**The rot in sheep : its nature, cause, treatment, and prevention : illustrated with engravings of the structure and development of the liver-fluke / by James Beart Simonds.**


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## NATURE, CAUSE, TREATMENT, AND PREVENTION.

ILLUSTRATED WITH ENGRAVINGS OF THE STRUCTURE AND DEVELOPMENT OF THE LIVER-FLUKE

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# THE ROT IN SHEEP.

## Introductory Observations.

We repeat but a truism when we say that the health of the animals of the farm, especially that of cattle, sheep, and pigs, influences to a considerable extent the amount of wholesome food which is available for the people; besides which, that it is also an abiding source of solicitude to the agriculturist, for upon it very frequently depends his own immediate success in the practice of his profession. Whenever, therefore, disease assumes an extraordinary type, spreading far and wide, and destroying in its progress many of the animals which supply our daily wants, the interests not only of the agriculturist, but of the entire community, are so far jeopardised, that on all sides inquiries are made as to the means which are best calculated to effect a diminution either of the extension or fatality of the malady.

During the past year—1860—an event of this kind was witnessed in the immense losses which occurred among sheep from rot: nor can it be affirmed that even now these have entirely ceased, or that any additional security exists against the disease being equally as destructive in succeeding years. Under such circumstances it is evident that benefit can alone arise from an accurate investigation of the pathology of the affection, as also of its causes, and of the laws regulating its spread. An inquiry of this kind was originally ordered to be made by the Royal Agricultural Society, which had, as its immediate result, the delivery of a lecture on the subject before the members, by the author of the present thesis. The views then given expression to were thought of sufficient practical importance to warrant their publication in a more available form for future reference than was afforded by the columns of the daily press; and accordingly the author was instructed to arrange the matter both for a pamphlet and also the pages of the Society's Journal.

## Antiquity and Extent of Rot.

The frequent occurrence, insidious progress, and fatality of rot place it at the head of the most serious affections to which sheep are liable. In this country no single disease produces such destructive effects; but on the Continent its fatality is probably now and

then equalled by the ovine small-pox, a malady against which our sheep are protected in a great measure by our insular position.

Rot is one of the most ancient diseases with which we are acquainted. The earliest writers on husbandry, as well as on the affections of cattle and sheep, make frequent mention of its ravages, and speak of a variety of causes as being in operation in producing it. Googe, Mascall, and Fitzherbert are among those of the 16th century; and Mr. Youatt, in his work on '*Sheep*,' remarks that even Hippocrates gave a very faithful account of the malady, "erring only in considering the flukes as hydatids; or rather his attention was confined to the hydatids, which are now frequently found in the liver of the sheep."

The disease would appear to belong to no particular country; and perhaps there are few if any parts of the globe where sheep have been domesticated in which it does not occasionally prevail. A fact of this kind is of much importance, because it goes very far to negative many of the views which are entertained with regard to *local* causes of the affection. For example, some persons in the present day speak of the deleterious effects of certain grasses, such as the "carnation-grass;"* but this, like many other plants, similarly regarded, grows only in wet and undrained localities, and, consequently, its existence is but an indication of dangerous pasturage. It may be affirmed that several of the supposed deleterious plants do not belong to Egypt nor to Australia, nor to many other parts of the world where rot is met with; vegetables of a special or particular variety being, as is well known, far more restricted in their distribution than even the lowest forms of animal life. Wherever, however, the disease is manifested, there the mortality will be found equal to our own, be this in the eastern or western hemispheres, in the torrid or frigid zones.

Mr. Youatt observes that "many sheep are destroyed by the rot in Germany. In the north of France," he adds, "they are frequently swept away by it, and in the winter of 1809 scarcely a merino in the whole of that kingdom escaped. It is destructive as far north in Europe as Norway, and even the most southern provinces of Spain have had occasion to mourn its ravages. It has thinned many a flock in North America, and in Van Diemen's Land and Australia it has occasionally been as destructive as on the worst undrained land in England."†

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* Discussion on Rot. Royal Agricultural Society, February 20th, 1861. See also the Society's Journal, *passim*.

"Carnation grass," correctly speaking, is a sedge, the *Carex præcox*. It is well known in the eastern counties. It has a creeping root like couch—*Triticum repens*—and owes its name to the colour of its leaves, which are of bluish green or glaucous hue.

† 'Sheep: their Breeds, Management and Diseases,' p. 445.

MM. Hamont and Fischer, of the Veterinary School of Abou-Zabel, in their treatise on the disease—a translation of which will be found in the seventh volume of '*The Veterinarian*,' 1834—state that "it appears every year in Egypt after the fall of the Nile, and follows and keeps pace with the subsidence of the waters. In the superior parts of Upper Egypt it commences about the end of July; nearer Cairo in August; in the environs of the capital in October and November; and during the months of December, January, and February, in the Delta. It is most obstinate, and continues the longest, in the neighbourhood of the confluence of the waters. In Lower Egypt it lasts about 120 or 130 days, and it disappears soonest and is least fatal when the rise of the Nile has not been considerable. Desolation and death accompany it wherever it passes. The Arabs say that this pest annually destroys 16,000 sheep in Egypt, and that its victims usually perish on the twenty-fifth, thirtieth, thirty-fifth, or fortieth day after the apparent attack."

Without entering into further particulars of the ancient history or wide-spread existence of rot—the facts we have narrated being sufficient for our purpose—we pass on to speak of its various outbreaks in our own country.

## Periodic Outbreaks.

The most reliable accounts we have met with of some of the early devastations from this disease are to be found in Ellis's *Shepherd's Sure Guide*, 1749. Speaking of "the great losses that several farmers sustained by the most noted sheep-rot of 1735," he says, "A farmer living in the vale of *Aylesbury*, who rented a farm of 165*l.* a year, declared to me he had lost two flocks of his folding sheep by the rot between May 1735 and May 1736, and thus came to great poverty indeed, for he never could surmount the loss of 300 sheep in one year.

"Another vale-farmer, living at *Stutely*, rotted his large flock by keeping them too long before he had them to market, and, when he did, the sheep were so lean that he could make no more than 6*d.* apiece of them, and at this price he sold 100 in Leighton market in October 1735, rather than drive them home again. He was sure they would die, and, dying under a lean rot, they would be only fit for dunging the ground with; for this rot came on so fast, and was so severe and general a one, that thousands of sheep were not worth offering for sale.

"This rot of sheep and lambs was the most general one, I believe, that has happened in the memory of man, because it rotted those deer, sheep, lambs, hares, and coneys, that fed on lands where rain-waters were retained on or near the surface of the earth for some time; and as I have elsewhere observed, the

dead bodies of rotten sheep were so numerous in roads, lanes, and fields, that their carrion stench and smell proved extremely offensive to the neighbouring parts and to passant travellers."

Ellis also describes another visitation in 1747, depending on a wet spring which succeeded a very mild winter. The rain, he says, began to fall at the beginning of May, and continued with but few intermissions throughout the month, as also that of June and part of July. "From all which," he remarks, "I would observe to my reader that a Midsummer rot ensued, and great numbers of vale-sheep became tainted by it, as did many also in the Middlesex grounds."

The year 1766 witnessed another and far more serious outbreak than that of '47. It is thus spoken of by Mills in his *Treatise on Cattle*, 1776. "Too rainy a season is very prejudicial to sheep, as was remarkably experienced *all over England* in the summer of 1766, when whole flocks perished with the rot."

The next visitation in the order of time, of which we have been able to collect some particulars, is mentioned by Dr. E. Harrison in his *Inquiry into the Rot in Sheep and other Animals*, 1804. He says that "in the year 1792 the country was uncommonly wet from the great quantities of rain which fell in the summer months, and this was a most destructive year to sheep and other animals. In the human subject, agues, remittants, and bilious autumnal fevers, were also prevalent in many places. Graziers soon took alarm and became very solicitous about their flocks. A breeder of rams informed me that to save his finest sheep he put them into closes which during an occupation of 40 years had never been known to rot, but he had the misfortune to lose them all. He was equally surprised to find that other pastures which had frequently produced the rot were this season free from it." Harrison adds, that, "upon inquiry I found that the suspected land was so much under water this year that the sheep were obliged to wade for their food; and that pastures of a higher, and consequently of a dryer layer, were, from the deluge of rain, brought into a moist or rotting state."

We come next to 1809-10, which appears likewise to have been a period of great fatality in some localities.

Fairbairn, who writes under the *nom de plume* of a Lammermuir Farmer, states, in his *Treatise on the Cheviot and Black-faced Sheep*, that in 1810 his stock consisted of 2000 ewes, hogs, and dinmonts [shearling wethers], out of which he lost by rot during the winter and spring following above 800. He also says that in 1816 and '17 the Lammermuir farmers suffered in many respects from the severity of the seasons. He describes 1816 as being very wet and cold, but comparatively free from rot in consequence of the low temperature which prevailed. He says,

however, that "the year 1817 was again very wet, rather more so than the preceding one, and the average temperature of the season was several degrees higher than the other, which produced a very abundant growth of grass in the months of September and October, the ultimate consequence of which was that one of the greatest fatalities by rot followed to which the memory of man bears evidence."

The year 1824 proved likewise a very destructive one in wet and undrained districts. Among many other sufferers at that time was a Mr. J. Cramp, of the Isle of Thanet, who stated in his evidence before a Committee of the House of Lords, which sat in 1833 to inquire into the causes of the depressed state of agriculture, that in the winter of 1824 the rot swept away 3000*l.* worth of his sheep in less than three months, which compelled him to give up his farm.

Notwithstanding the serious losses which we have thus been enabled to particularize, perhaps the greatest outbreak that ever occurred in this country took place in 1830-1. It is supposed that upwards of two millions of sheep perished at that time. Evidence of this immense destruction was given by various witnesses before the Committee just referred to; and it was satisfactorily ascertained that in 1833, two years afterwards, "there were 5000 sheep on every market-day in Smithfield less than what used to be the average number, and 20,000 less than usual at Weyhill Fair;"* circumstances which may assist in showing the enormous loss which had been sustained by the country.

From 1830 to the present time several visitations, which were more or less severe, took place. One of these occurred in 1853-4, when many thousands of sheep were swept away, and not only in undrained districts, but also in others of a more healthy character. Since 1830, however, no outbreak can at all be compared to the one of the autumn and winter of 1860. Speaking in general terms, it may be affirmed that all the western and southern counties of England, together with several of the eastern and midland, suffered to a ruinous extent. As in former years, so in this, the attacks of the disease were due to an excess and long continuance of wet weather. Eighteen hundred and sixty will be long remembered by agriculturists, not only as producing the rot among sheep, but likewise for its baneful effects on the root crops, as also on the hay and corn harvests.

We are acquainted with several instances, in our own immediate neighbourhood on the verge of London, where the losses of sheep amounted from 600 to 700 in a flock. These sheep were

* 'Sheep: their Breeds, Management, and Diseases,' p. 445.

principally Welsh ewes, which had been bought at the latter part of the summer for breeding by being crossed with Leicester tups. Some persons lost nearly all, and one in particular, who buys about 800 of these ewes annually, had not more than 40 or 50 which escaped. Tups, wethers, lamb-hogs, and half-breeds, alike succumbed to the inroads of the affection. A similar fatality attended the progress of the disease in all other districts. In many parishes in Devonshire where we investigated the malady, and of which Bridgerule may be taken as an example, five-sixths of the sheep perished, or were sold for a few shillings each for slaughtering, to the detriment of the health of the poorer classes.* In the instance thus particularised the losses occurred among the stock of small occupiers, the ill consequences of which were greatly added to by their young cattle being found to be affected with flukes to such an extent as seriously to injure their health later on in the year.

In Sussex and in several parts of Surrey the fatality was equally great. In the neighbourhood of Eastbourne a flock of about 600 Southdown ewes of great value was completely destroyed. Numerous cases of this kind might be narrated, but enough has been said to show not only the extent of the disease, but that sheep of every description, and placed under different systems of management, equally succumbed. It is much to be regretted that means do not exist whereby the total loss could be ascertained. People are left in doubt as to the amount of food of which they were deprived in one year by this disease alone, and of the efforts which must be made to replace the losses. The time, we predict, cannot be far distant when agriculturists will be convinced, not only of the propriety but of the positive necessity of making returns, at least of the *losses*, they sustain among their cattle, instead of simply deploring these among themselves. Elsewhere we have drawn attention to this important subject, upon which very much might now be said, if it were not somewhat unsuited to an essay of this kind.

## Names given to the Disease.

Various names, which are more or less expressive of certain conditional states of the system, are used in different localities to designate this affection. The one which is more generally applied is that which we have preferred to use in these pages, namely, "rot." It is not difficult to see that this term has had its origin in the evident unsound state of the animal during life,

* The Rev. S. N. Kingdon, the resident minister at Bridgerule, reported to the author, that on October 1st, 1860, 492 sheep were existing in the parish as the joint property of several small farmers; and that, by the end of the month, 410 of them had either died, or been sold at a price very little above the value of their skins.

and in the fact of the body undergoing quick putrefaction after death. Rot, however, like the majority of the names employed both in this country and on the Continent, fails to convey a sufficiently exact knowledge of the pathology of the malady. It is by no means easy to find a term which will do this, and which at the same time is also a suitable one for adoption by the public in general. The German term "*egelseuche*" is certainly far more expressive than many others; but even this does not admit of a better translation than the fluke disorder or infection. French veterinary surgeons usually designate the disease "*cachexie aqueuse*," which points to the dropsical condition of the organism of the animal in an advanced stage of the malady, referable to a bad habit of body. By the common people of France it is often called "*pourriture*," rottenness; and other terms nearly allied to this are also similarly employed.

In the western part of England, and particularly in Somersetshire, the disease is known as "*bane;*" the probable origin of the name being the baneful or injurious effects which attend its progress. In Dorsetshire, Devonshire, and Cornwall it is called "*coathe*" or "*coade*," which would seem to be derived directly from the Anglo-Saxon term "coðe," "*cothe*," or "*codhe*," signifying a sickly or fainting condition;* and may have been originally employed to show that a weak or debilitated state of the animal exists, which renders it incapable of exertion without tiring or fainting.

It may here be remarked that there are several diseases affecting sheep which pass by the common term "rot," a fact that explains why various opinions are entertained with regard to the disease by different observers. These persons in reality often describe two or more distinct affections, and hence they are not likely to agree as to their nature or cause. We occasionally hear such terms as "water-rot" and "fluke-rot," which would induce a belief that in one variety of the disease a dropsical condition of the body existed, and that in the other certain entozoa, commonly designated flukes, are located in a particular part of the organism. We desire, however, to confine the term "rot," if it is still to be used, to that affection in which flukes are present in the biliary ducts of the liver, setting aside entirely every other form of disease that has been designated by this name.

## Assigned Causes.

There are few affections respecting which so great a diversity of opinion exists with regard to its cause, as rot. All kinds of

* Bailey's 'Universal Etymological Dictionary,' 1773. The Rev. R. Forby, in his 'Vocabulary of East Anglia,' 1830, gives "Cothe, *v.* to faint."

Cothe, pronounced Cōthēe, is much used in Norfolk to express that a person feels sickly, poorly, or faint.

theories have been put forth in explanation of it, many of which have been very wide of the truth. Scientific men of the present day may even be said to differ as much from each other as did mere empirics of past ages, or as now do the proprietors themselves of affected animals. Ere long we hope to see a greater agreement on this point; and especially are we encouraged in this, when we observe that many investigators, both here and on the Continent, are at work for its elucidation. Before giving our own views of this important question, we purpose, for the benefit of our readers, to glean from others, according to the date of their writings.

The earliest authors on cattle diseases, almost without an exception, so far as our researches have gone, regard the feeding on particular plants as the principal cause of rot. Leonard Mascall, "chief farrier to King James," in his work, *The Government of Sheepe*, 1587, original edition, says:—"It is good for al men to understand, especially shepheards, which things do hurt or rotte sheepe, whereby, they maie avoide the danger the better. Ye shal understand there is a Grasse or weed called Speare Wort, the leaves are long and narrow like a speare, hard and thick, the steales hollow, growing a foote or more high, with a yellow floure, which is comonly in wet places, and there wil it grow most, or where water have stood in the winter. There is also another weed called Peniwort or Penie-grass; it wil commonly grow in moist and marrish grounds, and it groweth low by the ground, and hath a leafe on both sides of the stalke like unto a penie, thick and round, and without floure, yet some doe saie it beareth a yealow floure, which will (as they say) kil sheepe if they eat it. Alsoe all manner of Grasse that landfloods doe overrun before a raine is not good for sheepe."

Gervase Markham, in his *Cheape and Good Husbandry*, 1614, repeats Mascall's remarks, and adds, that "knot-grasse is not good, nor meldewd grasse;" and also that "there bee little white snailes which a sheep will licke up, and they will soon rot him." He likewise speaks of the necessity of keeping sheep from off low and moist grounds, "untill the sunne be risen, and that his beames beginne to draw the dewe from the earth." In another place he comments on the propriety of chasing the sheep up and down the pasture, because "this chasing, first, beateth away mill-dewes and all other dewes from the earth, as also the webbes, kelles, and flakes, which lying on the earth, and a sheep licking up, doe breed rottenesse."

Crawshey, author of *The Countryman's Instructor*, 1636, says, that sheep get the rot "by feeding upon ketlocks or other such weeds, growing in fallow fields; or by feeding upon short grasse, on leighes or land-ends where many worme sprouts be, which the

sheepe feeding upon that grasse doe licke up; also the gravell wrought up by the worme, and most of all the slime that is left by the wormes ingendering, which is a great cause of rottenesse." He further adds, that "others get it by feeding upon low levell ground, where, when a sudden raine cometh, the water standeth and cannot get readily away, and the sheepe that continually useth that ground will slop much water with the grasse, which if the weather be cold will doe them hurt, but not so much as if it be warm: many shepheards say, that if the weather be hot, their sheepe will take the rot in four and twenty hours, therefore carefull shepheards, as soone as they see the ground wet and the day hot, will remove them with all speede into higher grounds, for a space, till the water be dryed away."

"A. S.," the anonymous author of *The Husbandman's Instructor*, 1697, remarks, that "in moist years sheep are subject to the rot, where in dry years they are exempted from it, and that not only from the moisture, for then would sheep rot in all moist grounds, but there is a certain putrefaction in the air, grass, or herb, or all of them, that cause it."

Bradley, a distinguished Professor of Botany in the University of Cambridge, in his *Gentleman and Farmer's Guide*, 1729, after repeating most of the preceding statements, goes on to extend the observations of Gervase Markham respecting snails and slugs, and remarks that "in some pastures there are great numbers of white snails and slugs, which while they are small the sheep take in with the grass, and are distempered by them. The snails and slugs breed about April and August, or September, so that at the times when they are smallest the sheep are in most danger from them. They breed for the most part in damp and shady grounds, and retire from their feed (upon the grass or other herbs) to their places of shelter about nine or ten in the morning, if the sun shine strong; but in wet weather they remain upon the grass constantly, so that sheep should not be turned into such pastures but in fair weather, or after the dew is off the grass; for when there is no dew or other wet upon the grass, the snail or slug cannot feed, and therefore is never abroad in the dry part of the day; so that in dry weather sheep are not in danger of the rot by these creatures."

Ellis, in the work previously alluded to (1749), dwells particularly on the rotting of sheep by their being pastured in meadows in which swampy places exist, and also in such as have a clay subsoil, rendering the surface retentive of moisture. He speaks likewise of the injurious effects of the animals eating "rank, flashy grass," and a certain weed called "bean-weed, which grows in the mossy grounds of vales." He asserts that "sheep do not take the rot even when land is flooded, but they take the cause of it after the waters are abated; for, as the sheep by this means have been kept

off the grass for some time, when they come on it they meet with a slime and dirt on it, which brings them under the rot; for nothing rots a sheep or any other creature more than such slime and dirt."

Ellis is more distinct in his statements about the injurious effects of "plaise-worms"—flukes (*see fig.* 2.)—in the liver, than any English author prior to his time whose writings we have perused. He narrates a case of a very large number of these entozoa being found in the liver, and, after describing their size and other peculiarities, proceeds to give the following hypothesis of their production:—"These destructive worms are, I suppose, bred by the corruption of blood, for the blood must be first vitiated by the sheep's feeding on unwholesome grass or weeds, or by poverty or otherwise, from whence are bred the seeds or eggs of plaise-worms, which, circulating with the blood, make their nest or lodgment in the fountain; that is to say, in the liver of the beast, where, if they cannot be killed, they will eat till they kill the sheep."

It will be unnecessary in this place to combat Ellis's views of fortuitous generation, or to expose his errors of physiology, our object being rather to show that a distinct opinion existed in his time, that rot was caused from flukes in the biliary ducts.

Passing by several authors of minor importance, whose works contain nothing original on this subject, we come in the next place to the celebrated Bakewell, of whom it is said that he often produced the rot at will in his sheep, to prevent any attempt being made to use them for breeding purposes subsequently to their sale. We find the authority for this statement, as well as an account of Bakewell's opinion of the cause of the disease, in Arthur Young's *Farmer's Tour in the East of England*, vol. i.

Young thus writes:—"Relative to the rot in sheep, Mr. Bakewell has attended to it more than most men in England. He is extremely clear, from long attention, that this disorder is owing solely to floods—never to land being wet only from rains which do not *flow*, nor from springs that *rise*. He conjectures that the young grass, which springs in consequence of a flood, is of so flashy a nature that it occasions this common complaint. But, whether this idea is just or not, still he is clear in his facts, that floods (in whatever manner they act) are the cause.

"Perhaps the most curious experiment ever made in the rot of sheep, is what he has frequently practised. When particular parcels of his best-bred sheep are past service, he fats them for the butcher; and, to be sure that they shall be killed, and not go into other hands, he rots them before he sells, which, from long experience, he can do at pleasure. It is only to flow a pasture or meadow in summer, and it invariably rots all the sheep that feed on it the following autumn. After the middle of May, water flowing over land is certain to cause rot, whatever be the soil.

"He has acted thus with several of his fields, which, without that management, would never affect a sheep in the least; the water may flow with impunity all winter, and even to the end of April, but after that the above effect is sure to take place. Springs he asserts to be no cause of rotting, nor yet the grass which rises in consequence, unless they *flow*. Nor is it ever owing to the ground being very wet from heavy rains, unless the water *flows*. This theory of the rot" (adds Young), "upon the whole, appears satisfactory; and that part of it which is the certain result of experience, cannot be doubted."

The next author in the order of date (1804) whose opinions we shall notice with reference to the cause of rot is Dr. Harrison. We have already had occasion to quote from his writings respecting an outbreak of this disease in 1792.

Under the head of *Causes of rot*, he says, "the disorder has been imputed—

"1st. To a vitiated dew.

"2ndly. To a gruft, which adheres to the grass after wet weather, in the overflowing of running water.

"3rdly. To the luxuriant and quick growth of plants in hot, moist seasons.

"4thly. To grazing upon certain herbs; of which the Butterwort (*Pinguicula vulgaris*), White-rot (*Hydrocotyle vulgaris*), Round-leaved Sundew (*Drosera rotundifolia*), and the Long-leaved Sundew (*Drosera longifolia*) have been chiefly suspected.

"5thly. To Fasiolæ hepaticæ—flukes, or their ova—being introduced into the stomachs of animals by feeding on swampy and low grounds in moist weather.

"6thly. It is ascribed by Daubenton to poor diet and drinking too much water.

"7thly. It seems to be occasioned by poisonous effluvia, which under certain circumstances are emitted from marshy soils."

Dr. Harrison advances arguments against all these suppositions with a view to refute them with the exception of the last, which he endeavours to prove is the true and *only* cause. Speaking of the influence of the sun's rays on swampy ground, he remarks, "evaporation is copiously performed, and probably some of the water is decomposed, so as to generate in combination with other substances the poisonous effluvia, called *miasmata paludum*, which occasion the rot in animals." In another place he remarks, "for my own part I have declared for several years in various companies that marsh *miasmata* are the cause of both agues and rot."

Hereafter we shall offer some remarks on this opinion of

Harrison's, especially as we find it adopted by modern authorities on the diseases of sheep. In the mean time, we give the views of some other writers.

Hogg—The Ettrick Shepherd—observes in *The Shepherd's Guide*, 1807, that "it is a curious circumstance that of all other diseases of sheep, the greatest variety of opinions prevail with respect to the real cause of this, and amongst such a number it may reasonably be suspected that it is very difficult to alight upon the right one; but I have stuck to a theory laid down by a few of the most sensible men on the Duke of Buccleuch's estates, who have had abundance of experience that way, and which seems to account at once for all the different opinions. Yea, I hope to make it appear that all the various causes assigned for the rot only serve more fully to prove this the real and ultimate one. But, not to keep the reader in suspense, I hold it as an incontrovertible fact that *a sudden fall in condition* is the sole cause of rot."

Sir George Steuart Mackenzie in his *Treatise on the Diseases and Management of Sheep*, 1809, combats the Ettrick Shepherd's opinion, and asserts that "all the species of rot may be reduced to one, and *all the symptoms may be referred to unwholesome food.*" He says that "Mr. James Hogg and others assert that the rot is caused by 'a sudden fall in condition.' As these gentlemen do not mention what in their opinion occasions the fall, we may safely presume that it is not meant to ascribe it to any other cause than hunger. But hunger is not properly a disease, and its effects on the animal economy are very different from rot, whether the privation of food be sudden or gradual. Besides, we often hear of sheep having been buried in snow for weeks together, a situation in which they must be subjected to a fall in condition for want of food; but we never hear of sheep which have been so buried becoming rotten. This of itself is sufficient to overset Mr. Hogg's theory, notwithstanding that it is announced with an unusual degree of confidence. We learn from Mr. Hogg, himself, that sheep die of the rot while in good condition and even when very fat, and the whole account he gives of this disease seems to contradict his ideas respecting the cause of it. A sudden fall in condition may accompany the disease without having induced it. A sheep may continue to fill its belly and yet fall off. It is the cause of the transition from fatness to leanness, and not the transition itself, that ought to be looked to. If that cause be hunger, rot will *not* be the consequence, but the usual effects of starvation will follow."

Fairbairn, the "Lammermuir Farmer," likewise combats Hogg's opinion at considerable length, and among other things he remarks that "in no case that has hitherto come under my observation has '*a sudden fall in condition*' in the smallest degree

contributed to bring on this mortal ravager; nay, in many cases with which I have been most intimately acquainted, it could neither be traced with the strictest scrutiny to this source, nor did this follow even as the consequence of the disease."

D. Price, in his *System of Sheep-grazing as practised in Romney Marsh*, 1809, coincides in opinion with J. Lawrence, a well-known and contemporary writer on the diseases of cattle, that the affection is due to debility produced by excess of moisture in "*either the earth, air, or food:*" while R. Parkinson, author of *A Treatise on Live Stock*, 1810, favours the theory of flukes being the cause; but, like those who preceded him, gives no satisfactory account of their existence within the biliary ducts.

The "Lammermuir Farmer," in his *Treatise on Sheep*, 1823, previously quoted, considers the pasturing of sheep during the autumnal part of the year on meadows, where from the combined influences of warmth and moisture a superabundance of grass exists, as the cause of rot, and remarks that, "if any person can come forward and prove that it is not so caused, I shall freely grant that, with our present knowledge, the true cause still lies hid in the dark recesses of nature."

He also makes some observations with reference to the existence of flukes in the liver, which we transcribe, as thereby we have a distinct proof that the malady which he considers to be produced by luxuriant autumnal grasses is none other than the *true rot*. He says, "It is a curious and important fact that fluke-worms are found in the livers of all rotten sheep, and I have no doubt of these insects being the *immediate* cause of death, but how they come there has never yet been properly accounted for." He enters next on a dissertation as to the probable origin of the fluke, and concludes by remarking, "but in whatever way these worms are produced the fact is unquestionable that they are always *swarming in the liver of every rotten sheep;* and in proportion as a sheep is far gone in the disease the more numerous do they become; most certainly the two have some connection with one another, and that no small one, but whether they are the cause or the consequence of the rot remains yet to be determined."

Davy, in his essay read before the Bath and West of England Society, entitled *Observations on the Disease which has lately been so destructive to Sheep, called Bane or Coath*, 1830, does little more than reiterate the statements of others with regard to the causes, but dwells chiefly on enormous losses which were sustained during the year, and on the nature and prevention of the malady. His views of the pathology of rot will be hereafter referred to, as we find that to a very great extent they were adopted by authors of repute who wrote subsequently to his time.

To show that up to this period little more was known on the Continent with reference to the subject than among ourselves, we may here state that MM. Hamont and Fischer, whose investigations have been previously referred to (*page* 3), affirm that "all the veterinary surgeons of Europe agree with regard to the exciting causes of rot. Chabert, Dupuy, Hurtrel D'Arboval, &c., describe its prevalence in low situations; the feeding on marshy plants, as the different species of ranunculus, or plants which grow in or under water; the drinking of stagnant waters filled with insects, or where the fluke-worm and the leech abound; the infected air of the sheepcote, and the sudden change from dry to green food." MM. Hamont and Fischer, however, combat most of these opinions, and conclude by asking "whether the rot may not be an essential disease, dependent on a primitive alteration of the blood, due to watery food?"

The Arabs, they state, attribute this disease to the sheep feeding on a tender rushy grass, which they call *dysse*:—

"As soon as the waters of the Nile begin to subside, the pastures are covered with *dysse*. The sheep are exceedingly fond of it, and they are permitted to feed on it all day long, their feet being buried in the mud; and, as we have already said, for many months they have no other aliment. In the course of a very little time they begin to get fat, when, if possible, they are sold. Their flesh is then exceedingly delicate; but soon after this the disease begins to appear, and the mortality commences.

"In the neighbourhood of Abou-Zabel there is a vast tract of low land which the Nile overflows for two months. When the waters retire, it is found to be covered with these rushes. The neighbouring inhabitants hasten to drive their flocks thither, and they leave them on the marsh from the rising to the setting sun. Every year the rot carries off numerous victims; but it is a matter of general remark, that this disease is more frequent and fatal when the sheep are first turned on the newly-recovered pasture, than afterwards when the ground has become dried and the rushy grass harder."

We come now to a theory of the cause, which ought not to be too hastily rejected. It is founded on a knowledge of the manner in which many entozoic worms are propagated, *namely*, directly by ova, which produce young worms precisely like the parent. Long prior, however, to the period we are now alluding to—1836—it was well known to scientific inquirers that the liver-fluke was an oviparous creature, and that it deposited an enormous number of eggs (see fig. 9) within the biliary ducts. It had also by some practical writers on the diseases of sheep been stated that flukes might originate from the eggs of "*some insects*" which had been deposited on the herbage, particularly of wet soils. Others, however, far better informed on natural history, suggested that the existence of the fluke in the liver was probably due to the ova of the parasite being conveyed into the digestive organs of the sheep while feeding on

particular grounds. The extensive promulgation of the latter opinion is chiefly due to the labours of Mr. E. King, who published some papers on the subject, both in the 'Scotch Quarterly Journal of Agriculture' and also in the 'Agricultural Magazine.' We have been unable to learn whether Mr. King, who seems to have resided in Oxfordshire, but who wrote from the "Steam-carriage Station, Hammersmith," had received a medical education or not; nevertheless he writes like a person well informed on the structure and functions of the animal frame, as also on natural history in general. We give the following quotations from his writings:—

"Flukes' eggs float in the gall, and go with it out of the gall-bladder into the intestine. Here they commingle abundantly with the contents of the intestines; and if the sheep be very full of flukes, the eggs so abound in the contents of the intestines that the smallest portion of a sheep's droppings taken up upon the point of a penknife and placed upon the object-glass of a microscope and wetted with a drop of spring water will show several of them. A buyer of sheep for stores, if he can find one fluke's egg by this mode of examination, would do well to decline purchasing such sheep.

"Hasty rain liberates flukes' eggs from sheep's droppings, and splashes them round about upon the circumjacent herbage; but healthy sheep, protected by their nose, are in little danger here of swallowing these eggs. The next shower, or perhaps the fag-end of the shower which liberates the eggs from the sheep's droppings, carries the eggs down to the earth or into the crowns of grass plants. If the soil be sandy or from any cause porous, the water soaks into the earth and leaves the flukes' eggs upon the surface, where they perish either by frost or desiccation. Such ground is therefore called *sound* land.

"If, on the contrary, the soil be very compact and clayey, so that the rain-water cannot soak into the earth, it draws off upon the surface, floating with it the flukes' eggs into the furrows, the ditches, the brooks, &c., and the flukes' eggs go wherever the flood-water goes. These eggs are so nearly of the some specific gravity as water that the least motion of the water keeps them moving; but they will settle to the bottom gradually wherever water is perfectly at rest. Wherever flood-water, carrying lots of flukes' eggs, finds perfect rest, there these eggs will settle; and many of them settle into holes, where, after the water has drawn away, they will perish in time by frost or desiccation, and then the meadow becomes safe pasturage for sheep; but for a long time whilst they are moist, and for a short time after they are dry, these eggs retain their vitality. The period at which their vitality becomes extinct I have been unable to ascertain.

"This is, however, a point of considerable importance to flock-owners to enable them to judge with some precision when they may safely venture to depasture meadows subject to floods. If attention be directed to this point, accidental occurrences and casual observation may elicit facts which will throw light upon the subject."

This theory of the introduction of the *ova* of flukes leading to the existence of the entozoa in the bile-ducts would certainly appear at first sight to have a good foundation; but it has been fully ascertained that it also fails to account for sheep becoming rotten.

Some ten years ago we put this to the test of direct experiment. We collected a far greater number of eggs, fresh from

the biliary ducts and intestines, and therefore in their perfected condition, than we can conceive it would be possible for a sheep to obtain during a summer's grazing, and exhibited them to an animal, using a little water as a vehicle. The quantity was not less than a teaspoonful; and as it is often impossible to count the number of ova in the field of the microscope, which may be contained in a drop or two of water, we can scarcely imagine the hundreds of thousands which were thus given to the animal. The sheep was kept six months before being destroyed, and, on examining its liver and other organs, *not a single fluke was found.* This negative result was exceedingly valuable, and it fully confirms similar experiments which have been carried out in Germany and elsewhere.

Gerlach, who is connected with the Berlin School of Veterinary Medicine, has had recourse to experiments of the same kind, and invariably with the like result; thus showing that the ova of the fluke when introduced into the digestive system of the sheep, will not develop into or generate flukes. It may be said that we have almost a continuous illustration of the fact in the enormous quantities of fluke eggs which enter the stomach and intestines of dogs belonging to butchers, farmers, and others, from eating the livers of rotten sheep. These animals suffer no ill effects therefrom, and we have never met with the entozoon in the biliary ducts of the dog, although our opportunities have not been a few in making autopsies of this animal. No doubt many persons will object to this illustration, on the ground that the dog is a carnivorous creature, and therefore animal products of this or any similar description would be quickly digested in his stomach. We admit the force of the objection; but we may reply, that flukes have frequently been found in some of the carnivora, both wild and domesticated, and also in the pig, who is, it is true, omnivorous, but whose digestive powers are notwithstanding little inferior, if any, to those of the carnivora. The entozoon has likewise been occasionally met with in man, another of the omnivora. It may be affirmed, therefore, that all these theories have been more or less at fault, and that it is only within, comparatively speaking, a very short space of time that we have approximated to anything like a correct explanation of the cause of rot.

The year 1837 witnessed the publication of the best work extant on the diseases of sheep, from the pen of the late Mr. Youatt, entitled, *Sheep; their Breeds, Management, and Diseases.* It contains a lengthy article on rot, in which Mr. Youatt not only gives his own experience, but culls from nearly all those who had written upon the subject. He comes to the conclusion that the disease is due to the inhalation of miasm, and hence that it

shows itself more particularly during the summer months, though in its progress the disease is carried over to the autumn, through the winter, and even into the next year.

His words are, that "floods in the latter part of the summer are generally precursors of considerable destruction from rot. The meadows when the water clears away must be in the highest degree dangerous. The grass at this time had begun to die, the outer leaves and some of the stalks were perishing; they wanted only the agency of heat and moisture to run into perfect decomposition. The rain comes, and with it the summer's heat, and the decomposition is rapid, and the extrication of poisonous gases profuse."

Again, "The nature of the herbage and the character of the plants which the soil produces have nothing to do with the development of the rot. It is caused simply by the extrication of certain gases or miasmata during the decomposition of vegetable matter, under the united influence of moisture and air."

It is, however, not a little singular that Mr. Youatt, in stating facts with reference to the disease, should name one which positively contradicts his theory with regard to miasm; and he appears to have done so without noticing it at the time. The fact to which we allude is thus given:—"A farmer, in addition to other land, had a dry, hilly sheep-pasture, which he stocked rather hard. In a hollow place of that pasture was a swampy pond, which was preserved for the sake of supplying the wheel of the thrashing-machine. The farmer, notwithstanding the dry and favourable nature of his sheep-pasture, had occasional losses from rot in his flock. He fenced in the pond, and prevented the sheep from having access to the swampy border that surrounded it, and the rot entirely ceased."

The circumstance of the cessation of the disease at once negatives the idea propounded with regard to miasm. If the pond had been thoroughly drained, the water being thereby entirely removed, and the character of the soil improved, we can understand that miasmatic vapours would have ceased to arise from it; but the pond still remaining as a pond, with its swampy border, miasmatic matter would spring therefrom just as much when it was enclosed with an ordinary fence as when it was open.

The theory of miasmata being the cause of rot has already been shown to have originated with Dr. Harrison in 1804, although long antecedent to his time the injurious effects of "bad air" had been vaguely alluded to. We may further remark that the miasmatic theory was revived by Davey in his essay on 'Bane,' published just before the writings of Youatt.

D. Price, previously quoted from, rightly observes that "many objections might be urged against this theory, however plausible

it may appear. I shall here content myself, however," he says, "with stating a fact recorded by the learned and ingenious Dr. George Pearson, in a letter to Arthur Young, Esq., which powerfully militates against the hypothesis in question," and he adds, "as this communication is valuable, not only for the fact it contains, but on account of the philosophical spirit which pervades it, I deem no apology necessary for presenting it to my readers in Dr. Pearson's own words :—

"The paper lately written by my friend Dr. Harrison on the rot of sheep is very valuable indeed for the great number of facts with which it is enriched. These facts are of various applications for the economist, the agriculturist, the breeder, and the practitioner of physic. The subject of the rot in general, I am persuaded, is in very able hands for further investigation, as Dr. Harrison's opportunities, from his residence, are most favourable. Hence, if I had leisure, I should not be inclined to occupy myself in this inquiry ; but it may, perhaps, be the means of eliciting or of confirming truth to state an apparent objection to the ingenious author's conclusion—'*that the rot is occasioned by the same morbific agent which occasions intermittent and remittent fevers.*' This morbific matter is called *miasmata paludum* in the schools of physic, and those miasmata are engendered especially in marshy and boggy grounds or fens, particularly in the spring and autumnal season. In some of the marshes of Kent intermittent fevers affect a great proportion of the inhabitants ; and even persons in the neighbourhood, although living on dry chalky lands, where these disorders never appear if remote from the low grounds, unless by importation. I was lately in Chitney Marsh, on the Medway, near the Isle of Sheppey, one of the most prolific situations for agues to be found in the kingdom. It is famous also for its pasturage, by which very great numbers of sheep are fed. Observing the sallow, and indeed cadaverous, countenances of the inhabitants, most of whom were ill or were recovering from agues, I was led to inquire into the health of the sheep. Besides the evidence of the fine healthy condition of these animals I obtained that of the shepherd, who had been so fortunate as to live thirty-six years in the marsh. He attested that he had only seen the disorder once, and that was in the first year of his residence, nor is the rot at all common in any part of Kent. The Leicestershire breed, he said, were subject to it, but not the sheep bred in the marsh ; nor were these animals subject to any other disease more frequently than in other situations in general, or particularly in the uplands. Hence it appears that one kind of miasmata of marshes which produce agues do not in all situations also produce rot. It is not, however, logically just to conclude from the instance I have given that *miasmata paludum* of a different species may not occasion the rot and also agues. It is possible, also, that some concomitant agents or circumstances may render the same miasmata productive of one of the diseases in certain situations, but not of the other disease."

Harrison also, like Mr. Youatt, narrates some cases of exemption from rot which militate very much against his theory. He says that "in 1792, the fatal year, &c., often particularised, Mr. Young of Claxby divided a flock of sheep and placed fifty upon some good aftermath, where, in other seasons, the rot had frequently prevailed. Only this part of his flock escaped the disorder, which he attributed to the meadow not having been grazed, before it was well covered and defended from the weather."

Again, he observes—"Some time since he (Mr. Young) purchased a close in his neighbourhood which was reputed to be unsound. Before any sheep were turned upon it, he permitted the grass to grow till it would cover a man's ankle, and during the whole summer he took care that it should remain an exceeding good pasture. The rot did not appear in the field, though an adjoining close in his own occupation, and another in the tenure of Mr. Thorpe, suffered more than usual during the year."

Harrison adds some further instances of a similar kind, and says in explanation of them, that "luxuriant pastures seldom rot unless they be *eaten bare* in hot weather. *Whilst the ground is well concealed, it is so completely defended and protected that the sun exerts no deleterious effects upon it.*"* Now, allowing this explanation to be correct, merely for the sake of argument, we may ask how was it that the miasm, which was engendered in the *adjoining* fields to an extent sufficient to rot all the sheep placed therein, did not cross the boundary fences and exert its prejudicial effects upon the sheep in these "luxuriant pastures," seeing that, being mingled with the atmosphere, it must be wafted hither and thither by every gentle breeze?

Harrison makes one remark, however, which may perhaps help us to explain the immunity of these animals in quite another way. He speaks of the danger of pastures being "*eaten bare.*" Now, it is well known, that sheep are remarkable for their close biting, for which their lips and incisor-teeth are beautifully adapted, and hence probably their greater liability to receive the cause of rot than the ox which crops the longer grasses. Holding the opinion which we do that rot is none other than an entozoic disease, referable to the entrance of the penultimate forms of the liver-fluke into the digestive system of the sheep, we conceive that an explanation is to be found in the circumstance that these creatures are in greater abundance at the lower portions of the stems of the grasses—the parts eaten by the sheep—than elsewhere on the plants.

Cleeve, in his *Essay on the Diseases of Sheep*, published in the first volume of the *Journal of the Royal Agricultural Society*, p. 310, narrates a fact singularly corroborative of the view we have taken. He says that in the parish of Seaton, in Devonshire, all the sheep that were depastured in the marshes one year were attacked with rot and died, *only excepting four;* on examining these four, it was found that they were *hog-jawed*, and, from the under jaw being much shorter than the upper, they could not bite near the ground."

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* These italics are our own.

We may here leave the further consideration of this question for the present, to proceed with the history of the assigned causes.

In the year succeeding the publication of Mr. Youatt's work a small manual on the diseases of sheep made its appearance, from the pen of Mr. A. Blacklock, surgeon, Dumfries. This gentleman strongly repudiated the opinion of entozoa being the cause of rot, and considered that it arose solely from tubercles located in the lungs. He remarks that "everything that has a tendency to weaken the animal will more or less lead to rot. Exposure to cold and wet, mishaps at lambing-time, food bad in quality or deficient in quantity, and over-driving, will all predispose the constitution to the deposition of *tubercles*." Hereafter we shall have occasion to recur to the writings of Mr. Blacklock, and will only now incidentally remark that the so-called tubercles in the lungs of sheep have no pathological relation to those met with in cases of phthisis of man. Since the period at which this gentleman wrote, it has been ascertained that these deposits are produced by the well-known entozoon, the *Filaria bronchialis*.

Subsequently to this date we do not find that any author of note has propounded any new views of the cause of rot. Mr. Spooner, of Southampton, however, after reviewing the statements of others, in his *History, Structure, Economy, and Diseases of Sheep*, 1844, remarks "it appears to me that in addition to the consumption of food in which water greatly abounds it is essential that this food should be in a state of decomposition (partially rotten) in order to produce the fatal disease."

We come next to comment upon the general statements which have been made with regard to the pasturing sheep on water-meadows. It has long since been ascertained that during a certain period of the year sheep are sure to take the rot if placed on irrigated meadows, this being from about June to October. The cause of this is to our minds very evident; but we must leave its explanation for the present, and reserve it for another section of our essay.

Arthur Young, when speaking of watering meadows in his *Farmer's Tour*, vol. iii., says "that Mr. W. White, a tenant of Mr. Frampton's, of Moreton, Dorset, remarked, and it is the general observation of the country, that these watered lands never rot sheep in the *spring*, though they immediately follow the water, or are turned in at any time or in any manner; but if they are turned into the *after-grass*, it rots till the autumnal watering, after which they are safe."

Much has been said with regard to the draining and improving of twenty-five acres of imperfectly-made water-meadow

belonging to the Duke of Portland, which for twenty years previous to 1826, when the improved drainage was effected, had carried *ewes and lambs* without the occurrence of rot, becoming subsequently thereto so dangerous to sheep that it invariably rotted them.* The field is described as being during twenty years so wet as to grow rushes and coarse water-grasses, but yet to be *safe* pasturage. This it might possibly have been in the spring, but not in the summer and autumn. We are bound to receive the statement as it is; but we nevertheless think the entire evidence, both with reference to the safety and the subsequent dangerous condition of the pasture, to be wanting in that preciseness which would bear a rigid investigation.

An analogous case has been published in *The Quarterly Journal of Agriculture*, which has so many features in common that it would appear to be identical, but for a slight difference in the dates and a few other particulars. This case received such an excellent reply from an anonymous writer under the signature F. B., which also appeared in the same journal, that, although somewhat long, we venture to transcribe both the case and reply, as thereby some light may possibly be thrown on the other instance:—

"On Water-Meadows causing the Rot in Sheep.—About the year 1808 some land, part of which had been under water, much of which was a bog, and part of which was nearly dry, was drained, levelled, and irrigated. Although it was drained and was so far dry that horses could at all times walk upon it, yet it produced coarse herbage, rushes, and even some flags. In this state it remained for at least fifteen years, and during the whole of the time it was constantly fed by ewes and lambs in the spring, and no instance was ever known of any of these sheep ever showing the slightest symptom of the rot.

"As, however, the herbage was not good, and it was supposed that by obtaining a better outfall and a more effectual mode of drainage the meadow might be much improved, it was broken up in 1829, drained more perfectly, better levelled, and was again laid down to grass after a turnip-fallow. The land then appeared to be perfectly drained. The turnips were excellent, and the grass which was sown in 1831 was beautiful. It was mown that autumn, after having been irrigated, and produced abundantly. It carried great flocks of sheep the ensuing spring, and produced a very great crop of grass early in the summer; but afterwards in that year the land appeared starved, and the grass did not come a second time to the scythe. In the spring of 1833 the meadow yielded a good pasture to the sheep, but, except in those parts which were dry and steep, it produced little for the scythe. Rushes made their appearance; and as it was probable that the land was not sufficiently drained, more drains were made, which produced a great deal of water. Then for the first time suspicions were raised that the sheep fed on the land were tainted by the rot, and it has been ascertained that since Christmas 1833 sheep fed upon it have taken the rot in five days. In the spring of 1834 more drains were made in it; the consequence of which has been a great improvement in the quality and quantity of the herbage, but, as far as the rot is concerned, it has been equally fatal to every sheep put upon it. It is necessary to add, that, although the whole of this meadow is now so well drained that after a fortnight's irrigation it will

* See Royal Agricultural Society's Journal, vol. i., p. 368 et seq.

become so dry in a week as to admit of horses galloping over it without scarcely leaving the print of their shoe, yet, as some parts of it are much lower, and consequently nearer the water by some feet than others, it might be supposed that they would be more likely to produce the rot than those parts which are higher. But this is not the case. It has been ascertained that they are equally infectious. Other meadows in this neighbourhood, irrigated partly by the same stream, have equally rotted the sheep though perfectly well drained. As those other meadows are entirely new, it cannot be said of them that there was a time when, though less well drained, they did not rot the sheep. They do not affect the question, What can be the reason why land which when less well drained was fed by sheep with impunity rots them now when it is much better drained?

"It cannot be attributed wholly to the seasons, because other water-meadows in the same county but on a different stream did not rot the sheep in the spring or even in the autumn of 1834; some few out of very many have been supposed to take the rot; and that in the autumn of 1834,* even on these meadows, scarce one has escaped the infection. But where they have taken it some parts of the land have not been effectually drained.

"These occurrences naturally excited attention, and recourse to every known means supposed to be capable of preventing this infection was resorted to. It has been said that sheep folded on fallows and not allowed to go on to their pastures till the dew was off the ground have escaped the rot, when others which were allowed to remain constantly on them have taken it; that dry food given to them on dry ground during the night, and that salt and oil-cake, have acted as preservatives. The evidence of the good effects of all these antidotes has been such as it was impossible to doubt. But each and every one of them has been tried here with the greatest attention, and it is painful to add that they have all failed in *every instance*. The mode in which these experiments were made was this: Out of a large lot of fat wethers which were in the course of being killed, and which were all believed to be sound, three at a time were selected for the trial of each of these remedies, and put on the meadows. At the end of three weeks their livers were invariably found to be more or less infected, while the livers of the others of the same lot which had not been on the meadows, and which had remained in their usual dry pastures, remained unaffected.

"This continued for some time; but at last two wethers which had *not* been on the meadows were found to have diseased livers, and therefore it cannot be affirmed with perfect certainty that the subjects of the experiment had taken the disease in spite of the remedies, because it is just possible that, like the two last, they might all have taken the infection at some previous period."

To this statement F. B. replied:—

"In vol. v. p. 503 of this Journal is an article entitled, '*On Water-Meadows causing Rot in Sheep.*' The very extraordinary circumstances detailed in that communication led me at first to think it an imaginary case, given to the public for the purpose of provoking discussion; as lawyers say, 'a case stated for counsel's opinion.' But on farther consideration I shall treat it as a real one.

"The writer says, 'About the year 1808 some land, part of which had been under water, much of which was a bog, and part of which was nearly dry, was drained, levelled, and irrigated. Although it was drained, and was so far dry that horses could at all times walk upon it, yet it produced coarse herbage, rushes, and even some flags. In this state it remained at least fifteen years,

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* In the autumn of 1833, 200 ewes were fed on these meadows, and, when killed, were all found to be quite sound.

and during the whole of that time it was constantly fed on by ewes and lambs in the spring, and no instance was ever known of any of these sheep ever showing the slightest symptom of rot.' To this part of the statement I have to observe, that ewes and lambs are not liable to rot when pastured upon water-meadows in *spring*. It would have been satisfactory to have been informed whether sheep of any kind were *close-pastured* upon the meadow in its then partially improved state, either *in wet summers* or *in autumn*, and what was the result of such pasturage?"

F. B. then quotes the whole of the second paragraph ending with the question—

"'*What can be the reason why land which when less drained was fed by sheep with impunity rots them now when it is much better drained?*'

"This negative question," he continues, "appears to me as if put for a similar purpose to that of the witty King Charles in regard to the weight of live and dead salmon; and in answer I will apply the sentiment expressed by one of the sages on that occasion: 'Before I assign a reason, I could wish to prove the fact.' On entering upon this discussion it is but fair to acknowledge I do so under a considerable degree of prejudice, because I have experience of many instances of low marshy grass-land when in a state of nature, or but partially improved, rotting the sheep pastured upon it; and that land, on being subsequently thoroughly drained or converted into well-ordered water-meadows, did not rot sheep fed upon it in proper season. But I will endeavour to show, from the querist's own statement, it is probable that he has come to an erroneous conclusion in estimating the capability of his water-meadow.

"1. *The System of Irrigation.*—The most proper method of irrigating low marshy ground, such as the meadow described, is the bed or ridge system. It is not probable the meadow in question was so formed, because, if it had, the occupier would not have ploughed it up, cultivated it, and cropped it with turnips, as the re-formation of these beds with water-carriers and furrow-drains would have been attended with an unnecessary additional expense of from 10*l.* to 20*l.* per acre. Indeed it appears certain the meadow was not so formed, as he says, 'The grass-seeds were sown in 1831. They were mown in the autumn of that year *after having been irrigated.*' Now if water had been thrown over new-formed beds of loose cultivated earth, a great part of it would have been washed away, and the young grass-plants along with it. Neither is it probable his watering was done upon the catch-work principle, as that is not applicable to flat marshy land, such as a great part of the said meadow is described to be; and a loose formation of catch-work is still more liable to be guttered and the earth washed away than beds so formed. I am therefore led to believe the irrigation in question was something of the nature of warping, and effected by a rivulet dammed up, and the water from it caused to flow over the meadow at random, or with but little artificial direction; and although ewes and lambs may do well when pastured *in spring* upon land so managed, or rather mismanaged, yet sheep of any sort *close pastured* upon it *in wet summers* or *in autumn* would hardly escape rot, and that without any reference to whether the land was well or ill drained. The great advantages derived from the bed formations and catch-work systems of irrigation are the rapid flow of water over the surface, and quick delivery of it by the receivers and furrow drains, either to supply other beds at lower levels or convey it to the waste water channels, no water ever being allowed to stagnate upon any part of a well-ordered meadow. That desirable object cannot possibly be attained in warped or flooded meadows however much they may be drained, and hence the liability of such meadows to rot sheep.

"2. *The Quality of the Herbage.*—We are informed the land was sown with grass-seeds in the spring after the turnip crop, and that it was irrigated in the same year the seeds were sown, but the varieties of those seeds are not mentioned. If they were annuals or biennials, such as are commonly used in agriculture, they would of course soon die off, and all the tender and most nutritious of the natural grasses would be extirpated by the aration processes; while the roots of coarse grasses and other pernicious plants, so far from being eradicated, would in fact be renovated by the short course of arable culture. Indeed, it is purposely acknowledged, 'rushes again made their appearance in the second year after the seeds were sown,' and probably many other still more objectionable plants made their appearance at the same time. But even supposing the land had been sown with a proper selection of perennial grasses, these would have been weak in the second year. The narrator complains of his grass looking '*starved* after mowing in the second year, and that it did not come a second time to the scythe.' Also in the third year after sowing, he says, 'Except in those parts which were dry and steep, it produced little for the scythe;' the more valuable plants raised from seeds sown upon the low land being gone, and supplanted by pernicious plants as before stated. The sound pasturage on the meadow would be confined to a very narrow compass, and hence not without any reference whatever to draining.

"3. *The Manner of Pasturing.*—We are told that before the meadow was improved otherwise than by irrigation it did not rot ewes and lambs pastured upon it *in spring*. But it is not said it was at that time sound pasturage for sheep in *wet summers* or *in autumn*. Neither is it said that *after draining* it rotted ewes and lambs *in spring*. It is however stated that after the third draining in the spring of 1834 'the meadow was equally fatal to every sheep put upon it.' There is no mention of *the time of year* when the sheep were so put, nor is it stated whether the land was *full stocked with sheep* in that fatal pasturage. I, however, think that calamity took place *last autumn;* at least it is fair to infer so, because, as the third draining was effected in the spring of last year, the irrigation could not be carried on while the draining was in hand, consequently too late to produce early spring food; and if the meadow was mown for hay last summer, the fatal result will have arisen from the sheep eating the autumnal lattermath or fog, and not from the land having been more perfectly drained.

"Much more matter of a similar purport might be stated in support of my argument, but I trust I have already said sufficient to show that the querist has come to a hasty conclusion in supposing, as he states his case, 'that land when less well drained may be fed by sheep with impunity and rot them when much better drained.'"

In closing this section of our subject we would remark that neither water—pure or impure—innutritious herbage, nor noxious plants partaken of by an animal, nor exposure to rainy weather, location on damp and ill-drained pasturage, nor on water-meadows, in the abstract, can be regarded as the cause of rot. Singly or combined, if long enough continued, these influences exert their baneful effects upon the vital force, and by diminishing it render animals more susceptible to diseases in general, especially those of an asthenic nature. They fail, however, to produce rot, because, even if united with numerous other causes of a similar kind, they are incapable of producing the entozoa which are found in the biliary ducts of affected sheep.

We are not insensible of the injurious results which spring from the partaking of improper food, knowing full well that the due nutrition and integrity of every organ will depend very much upon this alone. We do not lose sight of the effects of a long-continued elevation or even diminution of temperature, a humid or dry atmosphere, on the *quality* as well as the quantity of the food itself. Neither are we unmindful of the consequences of a long exposure of the bodies of animals to the vicissitudes of weather; nor of the impaired function of respiration over the oxidation and decarbonization of the blood when the air is both warm and humid. The blood, we know, will be rich or poor, pure or impure, in proportion to the completeness of the change it undergoes by the process of respiration, and to the amount of albuminous and saline materials which enters it in a given space of time from the assimilation of the food. And further we are aware that it is by these means that it can alone maintain—assisted by the secretory and excretory organs—that purity of composition and proper specific gravity necessary for its free circulation, and the yielding up of its nutritive and vital properties to every tissue of the body.

But we object that many persons both write and speak about animals, and endeavour to explain the normal and abnormal functions of their several organs—particularly those employed in the digestion and assimilation of the food—entirely on chemical principles; as if an animal were merely a chemical laboratory. This we conceive to be an error. We admit the influence of chemistry—few perhaps more so—in many of the changes which are wrought in the animal organism; but we believe that this is controlled, kept in order, and, so to speak, even directed, by a far higher power, *namely*, vitality. Vital force, however, we do not hold to be antagonistic to chemical action, but to be in harmony therewith. Nevertheless, it is often diminished, without losing its supremacy, by many internal as well as other causes, especially if these should be of a persistent irritative character, as, *for example*, the presence of flukes in the liver. Under such circumstances a continued alteration of the function of one organ will exert a baneful influence to a greater or less degree upon all the others, and thus lead ultimately to the death of the animal by simply exhausting the vital force.

## Pathology.—Rot an Entozoic Disease.

When we reflect that the pathology of a disease is to a considerable extent elucidated by studying the lesions which are observed *post mortem*, it seems difficult to account for the differences of opinion which have prevailed with regard to the nature of rot. It cannot be denied that every investigator of this disease

has had at command numerous facilities for observing the state of the organism *directly* after the death of the affected animal. Nor is this the only advantage he has enjoyed; for a few visits to the *abattoir* have sufficed to show the several stages of the malady from its earliest beginning to its fatal termination. In *slaughtered* animals, it is likewise to be remembered, that disease is always seen in all its exactness. Changes consequent on *natural* death have not come on, and there is, therefore, no mistaking the real for the unreal.

The advantage thus possessed by the veterinary pathologist over his medical compeer is very considerable. We fear, however, that too many have not sought this knowledge for themselves, but been content to adopt the opinions of others, who may perhaps have been equally devoid of practical information. In no other way can we account for the varying statements which have been put forth respecting the pathology of rot. Some writers, for example, describe the disease as being essentially an *inflammatory affection* of the liver. Others, on the contrary, view it as a *general dropsy* associated with *chronic* disease of the liver and an impure state of the blood, and one author, in particular—a surgeon—has even contended for its being a *tuberculous* disorder of the lungs.

The gentleman thus alluded to is Mr. Blacklock, whose writings we have before quoted from. He says,—

"The lungs are always the principal, and I may also, from my own experience, add, the primary seat of the affection. When examined in the early stage of rot, they have a hard lumpy feel, especially at the upper part or lobe; and at this time a great number of irregular yellowish-white, patchy-looking bodies will be seen shining through the membrane, *pleura*, which surrounds the organ. These *tubercles*, as the hard white bodies are called, vary in size from that of a mustard-seed to that of a pea. They are sprinkled through all parts of the lung, and will, in every dissection, be found in a variety of stages, from the firm condition in which they were deposited, to the softened state which denotes their speedy expectoration. Each tubercle, however small, usually holds a particle of calcareous matter in its centre."

The confidence with which Mr. Blacklock speaks of the matter will be further shown by one other short extract from his writings:—

"Fluke-worms and hydatids are almost constant attendants on rot, and seemingly most important ones, especially the former, which have, I may say, kept a great bulk of the learned and unlearned for many years in a perpetual bustle, and have so hoodwinked writers on this subject as to prevent them seeing the truly important points of the disease."

The opinions thus authoritatively put forth respecting rot being a tuberculous disease of the lungs have no foundation in fact. Indeed, as has been already pointed out, sheep are not subject to depositions in their respiratory organs of this *aplastic* material, which proves so destructive to mankind.

The little hard lump about the size of a "mustard-seed," holding calcareous matter, mistaken for a true tubercle, is the product of the *Filaria bronchialis*. Examined in the early stages of its formation, and when it presents little more than an ecchymosed condition, or a pus-like deposit, a *male* parent-worm will be seen coiled upon itself in the isolated miliary body. Having served the chief purpose of its life, the entozoon is about to die and become entombed in calcareous matter, his own structure contributing to this end by being involved in the process of calcification. Similar changes we believe to take place with the female parent-worms, but these, from their greater size and number, produce depositions far exceeding those of the male entozoa. In the still *larger and softer deposits*, which give here and there to the lung a flesh-like appearance, myriads of ova and *young* filariæ of both sexes will be found, which, by their local irritation, produce the changed lung-structure in which they dwell. These are the revelations of the microscope, and beautifully do they exemplify one form of entozoic disease to which sheep are remarkably prone.

Among the advocates of the opinion that rot depends on *inflammation of the liver* was the late Mr. Youatt. He spoke very decidedly on the point, and attributed all the lesions which are observed in the body to this one primary cause. This view of the pathology of the malady appears to have emanated from Dr. Harrison, who affirms that "Rot always commences with inflammatory symptoms, and generally with an exudation of coagulable lymph under the tunic of the liver. In five or six days after contracting the rot, the thin edge of the liver," he says, "becomes of a transparent white or bluish colour, and this spreads along the upper and lower sides, according to the severity of the complaint. In severe cases the whole peritoneum investing the liver is diseased, and then it commonly assumes an opaque colour, interspersed with dark red lines or patches."

Similar views were held by Hurtrel D'Arboval and by Davey. The latter-named author, after describing several morbid states of the liver, which he enumerates as "enlargement, induration, gangrene, concretions, &c.," says, "Now, we are well assured that these appearances never occur without the existence of previous inflammatory action. *Inflammation of the liver* is a state of disease which it is evident has taken place."

It is not a little remarkable that not only surgeons, but also such eminent veterinary authorities as Youatt and Hurtrel D'Arboval, should have committed so great a mistake respecting a disease of such common occurrence. Every farmer knows that sheep give little or no evidence of ill-health at the commencement of rot, and that, when they do sicken, the symptoms indi-

cate *not an inflammatory state* of the system, but a *marked debility and prostration* of the vital powers. We may here, however, leave the further consideration of this statement, more particularly as its fallacy will fully appear when we come to a detailed account of the symptoms of the disease.

Thus far the opinions we have quoted on the pathology of rot may be regarded rather as exceptions than otherwise, since the majority of authors agree in considering it as a dropsical disease, associated with a disordered liver, depending on an impure, watery, or improper diet.

In confirmation of this view it has often been said that both hares and rabbits take the rot in wet seasons and die therefrom. Our *post-mortem* examinations of these animals, when diseased, have not been many; but, singularly enough, up to the present time we have rarely failed to find flukes in the biliary ducts. The liver of the creature, however, has occasionally been enlarged and softened, and its vessels turgid with imperfectly clotted blood—very dark in colour. The general hue of the organ has varied, being in some places paler and in others of a deeper colour than natural. The animals have been little more than skeletons, and their abdomens have contained a good deal of serous fluid. The cause of death was obvious in these cases; but in all this we have only another proof that bad food will give rise to grave affections of the liver, by first impairing the quality of the blood.

The influence of food—natural grasses in particular—when *surcharged with moisture*, in producing a deranged condition of the liver of sheep, was made the subject of our investigation during the wet summer of 1860. We found that the first ill effects were a *blanching of the lobules* of the gland,—the structures which are mainly composed of the secretory vessels, bile-cells, and origins of the biliary ducts. Affected livers, apart from any other pathological condition, showed white spots and streaks here and there, which were often not more than five or six in number, and of a size not exceeding an inch and a half in length.

A continuance of the cause led to the production of further structural changes. No embryos of the fluke, however, could be detected even by a microscopical examination of the bile, &c. Had means not been adopted to prevent the further inroads of disease, doubtless these animals would have ultimately sunk from *dropsy;* but food the very opposite of that they had been living on, combined with a daily allowance of salt, sufficed at once to put a stop to the disorder, which assuredly ought not to be regarded as being rot.

To the opinion held by most authorities that rot in its advanced stages is accompanied with general dropsy, we willingly assent; but that the anasarcous condition of the body in *this disease*

depends, *ab initio*, on watery or innutritious diet, and allied causes, we cannot admit.

Dropsy will doubtless arise from causes which affect the quality of the blood or the functions of the liver, and not only in sheep, but in all animals, man himself not excepted. Dropsy, however, will not produce flukes in the liver, although the existence of flukes therein will produce dropsy. Until we cease to use such terms as "water rot," and begin to speak of rot as an entozoic disease only, we shall continue to impede the progress of veterinary pathology, by encumbering her with an unmeaning nosology.

Rot, we repeat, is an entozoic affection, due to the presence of flukes in the biliary ducts of the liver, which early lay the foundation for structural changes of a special description in this organ, and ultimately cause the death of the animal from anæmia. No author denies the existence of flukes in this disease, although it may be that every one does not make mention of them. The accounts of their presence within the liver are some of them of early date. Thus Sir Anthony Fitzherbert, in his *Booke of Husbandrye*, 1532, in describing the rot of sheep, says "if thou cut the lyver, there will be lyttle quickenes like flokes; and also seeth the lyver, if it be rotten it will break in pieces, and if it be sound it will hold together."

To those who object to the statement that flukes are the direct cause of the malady, may be addressed the question, How is it that sheep bred and reared on *sound land* have flukes in their livers in *wet* seasons, and then only; and that under such circumstances they die from rot? It is admitted that they are so affected. Where, then, do the entozoa *now* spring from? No combination of ordinary causes can produce them. No, their propagation and development are governed by fixed and unalterable natural laws.

When conversant with the natural history of the fluke, we see fewer difficulties in accounting for this fact than might be supposed; but we will not now anticipate this division of our subject.

Entozoic diseases have been much investigated of late, and every day's experience goes to prove that they are neither few nor unimportant. Hitherto it has been too much the custom to look upon entozoa as an effect rather than a cause of disease. Are they so in that condition of the flesh of the pig vulgarly called "measled pork," or in "gid" in sheep, or in "dyspnœa" in calves and lambs? If not, why should they be so considered in rot?

Men who are unacquainted with the facts which have been brought to light through long-continued research into the natural history of the liver-fluke, and who probably may possess far more practical knowledge of the details of feeding and managing sheep

to a profit, than do most scientific observers, will be sure to find enough to cavil at in the revelations of science. It is doubtless far easier to argue that all entozoa are the consequence of impaired animal functions, than by a patient investigation to become conversant with their structure, habits, and mode of development, with a view to understand the way in which they enter the bodies of animals and exert a deleterious effect on health.

Our own researches have recently brought to light another and a fruitful cause of the death of sheep of all ages, even under every variety of good feeding, management, and location, from the existence of an undescribed variety of worm of the class *filaria* within the abomasum—the digestive stomach. These entozoa, to the extent of many hundreds, fix themselves to the inner surface of the stomach, by inserting their heads into the mucous membrane, where they are enabled to keep their hold without much effort, despite the peristaltic action, by being furnished immediately behind their heads with four barbs, whose points are directed backwards, after the manner of a fish-hook.* The symptoms arising from their presence are remarkably akin to those of rot, consisting principally of long-continued wasting of the affected animal, leading ultimately to dropsy—death being not unfrequently preceded by diarrhœa. Surely these cases are not—because their progress, symptoms, and fatality are so analogous to those of rot—to be designated by that name: if so it will require but another step for it to be boldly asserted that sheep take rot, and die therefrom, when fed on the richest and best food, when located, bred, or reared on the lightest land, and when exposed to a long prevalence of the driest weather, for, as before stated, it frequently happens that under all these circumstances these entozoa abound in the stomach of the sheep.

To proceed. It is important to remember, as bearing on the pathology of rot, that flukes occasionally locate themselves in young lambs, and so impair the structure of the liver by their number as quickly to destroy the animals—often before the true cause is suspected. A case in point was a few years since brought under our notice. In September, 1853, we received from an amateur pupil of the Veterinary College, then residing at Redgrave in Suffolk, two portions of the liver of two lambs that had died after a few days' illness. The lambs were black-faced Norfolks, and had been bred on heath-land near to Thetford, where rot may be said to be unknown. They had come upon the farm just *six weeks* before, and were at once placed on

* At some future time we hope to describe the anatomical peculiarities of this interesting entozoon, and to illustrate these by microscopic sketches.

fen-land, part of which was marsh. Their death, as stated, was comparatively sudden, and the gentleman who sent the specimens found in each case, on making a *post-mortem* examination, that a serous effusion had taken place into the cavity of the abdomen, and that the liver presented well-marked indications of disease.

We were at once struck with the remarkable softness or pulpy condition of the liver, and on a close examination we ascertained that many of the bile-ducts were filled with entozoa, which proved to be very young flukes. The presence of these parasites in such numbers, and in animals so young, had, contrary to the general rule, produced a quick destruction of the integrity of the liver, with its several concomitants. It is a singular fact, but one which fully accords with our present knowledge of the natural history of the entozoon, that not a single *fully matured or parent fluke* was met with in these cases. Having preserved several of these entozoa, we here insert a sketch of a group of three of them of their natural size, as drawn to a scale.

Fig. 1. Young Distomata.

Vogel has spoken of the young distoma as being four lines long, and one and a half broad. The smallest of our specimens, however, as will be seen, had not attained even these dimensions.

Notwithstanding their diminutive size a microscopical examination showed that the nutritive system of these young distomata —aquiferous and bile-digestive—was fairly developed and in active operation, but that only an outline of their generative organs—the female portion in particular—existed.

Before leaving this division of our subject it is necessary to say a word with reference to the ordinary pathological changes which the liver undergoes from the presence of flukes. In general, unless the entozoa are very numerous, little structural change takes place until they have attained a fair size, and have travelled onwards from the main biliary duct, which they entered from the duodenum, into its various branches and smaller ramifications to deposit their ova. Their existence now produces pressure, persistent irritation, and increased vascular action, which ultimately lead to the coats of the ducts becoming thickened, and their calibre increased. In medical language hypertrophy, with dilatation, takes place. It is these changes which give an altered outline, and often an increased size, in some parts to the gland. Nature may be said to strengthen the walls of the ducts, even to their minutest divisions, to prevent the entozoa from

gaining access to the parenchymatous structure of the liver; and in effecting this she does not even stop at mere membranous development, but often deposits calcareous materials within the animal tissue. This gives to the liver its hardened condition, and likewise imparts a gritty sound on cutting through its substance. The same structural changes lead to a partial blanching of the lobules, and an impaired function of the bile-secreting cells, so that at length the entire organ becomes changed in colour, often presenting a yellowish clay-like hue, with which the enlarged main-biliary ducts greatly contrast, standing out on its surface as bluish white lines or bands. Much more might be said with reference to these pathological changes, but our description of the *post-mortem* appearances must not be anticipated, and therefore we pass onwards to our next division, *namely*, the

## Anatomy and Natural History of the Liver-Fluke.

The branch of science commonly designated Natural History is acknowledged to be far more attractive than many others, and to possess allurements even for the uneducated. If this be so, it is easy to understand how men whose education and tastes fit them for such a study often become enthusiasts in its pursuit. It is well when investigations of this kind are not undertaken for mere intellectual gratification, but have for their end some praiseworthy object—the benefit, perchance, of the human race. It is this which gives a value, far beyond the simple attainment of knowledge, to researches into the history of parasites, because they mostly lead to the means of cure or prevention of the diseases which are due to the presence of these creatures. The introduction of the achromatic microscope has immensely increased the facilities for obtaining information on this subject, and has consequently led to the dispersion of many an error which had formerly prevailed. A new field of research has thus been opened up, and the wonders already revealed make the profoundest naturalist hesitate in expressing an opinion on any one point connected with the development of these creatures which he himself has not investigated.

Only a few years have elapsed since the scientific world was startled by the announcement of Von Siebold that the *Cyticercus fasciolaris*—the hydatid met with in liver of rats and mice—was only a "stray tape-worm which had become vesicular, and was, in fact, the *Tænia crassicolis* of the cat." Shortly after this, even greater surprise, amounting in some persons to unbelief, was produced when the same distinguished naturalist affirmed that the hydatid of the brain of the sheep *cœnurus cerebralis*—the cause of the disease termed "gid"—was only the scolex of the *Tænia serrata* of the dog; and that the detached segments of this worm,

in which its ova were alone perfected, would, if given to sheep, produce hydatids in the brain. Nor was this the only proof adduced in corroboration of the statement, for it was said that the converse was equally true—namely, that tape-worms were quickly developed in the intestines of the dog, by giving to this animal the so-called heads of the *cœnurus*.

A number of experimenters was thus called forth, in various parts of the Continent in the first instance, and afterwards in England, every one of whom confirmed the conclusions arrived at by Siebold. It was thus proved beyond disputation that some, at least, of the entozoa underwent regular metamorphoses, and that hydatids and tape-worms had a necessary and mutual dependence on each other. It could not be expected that investigations of this kind would end here, and it has since been shown that very many entozoa pass through far more complex changes than the tape-worm ; and that they often exist out of the bodies of the animals which they ultimately inhabit, in such peculiar forms, and for so long a time, as almost to set at nought the efforts of the helminthologist to unravel their several transformations. Among this number is the liver-fluke, the structure and metamorphoses of which we shall now attempt to describe, as it is upon knowledge of this kind that the means which, as pathologists, we possess for the treatment and prevention of the rot in sheep are based.

Technically speaking, the liver-fluke is known as the

*Distoma hepaticum, or Fasciola hepatica.*

The name *Fasciola*, to which many naturalists give preference, was originally bestowed on this entozoon by Linnæus, while that of *Distoma* was adopted by Retzius, under the belief, as would seem, that it was furnished with two distinct mouths—one at the anterior extremity (*a*, *fig.* 3), and a second a little behind the first named, on the ventral surface (*b*, *fig.* 3). The term *hepaticum* is employed in conjunction with Distoma to signify that the entozoon is met with in the liver.

The distoma belongs to the order *Trematoda*, a classification which denotes that it is a suctorial worm, and by most naturalists it is placed in the second family of this order. It will thus be seen that it is a matter of minor importance whether we speak of the creature as a liver-fluke, trematode worm, *distoma*, or *fasciola*.

Professor Owen, in his '*Lectures on the Invertebrate Animals*' (1843), says: "The *Trematoda* may be characterised as having a soft, rounded or flattened body, with an indistinct head, provided with a suctorious foramen, and having generally one or more sucking cups for adhesion in different parts of the body ; the organs of both sexes are in the same individual." From the same author we learn that Rudolphi, a pupil of Linnæus, adopted

external and easily recognisable characters for the generic subdivisions of the Trematode order according to the numbers and positions of the suctorious orifices and cavities. "When there is only a single one, it constitutes the genus *Monostoma;* when there are two, which are terminal or at opposite ends of the body, you have the character of the genus *Amphistoma;** when the posterior of the two suckers is not terminal, but on the inferior surface of the body, it constitutes the genus *Distoma;* three suctorious cavities characterise the genus *Tristoma;* five the genus *Pentastoma;* and a greater number that called *Polystoma.*"

*Form and Size.*—The *Distoma hepaticum* varies in size in the same animal, according to the age of the entozoon. Although this is the case, it is a singular circumstance, hereafter to be explained, that no distomata are found, even in long-existing cases of rot, so small as to warrant the belief that they had been hatched within the biliary ducts. The form of the entozoon is that of an oblong oval, flattened from side to side. Its greatest breadth is anteriorly, immediately behind the central sucker, from which point it gradually tapers to its caudal extremity. When fully developed, the distoma will attain a length of an inch and quarter, and a breadth of half an inch at its widest part. Many of the smaller specimens, however, do not bear the same proportion between their length and breadth, being somewhat rounder in form. It is, however, to be borne in mind, that on being removed alive from the biliary ducts, the creatures are seen to contract themselves, so as to appear very much smaller than they really are—a circumstance which has often led to an incorrect conclusion with regard to their real size, and consequently as to their age, and the length of time they had been located within the ducts.

Fig. 2.
Fully-developed Distomata.

We here insert an engraving (*fig.* 2) of two distomata of matured growth, which will assist our exposition. One of them is

* The fluke thus named is frequently met with in oxen and sheep, attached to the mucous surface of the rumen, in which situation it appears to be unproductive of mischief.—Author.

represented as exposing the ventral surface—that on the right—and the other the back or dorsal surface.

*Colour.*—The colour of the entozoon is found to vary, according to the amount of bile which is contained within its digestive system. If well filled with this fluid, the distoma has a dark-brown or occasionally a brownish-black hue; on the contrary, if nearly empty, its colour is a yellowish-brown. Very frequently, however, some of its digestive tubes are replete with

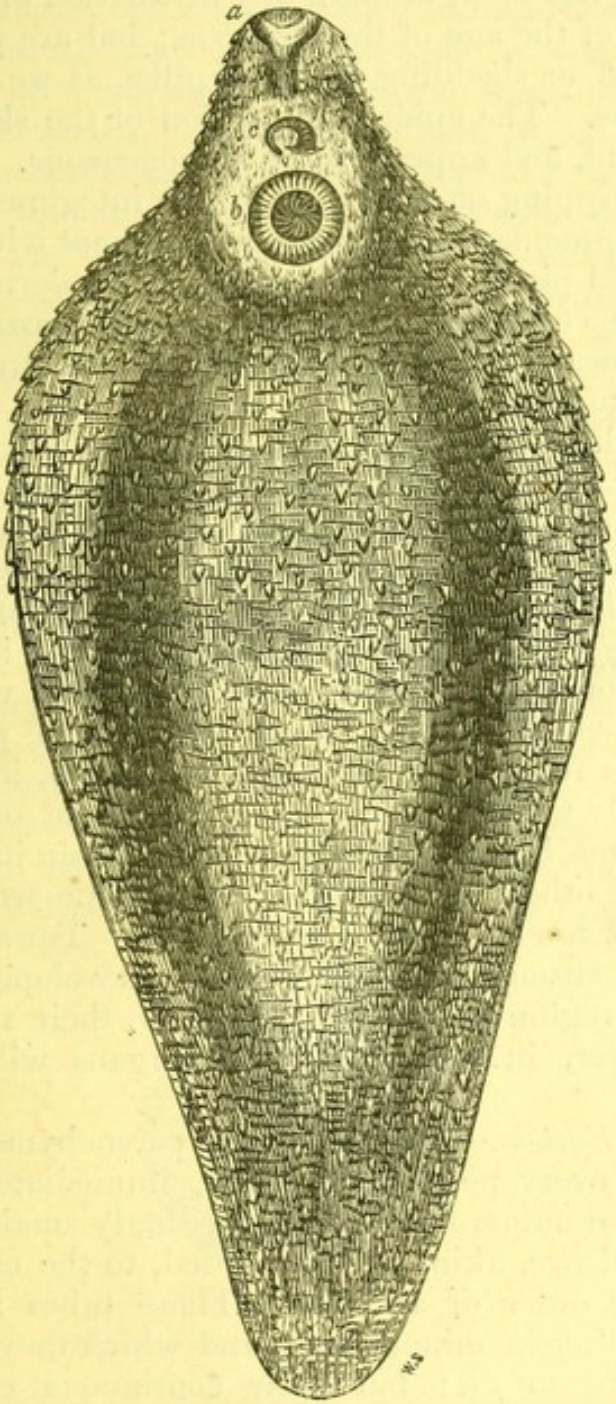


Fig. 3.

Magnified view of the external surface of the *Distoma hepaticum*, showing the papillated state of the skin, with the oral and ventral suckers, &c.

dark bile while others are empty, which gives to the creature a peculiar parti-coloured hue.

*External Surface.*—When the external surface is examined with a low magnifying power, the skin is found to be thickly covered with minute papillæ which point towards the posterior part of the body. (See *fig.* 8.) In some specimens we have found only the anterior half of the creature thus covered, while in others no papillæ could be detected on any portion of the skin. These differences do not seem to mark any distinction of species, nor to be indicative of the age of the entozoon; but are probably owing to a casting off or shedding of the papillæ, as we see in so many other creatures. The epidermic portion of the skin is very thin and transparent, and appears to be homogeneous. It is best examined by stripping off a portion of the integument as a whole, when torn fragments of epidermis will be met with on the edges of the detached piece. The substance of the dermis or true skin appears to be composed of minute granules, arranged in some parts in a linear form both longitudinal and transverse, incorporated with numerous cellules.

Several of these peculiarities are very well depicted in *fig.* 3, on the preceding page, which represents a magnified view of the external surface of the entozoon. In addition to the papillated skin, the mouth or anterior sucker (*a*), the ventral or posterior sucker (*b*), and the so-called intromittent organ or penis (*c*), are represented.

*Muscular System.*—Immediately beneath the integument lies the muscular or contractile tissue, on which the various motions of the entozoon depend. In an animal the parenchyma of whose body is so pulpy as that of the distoma, it is almost impossible clearly to demonstrate the arrangement of the muscular fibres. It seems, however, that most of them run in a longitudinal direction and others transversely, while some would appear to cross these at angles more or less acute. Towards the mouth the fibres are stronger and more clearly developed, as they also are about the region of the ventral sucker, their special arrangements, however, in regard to these organs will be hereafter considered.

*Aquiferous System.*—Traversing the parenchymatous and other structures in every possible direction, immediately beneath the integument, are numerous tubes, exceedingly small in size, forming a beautiful *rete*, akin, as is supposed, to the capillary system of the higher order of animals. These tubes have been described as ending in minute *cæca*, and which they would appear here and there to do; but their continuous connection and reticulated arrangement are well seen in flukes rendered transparent by immersion in glycerine. They give passage to a colourless fluid, among which are numerous granules. These

tubes would seem to be chiefly concerned in nutrition, but whether they have or not any direct communication with the true digestive system we have been unable to determine. Indeed, this is a point in connection with the organism of the distoma on which we hesitate to speak with confidence. In the young flukes, referred to at *page* 31, the aquiferous system appeared to be so connected.

In distomata which contain but little bile the aquiferous tubes are seen to advantage, but we have failed to find them united to a single vessel centrally placed, as described by some authorities. We have also been unable to detect the so-called "excreting organ" of Van Beneden, Aubert, and others, which is said to be situated near the caudal extremity of the entozoon, and to receive the contents of this single vessel. Is it possible that the "excreting organ" has been confounded with an occasional dilatation of one of the tubes connected with the external male organ —the *vasa deferentia*—at its inferior extremity? We have often found one, and sometimes both of these tubes to be thus dilated; although in the majority of instances such is not the case.

The readiness with which distomata imbibe tepid water, which causes them to swell out and become very opaque, led us in our original investigations to suppose that these aquiferous tubes might receive their contents by endosmosis, and we had recourse to a variety of experiments with coloured fluids to determine the point. At length we concluded, however, that such was not the case, although we found that distomata placed in *tepid bile* would imbibe some of this fluid, yet by no means so quickly nor in such quantity as they did water.

*Ventral Sucker.*—Before describing the internal structures of the fluke, we will add a few words in this place on the ventral sucker, a magnified view of which, when detached from the body, is here inserted. See *fig.* 4.

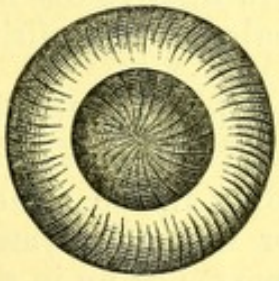

Fig. 4.
Magnified view of the Ventral Sucker.

This organ consists of an outermost raised border, of a circular form, surrounding a concave or sunken centre, which is imperforate. The border is very firm compared with the general

surface of the body of the distoma, and is chiefly composed of two sets of muscular fibres arranged after the manner of an ordinary sphincter. Muscular fibres also radiate from the centre of the sunken part towards the outer edge of the border. The whole arrangement is beautifully adapted for the attachment of the entozoon to the mucous membrane of the biliary ducts, whereby it is enabled to resist the contraction of the ducts to expel it with the bile into the intestine. Use, no doubt, is also made of this sucker as a kind of focal point in the entozoon's efforts to travel onwards into the smaller branches of the ducts to deposit its ova. Besides this, an opinion prevails that the organ is employed in the act of coition between two distomata, supposing such to be necessary for fructifying their ova. We, however, incline to the opinion that no such contact does take place, but that the entozoon is self-impregnating.

*Digestive System.*—This part of the organism of the distoma is more simple in its arrangement than many other portions, and although it has been described with much minuteness, several of these accounts are very far from correct. It commences at the bottom of the mouth or oral sucker as a single tube or œsophagus, which runs for a short distance directly downwards, and then divides into two main intestinal branches (See *figs.* 5 and 6). These branches diverge from each other, and in so doing they approach the outer borders of the entozoon. This divergence is greatest opposite to the ventral sucker, after which the tubes again converge a little, and then run in a parallel course towards the caudal extremity, where they split up into numerous fine divisions. Where their divergence is most, there also the tubes are largest, being often pouch-like in their form. Prior to their dilatation, they give off from their outer side four or five smaller branches, which take somewhat an upward course in this the cervical portion of the entozoon and run towards the margin of the creature, dividing in their course in an arborescent manner into numerous fine canals, to end ultimately in minute *cæca* (*fig.* 5).

From below these branches, usually about fifteen others leave each parent trunk, also on the outer side, and take a similar course, dividing and ending in the same manner. These, however, all incline more or less downwards. The parent trunks, thus diminished in size, next split up in the way before described. A few branches—rarely more than five or six—leave the trunks on their inner side, and running a very short distance towards the medium line of the distoma, end likewise in a similar manner. The situation of the intestinal tubes is about central between the dorsal and ventral surfaces of the entozoon, so that they are

visible on either side. The general arrangement of the trunks and branches is very well depicted in the annexed engraving, *fig.* 5.

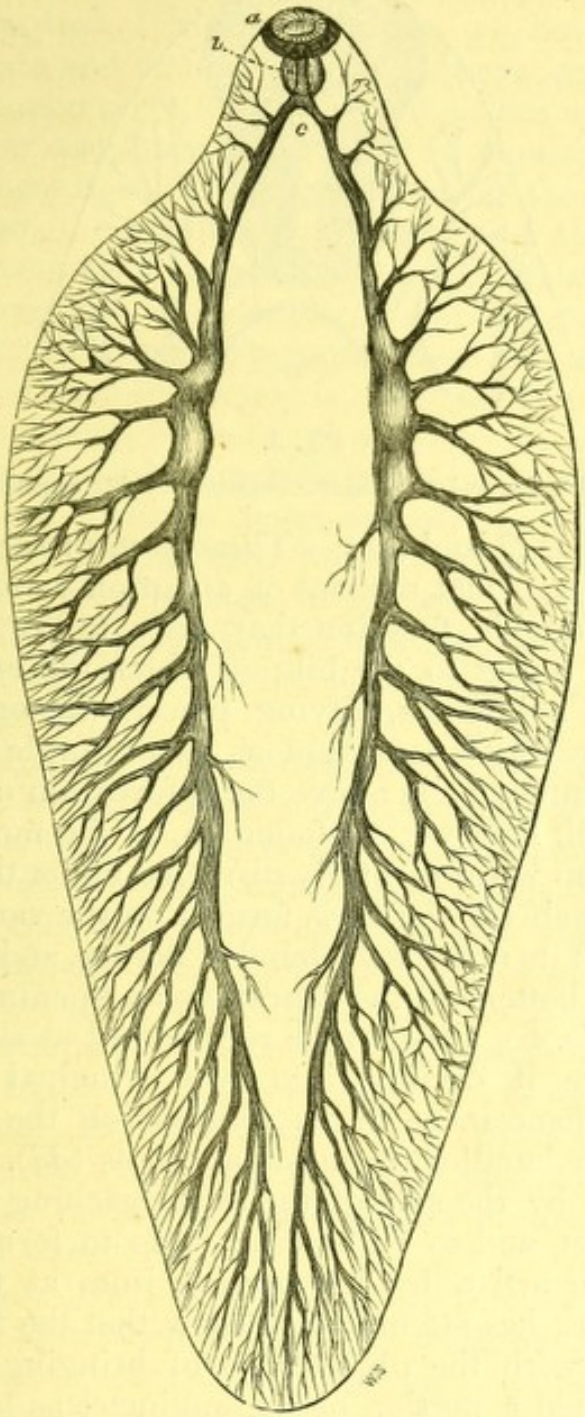


Fig. 5.
Digestive System of the Distoma. Magnified.

In this illustration, and also in the one following (*fig.* 6), *a* marks the oral sucker, *b* the œsophagus, and *c* its division into the two intestinal branches or parent trunks from which the others spring.

In *fig.* 6, inserted overleaf, an attempt has been made to depict the arrangement of the muscular fibres at the origin of

the digestive organs, but not with the success we could have wished.

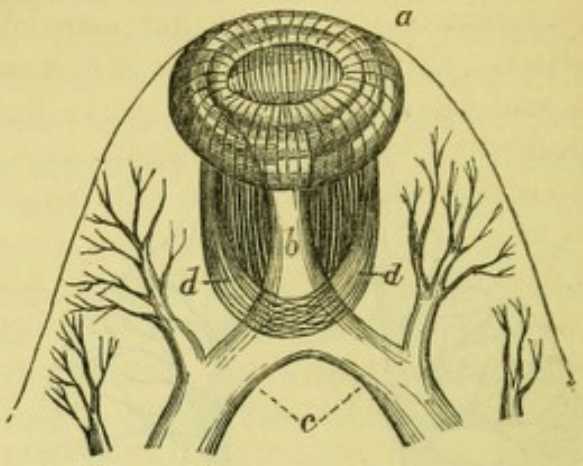


Fig. 6.

Oral Sucker and Œsophagean Sphincter. Highly magnified.

*Oral Sucker and Œsophagus.*—These parts of the distoma seem not to have received that amount of attention which is necessary to explain the double function they have to perform—namely, of an inlet and outlet to the bile on which the entozoon exists. Examined with a low magnifying power, the oral sucker and œsophagus appear to be continuous as a simple funnel-shaped body, situated immediately above the bifurcation of the digestive tube. They will, however, be found to be far more complex in their arrangement when carefully dissected under the microscope.

The sucker itself (*a*, *fig.* 6) is formed on the same plan as the ventral one, with its raised and rounded border, and sunken centre. Directly at the bottom of the concavity an opening leads to the œsophagus (*b*, *fig.* 6), a short tube represented as slightly dilating inferiorly, where it divides into two principal branches (*c*). From its commencement to its termination the œsophagus is surrounded with bundles of muscular fibres (*dd*). These fibres run lengthways by the side of the tube, reaching from its upper to its lower part, and so embracing it as to form an elongated sphincter. The artist, by intersecting lines at the lower part of the œsophagus, has attempted to show that the fibres surround the canal, and with the object also of bringing it into view, he has represented a portion of the sphincter as being cut away in front. Although the œsophagus lies in the centre of the muscular fibres, these are not equally developed all around it, but are stronger on the lateral parts than on the back or front.

Early after commencing the study of the anatomy of the liver-fluke—now several years since—we had an opportunity of seeing the entozoon eject from its oral opening considerable portions of the contents of the digestive tubes. We first witnessed this on placing one, obtained directly after slaughtering a sheep, in some

tepid water. The creature almost immediately elevated its head, and, with a leech-like action, ejected a portion of the contents. This was quickly followed by two other similar ejections, soon after which it died. Since that time we have witnessed the same thing again and again, for it has always been our object to obtain the entozoon alive for our investigations and dissections.

That a strong œsophagean sphincter is required can be easily understood, when it is remembered that on the creature having forced itself into the smaller ramifications of the biliary ducts, the pressure exerted on its body by the peristaltic action of the ducts is at times very considerable. This pressure might otherwise drive out the alimentary matter from the digestive organs. In dead flukes the sphincter is still so firmly closed that, although by pressure between two plates of glass under the microscope, the alimentary materials are easily driven backwards and forwards and made to press against the lower part of the œsophagus, none can be seen to be expelled through it into the mouth. The free passage of the contents of the digestive organs in either direction shows, however, that every facility is given for the oral sucker to act either as an inlet or outlet to the digestive system.

*Generative Organs.*—The reproductive system is without doubt by far the most interesting portion of the organization of the distoma, but at the same time it is the most complex in its arrangement, and difficult of investigation. This arises from the circumstance that the entozoon is hermaphroditic or bi-sexile, and as a necessary consequence the male and female organs are intermingled to some extent, while their naturally large development requires their occupancy of a considerable portion of the body of the creature. In the illustration (*fig.* 7) inserted overleaf, the generative organs are represented apart from any others—an arrangement which will materially assist our description. We shall first explain the several peculiarities of the female organs, and follow with those of the male.

*Female Organs: the Vitelligenes*, or yelk-forming organs (*a a*, *fig.* 7). These structures occupy the margins of the body on either side, extending from about opposite the inferior portion of the ventral sucker to the extreme end of the distoma. The yelk sacs are clustered around minute tubes in the form of branches, somewhat like currants upon their footstalks, giving a beautiful dendritic character to the whole arrangement. The stems of these tubes are in turn connected with two larger ducts, *b b*, which run more or less in a wavy course parallel with the margins of the entozoon. These collect the contents of the smaller tubes, which they transmit by two horizontal branches, *c c*, to an ovoid body situated in the centre of the creature at about its upper third.

This body has been by some helminthologists called the "*germ stock.*" In some specimens of distoma in our collection a third branch is seen to proceed from the yelk sacs towards the "germ stock," joining the main horizontal duct before it reaches that body.

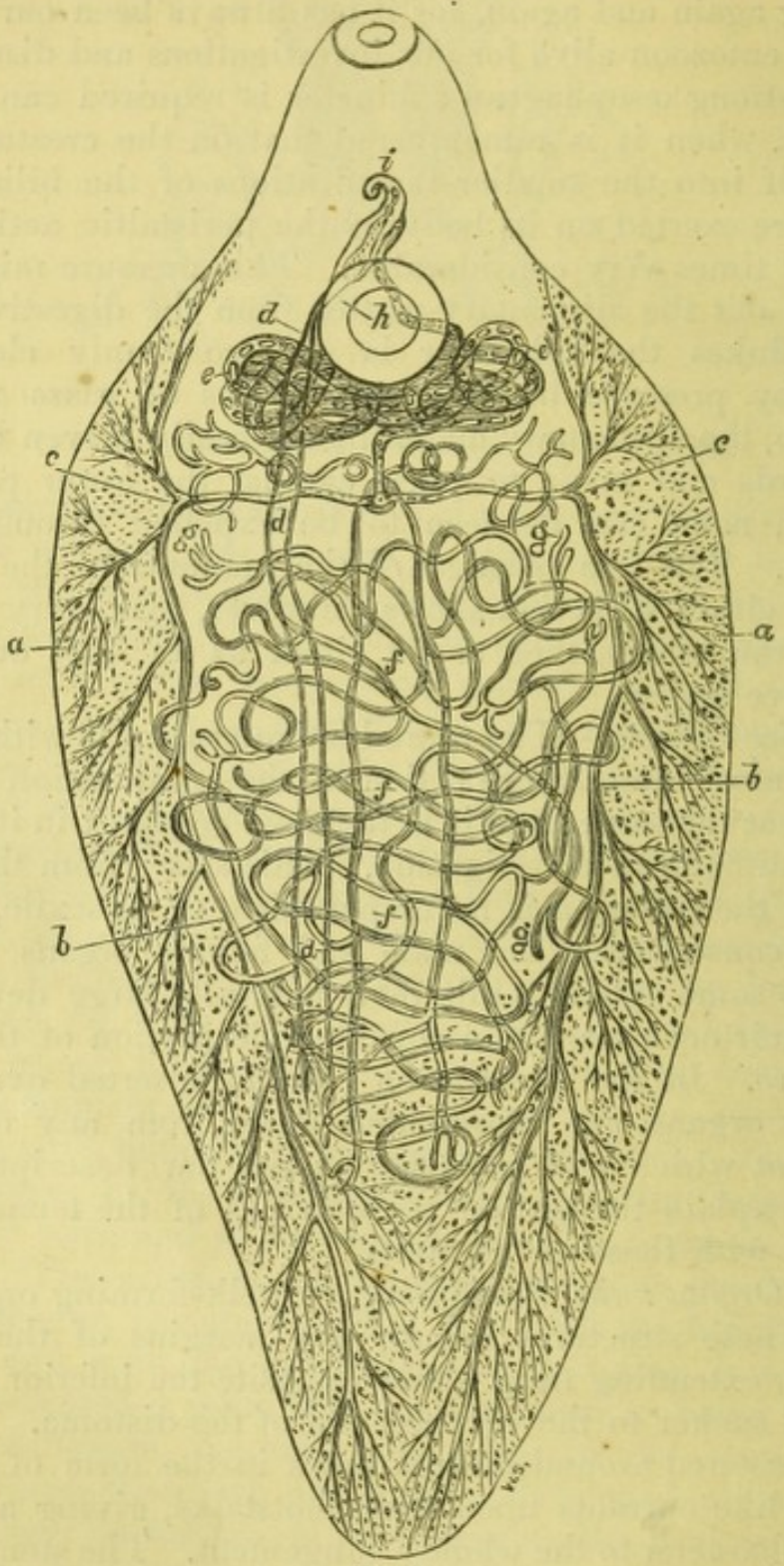


Fig. 7.

Generative Organs of the Distoma. Magnified.

From the "germ stock" a short duct arises which leads directly upwards into the uterus, *e e.* Within this duct the ova are first to be detected—a fact which we think of some import-

ance in determining the use of the "germ stock," about which authorities differ. The eggs are colourless before they reach the uterus, and have exceedingly thin cases or coverings.

*The uterus.*—This organ lies nearer to the ventral than the dorsal surface, and is therefore best to be observed on that side. It stretches more or less across the body of the entozoon both beneath and behind the ventral sucker. It is liable, however, to great variation in size—according to the quantity of ova it contains. In some instances the ova lie in many parts of the organ as a single file, while in others they are crowded together and overlie each other in all possible directions, so as to have an appearance of being placed in a largely dilated cavity, rather than in a duct coiled and turned upon itself. From the uterus the *oviduct* (*f*, *fig.* 8, *page* 45) passes in a tortuous course by the side of, or occasionally partly behind, the ventral sucker, to reach the sheath of the male organ (*i*, *fig.* 7, and *d*, *fig.* 8), upon the edge of which it opens. This opening is with very great difficulty to be detected, and we have spent many a fruitless hour in searching for it, only succeeding now and then.

The ova lie always along the *oviduct* in a single row (see *f*, *fig.* 8), and this entirely without reference to their number within the uterus. They therefore escape singly, but no doubt with very quick succession, so that a considerable quantity are soon voided. While in the uterus the ova undergo a singular change in colour by their shells losing their original white condition and becoming of a yellowish-brown hue. The shells also become harder and thicker, as would appear from an earthy deposition within them, for when the ova are slightly pressed on a slip of glass they are found to have a gritty feel, and to give a peculiar crepitating sound. The origin of this hardness is to our minds somewhat doubtful, although we would not dispute that it may be due to the secretory function of the internal membrane of the uterus. It is sufficient in this place to allude to the circumstance, more especially as we shall presently return to it again.

*Male Organs: the Testes.*—These organs occupy the central parts of the body, being bounded inferiorly and laterally by the yelk sacs and ducts, and superiorly by the uterus. They consist of a series of convoluted tubes, which seemingly follow no fixed plan of arrangement (see *f f*, *fig.* 7), being entwined and twisted in every possible direction. In many places they would appear to have cœcal beginnings, which are more or less forked and branched (*g g*, *fig.* 7). In size they exceed the ducts belonging to the female generative system, while their contents impart to them a much paler colour. Some of these seminiferous tubes cluster around the "*germ stock*," and have, we believe, a free communi-

cation with it; if so, we see no reason to doubt that it is here that impregnation takes place, and that the whole of the spermatic fluid finds in this place its proper outlet.

We are aware that a different opinion prevails among helminthologists, some of whom, however, speak doubtfully on the point; and we are also not unmindful that our statement assigns no function to the so-called "*vasa deferentia*" and generative appendage, or "*intromittent organ*" (*i*, *fig.* 7, and *a*, *fig.* 8) in the *fœcundating* process. One fact among several others which points to this conclusion is that the ova are seen *covered with their membranous cases* when issuing from the "germ stock," to enter the uterus (*see description of these parts, preceding page*).

Now it is evident that before being so covered their impregnation must have been effected. But supposing, on the contrary, the fœcundating fluid of the male organs to be ejected into the mouth of the oviduct, by being first conveyed, through the action of the "*vasa deferentia*," into the receptacle (*b*, *fig.* 8), which lies in the sheath (*d*, *fig.* 8) of the supposed intromittent organ, it is evident that it must traverse the entire convolutions of the uterus, pass all the perfected ova, and descend into the "germ stock" to exert its special purpose. This, at any rate, is a circuitous course, although none the less possible merely on that account. The other view, however, has simplicity if not positive verity for its support; it leaves, nevertheless, an office to be assigned for the so-called "*vasa deferentia*" and the other organs connected with them, of an entirely different character, unless absolute copulation between two distomata does take place.

We speak with some hesitation and with much deference to eminent helminthologists, when we say that the "*vasa deferentia*" (*d d*, *fig.* 7, and *c c*, *fig.* 8), which have their origin near to the *caudal extremity* of the entozoon, may possibly secrete a fluid which is carried into the receptacle (*b*, *fig.* 8), lying within the sheath of the generative appendage, hence to be conducted into the oviduct during the well-known retraction of the organ, to furnish the earthy materials necessary for the proper formation of the shells of the numerous ova existing within the uterus. From the peculiar arrangement of the parts it seems easy for the opening of the duct belonging to the appendage to be brought in contact with the mouth of the oviduct, when the organ is partially retracted into its sheath, and it is probable that in the act of retraction the materials are made to enter. That there must be a great demand for such matter all must admit who have carefully studied the ova of the *Distoma*. Such a view, of course, presupposes that the *vasa deferentia* are unconnected with the testes, which, by-the-bye, far exceed them in size; not that this fact

of itself negatives the opinions which are generally entertained, but in considering the function of these intricate organs it should not be lost sight of.

*Fig.* 8, here inserted, will, from the large scale on which it is drawn, materially assist the general description of the generative organs which we have given. It will also help to convey a correct idea of the formation of the "*intromittent organ*" (*a*), when exserted.

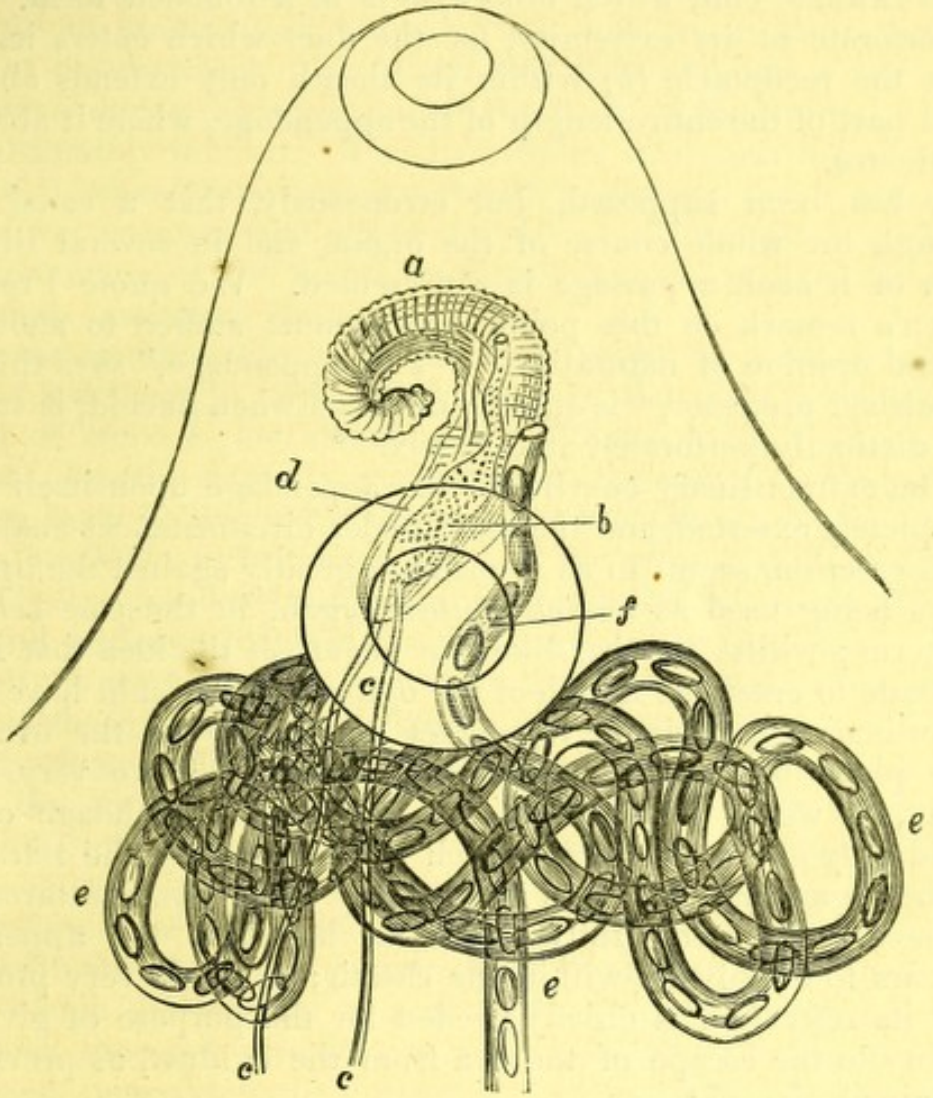


Fig. 8.

Highly-magnified view of the Uterus and Oviduct of the *Distoma hepaticum*, with the so-called Male Intromittent Organ, Seminal Receptacle, and Ducts.

*The intromittent organ, or generative appendage.* — Up to the present we have not met with any correct representation of this organ; we can, however, recommend the one here given (*fig.* 8) to the favourable notice of the reader. The illustration, together with most of the others which we have employed, is original, and we have preferred for each of them to represent special portions of the structure of this interesting and somewhat complicated entozoon, rather than to adopt the confused plan of

mixing the whole up together in one illustration. The generative appendage is strongly muscular, especially on the side of its curvature, as is attempted to be depicted by the lines there drawn. In addition to its longitudinal order of fibres, it has also a circular set, which are well developed. When fully pressed out the appendage curves upon itself, and always in proportion to the amount of pressure which is employed to produce its exsertion. It is also found to have a cauliflower-like projection at its extreme end, which otherwise is of a rounded form. It is imperforate at its extremity, for the duct which enters its base from the receptacle (*b*) within its sheath only extends about a third part of the entire length of the appendage, where it abruptly terminates.

It has been supposed, but erroneously, that a canal runs through the whole course of the organ, and in several illustrations of it such a passage is represented. We quote Professor Owen's remark on this point, which must suffice to show the general opinion of naturalists: "This appendage," says this distinguished professor, "is spirally disposed when flaccid, is tubular and distinctly perforated at the apex." *

The extraordinary curving of the appendage upon itself when completely exserted, and therefore under circumstances analogous to its erection, seems to us to militate greatly against the opinion of its being used as an *intromittent* organ, in the true sense of the term; whilst its size likewise negatives the idea that it can be made to enter the mouth of the oviduct as it would have to do in ordinary copulation. If contact for fructifying the ova does take place between two distomata, but which we very much doubt, it would appear that the generative appendage of one could only enter the *sulcus* which is produced by the retraction of the organ into its sheath in the other of the two creatures thus engaged. In being fully retracted, however, the appendage appears to simply lie within the sheath; and it is very probable that its retraction is chiefly needed for the purpose of giving a facility to the escape of the ova from the oviduct, as previously explained.

*Nervous system.*—In concluding our description of the anatomy of the distoma we add one word respecting its *nervous system.* Mehlis, some years since, described the nervous system of the entozoon as consisting of "a delicate œsophageal filamentary ring, with a slight ganglionic enlargement on each side, from which minute fibres pass into the suctorial sphincter; and two large filaments pass backwards, one on each side, as far as the ventral sucker" (*Owen*). We are free to confess that up to this time our investigations have not satisfied us of the existence of a

* 'Lectures on Invertebrate Animals.'

nervous system, but we certainly see no reason to doubt Mehlis' description, and therefore cannot say with Küchenmeister that it "is wanting."

Having now explained the general structure of the entozoon as fully as present circumstances seem to require, we pass on to speak of its natural history and development.*

### *Natural History of the Distoma hepaticum.*

The Distoma belongs to that class of creatures which, although parasitic to mammalian animals, are only so in their highest stage of development. To reach this they undergo a series of successive metamorphoses, out of the body of the animal which they ultimately inhabit. The liver-fluke, while passing through some of its transformations, is met with in rivulets, ponds, stagnant waters, wet pastures, and allied situations—a circumstance which explains many of the facts practically known to agriculturists and others respecting the rot in sheep.

Notwithstanding the rapid advances made by science within the last few years in unravelling many of the singular metamorphoses of entozoa, our description of those through which the *Distoma hepaticum* really passes from the *ovum to the perfect entozoon* must be somewhat incomplete, because all of them have not as yet been fully traced out. A far greater difficulty than might be supposed belongs to investigations of this kind, and the time and patience required for the purpose are immense. This difficulty is not a little increased by the circumstance that when many of these forms are existing in water as infusoria we fail to identify them with the particular entozoon to which they belong. Upon the correct solution of the problem, however, hangs our chief hope of affording security to animals against those entozoa which undergo such transformations.

The family of flukes alone is a very numerous one, and has been estimated by some naturalists at from four to five hundred, all of which are thought to pass through allied metamorphoses. As *flukes* they are parasitic to mammals, birds, fishes, reptiles, and even non-vertebrate creatures. With facts like these to grapple with, the only wonder is that so much is really known about the *Distoma hepaticum*, and that helminthologists are enabled to speak with confidence upon some of the transformations it undergoes; and not only so, but to give practical effect to this knowledge by advising flockmasters how to protect their sheep in a great measure from its attacks.

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* While these pages were passing through the press our attention was directed to a very excellent paper on the anatomy of the *Distoma hepaticum*, in the 'Intellectual Observer,' by Dr. T. Spencer Cobbold, Lecturer on Comparative Anatomy at the Middlesex Hospital, who, we are glad to see, agrees in very many particulars with ourselves.

*Ova.*—Sufficient has elsewhere been said to show that the number of ova yielded even by one fluke exceeds any estimate the mind is capable of forming. Examined microscopically the ova are of themselves very interesting objects, apart from any knowledge we may have of their destination. The annexed illustration (*fig.* 9) very faithfully depicts their appearance when

Fig. 9.

Ova of the Liver-fluke, showing the manner of the escape of their contents by the detachment of the Opercula. Magnified.

viewed in the field of the microscope. It not only represents their form, but shows the nature of their contents, and the manner in which these make their escape. Their size is liable to slight modification, some being rather larger than others. Many measure about $\frac{1}{180}$ of an inch long, and $\frac{1}{300}$ of an inch broad. To the unassisted vision each egg, however, may be made distinctly visible, by putting a number in a small phial filled with water, agitating this, and then watching their fall while holding it to the light. Their being rendered so perceptible by this procedure is doubtless due in part to their brown colour.

The density of the shells of the ova is probably an important means for enabling them to resist decomposition, and to retain their vitality for a much longer period than otherwise would be the case. How long their vital power may continue it is impossible even to conjecture. We have kept ova well covered with water for upwards of two years, exposed during the whole time to the air by leaving the cork out of the bottle, without observing any very great change in the larger part of them. Nothing at all approaching to decomposition could even then be detected, but whether all had retained their vitality could not be determined. That some, however, had done so, is evident from the result of the experiment.

The experiment was begun in January, 1853, simultaneously with another, hereafter to be described, and was continued to April, 1855. On September 28, 1853, here and there an ovum was observed to have parted with its operculum, and a few circular, *nucleated* cells were to be detected set free in the fluid, of somewhat larger size, but otherwise identical with those seen in the interior of many of the ova. They had a tremulous motion, which was interrupted now and then by a jerking action —thereby giving evidence of their being ciliated bodies ; but the

object-glasses then at our command were insufficient in magnifying power to bring the cilia into view. After this time, more and more of the ova parted with their opercula, always with a proportionate increase in the number of circular-shaped embryos. Judging from the developing process as seen to be going on in the interior of an ovum from the first gathering together of the yelk to the formation of cells, we reckoned that five or six embryos were yielded by each ovum.

In a short time numerous infusoria—polygastric monads—existed in the fluid, which were slow in their movements, devoid of colour, and in some other respects very similar to the *Monas enchelis* of Pritchard; but whether these were produced by an elongation of the original circular-shaped embryos of the fluke into the ovoid form of the monad, we could not satisfactorily determine. Throughout the entire year of 1854 a gradual increase of detached opercula took place, but at its close, and even down to April 15, 1855, when our observations were discontinued, a very large number of ova were as perfect in appearance as when originally placed in the water. Circular-shaped embryos, and flattened, flask-shaped monads were still abundant, but no higher form of animal life could be detected.

We have given the particulars of this experiment, because we consider that everything which tends to create thought is of the first importance in studying the history of the liver-fluke, and of material use in helping us to explain many of the phenomena connected with an outbreak of rot.

Several analogous instances of the long preservation of the germs of future creatures within the egg can be adduced. Küchenmeister, in describing the treatment for *Ascarides*, says: "The first thing to be done by the surgeon in practice consists in the destroying the eggs of the *Ascarides* whenever he meets with them, and exterminating every female that he can get at. It was H. E. Richter's merit that he first ascertained that the eggs remain uninjured in sewage, &c. Recently Barry, Bischoff, and others have proved that the process of segmentation of the eggs of *Nematoida* continues even in very concentrated alkalies or salts. According to the experiments of Verloren and Richter, already described, the eggs of *Ascarides* only attain their full maturity when free in nature (in water), and only undergo the process of segmentation in this situation. In the various species of *Ascarides* the time necessary for this purpose may be different; for whilst, according to Verloren, this is completed in one species of *Ascaris* within a few weeks, the eggs of the *Ascaris lumbricoides* require at least eleven to twelve months for the purpose. Even Richter's first statement spoke of such a period: according to a

communication from him in January, 1857, embryos had then begun to be formed in eggs which had been put into water by him in February, 1856, but they did not move." *

We have a similar experiment with the eggs of the *Ascaris lumbricoides* of the horse, now in the process of completion. They have been lying in water for several months, but without any evidence of the development of embryos. Hereafter we may find occasion to give the result of this experiment, together with others which we have adopted to elucidate the natural history of some of the entozoa.

It is difficult to say under what circumstances the embryos of the future distomata will be most quickly matured, so as to escape from the ova. The nearer, however, all experiments to determine this point are made to approximate the natural order of things, the greater will be their value. In exposition of this subject we come now to the experiment previously alluded to, which was begun on January 17, 1853. Reflection led us to adopt the following plan for keeping the ova *damp only*, while they were being freely exposed to the atmosphere—imitating in this respect their location on a wet pasture. Two or three layers of bibulous paper were floated on the top of water in an ordinary soup-plate, and upon these were sprinkled some ova obtained fresh from the biliary ducts of a rotten sheep. They were carefully examined day by day, and after a short time it was evident that the developing process was quickly going on in the interior of many of them.

On the 1st of March we detected, for the first time, some of the ova without opercula, and a number of free nucleated cells (embryos) identical with those previously described. By the 10th of the month more ova had parted with their opercula, and the number of embryos had consequently increased. Polygastric monads of the form previously described also made their appearance, and, we were inclined to think, bore a proportion to the original liberated embryos. It is probable, however, that they had no connection with each other. Matters thus continued throughout the month, and into May, but without any variation of sufficient importance for the further continuance of the experiment. By far the greater part of the ova were at this time as perfect in their form as when originally placed upon the wetted paper.

All helminthologists of repute appear to agree with reference to the nature of the embryos yielded by the fluke-egg, but, from the difficulties of following the changes which subsequently occur,

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* 'Animal and Vegetable Parasites.' Translated by Dr. Lankester. London, 1847.

conjecture to some extent takes the place of observation Judging, however, from analogy with regard to the development of other *Trematoda*, there appears no reason to doubt that the ciliated embryo of the *Distoma hepaticum* does not undergo any material change until becoming parasitic to water-snails, slugs, &c., and that when thus located it becomes converted into a peculiar organism called a *Cercaria*-sac (see *fig.* 10, *page* 52). From the nucleus of the distoma-embryo development goes on, and a brood of young *Cercariæ* are ultimately formed within the sac, by a species of successive budding, each one in turn thus becoming a parent. From the first, second, or third of these offspring a return to the form of the original parent distoma takes place.

This system of propagation has been described most accurately by Steenstrup, who has named it "*Alternation of Generation*," as differing materially from ordinary metamorphoses. We give his own definition of the process: "Alternation of Generation is," he says, "the remarkable phenomenon of an animal producing an offspring which at no time resembles its parent, but which, on the other hand, itself brings forth a progeny which returns in its form and nature to the parent animal; so that the maternal animal does not meet with its resemblance in its own brood, but in its descendants of the second, third, or fourth degree of generation." *

Many examples of this system of propagation take place in nature, and among creatures far higher in the scale of organisation than those of which we are now speaking; but it is unnecessary, in a treatise of this kind, that these should be furnished. We may, however, direct the reader seeking such information to Steenstrup's work, and also to Professor Owen's on *Parthenogenesis*, Küchenmeister's on *Parasites*, † and Von Siebold's on *Cystic Worms*. ‡

The *Cercariæ*, so called from their caudate form (see *fig.* 12 *page* 53), were for a long time considered as *Infusoria* when found to be floating freely in water, their origin and mode of propagation being unknown until the discovery of Steenstrup. The *cercaria*-sacs were designated by him "*nurses*," and the young *cercariæ* developed within them "*parent-nurses*"—terms which have helped rather to mystify the matter than to render it plain. Most *cercaria*-sacs are of simple organisation; but, notwithstanding this, they are found of various forms, according to the kind of *cercariæ* to be developed within them.

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* 'Alternation of Generations,' by J. Japetus Sm. Steenstrup, translated from the German by George Busk. London, 1845.

† Translated by Dr. Lankester. ‡ Translated by Professor Huxley.

In the accompanying illustration (*fig.* 10) we have represented the sac of the *Cercaria ephemera*, copied from Huxley's translation of Von Siebold's work. In it *a* represents the oral


Fig. 10.

Cercaria-sac, showing the formation of Cercariæ. After Huxley.

cavity of the cyst; *b*, the alimentary canal; *c*, a developed *cercaria;* and *d*, other *cercariæ* in the course of formation. In his description of these organisms Von Siebold remarks that "the whole of these multifariously-shaped *cercaria*-sacs enclose within the walls of their bodies a cavity which, besides the intestinal cœcum (where such a structure exists), contains nothing but young *cercariæ*. These young are developed, not from *ova*, but from *gemmæ*, which differ essentially from ova. They are solid, round, and somewhat flattened discs, which, growing and developing, become little caudate worms, resembling in form and organisation certain Trematoda (*Distoma*, *Monastoma*, &c.).

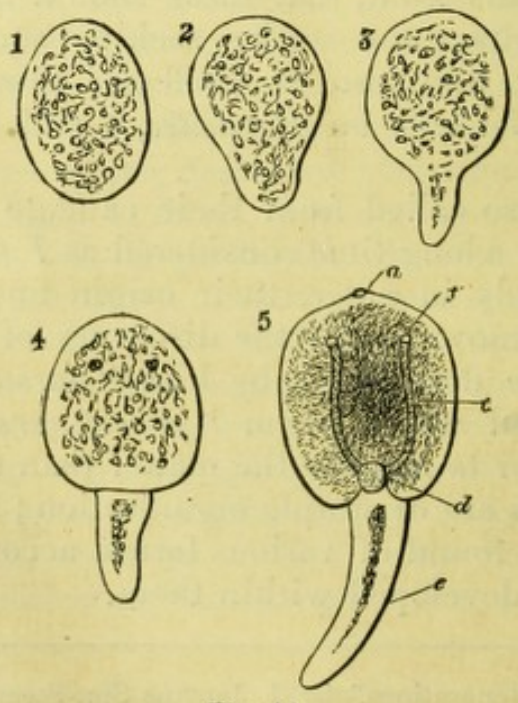


Fig. 11.

Magnified view of the development of Cercariæ. After Huxley.

*Fig.* 11 represents on a large scale the development of the *cercariæ* as it goes on within the sac from the first bud or sporule to the perfect embryo. A reference to the figures will show—1, a sporule; 2, sporule elongating; 3, sporule becoming caudated; 4, early form of *cercaria;* and 5, perfect embryo. In the last-named figure, *a* indicates the oral aperture; *c*, *d*, the urinary organ; *e*, the tail; and *f*, two pigment-spots.

When first set free from the sac the *cercaria* is rather tardy in its action, but after a time it swims freely about, assisted in its various movements by the length of its tail. *Fig.* 12, which we

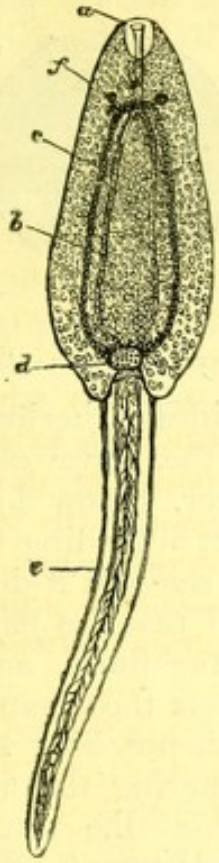


Fig. 12.

A fully developed *Cercaria ephemera*. After Huxley.

here insert, shows a fully developed *Cercaria ephemera*, the body of which, it will be noticed, bears a strong resemblance to a fluke. In this figure, *a* represents the mouth; *b*, the alimentary canal; *c*, *d*, the urinary organ; *e*, the tail; and *f*, pigment-spots. It is worthy of note that in the most perfected *cercariæ* no sexual organs can be detected, although in other respects their resemblance to distomata is so complete. It is evident from this that they have to undergo a higher form of development, which they can only attain by becoming entozoic to other creatures. Some varieties of them have been observed to

bore their way into water-snails, to cast off their tails, and *develope into flukes* with perfect sexual organs—thus completing the series of changes. After entering the body of the snail, and before being transformed into the fluke, the *cercaria* rolls itself into a little ball and passes into the *pupa* state, by emitting from the surface of its body a mucous secretion which hardens and encloses it. This change was first observed by Nitzsch, and afterwards by Siebold and others. The annexed engraving (*fig.* 13) represents the *pupa* state of the *Cercaria ephemera*. The letters point—*a*, to the oral sucker, and *c*, *d*, to the urinary organ.

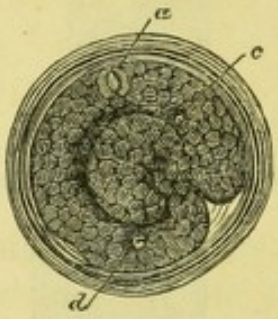


Fig. 13.

Encysted *Cercaria ephemera*. After Huxley.

Encysted *cercariæ*, besides adhering in large numbers to a great variety of *mollusca*, the larvæ of aquatic insects, &c., are likewise found free in water. How long their *pupa* state may continue is not known, but, according to the experience of Steenstrup, in some varieties of *cercaria* it does so "for many months."

Thus it has been proved that the *pupa* state of the *cercaria* is the *penultimate* form of the fluke, and it is probable that in this state the entozoon enters the organism of vertebrate animals as well as others. Küchenmeister states that "when De la Valette set about administering the tailed, free living forms—that is to say, the *cercariæ*—the result of a metamorphosis of these forms into mature distomata did not occur. He then directed his attention to the forms originating from the *cercariæ* just referred to, which are enclosed in cysts, and, although still asexual, are already in other respects somewhat further developed . . . . When administered in this state the young distomata are quickly provided with germ stock, testes, and ovaries. . . . . According to De la Valette's experiments, it is certain that the *Cercaria echinifera* is converted very rapidly in the intestine of warm-blooded animals, and slowly in cold-blooded species, into *Distoma echinifera*, Val.; that *Cercaria flava* of the *ephemera* becomes transformed into *Monostomum flavum* of the finches and sparrows; and that *Cercaria echinata* is converted into *Distoma echinata Anatis Boschadis* (Zeder)."

Although the transformation of *encysted cercariæ* into *distomata*

*hepatica* of the sheep and other mammalia has not as yet been fully ascertained, we see no reason to doubt that they follow the law of development belonging to flukes in general. Until, therefore, direct experiments shall have shown to the contrary, we shall continue to hold the opinion that the several metamorphoses of all the distomata are regulated by the same laws. Sheep, we believe in common with mammalian animals in general, receive the *cercariæ* in their *pupa* state, and not as free living forms. If the contrary were the case, it is evident that the *cercariæ* would have to undergo their *pupa* change within the digestive organs, and, judging from analogy, they would have as free *cercariæ* to first imbed themselves in the mucous membrane for this purpose. We do not regard this as being at all probable; besides which, we have seen that in De la Valette's experiment of administering free *cercariæ* to warm-blooded animals, he failed in producing distomata, and only succeeded when he gave them in their *pupa* condition.

Although distomata are so widely diffused, it is an established fact that ruminating animals are more frequently affected with them than others, and sheep most of all. We have directed attention to the latter-named circumstance in treating of the causes of rot, and have there said that the probable explanation of it was that the natural habits of the sheep led to its cropping the short grasses and feeding near to the ground, where the penultimate forms of distomata abound. The greater susceptibility, however, of ruminating animals would seem to depend on other causes, and to be rightly accounted for by reference to the special functions of their digestive organs. Encysted *cercariæ* received with the food of ruminants are not at once exposed to the solvent action of the gastric juice, but are detained for an indefinite length of time within the rumen and the other preparatory stomachs whose secretion is non-digestive. Within these organs, therefore, no special cause of destruction to the vitality of the *cercariæ* exists, and hence a greater number of distomata are perfected, ultimately to find their way into the bile-ducts by passing firstly into the true digestive stomach and onwards into the duodenum. The converse is the case with regard to the simple-stomached herbivora and other mammals, viz., that the encysted *cercariæ*, on entering the digestive system, are immediately exposed to the action of the gastric juice, by which many of them are doubtless destroyed, and consequently do not reach their proper habitat—the liver.

This circumstance may account in part for the well-known fact that horses graze almost with impunity on pastures where both oxen and sheep become affected with flukes. Other causes, without doubt, influence this immunity; among which must be placed the general plan adopted in rearing horses, which, together

with much of their food even when they are young, contrasts greatly with the feeding and arrangement had recourse to in the bringing up of cattle or sheep. Later on in life the uses to which horses are put likewise prevent to a great extent their reception of the penultimate forms of the fluke. Nevertheless, distomata have now and then been found in the horse and also in the ass, and they were so by Daubenton. The late Professor Sewell, of the Royal Veterinary College, likewise discovered some flukes in the ass, specimens of which are preserved in the College Museum. In addition to these examples, it may be mentioned that we were recently consulted by Mr. Pritchard, M.R.C.V.S., Wolverhampton, respecting a case communicated to him of flukes in the liver of a horse. Elsewhere we have spoken of the susceptibility of the pig and also of the hare and rabbit to flukes; so that the instances of simple-stomached animals being affected are not so unfrequent as might have been inferred from the formation and office of their digestive organs.

In herbivora of such large size as the horse and ox, the ill effects of the entozoa are not so marked as in the sheep and smaller animals. Besides which, their number is generally limited, few existing as a rule. Dr. Budd has justly observed in his work '*On Diseases of the Liver*,' 1857, that "the supposition that the distomata cause, in some way or other, a serous discharge from the gall-ducts they inhabit, accounts for their producing less effect on larger cattle than on sheep, hares, and rabbits. A loss of albumen that would exhaust these small animals would have little effect on an ox."

According to Küchenmeister, the entozoon has likewise been found in man by several persons, among whom he names Malpighi, Chabert, Biddloo, Pallas, Brera, Mehlis, and some others. In our own country similar cases of their existence are recorded by Mr. Busk, F.R.S., and Professor Partridge, of King's College. Mr. Busk took fourteen specimens of the variety called the *Distoma crassum* from the liver of a Lascar, one of which is preserved in the museum of the Royal College of Surgeons. The particulars of Mr. Partridge's case are narrated in Dr. Budd's work on the Liver, previously referred to.

In addition to these cases, distomata have also been discovered under circumstances which, although very remarkable, are good evidences that the entozoon can be matured within the external tissues of warm-blooded animals, as in those of the cold-blooded. Thus it is recorded that Giesker, of Zurich, took one from the sole of the foot of a woman, the wife of an overseer of a silk-factory near to that town, which it is supposed had embedded itself in the skin as a *cercaria* while she was engaged in "washing linen in the more stagnant parts of the Lake of

Zurich." Mr. Fox, of Topsham, Devonshire, also found one beneath the skin a little behind the ear of a sailor, which apparently in no way differed from the ordinary liver-fluke. Rightly considered, these cases tend to prove that the natural history of the liver-fluke is identical with that of others of the class.

To pass from these exceptional cases of development of flukes again to those of the sheep, we would repeat that the two causes which render this animal so remarkably susceptible to the entozoon, are its natural habit of feeding close to the ground and its being a ruminating animal. In the production, however, of rot, external causes are the chief in operation; these being an elevated temperature combined with excess of moisture. Under these circumstances myriads of *cercariæ*, which would otherwise perish, are brought to perfection, abounding wherever the ova of flukes may have been conveyed. Lands liable to flood are therefore the most dangerous, as the overflowing of rivers and brooks brings upon them these infusorial creatures in countless numbers. The danger increases in proportion as the soil of such land is of a tenacious character, and especially if the water accumulates in places and becomes stagnant. Nor can we wonder at any land of ordinary elevation, if retentive of moisture, springy, and undrained, being "liable to give the rot."

No limit can be put to the liabilities of the presence of *cercariæ*, where excess of moisture abounds. They may be conveyed in some of their metamorphoses, and in forms more or less active, by innumerable means, some of which would be scarcely suspected. In considering these causes, the long duration of the vital principle in the ova of the liver-fluke, of which notable examples have been given, must not be lost sight of, nor must the fact of the millions of ova which are constantly being cast from out of the intestines of rotten sheep and other animals, in all conceivable situations and under every variety of circumstance.

The more we reflect on the true cause of rot and on the facts connected with its appearance, and endeavour to interpret these by our knowledge of the natural history of the liver-fluke, the more easy of comprehension and simple does the whole subject become, till at last we see no ambiguity whatever belonging to it. In the course of these pages many proofs are given of the correctness of this position; but, as we are unwilling to multiply these without sufficient reason, we shall pass on to record, in the next place, several instances of the quick contamination of sheep with this disease.

## Quick Contamination.

The attention which has been given by practical observers to the several circumstances under which rot shows itself, long since

proved that the disease could be quickly engendered. Many such instances are recorded, some of which we purpose to give *in extenso*, as thereby we conceive additional confirmation will be afforded of the correctness of the statement that rot is an entozoic disease.

As early as 1636, allusion is made to the subject by Crawshey, who remarks, that "many shepherds say that, if the weather be hot, their sheep will take the rot in twenty-four hours." * Similar statements are made in general terms by many authors subsequent to this date; but the first special cases which are given in detail, that we have as yet seen, occur in Dr. Harrison's work, 1804. He asserts that the grandfather of a Mr. Harrison, then residing at Fisherton, near Lincoln, "removed ninety sheep from a considerable distance to his own residence. On coming near to a bridge which is thrown over the Barlings river, one of the drove fell into a ditch and fractured its fore leg. The shepherd immediately took it in his arms to a neighbouring house and replaced the limb. During this time, which did not occupy more than an hour, the remainder were left to graze in the ditches and lane. The flock was driven home, and in a *month afterwards* the other sheep joined its companions. The shepherd *soon* discovered that all had contracted the rot, except the lame sheep; and as they were never separated upon any other occasion, it is reasonable to conclude that the disorder was acquired by feeding in the road and ditches."

Again, "A Lincolnshire farmer purchased some turnips in Nottinghamshire, upon which he intended to winter a flock of sheep. The first division, consisting of about forty, were detained one night at a village near to the place formerly alluded to, by the overflowing of the Barlings Eau, and were put upon a piece of flat land which leads to the river. The water had not returned to its former channel more than a day or two. *Every one of the forty became rotten*, whereas the other division, which stopped nowhere by the way, escaped the disorder, and remained well." Harrison further adds, "I have likewise been informed by Mr. David Wright, that a few years since, as a drove of sheep were passing through a long lane in the parish of Irby, one of them, being weary, fell down in the middle of the road. The others were permitted to range at large till their companion was able to travel. They were then driven altogether into a pasture, and it was soon discovered that only the tired sheep had escaped the rot."

We select two more cases of a similar kind, one from Parkinson, 1810, and the other from Youatt, 1837. The former writer

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* See page 9.

states that "a farmer in the neighbourhood of Wragby took twenty shearing wethers to a fair in that town, leaving six behind in the pasture where they had been summered. The score sent to the fair, not being sold, were driven back and put into the same field where the six had been left. In the course of the winter every one of these died of the rot; but the six that had been left behind all lived and did well."

The case narrated by the latter-named author is as follows:—"A farmer in Norfolk bought a lot of sheep at a fair warranted sound. The greater part of them died of rot in the course of the winter. The purchaser brought his action for the recovery of the money paid for them. The defendant satisfactorily proved that he never had had a rotten sheep on that part of the farm on which these were bred and grazed. A considerable sum was spent in litigation, when at length it was discovered that the night before the sale—the whole town and its neighbouring pastures being occupied—the sheep were turned into a field in a neighbouring village, and which field bore a suspicious character with regard to this disease. There was then little doubt on the mind of either party that the mischief had been done on that night."

Although it may be unnecessary to multiply cases, still justice requires that we should place on record two more of a similar kind which have been furnished by a well-known agriculturist, Mr. Edward Umbers, of Wappenbury, Warwick. Mr. Umbers writes thus:—

"In the first place, I will relate a circumstance that occurred to my father (the late Mr. W. Umbers), who was an eminent breeder of Leicester sheep. At his first outset as a breeder he went into Leicestershire and purchased twenty ewes, and sent them to a ram belonging to another breeder in the same county. In due course my father received a letter stating that the ewes were ready to come back, and requesting him to send for them; the writer added that one ewe was lame, and would require a horse and cart for her removal. Accordingly, a careful man with a horse and cart was sent for the ewes, and all were brought home safely.

"In *eleven weeks and three days* after their arrival at home the shepherd came to my father saying, 'One of the bought ewes is dead.' This was a source of great disappointment, and when she came to be examined she proved to be rotten. My father at once wrote to the person of whom he purchased the ewes—they having been warranted sound—stating what had occurred. The gentleman, in reply, invited my father to his house to make every inquiry, he never having had a rotten sheep on his farm. My father went over and found to his entire satisfaction that the ewes were not rotted while there. He then proceeded to the farm where the ewes were put to the ram, and was equally satisfied they had not received the disease there. He then traced the sheep on their way home to a field where they remained for the night, the lame sheep being unloaded and lying in the field with the rest: there also he was perfectly satisfied from the most minute inquiries the rot had never been known. Still tracing the sheep homewards, he came to a pothouse by the roadside, where the man had gone in to have his dinner, leaving the nineteen

ewes in the road and the lame ewe in the cart; here was found to be a most rotting district. The result was that the whole of the nineteen died *rotten* before lambing-time, and the ewe in the cart lived for years and bred and did well.

"The second case I would mention occurred to a very intimate friend and neighbour of mine who placed his 'tegs' (viz. young sheep of the first year) on a piece of seeds adjoining a meadow by the river Leam, which in wet seasons is sure to give the rot. Such was the case in the year in question. Some trees had been felled between the seeds and the meadow, and, the gaps in the hedge not having been properly made up, the shepherd was sent after harvest to stop them. Having done a part of them he went home to his dinner, and to his surprise when he returned he found all the tegs in the meadow. He put them out immediately, and they never got in afterwards, and no one on the farm had ever seen them in before; but the consequence was, that the whole of the tegs were rotted, and most of them died before the next shear-day, and those poor wretched creatures which remained to that period cast off their wool and subsequently dwindled away and died. This farm is a perfectly sound one, with the exception of the meadow in question."

How, it may be asked, are we to account for such facts as these? The defenders of the theory of innutritious diet, exposure to wet, or allied causes, being the source of rot, surely will not be bold enough to assert that the feeding on watery food, for a few hours, would be so far *permanently* prejudicial to the functions of animal life as to produce a fatal disease of this kind, notwithstanding that the sheep are removed from such food to that which is in every way unobjectionable. We see no satisfactory solution of the problem, except that which is obtained by a knowledge of the natural history of the liver-fluke. This unravels the mystery, and leaves the mind free from doubt as to the cause of these occurrences. Nothing is easier to understand than that the partaking of grasses growing on low-lying and damp places, even for an hour or two, where the penultimate forms of the fluke abound, would convey a sufficient quantity of these organisms into the digestive system of the sheep—their now proper habitat for further development—to perfect flukes enough to lay the foundation for the disease.

## The Period of Greatest Danger.

It is considered by many and probably by the larger proportion of sheep-owners, that the months of September and October are by far the most fruitful in causing the rot. Especially does this opinion prevail among those who see in a luxuriant growth of *after-grass* the chief cause of the affection. Thus the "Lammermuir Farmer" states that in *October* of 1810, he "bought a lot of wethers in fine condition from land of a good sound bottom, where the rot was altogether a stranger. They came on the farm about the *middle of the month*, and in a short time were observed to be diseased. The stock on the farm whence they

were taken continued sound, so that the complaint," he says, "must have originated with myself."

The same author also, when describing the disease as it existed in 1817 in his own flock, observes that all the animals which were sold by him up to *August* of that year proved to be sound. To substantiate which he remarks, that in June he sold "a lot of about 1000 hogs and dinmonts to a gentleman in Roxburgh, all of which gave the greatest satisfaction. They were kept by this gentleman for two years, and afterwards sold in fine condition to the butcher. This was well," he adds, "for both parties, for the sales which I made in *October* were all tainted, and from that time the animals consisted more of skins than carcasses. Here, then," he argues, "the facts bear me out in saying that in 1817 no rot had taken place among my stock in the month of *August*, and the whole calamity that followed must have taken place subsequent to that period. Had any latent seeds of the disease been among them, the sales that I made in August must have turned out as bad to the purchaser as the animals that were retained did to myself, which was not the case, and which clearly demonstrates that the cause had been on my own farm. Of this I entertain not the smallest doubt; and, after the most minute investigation, I can attribute it to nothing but an unusual luxuriant growth of grass, occasioned by the mild, soft weather during the months of *September* and *October*, more especially during the first."

Many, if not the majority of practical farmers, concur in these views, but we think without sufficient reason. A wet autumn will unquestionably produce rot, but a wet summer is far more likely to do so. The experience of water-meadow farmers would even lead to the placing the origin of the disease as early in the year as the end of May or beginning of June. "The late Mr. Bakewell was of opinion that after May-day he could communicate the rot at pleasure, by flooding and afterwards stocking his closes, while they were drenched and saturated with moisture."* Very much, however, depends on the temperature which prevails. Should this be high, and much wet fall at the commencement of the summer, the danger would be proportionably great. Speaking in general terms, however, we have little fear of a wet month of May, or even beginning of June; but as Midsummer approaches, so does the danger increase.

Thousands of sheep took the rot at about this period of 1860, and as many, perhaps, subsequently thereto, and onwards into the autumn. The application as well as the value of preventive

* Harrison on Rot, p. 36.

remedies rests on our being enabled to fix the time of the commencement of the disease. It is the circumstance of sheep falling away in flesh, and exhibiting the general symptoms of rot in *the autumn*, that has too often led to incorrect conclusions as to the time of the origin of the malady. Effects have been mistaken for causes. Men have not generally known that from three to four months are frequently needed for flukes in the liver to produce their debilitating effects on the organism of the sheep. Elsewhere we have explained the reasons why an elevated temperature, combined with excess of rain-fall, is dangerous, and need not repeat the argument. We may, however, add that with the end of October all danger, as a rule, has passed away; the approach of cold weather, and especially the occurrence of frosts, speedily removing the cause of the mischief. The natural history of the liver-fluke also satisfactorily explains this. If it be true that practical men hold that the autumn is the most dangerous period of the year to sheep, it is equally true that they agree that a frost at once puts a stop to the reception of the rot. Fairburn, in combating Hogg's opinion of the cause of the disease, remarks, "I have lost from time to time a great number of hoggs by poverty, and I could certainly trace their death to 'want of meat and shelter;' but there were none of those diagnostic symptoms apparent which indicate the complaint called rot. Cold and frosts are always severe on hunger-stricken hoggs; but *I have uniformly found that frost prevented the rot*, and that if the disease had not been taken previous to the arrival of frost, *it never followed that kind of weather*."

## Symptoms of Rot.

As every disease is accompanied with a train of phenomena usually designated symptoms, it becomes necessary that these should be carefully investigated, so that the nature of each separate affection may be fully understood. The importance of this procedure is further shown by the circumstance that many symptoms are common to several diseases; while others, on the contrary, belong only to particular affections, and hence afford the pathologist a ready means of forming a correct diagnosis. *Sthenic* diseases as a rule, and especially those centered in the more important organs of the body, are accompanied with such well-marked peculiarities, that the practitioner rarely fails in recognising either their nature or seat. *Asthenic* maladies, on the contrary, are often attended with such general or ambiguous symptoms, that even the most experienced pathologist may, at the outset, fail to fix their site or determine their true character. Affections, however, of internal organs, which commence with

only a slight impairment of function, due to a hidden or unknown cause of irritation, are of all others the most difficult to diagnose. Among these may be named some of the parasitic maladies, of which rot in sheep may be taken as an example. Even in those instances where no difficulty exists with regard to the time of the application of the cause of rot, we sometimes look in vain, for many weeks, for clear evidence of its existence.

Simon, in his 'Lectures on *General Pathology*,' delivered at St. Thomas's Hospital, in the session of 1850, rightly remarks that "if you examine parasitic diseases from first to last, you will find that they are, perhaps of all known maladies, the most essentially *local*. They may be very extensively diffused—may be in very many spots of the body—and the sum total of many small irritations may be a large general irritation; or if the parasites are large, as well as numerous, they may drain the system of blood, and anæmiate and kill the animal, as we see in the rot of sheep. But all we know of parasitic influence on the health—and I may observe that a good deal is known—all, I say, is referable to these two heads: *local* inconvenience from pressure or from irritation; *general* inconvenience, either febricular, from that local irritation becoming inflammatory, or anæmiative by draining and impoverishment of the blood."

The latent stage of rot—viz. the period which elapses between the entrance of the penultimate forms of the fluke and their change into perfect flukes and attainment of sufficient size to begin to drain the organism—is the one which perhaps interests the pathologist more than any other. He sees in it the gradual development of causes which he would fain interpose to arrest; because, if unchecked, he knows they must ultimately undermine the constitution. But he is without sufficient warrant to take action, in so far as the animal itself is concerned, for he can recognise no symptoms of ill health. In some instances, however, practical knowledge will come to his assistance, and when he finds animals surrounded by circumstances that experience has proved will engender rot, he does not hesitate to put into operation the power of prophylactics.

The latent stage of the disease is also the one of the first importance to the practical agriculturist. During its continuance he may avail himself of many means which will to a great extent secure himself against loss; but he, also, too often fails in the right application of these, because he is not warned by any symptoms to suspect the existence of the malady.

Much has been said about sheep fattening somewhat quicker than is usual in the early stages of rot, and occasionally attention has been drawn to this circumstance as warranting a suspicion of the animal's soundness. Mr. Youatt, when speaking of the

early evidences of the disease, says, "there is no loss of condition, but quite the contrary, for the sheep in the early stage of rot has a great propensity to fatten. Mr. Bakewell," he adds, "was aware of this, for he used to overflow certain of his pastures, and, when the water was run off, turn those sheep upon them which he wanted to prepare for the market. They speedily became rotted, and in the early stage of the rot they accumulated flesh with wonderful rapidity By this manœuvre he used to gain five or six weeks on his neighbours."

Dr. Harrison has also some remarks to the same purport. "Several graziers and butchers," he says, "with whom I have conversed at different times, having observed that sheep are much disposed to feed during the *first three or four weeks after being tainted*, omit no opportunity of producing the disease to increase their profit."

Ellis likewise, as far back as 1749, drew attention to the same fact, remarking, that "at the beginning of a rot, no sheep feeds nor fats faster than a rotten sheep, notwithstanding the plaise-worms multiply as the rot increases. This makes the common saying true, that no sheep thrives faster than a rotten sheep does for a time, and that no sheep decays sooner after it begins to sink in its flesh."

The tendency to accumulate fat by a diseased animal may seem paradoxical, but the more we know of the nature and cause of rot, and of the physiology of the organ chiefly implicated in the malady, the less contradictory does the fact become. The physiological intricacies of this question, involving as they do a knowledge of the processes of digestion and assimilation of the food, respiration, circulation, and the maintenance of animal heat, forbid, however, in an essay of this kind, our doing more than giving a mere epitome of the subject.

Physiologically considered, the liver is an *assimilatory* and *secretory* organ, as well as an *excretory* one, in all of which offices it plays an important part in the manufacture and purification of the blood. The vessel by which it receives blood for the secretion of bile—the portal vein—takes its origin from the capillaries of the *chylo-poietic* viscera; and the nutritive materials of the food, apart from the chyle, which enter these vessels from the intestinal canal are consequently not conveyed at once into the general circulation, but first subjected to the action of the liver. "The blood in the portal vein differs materially from venous blood in other parts of the body. Among other things it is deficient in fibrine and albumen, but contains more red corpuscles, and about twice as much fatty matter; and in animals fed on farinaceous substances more sugar" (Kirkes). "And as, after having passed through the liver, the

fibrine is increased, and other no less important changes wrought in the blood, there seems no reason to doubt that this fluid has been both *depurated* of materials which would be injurious, and *assimilated* more to the character of ordinary blood. Apart from this, fatty matters especially would appear to be elaborated within the gland, either from saccharine substances or from albuminous compounds; for even when no fat can be detected in the blood of the *vena portæ* that of the hepatic vein contains it in considerable amount" (Carpenter).

In the recent experiments also of Dr. Harley and Professor Sharpey communicated to the Royal Society, it has been shown that even when the portal blood is devoid of sugar, as in a fasting animal or one fed *solely on flesh*, sugar is found in the liver, having been formed therein. We may here observe that, chemically considered, starch, sugar, and fat, are allied substances, being all hydro-carbonates, sugar containing a somewhat greater quantity of carbon than starch, but less than fat.

The bile, as may be easily supposed from the foregoing premises, is a very complex fluid, and has a more important office to perform in the assimilation of food than in the carrying away of materials which impair the purity of the blood. Entering the intestine—*duodenum*—by means of the main biliary duct, it commingles with the chymous mass—the digested food—as this passes from the stomach; and, assisted by the fluid secreted by the pancreas, which is also present in the intestine, effects the chylification of the chyme. The chyle thus formed is absorbed by the lacteals, and carried by them into the general circulation. In the process of chylification a portion of the bile—the colouring matter in particular—as excrementitious material is moved onwards with the unassimilated parts of the chymous mass and ejected as fæculent matter. That portion of the fluid, however, which is employed in effecting chylification, among other things, acts on the amylaceous matter—starch of the food—and converts it into sugar, ready to be taken up by capillary blood-vessels. The presence of bile in the intestine is also said to cause a more free absorption in augmented quantities of the fatty matter of the chyme.

The liver may thus be regarded as the great regulator of the amount of sugar and fatty matter in the blood, any excess of which, not required to support animal heat, accumulates in the various tissues of the body. If this be so, the more active the secretory function of the liver, the greater the amount of sugar and fat which will be absorbed from the food.

Now it is to be remembered that *irritation* simply increases the normal secretion of a gland; but that *inflammation*, on the contrary, alters its character. The entrance of recently developed flukes into the biliary ducts, acts for a time, as has been

previously explained, as a local irritant only, and as such keeps the liver in a state of activity, so that in turn more fat is deposited in the tissues. Thus the placing of sheep upon good grazing, but rot-giving pastures, proves not to be an *immediately* unprofitable proceeding.

The time for the accumulation of fat having passed away, the animal begins to lose condition. The entozoa have now turned the scale. They have laid the foundation for *structural* changes in the liver. The bile also is being gradually changed in quality, and the liver can no longer efficiently maintain its office of a sugar-forming organ, or an elaborator of fibrine. Imperfect chylification is a necessary accompaniment, and the blood soon lacks purity as well as quality. Its quantity likewise suffers, for its development is restricted. The same amount of food which had sufficed to support, or even to give increase of bulk to the body, cannot now minister to the growing wants of the system.

These great changes in the condition of the animal may have insidiously crept on, but they are none the less serious on that account. As time passes, the wasting becomes more and more perceptible. The placing of the hand on the back of the animal will show that the muscles on each side of the vertebræ are so attenuated that the spinous processes of the bones project above them. The animal, in common language, is "razor-backed." The same leanness pervades the entire frame, and everywhere the processes of the bones are more prominent than usual. The general contour of the body is also changed. Often, when the wasting commences, the belly is gaunt, but it soon begins to enlarge and grow pendulous from effusion into the cavity. In the advanced stages of the malady this gives a still further altered outline to the body, for the loins now sink or droop, and the animal becomes "hollow-backed."

The general surface of the skin loses its ruddy hue, and becomes deficient of the unctuous secretion which in health belongs to it. This renders the wool harsh and dry, and leads also to its easy separation from the follicles. A dry scaly state of skin, on the inner parts of the thighs, particularly where it is uncovered with either wool or hair, is likewise early to be recognised.

The animal soon becomes dull and dispirited, and has a peculiar dejected appearance, with an expression of countenance common to many entozoic diseases. "The Ettrick Shepherd" has a quaint tale about this. Once, he says, he was conversing with Mr. Adam Bryden about distinguishing a rotten sheep while at large with the flock, and asked him how this could be done; when "he answered in his usual shrewd and comical style: The late Advocate Mackintosh's method of discerning a good man is the best in the world whereby to distinguish a

sound sheep. His maxim was, 'I never like a man if I don't like his face!' So say I of a sheep."

An examination of the eye will materially assist in determining the question of disease. If the lids are everted and the *membrana nictitans* pressed forward, it will be found that in the *early stages of the malady*, and especially if the animal has been excited by being driven a short distance, *the vessels of the conjunctiva are turgid with pale or yellowish coloured blood, and that the whole part has a peculiar moist or watery appearance.* Later on, the same vessels are blanched, and scarcely to be recognized; excepting perhaps *one or two* which present a similar watery condition, or are turgid with *dark-coloured* blood. The state of the conjunctival membrane is held to be a symptom of importance; and rightly so, because it affords a good means to determine the extent of the changes the blood has undergone. It marks the amount of loss of the red cells of the fluid, and shows also the diminution of the relative quantity of the albumen and saline materials, upon which its specific gravity depends. It is only in blood of proper density that the red cells can be developed. The loss, therefore, of albumen and salts will lead to a relative decrease of the cells, and a corresponding increase of the watery element.

This blanching of the vessels of the eyes has been commented on by some of our earliest writers. Sir Anthony Fitzherbert thus spoke in 1532: "Take both your hands and turn up the lid of his eye, and if it be ruddy and have red strings in the white of the eye, then he is sound; and if the eye be white like tallowe, and the stringes dark-coloured, then he is rotten."

Gervase Markham, in his *Cheape and Good Husbandry*, previously quoted from, has a curious epitome of the symptoms, which we here transcribe: "If a sheepe be sound and perfit, his eye will be bright and cheerefull, the white pure without spot, and the strings red; his gummes also will be red, his teeth white and even, his skinne on his brisket will be red, and so will each side betwixt his body and his shoulder where the wool grows not; his skinne in general will be loose, his wool fast, his breath long, and his feete not hot; but if he be unsound, then these signes will have contrary faces, his eyes will be heavy, pale, and spotted, his breast and gummes white, his teeth yellow and foule, and his wooll when it is pulled will easily part from the body."

In addition to the symptoms we have named it will be found that the animal's appetite becomes fastidious. To-day it feeds pretty well; to-morrow it will scarcely touch food of any description. An increased thirst, however, is now present, and continues till the end. The animal is often going to the brook or pond, or, if prevented from doing this, will omit no opportunity of drinking from the little hollows which may exist on

the surface of the field. This desire for water evidently depends on the continued drain from the blood of this important constituent of its composition. No less than 784 parts out of every thousand of pure blood consist of water. The relative proportions of its constituents may be here given, as it will help to explain many of the phenomena of the disease. They are as follows:—

| | |
|---|---|
| Water .. .. .. .. .. .. | 784· |
| Red corpuscles .. .. .. .. | 131· |
| Albumen of serum .. .. .. .. | 70· |
| Saline matters .. .. .. .. .. | 6·03 |
| Extractive, fatty, and other matters | 6·77 |
| Fibrine .. .. .. .. .. .. | 2·2 |
| | 1000· |

Associated with the increased thirst is an irregular state of the bowels. For a few days together diarrhœa will be present, when it gives way to the ordinary condition of the fæces. A persistence of this variable state of the evacuations, when not traceable to a change of food, or other common causes, is to be regarded as a suspicious circumstance. It is often due to an altered state of the bile, by which the fluid acts as an irritant to the mucous membrane of the intestines: sometimes, however, it would appear to depend on an irregular flow of this fluid from the biliary ducts. The distomata by their movements must occasionally form mechanical impediments to the free passage of the bile, leading firstly to its accumulation, and then its sudden flow onwards, when the obstruction is removed, particularly when they locate themselves within the *ductus communis choledochus*.

As the disease advances to its fatal termination the breathing becomes short and quick, and is occasionally accompanied with a slight and nearly inaudible cough. Œdematous swellings come on in different parts of the body, especially around the throat and beneath the lower jaw. The accumulation of the effused fluid in this situation is to be referred chiefly to the pendant position of the head in feeding. There is no surer proof of approaching death than these œdematous swellings, for they indicate a dropsical condition of the entire system. The prostration of the vital powers day by day increases. The pulse becomes weak, wavering, and indistinct. The animal lies a good deal, refuses all food, is in a state of semi-stupor, and dies from pure exhaustion, as the consequence of general anæmia.

## Progress and Duration.

Many causes are in operation to influence the rapidity with which the organism of the sheep yields to the influence of rot.

Some of these belong to the conditional state of the animal itself, and others to the circumstances by which it is surrounded. Apart from such diseases as may co-exist with rot, the chief of the systemic causes are the number of distomata inhabiting the biliary ducts, the natural stamina of the animal, and its condition as to amount of flesh at the time of the declaration of the symptoms. Age also, and the purposes for which the animal is kept, exercise an important influence upon the progress of the affection. Thus breeding or nursing ewes, from the demand made on their systems for the development or support of their young, will generally succumb more readily than store sheep, and most assuredly much sooner, all other things being equal, than those which are being fattened for the market. Lambs also, when affected in the first few months of their age, for want of sufficiently matured strength of constitution, will soon sink under the malady.

Among the external or surrounding circumstances few are so potent for good as a continuous supply of food rich in the elements of blood, and containing comparatively a small proportion of water. Sheep thus fed will long resist the progress of the malady. A notable instance of this is furnished by the following fact:—A gentleman residing in Norfolk, the occupier of a large tract of heath-land, purchased, a few years since, a number of sheep in the latter part of August. In the month of February of the following year he became aware for the *first* time that the animals were affected with rot. Subsequently to this they began to die, and a great number were soon lost. Being fully satisfied that the sheep had not contracted the disease while they had been in his possession, he sought out the dealer from whom they had been bought; and on inquiry it was found that other sheep from which these had been selected were also the subjects of the malady. So satisfied was the dealer that the whole were diseased when sold by him in August, that he at once agreed to take them back and refund the money.

The remarkably slow progress of the malady in this case was due to the circumstance that the sheep, after coming into possession of their new owner were placed upon a dry sandy soil, and were well supplied with food rich in nitrogenous materials, besides being protected in a great measure by folding from inclement weather. Had causes the opposite of these been in operation, the disease, without doubt, would have declared itself at a much earlier date, and have run its course far more rapidly.

For similar reasons many sheep which contracted the rot *late* in 1860 lived on through the winter, and, not only so, but far into the following year. The weather of 1861 proved the very

opposite of that of 1860, and we are acquainted with numerous instances, even on the cold-clay, grass-land farms of Middlesex, where diseased animals were kept throughout the entire *summer* without any material loss to their owners. Some few persons even ventured to select their ewes for breeding from among them, believing that, as the sheep had done so well hitherto, they would still answer for this purpose. They had, however, to repent their temerity, for no sooner did the grasses begin to lose their goodness, and autumnal weather to set in, than the animals rapidly declined, despite all the care which could be bestowed upon them.

Fairbairn, so often quoted by us, narrates an instance of the inutility of good food and shelter to diseased sheep *at the end of the year*. He says, "In 1810 I put a fine lot of dinmonts upon turnips before Martinmas," — November 11th — "and although in very favourable condition, as I was beginning to suspect they were affected, and under the idea that meat and shelter would provide against every exigency, I sent them from my own farm to a fine, dry, well-sheltered situation in the middle part of Berwickshire, where I expended no less than 100*l.* upon turnips, but before the month of March there were few of them remaining, and I did not realise as much as defrayed the expenses laid out upon the turnips." A result of this kind was to be expected, and forcibly shows the folly of expending money upon rotten sheep in the *winter months*.

It is easy to understand that the existence of flukes in the liver being associated with an almost continuous supply of watery or innutritious food, and exposure of the animal to a low temperature and variable weather, will the sooner produce an anæmiated state of system than when the opposite state of things obtains. The entozoa will of necessity now drain the blood of its albuminous constituents faster than these are furnished. Besides, their presence within the biliary ducts under such unfavourable circumstances will earlier lay the foundation for those structural changes in the liver itself which unfit it for the secretion of sufficiently pure bile to contribute to the making of healthy blood. Hence an additional cause of the quick progress of rot in the autumn and winter, more especially if wet weather should long prevail.

In innumerable instances, however, and at other periods of the year, the two chief causes of mischief—innutritious diet and existence of flukes—are not combined sufficiently long for the former to play so important a part as to produce *persistent* deleterious effects. We have a good proof of this in those cases of the engendering of rot by the pasturing of the sheep on wet

meadows for a limited space of time, and hence we must look to the presence of the flukes themselves, and also to their number, for an explanation of the fact.

The ill effects attending entozoa of every description are mostly dependent on the largeness of their number, but not unfrequently also on the importance of the organ in which they are located. A few flukes, by the simple irritation they produce, are frequently non-productive of mischief, at least to any practical extent, in deranging the functions of the liver. Hence the daily occurrence of sheep, which had been fed for the market, and which had gone on to the perfect satisfaction of their owner, being found to have a limited number of these entozoa in their biliary ducts, the existence of which was not only unsuspected, but would perhaps not have been believed in, but for the circumstance that they were brought to light by the slaughtering of the animal.

This fact is mainly due to the circumstance that the fluke, as has been explained, does not multiply its species within the biliary ducts; for if the contrary were the case—*namely*, that young flukes were produced therein, and that these in due time became the parents of others—what, it may be asked, would then have been the result? Why, that these infected sheep, instead of being made fat enough for slaughtering, would gradually have lost flesh, and ultimately have died anæmiated, even if not more than a dozen of the entozoa had originally occupied their biliary ducts.

Thus we see the necessity of becoming conversant with the method of propagation of each entozoon, to be enabled to speak with any certainty of the ill effects attending its presence. The trite remark, "Oh, a few worms do no harm," may prove true, provided the parasites are inhabiting a part of the organism which is comparatively of little importance to the direct maintenance of vitality, and that they do not multiply their species therein so as greatly to increase in number and speedily lay the foundation for structural disease.

Much also of the ultimate mischief resulting from entozoa will depend, as has been stated, on the importance of the organ in which they may be situated. Thus a *single hydatid* in the brain will by its pressure produce serious disease, and ultimate death of the affected animal; while a dozen or more hydatids located within the lungs, liver, or other organs, will be unrecognised during life from any pressure or irritation they may produce. Facts of this description are frequently too little regarded in estimating the influence of parasites on the health of animals. They have, however, an important practical bearing on the disease in question, as has been already explained.

Thus we see that the rate of the progress, as well as the duration of rot, are governed by a variety of circumstances, and that many of these are so occult and changeable as to forbid our predicting with any degree of certainty how long affected sheep may bear up against the disease.

With regard to the time of the manifestation of the symptoms after flukes have entered the biliary ducts, it is also impossible to speak with any degree of certainty. A combination of unfavourable circumstances may give rise to the symptoms in five or six weeks; while, on the contrary, the majority of things being favourable, even months may pass before rot is suspected to exist. No hasty generalizations should ever be come to on such a point as this, and more especially when an action at law may hinge on the opinion which is given. A patient inquiry into the history of each individual instance can alone furnish correct data to act upon.

## Post-mortem Appearances.

The lesions to be observed on inspecting the body of a sheep affected with rot will vary according to the progress of the malady, be it quick or slow. They will also be modified by the circumstance of the animal having either sunk from the disease, or been slaughtered in its early or late stages. The emaciated state of the frame often strikes us with surprise, the dead animal appearing to be little more than "skin and bone." The wool is found to be harsh and dry, and to pull easily from its follicles. The colour of the skin is pale, excepting perhaps in places where it assumes a purplish hue from approaching decomposition. It likewise tears readily on the application of moderate force, from having lost much of its natural firmness. The visible mucous membranes are colourless, or have a slight yellow tinge. The belly is often large, and gives evidence of containing a quantity of fluid.

On removing the skin, the fascia covering the muscles is frequently found to have a yellowish hue, while the muscles themselves are shrunken in size, soft, and flabby. They have also lost very much of their normal colour, and do not stiffen as is usual. Little or no fat is met with; but, on the contrary, the areolar tissue is infiltrated to a greater or less degree with serous fluid, remarkable for its watery character. This dropsical effusion is observed to have accumulated here and there, and particularly about the front and lower parts of the neck, and around the lower jaw.

On laying open the abdominal cavity exit is given to a quantity of serous fluid, the physical properties of which vary considerably in different cases. In sheep *killed* for an investigation

of the disease, even in the advanced stages, the fluid will mostly be found limpid and transparent, differing but little in appearance from ordinary serum; while, on the contrary, in those that have succumbed to the affection it is often turbid and of a dirty yellow or yellowish-red colour. Much of this variation in colour is due to transudation from the vessels after death; and the hue will consequently be modified according to the time which has elapsed between the death of the animal and the making of the autopsy.

The blood-vessels of the mesentery are indistinct, and effusion exists between its serous layers. The omentum is almost devoid of fat, and, like the other structures, has a yellow tinge. The coats of the stomachs and intestines are pale; and the fæculent matter contained in the latter is usually soft and pulpy.

Effusions of serum, wholly or in part, supplant the fat which ordinarily covers the kidneys; and when the two co-exist a peculiar speckled appearance is produced beneath the serous membrane by the commingling of the fat with the fluid. The kidneys are both paler and softer than natural; but their structure is otherwise unaffected. The rest of the urinary organs, and also those of the generative system, are healthy, but partake of the general pallor which pervades the frame.

The liver is the organ chiefly affected, nevertheless it presents characters in some instances the very opposite of those which are met with in others. It is mostly altered in shape, size, and colour. Its outline is irregular, and its surfaces, especially the abdominal one, often nodulated by a condensation or shrinking of the substance of the gland in some parts, beyond that of others. As a rule, it is diminished altogether in size, and changed from its reddish-brown or chocolate hue to a pale or dirty-coloured yellow. Occasionally its surface is studded over with red spots, which contrast greatly with the yellow clay-like colour on which they rest. Sometimes these specks are mingled with others of various hues, imparting to the organ a peculiar mottled condition, which led Harrison to remark, in 1804, and Youatt to repeat many years afterwards, that the liver "in some cases is speckled like the back of a toad."

Its general structure is condensed, imparting a hard and sometimes gritty feel to the finger, more particularly in long-standing cases of the disease. In other instances the normal colour is less altered, and there are greater evidences of simple venous congestion. This is denoted chiefly on the abdominal surface, which is both striated and spotted by the enlarged and congested blood-vessels which lie in the course of the main biliary ducts. These ducts are diseased more or less in all cases of long standing. Their coats are thickened and hardened, and their calibre dilated, often to an extent sufficient to admit the end of the finger. They appear

as bluish-white lines, more or less continuous, running by the side of the congested blood-vessels, from the central part of the gland towards its lower edge. In some places they are rendered very distinct by projecting above the surface, being here dilated into pouch-like cavities. The coats of the *ductus hepaticus*, as also of the *ductus communis choledochus*, are not unfrequently so thick as to be upwards of ten times their normal substance, and likewise so hard as to approach the nature of cartilage.

On slitting up the ordinary biliary ducts, as we approach the smaller branches, this hardness increases, and the coats are found to be rough and uneven, arising from calcareous deposits —phosphate of lime and magnesia—within their tissue. It is this which gives the gritty feel to the surface of the liver, and imparts a crackling sound on cutting through its substance.

Within the ducts we encounter numerous *distomata*, which are often here and there, and especially in the pouches, so closely packed as to block up the passage. Their number, however, is liable to great variation, and, it has been rightly asserted, is not always in proportion to the extent of the structural changes in the liver. No doubt secondary causes play a not unimportant part in these changes, and so also does time; but nevertheless the lesions of the liver are upon the whole so peculiar that, were no entozoa present, a pathologist would ascribe them to such a cause, and none other. Distomata will often quit the liver by passing into the intestinal canal through the *ductus communis choledochus*, especially when the *entire* structure of the organ has become impaired. Their food is the bile, and the more this is changed in quality, which is always in proportion to the extent of the structural disease of the liver, the less suitable it will be for their support. Besides this, these entozoa, in common with all other creatures, have their ordinary limit of life, and, be this what it may, it is not unreasonable to suppose that their approaching dissolution may at times possibly be an additional reason for their quitting the biliary ducts.

We have frequently met with dead flukes in the intestines and sometimes in the liver, and occasionally have found them forming the nuclei of biliary concretions. One remarkable instance of this was a short time since brought to our notice, where the concretion was as large as an ordinary hen's egg, and when broken up was found to contain about a dozen dead flukes. It was lying in a pouch-like cavity of one of the biliary ducts.

Another reason must be named as explanatory, perhaps, of the cause of but few flukes being met with in the biliary ducts, when the extent of the lesions of the liver does not bear a comparison

with their number, *viz.*, that on the death of the animal, whose body they inhabited, taking place, they leave their original location, as if making an effort to escape from their own consequent death. Many of the intestinal worms, the *ascares lumbricoides*, the *tæniæ*, *trichocephali*, &c., comport themselves in this manner; and in so doing they often form large masses or knots in a part of the intestinal canal foreign to their ordinary dwelling. The lumbricoid worms have been known, under such circumstances, to enter the stomach, and even to pass up the œsophagus into the mouth to effect their escape. We have occasionally found them crowded into the duodenum so as to literally block it up throughout the greater portion of its length, being arrested in their effort to enter the stomach; two remarkable specimens of which are preserved in the Museum of the Royal Veterinary College, one from the horse and the other from the pig.

Should the same thing take place with regard to flukes, a search for them in the intestinal canal will prove successful. That their number, however, is often very large within the biliary ducts, we have daily proof; and it is said that Leeuwenhoeck took no less than "870 out of one liver, exclusive of those that were cut to pieces or destroyed in opening the various ducts."*

Tracing the smaller ducts onwards, exit is given to a dark-brown and thickish fluid, among which are masses varying in size from the head of a pin to a pea, or occasionally larger—collections of the ova of the distomata held together by the mucus of the ducts and inspissated bile. A drop of the fluid, or a minute portion of one of these masses, placed under the microscope, reveals the fact that in the small ducts, especially, the ova are to be met with in countless myriads. We obtain evidence also of another very instructive circumstance, to which attention has been previously directed, by simply putting a little of the matter upon the edge of a plate or slip of glass and lightly pressing it with the point of a scalpel — namely, that the ova have remarkably hardened shells or cases, which doubtless enables them, when out of the body of the sheep, to long retain their vitality by resisting all ordinary causes of decomposition. We feel them as so much gritty matter, and we hear them cracking under the pressure of the knife.

The gall-bladder itself is not much altered in structure, nor does it in general contain many distomata; but the bile within it is mixed with a considerable quantity of mucus, and its colour is altered from that of the greenish-yellow which normally belongs to it. Ova are also met with here, but in scanty quantities compared to the biliary ducts.

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* Youatt on Sheep, p. 449.

The morbid states of the liver which we have attempted to describe are, without doubt, chiefly due to the presence of the entozoa within the biliary ducts. Küchenmeister has correctly observed, that "the *first* consequences of the flukes in the liver are dilatation and catarrh of the gall-ducts, and destruction, by pressure, of large portions of the parenchyma of the liver in the vicinity of the enlarged ducts." No kind of food or location, however prejudicial, could possibly *per se* produce such structural changes in the liver as belong to rot; but it can be easily understood that an organ like this, whose office at one and the same time is to depurate the blood by its *excretory* function, and to assist in the assimilation of the food by its *secretory* function, being so extensively diseased, must ultimately cause emaciation and death of the animal, without regarding the distomata as an additional cause in producing a continued drain on the system of the sheep.

To return to our description of the autopsy. The viscera of the chest, in common with every other organ of the body, give evidence of anæmia. Some serous effusion exists in the cavity, which, however, is mostly devoid of colour, limpid, and transparent. In quantity it is considerably less than that met with in the abdomen. Little or no fat is present about the heart; and that which does exist is of a slightly yellow colour. The walls of the heart are flabby and pale. The blood contained in its cavities, as well as that in the large venous trunks, is watery and imperfectly clotted. The lungs, apart from other diseases of these organs which may co-exist with rot, do not present any special lesions. Like other parts of the organism, however, they give evidence of general anæmia. In our section on the pathology of rot, we have fully discussed the opinion of Mr. Blacklock, as to the malady being a tuberculous one of the lungs, and therefore need not repeat our arguments against the correctness of this statement.

The condition of the brain and its meninges agrees with that of the body generally. A larger amount of fluid than ordinary is present in the ventricles of the brain, and the vessels of the meninges are indistinctly seen in consequence of the watery character of the blood within them. Such, then, are the general *post-mortem* appearances of rotten sheep.

We have, however, many proofs that affected sheep often die long before this general break-up of the organism is accomplished. This is particularly the case at the commencement of winter, and on the occurrence of white or hoar frosts. Such animals sink from *passive congestion* of the lungs, the tendency to which is given by the altered condition of the blood from a change in the relative proportion of its several constituents. Dr. Carpenter and

other physiologists rightly remark that a diminution of the specific gravity of the blood, from a loss of its saline and albuminous materials, predisposes to hæmorrhage, congestion, &c.; and such we know to be the condition of this fluid comparatively early in this disease. The lungs, in such cases as these, are red throughout, being charged with blood. They are also heavy to the feel, and portions of them will be found to sink in water. The vessels of the pleura and pericardium are likewise overloaded with blood. The flesh of such animals is of fair colour and tolerably firm. Some fat also, not much changed in consistence, exists around the kidneys, and in other places of ordinary deposit. The yellow hue of the tissues, so generally present, is considerably less in amount, and is sometimes scarcely to be noticed. The liver, however, is mostly of a clay colour, and its ducts are crowded with distomata.

In concluding this section of our essay, we add a few words with reference to the effluvium which arises from the carcasses of rotten sheep. This is often extremely nauseating, even when the animal is opened directly after death. We have on more than one occasion known persons to be taken seriously ill when engaged in opening many rotten sheep at a time. A remarkable instance, not only of sickness, but of death, was brought to our notice in *August* of 1854. A person of intemperate habits, following the occupation of a country butcher, was employed in skinning and dressing a number of rotten sheep on the premises of a farmer in the county of Norfolk. The sheep were necessarily opened when *warm;* and, while he was so engaged, he complained greatly of the sickening smell. The same evening he was attacked with choleraic disease, and two days afterwards was a corpse.

That the bodies of rotten sheep quickly undergo putrefaction is well known, and elsewhere this is assigned as a reason for the name given to the malady; but that injury may arise from the effluvium accompanying the vapour given off from their still warm bodies after death is not so generally understood.

## Treatment of Affected Sheep.

The successful treatment of a disease is necessarily based on a knowledge of its pathology, without which the application of all remedial means becomes mere empiricism. It were well for the ends of science if information of this kind invariably tended to the discovery of a cure for each separate affection, but unfortunately it too frequently leads to the very opposite result. The more we understand of the nature of some diseases, the more

we despair of being able to eradicate them, or even to mitigate their effects. It is the possession, however, of this knowledge which marks the difference between the man of science and the mere empiric. The latter rushes in, and boldly declares his ability to cure that which is incurable; while the former honestly declares his inability to do anything for good. Correct pathological knowledge will doubtless prove that the *cure* of rot can scarcely be hoped for, although much may, nevertheless, be done to arrest its progress.

Many remedies of empiric origin have been forced on the notice of agriculturists from time to time, both in this country and also on the Continent, for the cure of rotten sheep—all of which have, however, signally failed in verifying the statements of their originators. At the commencement of the present century a remedy emanating from a Dutch source was loudly extolled, and even largely used in this country as well as in Holland, but it soon fell into disrepute—following in this respect those which had gone before or have since succeeded it.

Mills, in his work on cattle, after speaking of the employment of certain medicinal agents which are too commonplace and valueless to be here quoted, says that a Mr. Baldwin, of Clapham, Surrey, found *burnet* to be a remarkably efficacious cure for rot, "as appears from a letter of his published in 'The Repository for Select Papers on Agriculture, Arts, and Manufactures,' 1768." Mills adds to this statement the following: "A farmer in the north, in the autumn of the year 1766, when all his sheep were so far gone in the rot that he did not expect one of them to live the winter over, sent them into a field of burnet, which in a month's time restored them to perfect health."

After diligent search we have been unable to find any other authority on the *curative* properties of burnet, nor do we believe in this power of the plant. All that could be hoped for would be that sheep feeding upon it, especially when mixed with good grasses, might be enabled to resist for a somewhat longer time the inroads of the disease.

Martyn, a late Professor of Botany in the University of Cambridge, in his '*Flora Rustica*,' 1792, says: "Burnet is common in high pastures on a calcareous soil. It flowers in the beginning of May, and sometimes in April. The leaves, when bruised, smell like cucumber, and taste something like the paring of that fruit; they are sometimes put into salads and cool tankards." He adds that "Some years since Mr. Rocque attempted to introduce it as food for cattle. It has one good quality, which is, that it continues green all winter, and affords some food early in

spring, when it is commonly wanted. But cattle are not very fond of it, nor does it yield a sufficient burden to pay the farmer for the expense of cultivating it."

Several writers on agriculture remark that when burnet constitutes a moderate proportion of meadow-hay it imparts a stimulating property to the fodder, thereby rendering it more suited for feeding with turnips; but if burnet be cultivated by itself and made into hay, the provender is coarse and unpalatable, and rejected as a rule by most animals.

Most authors, however, on the diseases of the sheep, place their chief reliance on medicinal agents for the cure of rot; the particular remedies they advocate depending rather on their own preconceived notions of the disease than on any precise information of its nature. We give a few extracts:—

Sir G. S. Mackenzie directs attention to the beneficial use of mercury, but says that "it would, perhaps, be improper to administer this agent internally. The safest and most effectual method of applying it is in the form of the common blue ointment, and a trial of this is strongly recommended to those whose flocks are liable to rot. It should be applied to the bare skin in the region of the liver; and the size of a nut rubbed in till it is all dried up twice a day for a week or ten days. This, in conjunction with wholesome food, will in all probability prove to be the most effectual treatment. Mercury is well known to be a specific for diseased liver of the human body, and on that account we may presume that it will be efficacious in the cure of the same organ in sheep, and it is also recommended as the most effectual means of destroying the fluke-worm."

Mr. Youatt, adopting the views of those who regard the affection as an inflammatory one of the liver, advises at its commencement that the animal be bled to the extent of "8, 10, or 12 ozs.," and that this be followed up by an aperient, consisting of 2 or 3 ozs. of Epsom salts; and he adds, "the physic having operated, or an additional dose, perchance, having been administered in order to quicken the action of the first, the farmer will look for further means and appliances. Friction with mercurial ointment on the region of the liver has been recommended, but not by those who have had opportunity to observe its secondary effects on the ruminant. Still the disease under consideration, with evident determination to the liver, requires the agency of this powerful but dangerous medicine. Two or three grains of calomel may be given daily, but mixed with half the quantity of opium, in order to secure its beneficial, and to ward off its injurious, effects on the ruminant. To this should be added—a simple and cheap medicine, but that which is the sheet anchor of the practitioner here—common salt."

Clater, who boasts of curing "9 *sheep out of* 10 *even in the last stage*" of the malady, recommends the following medicament:—

"Nitre in powder, 6 ozs.
Ginger, fresh powdered, 4 ozs.
Colcothar of vitriol (red oxide of iron) in fine powder, 2 ozs.
Common salt, 3½ lbs.
Boiling water, 3 gallons.

"Pour the water hot upon the ingredients; stir them, and when new milk warm, add to every quart of the mixture 3 ozs. of spirit of turpentine, and bottle it for use."

When using the medicine, we are instructed that "the following directions must be strictly regarded:—Keep the infected sheep from food all night; on the following morning give to each 2 ozs., or 4 table-spoonfuls of the above mixture (remember to shake the bottle well at the moment of pouring it out). To those which are weak and much reduced by the disease, one-half, or three parts out of four, may be sufficient for a dose. Keep them from food three hours after giving the medicine, and then turn them into a dry pasture. It will be necessary to repeat the medicine every fourth day for three times, observing the above rules; but where only half the quantity has been administered, it will be proper to repeat it every second or third day for six times."

This recommendation of Clater may be taken as a fair specimen of the treatment generally advised by the empiric writers of his day. It is, however, unnecessary to quote from their works, as nothing of value can be obtained therefrom. No instances of cure are given, nor is any light thrown on the nature of the disease.

We find, however, a circumstance narrated by Fairbairn, which we transcribe, in further proof of the value of salt:

"In the year 1817," he says, "an active shepherd in my neighbourhood, who had the charge of 200 ewes, observing some of them tainted with rot, bethought himself of trying the experiment of curing them, and conducted it in the following way:—Whenever he saw any one or more of them showing unequivocal symptoms of rot, he brought them into a dry court-yard or empty house, and fed them with hay, turnips, or a few oats. To every one of them he gave *twice* a day a handful of salt, which he dissolved in water, and putting the solution into a teapot, poured it down their throats.* This was repeated for several successive days, and continued till some improvement in the condition of the sheep was discernible, after which they were turned into the field. If the reappearance of the symptoms did not justify their continuance with the flock, they were again conducted home, and the salt, as before, administered. Few of them required more than two such courses, but a great proportion of the flock was treated in this manner, and the shepherd delivered the whole of them alive at Whitsunday, except one ewe which had died in lambing."

* The quantity of salt here recommended would weigh nearly three ounces, an amount which could not be daily used with safety.—AUTHOR.

Before commenting on any of the foregoing methods of treating rot, we purpose to give the one which is adopted by the Bedouin Arabs. We learn from the writings of MM. Hamont and Fischer, previously quoted, that when the Nile returns to its bed, the sheep of the Arabs go to feed on the *dysse* which springs up on the partially-recovered land (*see p.* 14), and as soon as "the first symptoms of the affection appear, the vigilant Bedouins lose not a moment; they reassemble their flocks, and drive them back to the desert. In the midst of the sands their principal food is the *salt-wort*"—*Salsola Kali.* After some days the symptoms of the rot gradually disappear, and the sheep regain their former health." It further appears that the Bedouins know of no other remedy, and should this not prove beneficial, they proceed to slaughter the affected animals.

To return to some of the opinions we have quoted; and first, a word with regard to Sir G. S. Mackenzie's mercurial inunction. Apart from the arguments advanced against it by Mr. Youatt, in the extract we have given, we object to this method of employing mercury, as being perfectly useless. No amount of absorption of the agent from the skin could possibly affect the vitality of the flukes; and as the cause of the malady would remain unchecked, so must its effects necessarily continue. But even a greater objection could be raised against it than this. Mercury is well known to produce a particular effect on the blood, lessening the amount of its fibrine, and rendering the fluid aplastic, and therefore doing the very thing we desire to avoid in this disease. It is only by our keeping the blood rich in its proximate principles, as has been elsewhere pointed out, that the system is enabled the longer to resist the progress of the malady. For similar reasons we dissent entirely from Mr. Youatt's advice to use mercury in conjunction with opium. This compound would be of great value succeeding upon the withdrawal of blood and the exhibition of aperient medicine in *active inflammation* of the liver, as also in a similar condition of other organs, but it is positively injurious in rot. We are unable to reconcile Mr. Youatt's treatment with anything belonging to the pathology of this disease. It can only be accounted for by his having erred in considering the affection originally as one of inflammation.

With reference to Clater's prescription, which, as has been explained, is but a type of many others of similar origin, we have a good proof of the want of scientific knowledge which generally prevailed among those who wrote of the diseases of animals at the beginning of the present century. Whatever value it may possess lies in the amount of salt it contains; otherwise it is but little calculated to do any good.

No treatment of rot can be considered as being more than

palliative; still in carrying this principle into practice great benefit often arises, as the owners of infected animals are secured against losses which otherwise would be very heavy. The earlier the disease is detected the better, but unfortunately its discovery is too frequently not made until the autumnal period of the year, when external circumstances are much against the success of any system of treatment or management, and when also structural changes have begun in the liver. Should the disease not be detected until this period, no effort must be spared to quickly check its progress; otherwise the fatality will be very great.

The animals must be carefully guarded against all vicissitudes of weather by being folded in the best sheltered situations, more especially at night. Their food should consist of the most nutritious materials. Indeed, waste of the tissues, particularly when due to simple anæmia rather than organic lesions, will demand not only a liberal supply of food rich in flesh-forming—nitrogenous—principles, but also such as contains a large proportion of sugar, starch, or other carbonaceous matters, that the heat of the body may be kept up equally with nutrition. If placed on meadows or artificial grasses, the sheep should be often changed from pasture to pasture, care being taken to avoid those which are wet and cold, or which contain inferior herbage. Manger-food must be supplied, and this should consist, in part at least, of *crushed* corn, of which the leguminous plants, beans, peas, lentils, &c., are to be preferred. Oats and maize are also good, and to these a moderate allowance of oilcake may be added. Frequent changing of the food will induce the animals to eat more, for which reason, when they are on the pastures, we take no objection to an occasional supply of turnips or other roots; but, unless compelled by the character of the farm and the system of cultivation, we would avoid continuous folding on turnips. Where this has to be done great care will have to be exercised in regulating the quantity of turnips according to the condition of the crop, the state of the weather, &c. Under such circumstances an allowance of good hay, in addition to the other food, will be imperatively required.

By these means rigorously carried out, provision will be made for the due supply of albuminous and heat-giving materials to the blood, and the consequent nutrition and health of every part of the organism. Dependence, however, must not be exclusively placed on diet. Medicinal agents will have to be had recourse to, preference being given to those which impart tone and vigour to the system. Conjoined with these should be such as experience has shown to possess anthelmintic properties.

Salt cannot be dispensed with. It does good in several ways. It is an agent which acts as a stimulant to the process of digestion,

and, by its ready solution and free entrance into the blood, it will supply also any amount of soda which may be required in the secretion of bile, the saline constituents of which include the chloride of sodium—common salt—with that of potassium, and the phosphates and sulphates of soda, potash, lime, and magnesia. Another advantage is connected with the exhibition of salt and its entrance into the blood, namely, that it contributes with other saline and albuminous matters to preserve that proper specific gravity of the fluid which ought to be "equivalent to that of the contents of the red corpuscles, as it is only in this condition that the formation of the latter can duly take place."—(*Carpenter.*)

The other medicinal agent to which we refer as indispensable is the sulphate of iron. As a tonic it is excelled by few, if by any, therapeutic agents; while the readiness by which it can be obtained, and the lowness of its price, give it an advantage over many others. Sheep also do not object to take it with their food when mixed in proper proportions; nor is it a matter of much moment if one animal should get rather more than his fellow, by more rapid or longer feeding at the trough. Sulphate of iron is likewise an excellent anthelmintic, quickly leading to the expulsion of several of the varieties of *intestinal* worms. Its chief use, however, in rot is that it is a powerful agent in the reproduction of the red cells of the blood—iron entering largely into the contents of these cells—the *hæmato-globuline*. In all diseases therefore in which there is a diminished power of producing red cells, the sulphate of iron is a valuable remedy.

Stomachics or carminatives are likewise required; of which medicaments we give a preference to aniseed in this affection.

A good compound of these medicinal agents with some highly nitrogenized alimentary matters we have in the following formula. Take of

| | | |
|---|---|---|
| Finely-ground oil-cake (linseed) .. | } each 1 bushel. | |
| „ pea-meal .. .. .. | | |
| „ salt .. .. .. .. | } each 4 lbs. | |
| „ aniseed .. .. .. | | |
| „ sulphate of iron .. | .. | 1 lb. |

Let the salt, aniseed, and sulphate of iron be mixed together first, and afterwards well incorporated with the cake and pea-meal.

We have the authority of eminent chemists for saying that *even when solutions of salt and sulphate of iron* are mixed together in the proportions here recommended they undergo but little change. The products of the change are sulphate of soda and protochloride of iron, the therapeutic action of which, especially in the quantities in which they are formed, will not materially interfere with the undecomposed common salt and sulphate

of iron. Apart, however, from the question of a partial change in the agents, we can speak confidently of the practical utility of the compound in the treatment of rot. The quantity of it to be given to each sheep daily should be half a pint, in addition to an ordinary allowance of corn or cake and hay-chaff. It may be used with advantage for three or four weeks in succession, but should be discontinued occasionally for a day or two, especially if the animals become affected with diarrhœa.

In the further treatment of rot, attention should be given to the expulsion if possible of the flukes from the biliary ducts—not that we think any medicinal agents can be depended on for this purpose. Nevertheless, trial may be made of the oil of turpentine, combined with linseed oil and nitric æther, in the following proportions :—

| | |
|---|---|
| Oil of turpentine .. .. .. .. .. | } of each 2 drachms. |
| Nitric æther .. .. .. .. .. .. | |
| Linseed oil .. .. .. .. .. .. | 2 ozs. |

This may be administered once a day for three or four succeeding days, at intervals of about a fortnight; and, although not positively required, it may be as well if the medicated food compound be suspended at these times. Beyond the adoption of these measures we can see no advantage in the medical treatment of this disease.

Under the head of treatment, however, we must not omit to mention that trial has recently been given to a French remedy for rot. The full particulars of this are set forth in the subjoined report to the Royal Agricultural Society by the author of the present thesis. We deem it right that this should be transferred to these pages for the sake of completeness, and also to record our meed of praise to the gentleman who introduced the remedy to the notice of the English public :—

"*Report on the Employment of a French Remedy for the Cure of Rot in Sheep.*

"It will be remembered that in the early part of the year M. Trehonnais called the attention of the agricultural community to a remedy, much extolled for its curative properties, which had been employed in some parts of France for the rot in sheep, and that M. Trehonnais also very liberally engaged to obtain a sufficient quantity of the agent for trial in this country. The Council resolved, in consequence of this favourable report, on the recommendation of the Veterinary Committee, to purchase some sheep for the experiment, and voted a sum of 12*l*. for the purpose.

"In accordance with this resolution, instructions were given me to procure such animals as I deemed fitting for the purpose, and to commence the experiment as early as circumstances would permit. In selecting the sheep, which were of the improved Dorset breed, I took care that they should be of the same age as near as possible, be also in a condition warranting the belief that they would survive long enough to give a fair trial to the medicine, but

be in different stages of the malady. I preferred one-year-old sheep as offering most of these advantages, and for the further reason that an approximation could be made as to the time they had been the subjects of the malady. Everything being arranged, the experiment was commenced on April 22, 1861, the first thing done being to divide the sheep into two parts, leaving one moiety at the Royal Veterinary College and sending the other to my farm, Oakington, in the parish of Harrow. This was deemed important, as each division would be placed under totally different circumstances, especially as to the kind of food which would be supplied to the animals, and the protection which would be afforded them from ordinary atmospherical changes.

"The sheep left at the College were kept entirely on hay and oats, housed every night in a shed, but allowed the use of a small enclosure during the day. Those sent to Oakington were, on the contrary, placed in a meadow, and had an abundant supply of grass, but no corn; nor were they protected of a night, save when the weather was wet.

"I further determined to give the medicine to *three sheep only* of each lot, leaving the others entirely to their chance. In doing this I selected the apparently strongest sheep for taking the medicine.

"The directions received from France for the use of the agent were that a tablespoonful should be given to each sheep every morning, half an hour before feeding-time, and be continued from fifteen to twenty days to animals in the early stages of the disease, and from thirty to forty days to those in the advanced or latter stages; or even for a longer time in very severe cases. It was further ordered that, as soon as the animals had gained their appetite and strength, whatever other indications of the disease might still exist, no more medicine should be given, as these were signs of convalescence—proper care as to feeding and management sufficing to complete the cure. Under the influence of regimen, care, and exhibition of the medicine, it was also stated that a cure would be effected in a month or six weeks of the sheep in the early stages of the disease, and in about three months of those in the advanced stages. The recoveries were said to be *all* in the first, and *two-thirds* in the latter stages.

"The exhibition of the medicine for the first fortnight appeared in neither lot to have any marked effect, the animals, with one exception, continuing in their original condition. In the exceptional case alluded to, and which was one of the sheep taking the medicine at the College, the disease was evidently fast gaining ground, foretelling a fatal result.

"On the twenty-first day from the commencement of the experiment this animal died, and on being examined *post mortem* numerous flukes were found in the liver. The organ was pale in colour and had undergone the structural changes commonly met with in rot. Effusion of serum had also taken place into the abdominal cavity, and the entire carcass of the animal was flaccid and paler in colour than is natural from general anæmia, thus proving the true nature of the malady.

"Under these circumstances I resolved to give the medicine to one of the three animals which up to now had not taken any, as the trial did not appear quite satisfactory, death having resulted so soon in the case alluded to.

"Continuing the report of the College sheep, it is next to be observed that the remedy was continued to the middle of June, and this, not only without any apparent benefit, but seemingly with some disadvantage, as each of the three sheep taking the medicine was more emaciated than either of the other two.

"This untoward circumstance evidently depended on the nauseating effects of the medicine, as the animals would often refuse their food for some hours after its exhibition, and sometimes even to the latter part of the day.

"It may be here remarked that the medicine apparently contained some

oleaginous material which had a very unpleasant smell, not unlike fetid animal oil, which had probably to do with its sickening effects.

"On the 20th June, being two months from its first exhibition, the medicine was discontinued to the College sheep. All the animals were kept, however, about six weeks longer, by which time they had become so emaciated that it was determined to destroy them, which was accordingly done. A *post-mortem* examination was made of each, and it was found that no real differences existed in the lesions wrought by the disease in the sheep which had taken the medicine from those of the others which had not. *Living flukes* existed in large numbers in the livers of all the animals.

"To return to the sheep at Oakington. It has been already stated that in this moiety of the animals, for the first fortnight subsequently to April 22, no material alteration had taken place. By the end of May, however, it was very evident that three of the sheep were gaining flesh, and presenting a far more healthy appearance than the others. Two of these were sheep not taking medicine, and one which was. The other three sheep were wasting, and becoming day by day more debilitated; but nevertheless, when compared with those at the College, they were in far better condition.

"On June 6th, forty-five days after the commencement of the experiment, one of the Oakington sheep died, and this, as at the College, was one which had taken the medicine. The lesions met with on examination of the body agreed with those already described, and need not, therefore, to be repeated. The medicine was continued up to the 20th of this month with one of the remaining sheep, and for a fortnight longer with the other—the latter being an emaciated and gradually declining animal.

"The three sheep spoken of as doing well were by this time so much improved that I had little apprehension of their speedy death. The weather was dry and the herbage of the pasture good—circumstances most favourable for their resisting the progress of the malady. All five were kept throughout July, and until the 4th of August, when I determined, as it was evident two would ultimately sink, to kill three of the lot, viz., the two in question together with one of those which had greatly improved in condition, and which had taken no medicine throughout. My chief reason in taking the resolve with reference to the latter named animal, was to ascertain on what its improved state depended, or whether in fact it was the subject of the entozoic disease—rot. On making a *post-mortem* examination of this animal it was found that only a few flukes were present in its liver, and that the structure of the gland was but little changed—facts which fully accounted for its well-doing.

"With reference to the two remaining sheep, one of which had taken the medicine and the other not, I feel assured that their improvement is due entirely to the circumstance that few flukes are present in their livers.

"I have further to report respecting these sheep, that being ewes, I placed them with my breeding flock at the time of putting the rams to the animals, and intend to keep them throughout the winter to mark the result, giving them no more attention as to feeding and management than the flock in general will receive.

"On reviewing all the details of this experiment I fear we must conclude, that this supposed cure of rot in sheep has proved quite ineffective for good in our experience.

(Signed) "JAS. B. SIMONDS."

Subsequently to this report being made to the Royal Agricultural Society one of the two remaining sheep began to give evidences of declining health, particularly by a gradual falling away in condition. This was first observed about mid-winter; but the animal nevertheless lived on and produced a lamb—a

small and weak one—at the end of February. The ewe still survives at the time we write, namely, at the latter part of March, and seemingly may continue for many weeks.

With this report we conclude this section of our subject, and pass on to consider in the next and last place the

## Prevention of the Disease.

When investigations into the nature of a disease forbid the hope of its cure, it is indeed most fortunate, should they tend to prove that very much may be done to prevent its occurrence. The old adage rightly teaches that "prevention is better than cure," but the prevention of that which is incurable seems to rise above the proverb itself. Rot when fully established can only be viewed as being incurable; but nevertheless, the knowledge of its cause and nature holds out no faint hope of our being able to prevent it. In times gone by various means for the attainment of this desirable end were suggested, and as some of these have a close connection with those now advocated, we shall follow the course we have adopted throughout these pages, and glean from the early writers on the disease.

Leonard Mascall thus advises,—

"Against the rot, if you feare your sheepe in wet times, ye shal put them into a house three daies and three nights without meat or drinke. Then give to euery hundredth one bushel of bran mixt with so much salt laid in troffes, and hunger will make them eate it; then driue them to the water and let them drinke their fill. Then let them be chast with a curre a good space after, and put them then into what ground yee will for one quarter, and they shall take no hurt. Then must you take them up the next quarter and serue them so again. Thus must ye vse them foure times in the yeare in doubtfull times, if ye will saue your sheepe from rot."

We can scarcely imagine that even under the pressure of severe hunger sheep would eat anything like the amount of salt here spoken of, viz., presuming the bushel of 1587 to be equal in size to the one in present use. Be this as it may, the proceeding could not be adopted without considerable danger to the lives of the animals, for the quantity of salt would exceed half a pint to each sheep. It is easy, however, to understand the principle here intended to be put into operation, namely, that of producing a quick action on the bowels by the direct irritating effects of the salt, for the purpose of expelling any injurious matters which might be contained within them. This probably was regarded as the chief source of benefit; but then it is to be noticed that Mascall speaks of the security afforded to the animals for the three succeeding months. Immunity, if existing, could only arise from a portion of the solution of salt being absorbed into the general circulation, and exerting its secondary

effects on the secretory organs of the body. The liver would be chiefly concerned in this process; but we imagine that any flukes which might perchance be inhabiting the biliary ducts would escape all injury, and would cling to their habitat with undiminished tenacity.

Considering the importance of the question involved—for we have known *three* ozs. of salt, dissolved in a pint of warm water and given to a sheep *after two days' fasting*, to produce immediate efforts to vomit and speedy death—we have looked closely into the matter, but after considerable research have been unable to arrive at a satisfactory conclusion as to the exact size of the bushel in Mascall's time. It seems by the statutes of Henry III., 1216-72, and also of later kings, to have been enacted that the *gallon* should contain eight troy pounds of dry wheat from the middle of the ear, and that all *ale*, *wine*, and *corn* should be measured by the same gallon, but which nevertheless appears not to have been done—ale and wine being measured each by a different and a *smaller* gallon than corn.

Sir H. Spelman (born 1562, died 1641), and therefore contemporary with Mascall, says that the bushel contains "*four gallons of wine;*" while Dr. Barnard, who was born in 1638, three years before Sir H. Spelman's death, and who wrote on ancient weights and measures, asserts the bushel to be rather more than 59 lbs. *avoirdupois* of common corn (*triticum*), or, allowing for the difference between troy and avoirdupois, to be about double the size named by Spelman.

It further appears that in 1650, the gallon for measuring "*drie things as corne, coals, salt,*" &c., contained 272·25 cubic inches, which would give the content of the bushel then in common use as 2178 cubic inches. By the Act of 1697 "The Winchester round bushel was to be eighteen and a half inches in internal diameter, and eight inches deep," thus fixing the gallon at 268·6 cubic inches.

In 1824 the Imperial bushel was fixed at 2218·2 cubic inches, so that it would appear that the bushel of 1650 was intermediate in size between the Winchester and the now Imperial bushel, containing in round numbers about a pint more than the former, and a pint less than the latter; but whether this was the size of the *bushel*, or one of half that capacity, in use in 1587 is not clear.

The weight of salt varies, depending on the amount of its dryness and pulverulent condition; but taking an average specimen of table salt of ordinary dryness, an Imperial bushel will weigh 64 lbs. avoirdupois, while of rough salt, such as in all probability was used in Mascall's time, it will weigh 70 lbs. Putting the weight at the lowest, viz., 64 lbs., merely for the sake

of a position, and making an allowance also for the estimated differences in the sizes of the bushels at the different periods spoken of, we have the enormous quantity of 10·24 ozs. of salt allowed for each sheep; or supposing Sir H. Spelman's statement of the content of bushel—wine—to be correct also with regard to corn and salt, then about half this amount: a quantity which we have shown could not be taken without serious risk to the safety of the animal.

Leaving this question somewhat undetermined, we proceed to quote from other authorities on the prevention of rot.

Gervase Markham, alluding to these means, says:—

"This disease is the cruellest of all other amongst sheepe, and extendeth his violence ouer townеships and countries; and though it be held of most men incureable, yet good gouerment, and this receit I shall deliuer you, will not onely preuent, but preserue your sheepe safe. Therefore as soone as you perceiue that any of your sheepe are tainted, you shall take *Adraces*, which is a certain salt gathered from the salt marshes in the heat of sommer, when the tide going away, and leauing certaine drops of salt water on the grasse, then the violent heat of the sunne turns it to salt: and to speake briefely, all salt made by violence of the sunnes heat onely is taken for *Adraces*, of which there is an infinite store in *Spaine*. With this *Adraces* rubbe the mouthes of all your sheepe once a weeke, and you shall neuer need to fear the rotting of them, for it hath beene well tried; and as I imagine the experiment was found out from this ground. It is a rule, and well knowne at this day in *Lincolneshire* and in *Kent*, that upon the salt marshes sheepe did neuer die of the rot; no other reason being knowne therefore, but the licking up of that salt, and without doubt it is most infallible and most easie."

The allusion made in the foregoing extract to the security given to sheep by placing them on salt marshes is the earliest we have yet met with, and as these remarks were penned in 1614 we have a satisfactory proof of the antiquity of the opinion. Later on we find many authors making mention of the same fact with more or less precision, and some even stating that *affected sheep are cured* by being removed to such pasturage; we shall, however, content ourselves with one other quotation on the subject.

Price, in describing the management of Romney Marsh sheep, says: "I know many acres of pasture land in the marsh which the tide frequently overflows, and sheep are constantly fed upon afterwards. They are fond of feeding upon these wet salts; but more so after a shower of rain. They thrive remarkably well, and *are never known to rot*, though the ground is always saturated with moisture, and the grass has particles of earth adhering to it: two causes which many think produce the rot. Sheep affected with this disease soon die, or recover if put upon this land."

If more evidence be required to show the immunity possessed by sheep thus located, we would turn from our own authors

to those of other countries, where we shall find abundant proofs of the fact. Italian writers are very precise in their statements respecting it, and so also are those of France and Spain. With such a mass of practical and scientific evidence, few persons, we imagine, would have the temerity to deny its truth. It may, however, be rightly asked by all, upon what cause the immunity depends? The answer to the question is both easy and satisfactory. Salt water is destructive to the *cercariæ* of the fluke eggs. These infusorial creatures belong to fresh water, and to this alone. It is here only they can pass through their several gradations when out of the body to fit them for their ultimate development into flukes by entering the digestive organs of sheep. If flukes, however, should have taken up their abode in the biliary ducts prior to the placing of the sheep on salt marshes, they are beyond all reach of harm. The character of the food will have but little effect on the entozoa, and the disease will progress to a fatal termination. The cure spoken of by some authors is only apparent, not real. Sheep, viz., sound ones, "thrive remarkably well," writes Price, when thus located; and we may add, so will many affected animals for a time,—the causes for which need not to be repeated.

That the utility of this change of pasturage to diseased animals is not permanent, we have had many proofs in our own experience, but will cite one only in corroboration. A farmer living in Sussex sent in 1860 a number of rotten sheep to the salt marshes of that county, with a hope of their being cured thereby. For a few weeks the animals improved in condition, thus encouraging his hopes; but very soon they began to waste, and ultimately all succumbed to the disease. Removal to salt marshes as a *preventive* measure is valuable, but as a curative one it is only fallacious. It is, however, a preventive within the reach of but very few persons, and even these may not use it aright. They may keep their sheep at home in early summer, until all the mischief has been done.

The benefit of salt is so universally admitted that we might be content to leave the question without further comment; we shall, however, offer a few additional remarks upon the practical application of this prophylactic agent, but before doing this, we are desirous of recording other supposed means of ancient date of securing sheep against the disease.

Crawshey advises the making of a *malt liquor*, and boiling in it certain herbs, such as shepherd's-purse, comfrey, sage, wormwood, &c., and then to add salt in the proportion of $1\frac{1}{4}$ lb. to the gallon; and "after Aprill come to give your sheepe seaven or eight spoonefuls a peece, every weeke, once if the weather be wet; if it be dry, you neede not so often; and thus continue till

May and after, as you see cause, according to the drynesse or wetnesse of the weather. If you be carefull to follow this practice," he says, "you shall keepe your sheepe from rot."

Our chief object in giving the above quotation is to show that, as early as the beginning of the seventeenth century, some persons had great fear of a wet spring producing the disease. The placing of the period of danger, however, so early as April, we conceive to be an error; but we agree, nevertheless, if not with the manner, at least with the principle of giving to sheep a saline and saccharine mixture during the continuance of wet weather. The quantity here ordered of salt might possibly be sufficient for good, as a destroyer of the penultimate forms of the fluke, but certainly not that of the malt liquor as a heat-giving element to the body.

Bradley recommends two drachms of powdered juniper-berries to be mixed with a quarter of a pint of sea-salt, and added to a bushel of oats, for feeding sheep in wet weather; and he remarks that where the juniper grows naturally "sheep never are subject to rot."

Few sheep would eat food containing even a small quantity of juniper-berries, and if it were otherwise, we can conceive of no advantage resulting from their use. The observation of sheep being free from rot where the juniper-tree is indigenous seems to us to be putting effects for causes. The plant luxuriates in a dry and sandy district, and in such a soil the cause of rot is not encountered.

Ellis's remarks point to the protective influence, among other things, of the turpentines as existing in the Scotch and other fir-trees, and he recommends their cultivation both "in moist and barren gravelly land." "Sheep," he says, "may be preserved in a great measure from rot by having enough of the loppings of this tree to browse on, for the quality of this evergreen turpentine-tree is hot, dry, and balsamick, and is a purifier of the blood, and an utter enemy to the breed of worms and other insects in the bodies of animals."

After the statements we have made with reference to turpentine when speaking of the treatment of rot, it is unnecessary to comment on this recommendation. We take no objection in the abstract to sheep being allowed to eat of the leaves of the Scotch or other common varieties of fir, but unless far more efficient means are adopted, the disease will not be prevented thereby.

With these selections from the older authors we shall be content. The prophylactic measures which possess the greatest variety have been chosen as examples, and therefore we shall now give our own view of the means which should be adopted. It

is to be remembered that security depends upon the placing of sheep under circumstances which are calculated to *prevent the development of flukes* within their digestive organs. In other words, the encysted *cercariæ* must be either destroyed or expelled the system of the sheep before as perfected distomata they find their way into the biliary ducts. Prevention rests on this foundation alone, when the animals are so located that encysted *cercariæ* are day by day conveyed with the food into their stomachs.

Another and equally sure way of preventing the disease is doubtless to keep the sheep in those situations where, from the nature or improved condition of the soil, these penultimate forms of the fluke have no existence. This, however, cannot be done in many districts, especially in particular seasons; for example, as the summer of 1860. So rife was rot in this year, in consequence of the excessive rainfall, that sheep took the disease on many farms where it had had no existence for a very long time before. Thus we see that in some localities rot is always to be met with, while in others it is only an occasional visitant. It persists in wet and undrained, or it may be in badly-drained land, independent of the state of the weather, becoming, of course, augmented in severity and more rapid in its progress in wet years than in dry.

The improvements which are gradually, but far too slowly, being made by *complete* under-draining will do more on many farms *to prevent* rot than the driest season does now *to retard its progress*, while on certain other farms it will *exterminate* the malady. In this respect under-draining becomes a national question, without reference to any other point, and if the wealth of the country is to be maintained and food preserved to the people, every facility must be given to the effectual removal of all surface-water from our cold, retentive soils. Water must be made to percolate these soils, and yield the nutritive materials it holds in solution to the growing plants, instead of being left as now to stagnate on the surface—weakening vegetation, rotting sheep, and producing rheumatism and ague among our fellow-men.

We speak from long experience in this matter, and also from the woful effects we have observed to attend the want of under-draining in the neighbourhood in which we dwell. The grass-lands of Middlesex, in the so-called Harrow district, the surface soil of which rests immediately on the London clay, are immensely lessened in value from this cause. Here *rot persists*, and here, as a consequence, instead of finding the meadows stocked with large and profitable sheep as meat-producing and wool-growing animals, we see them occupied with Welch and other mountain-

breeds of little or no worth. The grass on two-thirds of many of these farms has also no feeding properties whatever. The hay-making system contributes to the continuance of this sad state of things, and ever must while the produce of six or seven acres is annually carted off the farm into London to bring back manure enough for one.

Let these farms, however, be effectually under-drained, let the impoverished meadows be moderately limed to begin with, let them be subsequently dressed with well-selected artificial manure —and thus made fit for the keeping of better sheep and for the profitable feeding of them with cake and corn—and soon the whole district will wear an altered appearance, and rot be almost unknown.

We cite this condition of a neighbourhood with which we are most familiar, as an example only of what we daily see in our professional travels, and it is not too much to say that were good drainage generally adopted thousands of sheep whose lives are yearly sacrificed to rot and other diseases would be saved to the benefit of the community.

Parkinson has a case so much to the point that we transcribe it. He says :—

"The very farm on which I was born, at Abey Grange, Lincolnshire, was deemed so rotten that the oldest inhabitants advised my father, when he took it, not to keep sheep, but to breed horses and cattle. The greatest portion was a poor, sour, hungry clay, so tenacious as to hold water in most parts like lead ; but when drained properly with open drains, I question if there was a sounder farm in the kingdom. I acted as shepherd four years, and as we killed our own mutton, I officiated as butcher during that time, and also for four years after, but do not remember seeing a single fluke in any one liver. Even during the year when nearly all the sheep in the neighbourhood were rotten, my father lost but seven out of about four hundred on that farm. Therefore it appears certain, that were lands properly drained, they would seldom produce the rot in sheep ; for though water of itself will not occasion the disease, yet on over-moist lands something is bred that will."

It will be observed that Parkinson alludes to open drains, a system now rightly exploded. The allusion, however, is valuable, because if by so imperfect a plan of drainage much benefit was produced, none can doubt that, by a more perfect system, the gain would be far greater to the occupier. In another place we are told that these open drains were often made 2 feet wide and 14 inches deep, so that the loss of land alone must have been considerable.

We may now pass to the other grand principle in preventing this disease, *namely*, that of destroying the immature forms of the fluke after they have entered the stomachs of the sheep. This brings us again to the question of the administration of salt as an effectual agent for this purpose. Its combination with sulphate of iron and aniseed will materially increase its prophylactic

power. Indeed no better medicinal compound for this purpose can be employed than the one named by us when speaking of the treatment of the disease. The daily use of this will not only arrest the last metamorphosis of the *cercariæ*, but destroy the early hatched distomata, and thus remove the cause of the malady. The rules for the exhibition of the medicated food must, however, be modified, as the object sought is somewhat different.

It is almost impossible to reckon upon the time the compound may have to be employed, and therefore care should be taken that no ill effects follow its long-continued use. In a wet year, like 1860, it may be found requisite to commence its use early in June, if not in May, and to continue it to the end of October. Under such circumstances, however, if a moderate quantity only is daily allowed, no possible harm can arise from the medical agents. To meet a difficulty of this kind we would, however, alter the proportion of the medicine to that of the nitrogenised food, by adding to the two bushels of linseed-cake and pea-meal two more bushels of corn. We should prefer *one of crushed oats and another of crushed maize*, to both being of the same kind. Either is good food for sheep, but a mixture of them is better. The relative proportion of the salt and of the other ingredients is thus reduced one-half, thereby enabling the agriculturist to vary the amount of the medicine according to circumstances, but always securing the exhibition of some of it by giving from half a pint to a pint daily of the food-compound, divided or not into two feeds. Provision also is thus made for the nutrition of the animals when the grasses have lost much of their quality, as they invariably have when surcharged with moisture.

A difficulty frequently exists in getting sheep to eat "manger food," especially if mixed with hay-chaff, when the animals are on the pastures during the summer, but this is not insurmountable. Every farm yields at this period of the year some green food, such as tares, clover, Italian rye-grass, &c., a small quantity of which can be daily cut into chaff, with a proportion of hay, for mixing with the other food. Judicious management will surmount every little obstacle, and the result be an ample reward for the care and attention which has been bestowed. If the system be properly carried out we should have little fear of the occurrence of rot, even in the most unpropitious seasons or on land proverbially bad for sheep.

It will be seen that the quantity of salt we have named is much below that which is ordinarily used. No doubt a larger amount may be safely employed, but in our opinion its prophylactic power depends more on its long-continued use than on the largeness of its quantity for a time. A change of weather may call for its complete withdrawal, but, on the contrary, it

may have to be continued throughout the entire summer and autumn. The fondness of animals for salt will lead them to partake readily of an amount which may under certain circumstances be productive of considerable mischief. We would therefore put agriculturists on their guard respecting an abuse of this valuable agent.

Very recently we investigated a case where a number of ewes began suddenly to "cast their lambs" about three weeks before the time of parturition, all of which were dead. The most searching examination into the circumstances of their feeding and management failed at first to throw light on the cause. No objection could be taken to the condition of the animals, their apparent state of health, or to the quality or quantity of their food. Observing, however, at a subsequent date, some of their fæculent matter to be softer and larger in amount than ordinary, and also to contain a little *blood-coloured mucus*, we at once suspected some cause of intestinal irritation, and made a remark accordingly. This drew from the shepherd the expression, "I don't think they are right in their insides, for they drink so much." A clue was obtained; further questioning brought out the fact that several "double handfuls" of salt had been given twice a day with their food for many weeks. We took no objection to this, but requested the shepherd to bring one of the "double handfuls" of which he spoke. This done, we weighed it, and on calculating the quantity, found it to exceed three-fourths of an ounce daily to each sheep.

It immediately occurred to us that the blood of the ewes was so saturated with salt that it was unfitted for the continuance of the life of their lambs, and hence the cause of the premature labours. We forbad entirely the further employment of salt, making no other alteration with reference to the food or management of the animals. As was to be expected, the ewes continued to bring dead lambs for about a fortnight afterwards, when a living one was born. This was followed by others, with an occasional dead one in a state of decomposition from long retention. But the evil was checked, the cause was removed, and the rest of the flock subsequently brought forth an average number of healthy living lambs.

We need add little more respecting the employment of salt in the prevention of rot, except to take objection to the suggestions which have been made to sow it on the land, with a view of destroying the *cercariæ*. If one application of it in a year would do this, even should the herbage suffer for a time, we, perhaps, should not be found to dissent from the practice. But when we remember that the natural history of the *Distoma hepaticum* reveals the fact that brood after brood of *cercariæ* is being produced from ova, cast daily out of the bodies of rotten sheep,

and that the hatching process therefore goes regularly on week by week, we see the necessity for frequent repetitions of salt in the same year, which could not fail to be highly injurious to the pasturage, and also to the soil of the retentive clays, where rot prevails. Repeated small dressings of lime we can conceive to be nearly, if not quite, as efficacious as those of salt in destroying *cercariæ*, and these would stimulate a growth of the better grasses, besides proving of permanent benefit to the soil.

Our province, perhaps, is more with the science of medicine in the treatment and prevention of disease, than with the science or practice of agriculture; but unless some knowledge of the latter accompanies the former, the veterinary pathologist will often fail in detecting the causes of disease, and therefore in rightly suggesting preventive measures. The fundamental principles of preventing the rot of sheep consist, as has been explained, in the destruction of the liver-fluke in one or other of the several stages of its development from the egg to the perfect entozoon, and as an adjuvant to this, the science and practice of agriculture must be brought to bear. Veterinary medicine and agriculture are kindred sciences, and the closer their union, the greater will be the advantage derived by each.

We must not, however, be drawn aside by descanting on an inviting theme of this kind, but rather conclude our exposition of the disease we have been investigating by remarking, that if we would save our sheep from rot, we must thoroughly underdrain our wet lands, and improve the condition of the soil and the quality of the herbage; that we must well protect our sheep in seasons of excessive rainfall; that we must provide for their nutrition by supplying them with a rich and generous diet—flesh-forming and heat-supporting—in proportion to the demands made on the system, and lastly, that we must exhibit those medicinal agents which experience has shown will effect the destruction of the liver-fluke in the earlier stages of its existence, and prior to its entrance into the biliary ducts. These means must be begun early, and not too hastily laid aside. Most of them have also a general application in providing for the well-being of the flock.

Rightly may it be said with the poet of Mantua:—

> "On winter seas we fewer storms behold,
> Than foul diseases, that infect the fold;
> Nor do those ills on single bodies prey,
> But oft'ner bring the nation to decay,
> And sweep the present stock and future hope away." *

* Dryden's translation.

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