother and the total bulk of the young born, it is also possible that large dogs do not produce young so often as the smaller breeds and that therefore the latter may well produce fewer at each gestation. On these points I have no conclusive evidence, all that can be asserted is that there is a definite relation between the size of different breeds of dogs and the average number of pups produced per litter.

Besides the above breeds there are a considerable number of others, the pups of which are from time to time recorded, some of these are large, some small dogs. These I have added to the records of special breeds and have collected the totals for each of the three years 1889—1891 (Table V) in order to test the degree of regularity of these records.

TABLE V.

Stock Keeper, Kennel Register. All Breeds, 1889—1891.

Year	Dogs	Bitches	Total	Dogs per 100 bitches	Litters	Pups per litter
1889	3591	3059	6650	117·39	1037	6·41
1890	3415	2959	6374	115·41	997	6·39
1891	3294	2832	6126	116·31	964	6·35
Totals	10300	8850	19150	116·38	2998	6·39

I think it must be admitted that the close approximation of the total results for each year is very remarkable. The greatest variation under the heading dogs per 100 bitches is 1·98, and under pups per litter ·06. This yearly comparison is far more regular than the yearly records for Greyhounds (Table I), and I am disposed to think the reason for this is that the breeding time is not artificially controlled to the same extent as we have seen is the case for Greyhounds.

The only breed dealt with in the *Kennel Register* returns which is at all comparable to the Greyhound returns, so far as the number of pups is concerned, is "Collies and Sheep dogs"; I have therefore tabulated details of the latter breeds to show monthly returns of births, &c.

The result is given in Table VI and it is seen to be, in some respects, different from that obtained from the *Greyhound Stud Book*.

March to June are the months in which the greatest number of births is recorded for Greyhounds, while for Collies most births are recorded from May to August. As I have already stated the purpose for which most Greyhounds are bred is accountable for the period of greatest fertility and it may be assumed that in this respect the natural breeding habits of Collies are much less interfered with. For the same reason, while for Greyhounds the months of August to December show a very low rate of fertility, there is no such great variation for Collies at any time of the year, though the birth rate from October to December is the lowest of the year.

Thus, while the Greyhound records, years 1886—1892, show only 65 births in December against 3099 in May, the lowest record for Collies, years 1889—1891, is 410 births in November and the highest 796 in July.

That the rate of fertility (pups per litter) is not responsible for the seasonal variation in the number of Collies born is clear, and a glance at the litters will show that, for Collies, there is a gradual falling off in the number of litters from the month in which most births are recorded to the end of the year, and a gradual rise from the beginning of the year to the date of the maximum births.

Concerning the sex of the pups produced. The totals for Greyhounds show a proportion of 118·5 dogs and for Collies 118·19, a very close agreement. Not less remarkable is the similarity in the difference between the variation of this percentage each year; that for Greyhounds, 1887—1890, being 6 (115—121), that for Collies, 1889—1891, being 7 (115—122).

It is the monthly returns of the proportion of dogs where the greatest difference between the records of these breeds is apparent.

TABLE VI. *Stock Keeper, Kennel Register. Collies, births per month for years* 1889—1891.

Month of birth	Dogs	Bitches	Total	Dogs per 100 bitches	Extreme variation during years 1889—1891. Dogs per 100 bitches	Difference	Mean of variation during years 1889—1891. Dogs per 100 bitches	Litters	Pups per litter	Month of conception
Jan.	273	203	476	134·48	123—150	27	136·5	62	7·67	Nov.
Feb.	265	205	470	129·27	112—149	37	130·5	64	7·34	Dec.
Mar.	302	252	554	119·84	119—121	2	120·0	76	7·29	Jan.
Apr.	314	268	582	117·16	110—123	13	116·5	80	7·27	Feb.
May	395	346	741	114·16	85—138	53	111·5	103	7·2	Mar.
June	367	315	682	116·5	95—144	49	119·5	95	7·16	Apr.
July	438	358	796	122·35	110—138	28	124·0	103	7·73	May
Aug.	435	328	763	132·62	116—147	31	131·5	102	7·48	June
Sept.	235	241	476	97·51	83—117	34	100·0	63	7·5	July
Oct.	229	185	414	123·78	106—145	39	125·5	56	7·39	Aug.
Nov.	210	200	410	105·0	94—115	21	104·5	53	7·73	Sept.
Dec.	208	205	413	101·46	96—112	16	104·0	60	6·88	Oct.
Totals	3671	3106	6777	118·19	115—122	7	118·5	917	7·39	

The great excess of dogs produced by Greyhounds in the winter months is not seen in Collies, on the contrary it is during those months that the lowest proportion of dogs is recorded. My own interpretation of the cause of this difference is, that while amongst Greyhounds most of the few litters born at this period were probably conceived, in consequence of some carelessness of the kennel-man, by bitches in training and not carefully nurtured for breeding, amongst Collies the conception of pups born during these months takes place in bitches which are not so affected but which, on the contrary, are probably in specially good condition (i.e. July to October). In a future communication I propose to submit evidence in favour of this view.

A comparison of the columns showing the extreme variation of dogs per 100 bitches born and of the difference in these proportions, for Collies (Table V) and for Greyhounds (Table II) shows, that while among Collies the greatest difference occurs as a rule in those months in which the largest number of pups are born, in Greyhounds the greatest difference is associated with the fewest births. This may be interpreted as indicative that the latter are more susceptible to annual variation of climate, temperature, &c., than the former, an interpretation which is perhaps strengthened when the structure and habits of the two breeds and the life they lead are compared.

Evidence in favour of this interpretation I must also defer to a future communication.

Breeders' Schedule Returns.

In these returns the breeders applied to supplied me with details of the sex of every pup produced in each litter whenever that was possible. In a few cases still-born pups were produced in a condition which did not admit of sex determination; in these cases, and in all others regarding which there was any doubt, the litters are not included in the figures given below.

The totals for each breed are given in Table VII.

As in Table IV, I have again divided the breeds into Large dogs and Terriers. The pups per litter for the Large dogs, as returned in the Schedules, are ·57 smaller than those given in the *Kennel Register* (Table IV), for the Terriers they are practically the same. Here again it is shown that the bigger dogs have the larger litters and, with the exception of Pointers, this is as true in detail as was seen in the *Kennel Register* records. There is undoubted correlation between the size of the animal and its fertility per litter.

The pups per litter for Collies and Mastiffs are closely approximate in both Tables, while the Schedule returns for

Bloodhounds show 1·54 fewer pups per litter than the *Kennel Register* gives. Basset hounds and Pointers are not represented in the figures given from the *Kennel Register* and it is these breeds which are chiefly responsible for the lower average fertility of the Larger dogs in the Schedule returns. The number of litters dealt with for Basset hounds is exceptionally large and the returns very complete, while for Pointers the returns are exceptionally incomplete and the litters available for my purpose but a small proportion of the whole sent to me. Among Terriers, Scotch Terriers show about the same rate of fertility in both Tables, while the Schedule returns for Irish Terriers are ·7 below, and for Dandie-dinmonts ·46 above those of the *Kennel Register*.

TABLE VII.

Summary of Schedule Returns.

Breed	Dogs	Bitches	Total	Dogs per 100 bitches	Litters	Pups per litter
Bloodhounds	111	85	196	130·59	23	8·52
Mastiffs	86	88	174	97·73	22	7·91
Collies	60	50	110	120·0	15	7·3
Basset hounds.....	198	136	334	145·59	54	6·18
Pointers	26	26	52	100·0	11	4·73
Totals for large dogs	481	385	866	124·93	125	6·93
Dandie-dinmonts	73	71	144	102·82	25	5·76
Irish Terriers.....	65	49	114	132·65	21	5·43
Scotch Terriers	116	84	200	138·09	37	5·4
Dachshunds.....	214	175	389	122·28	73	5·33
Skye Terriers.....	32	24	56	133·3	11	5·09
Various	10	14	24	71·43	5	4·8
Totals for Terriers	510	417	927	122·3	172	5·39
Totals for all breeds	991	802	1793	123·57	297	6·04

The average of pups per litter of all breeds is ·53 in favour of the *Kennel Register*. In other words the rate of fertility shown in the latter is 8 % above what is recorded in the Schedules. It is the Basset hounds and Bloodhounds which are chiefly re-

sponsible for the reduction, and as the other breeds show very similar results there is good reason to believe that the litters recorded in the *Kennel Register* very generally include all the pups born.

If this assumption is correct a comparison of the proportion of dog and bitch pups born is of increased interest.

In both classes, both Large dogs and Terriers, the proportion of dogs born is considerably greater in the Schedule than in the *Kennel Register* records, namely for Large dogs 7·42, for Terriers 9·3, and for the totals 7·72 greater. The difference being specially marked for Terriers.

Taking particular breeds in the Schedules, as compared with the same in the *Kennel Register*, Bloodhounds show + 3·83, Collies + 1·81, Mastiffs − 9·82, Scotch Terriers + 23·22, Irish Terriers + 24·12, Dandie-dinmonts − 12·51

The only breeds in the Schedules showing fewer dog than bitch pups are Mastiffs with 97·73 and various Small dogs with 71·43 dogs per 100 bitches; while in the *Kennel Register*, Setters 96·43, and Bedlington Terriers 96·15, are the only breeds in that category.

In the case of neither the Mastiffs, Setters, or Bedlington Terriers can it be claimed that either fertility or the number of litters included in the calculation, affect the proportion of the sexes produced.

From the totals it appears that the Schedules show a greater proportion of dog pups than either the *Greyhound Stud Book* or the *Kennel Register*, and, while making allowance for racial variation, it would seem probable that the opinion expressed by Greyhound breeders, recorded by Darwin, that bitches are produced in excess, is not true; on the contrary such difference as does exist in these three returns would indicate that, as in human beings, young males are more difficult to rear than females, and that there is an excess of deaths among young dog pups.

The Schedule returns again show that, taken as a whole, the larger breeds of dogs with the greater fertility produce a larger proportion of dog pups.

The difference is not so great as was shown by the *Kennel Register* records, being only 2·63, but still it exists. No such regular difference, however, can be shown for individual breeds in Table VII, and it seems probable there are not a sufficient number of litters among these Schedules to admit of a fair comparison with those detailed in Table IV on this point.

As regards the effect of in-breeding on the proportion of the sexes produced, the most marked instance among my records is that of Basset hounds. A very large proportion of the litters recorded for this breed came from one kennel, that of the late

Sir Everett Millais, whose finely bred strain of this breed was well known. Bloodhounds, again, have a high proportion of dog pups and they are for the most part highly bred in this country. For the rest, Bulldogs, Retrievers, Scotch, Skye, Irish, and English White Terriers, I have no certain information. Taken as a whole, however, the animals treated of in the Schedules are probably more finely bred than those recorded in the *Kennel Register*, and the proportion of dog pups in the former is considerably greater than in the latter; thus, such evidence as I have is in favour of the view that in-breeding tends to the production of an increased proportion of males.

In the Schedules submitted to breeders information was asked about feeding and the condition of individual bitches, at the breeding time and during gestation, in order to attempt to discover whether "condition" at the time of conception showed any marked effect on the proportion of the sexes born. The descriptions given were usually "good" or "very fair," &c.; no detailed information was supplied, and nothing was shown which could in any way be interpreted as affecting the proportion of the sexes born.

The length of gestation was also recorded for 278 litters. This detail was asked for to check the opinion very generally held by breeders of stock, that when the period of gestation is prolonged beyond the normal time the produce are generally of the male sex.

I have divided the period of gestation into three divisions, making allowance for errors of calculation, which I have assumed are but small on the side of short gestation and mostly due to retarded fertilisation of the ovum *after* impregnation, thus:

(1) a short gestation period, from 53 to 61 days; in which there are 69 litters recorded with an average of 117·82 dogs;

(2) a normal gestation period, from 62 to 65 days; in which there are 194 litters with an average of 130·98 dogs, and

(3) a long gestation period, from 66 to 69 days; in which there are 15 litters giving an average of 140·48 dogs.

On the whole the results undoubtedly bear out the popular opinion, the totals for each division showing a gradual increase of male births as the period of gestation is prolonged.

In the latter division the litters recorded are few and the individual results very various, but in the first division this is not so and yet there is a marked difference in the proportion of dog pups between the first and second divisions.

In these returns it is remarkable that Bloodhounds are represented under almost every day both of the short and long periods of gestation. Altogether, no less than 11 litters of Bloodhounds out of a total of 22 recorded, that is 50 %, were produced outside the normal period.

TABLE VIII. *Schedule Returns. Proportion of sexes and length of gestation.*

Days of gestation	Dogs	Bitches	Total	Dogs per 100 bitches	Litters	Pups per litter	Breeds and number of litters
53	5	4	9	125·0	1	9	Bloodhound
55	6	3	9	200·0	1	9	Bloodhound
56	3	3	6	100·0	1	6	Dachshund
57	6	6	12	100·0	3	4	Dachshund (1), Scotch Terrier (2)
58	30	24	54	125·0	8	6·75	Bloodhound (1), Mastiff (1), Scotch Terrier (5), Various (1)
59	62	46	108	134·78	15	7·2	Bloodhound (3), Mastiff (3), Collie (1), Dachshund (1), Scotch Terrier (4), Dandie (1), Irish Terrier (1), Various (1)
60	45	39	84	115·38	15	5·6	Bloodhound (1), Mastiff (1), Basset (2), Collie (1), Dachshund (3), Scotch Terrier (4), Dandie (3)
61	81	77	158	105·19	25	6·32	Bloodhound (2), Mastiff (2), Dachshund (11), Dandie (9), Irish Terrier (1)
Totals (1)	238	202	440	117·82	69	6·38	Large dogs (20), Terriers (49)
62	135	98	233	137·75	41	5·68	All breeds
63	386	293	679	131·74	111	6·12	
64	67	50	117	134·0	20	5·85	
65	63	56	119	112·5	22	5·41	
Totals (2)	651	497	1148	130·98	194	5·92	Large dogs (81), Terriers (113)
66	11	12	23	91·$\dot{6}$	5	4·6	Bloodhound (1), Collie (2), Dachshund (1), Various (1)
67	30	16	46	187·5	6	7·$\dot{6}$	Bloodhound (1), Mastiff (1), Basset (1), Dachshund (2), Scotch Terrier (1)
68	9	3	12	300·0	1	12·0	Bloodhound
69	9	11	20	81·$\dot{8}\dot{1}$	3	6·$\dot{6}$	Bloodhound (1), Scotch Terrier (1), Skye Terrier (1)
Totals (3)	59	42	101	140·48	15	6·7$\dot{3}$	Large dogs (8), Terriers (7)
Totals	948	741	1689	127·93	278	6·07	Large dogs (109), Terriers (169)

This breed then is specially adapted for checking the general result given above and I have set it forth in Table IX.

TABLE IX.

Schedule Returns. Bloodhounds, gestation and sex of pups.

Days of gestation	Dogs per 100 bitches	Litters	Pups per litter
(1) 53—61	125·64	9	9·7
(2) 62—65	138·46	9	6·8
(3) 66—69	157·14	4	9·0

Here is a very striking confirmation of the view advanced.

The returns of the pups per litter in Tables VIII and IX do not indicate that the size of the litter has anything to do with prolonged gestation; the litters produced both in divisions (1) and (3) in each of these tables are bigger than those in division (2), the normal gestation period, so it does seem as if the excess of male embryos in the uterus is directly responsible for the delay in parturition.

I do not of course maintain that the length of gestation has any influence whatever on the sex of the young born, these results only show the tendency to prolong gestation when an excess of male embryos are present in the uterus.

The association of a longer gestation period with the production of an excess of males may be regarded as evidence either that male embryos require a longer uterine life for their full development or that they are born, when possible, in a more advanced condition than the females. This is a question of considerable interest in relation to the physiology of breeding, and also regarding various sexual differentiations.

Another point of interest with regard to Table VIII is that whereas 20 litters of Large dogs (18·35 % of the whole) and 49 litters of Terriers (29 %) have a shorter gestation than normal, 8 litters of Large dogs (7·34 %), and 7 litters of Terriers (4·14 %) experience a longer gestation than normal.

Thus, while on the one hand abnormally short gestation is more usual than abnormally long gestation for both classes of dog, the proportion of Terriers is greater than that of Large dogs for short gestation, and the proportion of Large dogs greater than that of Terriers for long gestation periods.

Table X.

Schedule Returns. Proportion of dog pups produced by individual parents.

Breed	Dogs per 100 bitches. Average for breed	Sire No.	Litters	Dogs per 100 bitches	Bitch No.	Litters	Dogs per 100 bitches
Basset hounds ...	144·58	1	13	155·17	4	6	161·54
		5	6	131·5	15	6	122·2̇
		14	5	100·0	17	4	130·0
		3	4	200·0	28	4	266·6
		6	4	133·3̇			
		10	4	133·3̇			
Bloodhounds ...	130·59	3	9	140·0			
		1	5	182·35			
		4	5	104·0			
		2	4	92·3			
Collies	120·0	3	4	120·0	7	5	118·75
Mastiffs	97·73	1	13	91·3	1	4	153·3̇
Scotch Terriers..	138·09	3	5	141·6̇	5	7	104·5
Skye Terriers	133·3̇				1	4	466·6̇
Irish Terriers	132·65	3	8	160·0	1	7	72·7̇2̇
					2	4	320·0
Dachshunds.....	122·28	1	19	170·27	5	5	144·4̇
		2	19	108·3̇	6	5	112·5
		3	9	88·8̇	12	5	100·0
Dandie-dinmonts	102·82	1	6	68·75	2	4	116·6̇
		2	4	84·61			
Totals.....		19	146		14	70	

I have taken advantage of the fact that, in the Schedules returned to me, the performance of each sire and bitch is recorded for each litter, to test the tendency of individual male and female parents to produce a marked proportion of offspring of one sex. Only those cases are recorded in which the sire or the bitch have been concerned with four or more litters and the results are compared with the average obtained for the breed to which each animal belongs (Table X).

Of the six Basset hound sires one has got 44 fewer and one 56 more dog pups than the average, whilst the four bitches show great variation and one has 122 dog pups above the average.

Of the four Bloodhound sires one has 52 more and two others 38 and 26 fewer dog pups than the average; there are no bitches of this class recorded as having produced four litters.

A single dog and bitch among Collies produce about the average.

Of Mastiffs there is one sire responsible for more than half of the whole litters recorded in Table VII for that breed, and the low percentage of dog pups he is responsible for dominates the total results. A single Mastiff bitch, on the other hand, produces 56 more dog pups than the average for the breed.

Only one Scotch Terrier sire is recorded with about the average of dog pups, while a single bitch falls short in her produce of dogs by 34.

Only one Skye Terrier bitch is recorded and the proportion of males she produced was 333 above the average.

Of Irish Terriers there is one sire and two bitches, the latter with a proportion of dog pups of 60 less and 188 more than the average, while the former has 28 to his credit.

Dachshunds again are very variable, especially the sires, of which there are three, varying from 88·8 to 170·27 dogs, while the three bitches show variation from 100·0 to 144·4 dog pups, the average for the breed being 122·28.

Amongst Dandie-dinmonts two sires give extraordinarily low results, 34 and 18 less than the exceptionally low average for the breed (102·82); the single bitch whose produce is recorded shows 14 more than the average of dog pups.

Thus of the total number of litters (297) recorded in Table VII, 146 (or 49·16 %) are got by 19 sires, and 70 (or 23·57 %) borne by 14 bitches.

Of these 19 sires, 15 show a variation of 10, 9 a variation of 20, 7 of 30, and 2 of 50 from the average. Of the 14 bitches, 12 show a variation of 10, 10 of 20, 6 of 30, and 5 of 50 from the average. It is therefore clear that the bitches show a much higher proportion of variation than the sires.

The numbers concerned are of course too small to allow of

wide generalisations, but there is evidence enough to show, as for instance in the case of Mastiffs, that the sire does also exert influence, and therefore that, if fertilisation of the ovum is effected by sperm of the complementary sex, a large proportion of the sperm produced by this animal must have been of one sex.

Finally, I have abstracted figures to test the opinion, held by many breeders of stock, that while in some years males are produced in marked excess, in others females predominate.

The figures at my disposal are far too few to admit of elaborate analysis but, taking Basset hounds and Dachshunds as representative of the two classes of dogs, I find that, during the 16 years Mr Millais bred Basset hounds, dog pups were produced in excess 11 years and bitches 1 year, while in 4 years the sexes were equal; and during the 11 years Mr Mudie bred Dachshunds, dog pups were in excess 6 years, bitch pups 4 years and the sexes equal 1 year. The racial tendency to produce a greater or less proportion of one sex, to which I have referred above, no doubt influences this comparison; Basset hounds produce a very much larger proportion of dog pups, on an average, than is the case with Dachshunds (Table VII), so it is not surprising to find a more even balance, per year, among the latter.

It is of special interest to note that, taking 9 years for which I have results from both kennels, only two of them show widely divergent results, and that in three consecutive years the results are: for (1), both kennels produced a small excess of bitch pups; for (2), a specially large proportion of dog pups were born in both, Mr Millais' results showing 180, Mr Mudie's 380 above the average; while for (3) there is a similar result, Mr Millais breeding 123·4 and Mr Mudie 162·5 above the average.

It is quite possible this is purely a chance coincidence and I don't attribute any great importance to it. The methods of feeding and housing dogs in large breeding kennels must eliminate much of the effect of variation in the seasons which might be supposed to exert influence.

Trustworthy records of the breeding of farm stock would supply what is needed to test this view and it is unfortunate that they are so difficult to obtain regularly and on a sufficiently large scale. For pheasants it is, I think, undoubtedly true that there is a marked difference in the proportion of cocks and hens driven to the guns in different years, and I am strongly disposed to believe there is truth in the popular belief.

Conclusions.

We have dealt with 19916 dog pups, 16951 bitch pups, a total of 36867 pups, of which the proportion of dogs per 100

bitches is 117·49. Nearly 50 % of these pups are Greyhounds (17838), with 118·5 dogs per 100 bitches, and no other breed dealt with is represented in anything like the same numbers; Collies with 6777 pups are the nearest and the proportion of dogs per 100 bitches in this breed is 118·19.

Apart from Greyhounds the returns deal with a variety of breeds and if details of all Large dogs are abstracted therefrom it is seen that of the total pups recorded (11846) 6413 are dogs and 5433 bitches, i.e. there are here 118·04 dogs per 100 bitches. Thus there is a very remarkable approximation in the proportion of the sexes produced by Greyhounds and Collies or by Greyhounds and the other Large dogs, taken as a whole, with which we have dealt.

The Terriers, taken as a whole, give a somewhat different result. Of these we have a total of 7183 pups, 3829 dogs, and 3354 bitches, giving 114·16 dogs per 100 bitches. A difference of four is not a wide variation, especially when the numbers dealt with are considered. Still there is this difference and I am disposed to think a more extensive series of data will demonstrate that there is a distinct racial variation in the proportion of the sexes produced by these two classes of dogs.

Again there is wide diversity in the results obtained for different breeds of both Large dogs and Terriers. The numbers dealt with are too small for safe generalisation, but the results are so marked in several cases that I believe racial variation will be found to exist between different breeds as well as between different classes of dogs.

Greyhounds. The data supplied to Darwin for Greyhounds gave 110·1 males per 100 females during the years 1858—1868, as against 118·5 in the above records 1886—1892. It is possible that in-breeding in these later years has had some effect in the direction of an increase in the proportion of dog pups born, but in the absence of assurance that all pups born were recorded by Darwin's informants, it seems probable that the difference is chiefly due to neglect of this source of error.

The returns now presented show the proportion of dogs born each year (Table I) and the proportion born per month for all these years jointly (Table II).

It is seen that most Greyhounds are born during certain months, March to June, and that the proportion of the sexes born then varies but little.

During every month in a series of years there is a preponderance of dog pups born, but during October to December, when the fewest pups are born, the proportion of dog pups is at its highest. The conclusion is drawn that conception during August to November is especially favourable to the production of dog

pups among Greyhounds under the conditions of breeding now practised, and this result is attributed to a selective action on the ova produced at this time.

Collies. The above returns are compared with similar ones obtained for Collies (Table VI). The latter show much less variation in the proportion of litters produced at different times of the year, the breeding of these animals being conducted much more in accordance with the natural breeding time for the species. Still in Collies there is a marked increase of births from May to August, and from October to December is the season when fewest births occur.

This result is due to the number of litters produced and not to any variation in the rate of fertility per litter.

The returns for Collies show no evidence that conception at any particular time of year affects the proportion of the sexes born; they rather indicate, if my supposition is correct, that when the animals breed at a time which is unfavourable for the rearing of the pups, special care is exercised.

Kennel Register and Breeders' Schedules. Data obtained from the *Kennel Register* for the years 1889—1891 (Table IV) are checked by information derived from Schedules filled up by breeders, in which latter returns accurate details are supplied for all the litters there dealt with (Table VII). In both Tables details are given for each breed dealt with and these are again classified under headings of Large dogs and Terriers. It is found that the fertility per litter is the same for Terriers in both the *Kennel Register* and the Schedules, while the latter show ·57 smaller litters for Large dogs. On the whole it may be assumed that the *Kennel Register* very generally includes all pups born. Where this is not the case it would appear that still-born pups or pups destroyed on account of weakness, which are not recorded in the *Kennel Register*, are usually of the male sex, since there is a considerably higher proportion of dog pups recorded in the Schedules than in the *Kennel Register*.

It is highly probable that the animals included in the Schedule returns are more in-bred than are those entered in the *Kennel Register*, and that this fact may account for some of the excess of male births recorded in the former. There is not wanting evidence from other sources that in-breeding is associated with the production of a high proportion of males. The bulk of the data at my disposal for dogs is not of a character which admits of wide generalisation on this point; there is, however, some evidence in the Schedules that an excessive production of males is associated with in-breeding and the details given of Bloodhounds may be said to be strongly in favour of this view.

In both these returns the Large dogs are found to produce

a higher proportion of males than the Terriers (compare Table III). It is also found that both support the view that there is almost regular correlation between the number of pups of the average litter for each breed and the size of the dog producing it; the larger dogs producing the larger litters.

Thus it would seem to be true that a bigger proportion of males is produced in the larger litters, or, as stated above, that large dogs have a racial tendency to produce an excess of dog pups.

It is suggested that the rate of fertility in different breeds is probably coincident with the degree of their specialisation from the parent type.

The annual returns for all breeds dealt with in the *Kennel Register* (Table V) show a remarkable regularity both in the proportion of the sexes born and in the fertility per litter.

The popular belief that there is a tendency to prolonged gestation when the embryo is of the male sex is strongly supported by the Schedule returns, in which it is shown (Tables VIII and IX) that prolonged gestation is clearly associated with a greatly increased proportion of male pups born. The size of the litter has apparently nothing to do with the length of gestation.

The tendency of individual male or female parents to produce a marked proportion of offspring of one sex, is examined (Table X). It is seen that bitches which are concerned in the production of four or more litters show a much higher percentage of variability than sires, but that the sire may exert influence is clear from the Mastiff records.

Details supplied by Basset hound and Dachshund Schedules give some support to the popular belief that seasons affect the proportion of males and females born; the figures available, however, are far too small to allow of a trustworthy test being made.

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