THE GROUSE

IN HEALTH AND IN DISEASE

With 21 full-page plates, mostly in colour, and numerous text illustrations.

Frontispiece.
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PAIR OF RED GROUSE IN SUMMER WITH YOUNG CHICKS.

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THE GROUSE IN HEALTH AND IN DISEASE

BEING THE POPULAR EDITION OF THE REPORT OF THE COMMITTEE OF INQUIRY ON GROUSE DISEASE

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DEDICATED

TO

THE GAMEKEEPERS ON THE GROUSE MOORS

OF GREAT BRITAIN

PREFACE TO POPULAR EDITION

The present volume is an attempt to give, in an abridged and popular form, the results of the recent inquiry into "Grouse Disease," which were published last year in the Report of the Grouse Disease Committee.

The need for a second and shortened edition of the Report became evident soon after the first edition had been published, for the whole of this first edition was absorbed within a few weeks of its publication, and, although the price was considerable, there would have been little difficulty in finding purchasers for at least double the number of copies available.

It is impossible to reproduce the second edition on the same scale as the original Report, for the greater number of the coloured plates, which formed part of the work, have now been removed from the lithographer's stones. It is also felt that those who ordered copies of the work, on the assumption that the original edition would be limited in number, are entitled to expect that this understanding would be respected, and that any subsequent publication of the results of the inquiry would not be a mere republication of the original Report. The Committee have, therefore, decided that a popular work in an abridged form should be issued. Such a volume cannot include all the elaborate coloured plates and scientific details which gave to the original edition much of its special value.

The Committee have come the more willingly to this decision in view of the widely expressed desire that its conclusions should be made available to a larger class of reader than would readily purchase the more expensive and detailed work. Many gamekeepers and their masters, while deeply interested in the objects of the inquiry, are naturally not familiar with pathological science, and cannot be expected to follow the technical details necessary to show how each conclusion is arrived at; indeed, such technical details might in many cases fatigue the mind and might deprive the book of its interest to the general reader. It has, therefore, been decided to leave out certain of the purely scientific portions of the original Report, and only to refer to such pathological details as are necessary for the proper appreciation of the conclusions to which they have led. It is without apology that the authors have omitted the long lists of specimens examined, the lists of subscribers and local correspondents to the Committee, the notes on experiments and the inventories of the contents of crops and gizzards. All these details have been recorded in the original Report for those who wish to refer to them, but they are out of place in the present volume.

Many chapters in the original Report have been condensed or transposed so as to simplify and shorten the book. Chap. i., on "The Systematic Position of the Grouse," has been incorporated with Chap. ii. into a chapter entitled "The Classification and Life History of the Grouse." Chap. iii., on the plumage of the Grouse, Chap. iv., on the food of the Grouse, and Chap. v., on the "Physiology and Anatomy of the Grouse," have been shortened. Chap. vi., on "The Weight of Grouse," has been omitted, but such portions of it as are necessary for the proper comprehension of the chapters on Life History and Grouse Disease respectively have been embodied in the chapters dealing with those subjects. In Part II., which deals with the diseases of Grouse, Chaps. vii. and viii., on "Causes of Mortality," have been combined into one chapter; Chap. ix., on "Grouse Disease," has been shortened by the omission of much of the detail of past controversy on the subject. The first part of Chap. x., dealing with the threadworms of Grouse, has been combined with Chap. xiv., on the Parasitic Protozoa, Chap. xv., on the Tapeworm, and Chap. xvi., on the Ectoparasites, into a chapter dealing briefly with all the Parasites and Protozoa of Grouse other than those which are directly responsible for "Grouse Disease." The subject of "Grouse Disease" proper is dealt with in the original Report under the headings of Chap. x., Strongylosis, and xi., Coccidiosis, and these two chapters are again published in an abbreviated form in the present volume. Chap. xii., on Pathology, and Chap. xiii., on the Blood of Grouse, are omitted, but reference to these subjects is made in some of the other chapters of the book.

It will be seen that Part II. of the original Report has suffered very considerable reduction, but this is quite in accordance with the intention already expressed of making this book a practical guide to sportsmen and naturalists rather than a specialised study of the diseases of Grouse. With the same object, a special chapter has been added, in which an attempt is made to show how far the observations in the laboratory have been confirmed by observations on the moor, and though it is not claimed that this department of the investigations is complete, the chapter may indicate the lines on which future investigations may proceed.

Part III., which deals chiefly with the management of Grouse moors, is of direct practical interest to moor-owners, and has been reprinted almost without alteration.

As already stated, the lists and inventories which compose a great part of the Appendix to the original Report, are omitted, and the only other subjects dealt with in the Appendix are incorporated in Part II. of the present edition.

Owing to the manner in which the work of separate writers has often been combined in the same chapter, it would be invidious to ascribe each chapter to the authorship of one or other of the Committee's Staff, but it may be of interest to give the names of those who are principally responsible for the departments into which the subject has been subdivided.

In Part I. the subject of Life History has been dealt with by Mr Leslie, the Secretary of the Committee, aided by Mr A. H. Evans, Mr E. A. Wilson, and the local correspondents of the Committee. The chapters on Plumage and Food are almost entirely the work of Mr E. A. Wilson, with notes on Insect Food by Mr P. H. Grimshaw, Grit by Dr H. Hammond Smith, and Mr R. H. Rastall, and Water by Mr Leslie.

In Part II. Mr E. A. Wilson is chiefly responsible for the chapter on Causes of Mortality, and the chapter on "Grouse Disease" is written by him and Mr Leslie. The chapter on Ectoparasites and Endoparasites is written by Dr A. E. Shipley, who also, in conjunction with Dr R. T. Leiper, wrote the chapter on Strongylosis. The chapter on Coccidiosis is the work of Dr H. B. Fantham, and throughout this part frequent reference is made to the chapter on Pathology by Dr Louis Cobbett, and Dr G. S .Graham Smith, which appeared in the original Report.

Part III., dealing with the question of Moor Management, Heather-burning, Keepers, Stock and Grouse Driving, are almost entirely the work of Lord Lovat, the Chairman of the Committee, assisted by the Secretary and other members of the Committee. The subject of the Heather Beetle is dealt with by Mr Grimshaw, and Grouse in Captivity by Dr Hammond Smith.

The Editors have to acknowledge their indebtedness to the Zoological Society of London for their permission to include in this edition a selection of the plates representing the plumage of the Grouse which were prepared for the Committee by Mr E. A. Wilson and were first published in the Proceedings of the Society. They have also to thank Mr William Berry and Mr Edward M. Murray for their valuable assistance in preparing this volume for the press.

A. S. LESLIE.

July 1912.

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INTRODUCTION

The importance of Grouse and Grouse Shooting not only as a form of sport and profit, but also as a means of support to a rural population has long been recognised.

Grouse shooting is, of all forms of sport, the most profitable to the general population; it causes little clashing of interests between the sportsman and the pastoral or agricultural tenant, while the policy to be adopted for the scientific management of moorland is equally beneficial to both. It produces a maximum of profit to the wage earner with the minimum of waste, an otherwise unproductive subject is converted into a source of profit, and districts which but for the Grouse would be uninhabited, except by a solitary shepherd, are occupied by shooting tenants and the men employed by them, and the tenure of many small and otherwise uneconomic agricultural holdings is thereby rendered possible.

In connection with all moorland sport one point stands out prominently—the land which is suitable for Grouse is not well adapted for anything else except sheep and cattle. But the pastoral value is in no way impaired by the presence of Grouse, for Grouse and sheep are found to flourish together on the same hillside; indeed the flockmaster is often under obligations to the sportsman for the labour which the latter expends upon the burning and draining of the moor.

It has been stated that land which is at present given up to Grouse might profitably be reclaimed and utilised for agriculture. Experiments have often been made. In the county of Sutherland alone over 100,000 acres were apportioned among an industrious class of agricultural tenants with a view to being brought under cultivation ; but the experiment was a failure, and the land gradually reverted to its former state.

The best Grouse ground, that is ground that grows nothing but heather, is always of a poor peaty nature, and is incapable of growing crops to advantage. In this respect it differs from the green land where the soil is rich enough to grow grass and bracken ; this green land is of little value for Grouse, but might with advantage be planted with trees or even crops. It is probably true to say that in the selection of waste land for cultivation good Grouse ground is the last that would be chosen by practical agriculturalists.

The value of Grouse Shootings to the proprietor is represented by the shooting rents which they produce after deduction of the expenses of management. Grouse rents have been steadily rising for many years past, and at present show no signs of falling off. This is scarcely to be wondered at when we take into account the limited number of Grouse moors available to meet the increasing demand. The popularity of this form of sport has indeed increased so much that it is now extremely difficult to secure a first-class Grouse moor on any terms, and even the smaller shootings seldom remain unlet. As might be expected, rents have tended to rise. Not many years ago £1 per brace was regarded as the normal rent to pay for a Grouse moor, now this rate is practically doubled in the more favoured districts.

While it is clear from the foregoing remarks that the ownership of Grouse moors may be profitable to the proprietor, it is not the owners alone who benefit from this important source of revenue.

It has been estimated that the approximate value of the Grouse moors in Scotland is about £1,000,000 a year in gross rent, and in England not less than £270,000. It has been further estimated that the foregoing gross rent may be apportioned roughly as follows :—

Net profit to the proprietor about 34 per cent.

Wages to the permanent staff about 35 per cent.

Cost of upkeep, interest on capital expenditure, value of gamekeepers' houses, wear and tear, rates and taxes, etc., about 31 per cent.

The result in actual figures would therefore be —

Profit	£431,800.
Wages	444,500.
Cost	393,700.

Apart from the direct profits derived from shooting rents, Grouse Shooting also produces a large amount of indirect profit to the community. This indirect profit consists mainly of wages for temporary assistants, such as drivers, ghillies, pony men, and dog men—traffic in household supplies, sporting requisites, hiring, carting, etc., and outlay on building, equipping, and maintaining shooting lodges. These indirect profits cannot be very exactly stated, but a fair estimate of their amount may be obtained when it is stated that it is the combined experience of shooting tenants that for every £1 spent in rent from 15s. to £1 is spent on other expenses connected with the undertaking.

In spite of the favourable conditions referred to it seems unlikely that the rent per brace will continue to rise indefinitely, and moor owners have recognised that the best method of profiting by the present active demand is to develop the capacity of their moors so as to give as large and as steady a yield as possible. That this object can be achieved has been proved by the example of a few well-known moors, where the average yield has been increased by many hundreds per cent. as a result of judicious management. In the majority of cases, however, little progress has been made in this direction. The proprietor often has not the leisure to devote to moor management, sometimes he has not the necessary knowledge, and very frequently his executive staff is insufficiently trained for the purpose.

Another factor which has greatly hampered the owners' efforts to improve the yield of their moors is the constant recurrence of epidemics of mortality, more or less severe, among the Grouse stocks; this mortality always tends to break out wherever the stock has become unusually large, and its effect has been to produce a set-back in the bags just as they begin to show marked improvement. This mortality was found to be so prejudicial to the satisfactory development of Grouse moors that in 1904 a number of representative moor owners asked for an official inquiry into the causes of "Grouse Disease," and the methods to be adopted for its prevention. The outcome of their representations was the appointment of a Committee of the Board of Agriculture and Fisheries. This Committee carried on their investigations for a period of six years, and published the results in a Final Report, which appeared in the autumn of 1911. The present volume attempts to give the main findings of the Committee in an abbreviated form, and it is hoped that it may prove to be a useful handbook to those who have not an opportunity of referring to the original Report.

LOVAT.

THE GROUSE IN HEALTH AND IN DISEASE

PART I.—THE GROUSE IN HEALTH

CHAPTER I

THE CLASSIFICATION AND LIFE HISTORY OF THE GROUSE

The name Grouse.

THE name Grouse, in the form "Grows," has been traced back by Salusbury Brereton to the reign of Henry VIII. (1531), and in its present form to 1603. But, since it first occurs in an ordinance for the regulation of the Royal Household at Eltham in Kent, it ought in all probability to be applied to the Black Grouse which may then have inhabited that county, though no actual record has yet been discovered. Further particulars are given by Professor Newton in his "Dictionary of Birds." [1] The appellation has, however, by universal consent been long transferred to the Red Grouse, the Moorfowl of our forefathers, and when standing alone would never now be understood otherwise.

Distribution.

This species is the most characteristic bird of the Scottish moorlands, including the Hebrides and the Orkneys, and is plentiful thence to the northern counties of England; in few

[1] A. Newton, "Dictionary of Birds," p. 388. London: A. and C. Black, 1893-1896.

places is it more numerous than on the moors of South Yorkshire and Derbyshire in the vicinity of Sheffield; while to the west it not only occurs in decreasing numbers to Shropshire, but is found in Wales as far south as Glamorganshire, and in Ireland in most suitable localities. Attempts have been made to acclimatise it to the north and south of its proper range; but the few pairs turned down in Shetland between 1858 and 1883, with a greater number in 1901, have never thriven, while their descendants are apparently extinct, and the same may be said of those introduced into Surrey, Norfolk, and elsewhere, with three exceptions. The first instance is that noticed by Professor Newton in his "Dictionary of Birds,"[1] where it is stated that Baron Dickson succeeded in acclimatising the species near Gottenburg in Sweden; the second is that of its introduction in 1893-1894 to the Hohe Venn, a high tract of moorland on the borders of Belgium and Germany, south of Spa, where Red Grouse are still thriving; and the third the successful experiment on Lord Iveagh's property at Icklingham in Suffolk in 1903, where the birds, despite the necessity of an artificial water supply on the dry, sandy heaths, had increased in 1909, and appeared likely in 1910 to form a permanent colony. In the Hohe Venn district after two failures fifty pairs or more were liberated in August 1894, and by 1901 had increased to about a thousand head in spite of regular shooting. Professor Somerville of Oxford, who has kindly furnished particulars, saw the birds there in September 1910.

Classification.

The Red Grouse of Britain belongs to *Lagopus*, the only genus of Grouse common to both hemispheres in which even the digits are feathered. This genus contains six well-defined species: the Spitsbergen Ptarmigan (*L. hemileucurus*) and the Rocky Mountain Ptarmigan (*L. leucurus*)—only found in the regions after which they are named—the Ptarmigan of Scotland and the mountains of the Palæarctic area (*L. mutus*), the "Iceland" Ptarmigan of that island, Greenland and the lower grounds of Northern Siberia and Arctic America (*L. rupestris*), the Willow

[1] "Dictionary of Birds," p. 389.

Grouse of the north of Europe, Asia, and America (*L. albus*), and the British bird (*L. scoticus*)—with which alone we are concerned—indigenous in no other country.

All the forms of the genus *Lagopus* are anatomically identical, but the Red Grouse differs from the remaining members in that it does not turn white in winter. It has been thought to be merely the British representative of the Willow Grouse, though it differs from that species even in its summer plumage, and never possesses white wing-quills. It varies considerably in coloration, as will be seen from the following quotation from "The Cambridge Natural History." "The male in both summer and winter is more or less chestnut-brown above, with black markings and a reddish head; the lower parts are similar, but are usually spotted with white. In autumn the brown of the upper parts becomes buff and the lower surface is barred with buff and black. Mr Ogilvie-Grant recognises three types of plumage in the male, a red form with no white spots from Ireland and Western Scotland, a blackish variety comparatively rarely found, and another largely spotted with white below or even above. Intermediate specimens constitute the bulk of our birds. The female exhibits, moreover, a buff-spotted and a buff-barred form, but in summer she is typically black above with concentric buff markings, and buff below with black bars. Her autumn plumage, which continues throughout the winter, is black, spotted with buff and barred with rufous."[1] Mr Ogilvie-Grant has recently published in the "Bulletin of the British Ornithologists' Club"[2] an elaborate account of the changes of plumage undergone by the Red Grouse, and of the points wherein he differs from Mr Millais and Mr Wilson; but this is not the place to enter into controversial matters, and our readers must form their own opinions on the subject.[3] Various reasons have been suggested for the absence of a white winter plumage in the British bird;

Plumage.

[1] "Cambridge Natural History," vol. ix., *Birds*, p. 338. Cambridge, 1899.

[2] "British Ornithologists' Club," vol. xxii. p. 122. London, 1910.

[3] *Vide* also chap. ii. pp. 42 *et seq.*

for these reference may be made to the late Professor Newton's "Dictionary of Birds."[1]

Pairing.

No precise date can be given at which Grouse begin to pair, for this depends more upon the climatic conditions than upon anything else. In a mild winter Grouse will pair as early as December or January; but if, after they are paired, the weather becomes rough and stormy, they will again congregate in packs, even after the usual date of nesting has arrived.

The time at which they select their nesting ground (March and April) is also, to a limited extent, influenced by climatic conditions. On high moors, where the snow lies in late seasons till far into spring, it sometimes happens that during the whole winter, and even up to the month of April, there is hardly a bird upon the hill, the whole stock being congregated on the lower-lying moors where there is "black ground" on which food can be obtained. In such seasons it is interesting to observe the return of the stock to the higher parts as soon as the snow begins to melt. As a rule the birds do not pair upon the low ground, but congregate in packs upon the edge of the snow, waiting for an opportunity of returning to breed on their native hill. A good example of this was furnished in the spring of 1908 on a high-lying moor in Inverness-shire. During the preceding winter there had been a heavy fall of snow which lay for many months on the higher ranges, and drove the Grouse down in vast numbers to the lower levels. On the moor referred to there was not a Grouse to be seen until the snow began to melt about the end of April. But at the first sign of thaw the stock began to return, and as each patch of bare ground came into sight a pair of birds arrived as if guided by instinct and commenced to nest. That year the shooting season turned out to be a record one, for upwards of five thousand brace were killed upon an area of 20,000 acres, and many more might have been shot without unduly reducing the stock.

While heavy snow during the winter may do little harm though it lies till far into the spring, a loss of stock may result

[1] "Dictionary of Birds," p. 391.

where the fall occurs after the birds have returned to their nesting ground on the higher ranges. This occurred on a moor in Ross-shire in the year 1909, when a correspondent of the Committee reports as follows: "A heavy snowfall on April 24th put all the birds down to 'black ground.' They never went back to nest, and consequently the high ground, *i.e.*, over 500 ft., was a failure, and the low ground better than usual." Again, a correspondent in West Perthshire writes:—"In spring, when the breeding season is approaching, a heavy snowstorm of some duration has on several occasions caused a most serious loss of stock, amounting to as much as half or more of the whole number of birds. After such a spring snowstorm and migration, large numbers of Grouse undoubtedly remain to breed on low and favourable moors within, say, ten or fifteen miles. These low moors are very heavily shot every year, but there is a constant migration of Grouse to them, both from overstocked moors, and from the high moors affected by snow." This is corroborated by a correspondent in the south of Scotland, who says: "I have an idea that if birds are forced to leave their usual ground (in spring), through deep untrodden snow, a good number may remain away and not return to their former ground."

The subject of migration is more fully dealt with in another part of this chapter.[1]

During the mating season the pugnacity of the cock Grouse is well known, and in captivity the cocks have to be kept separate at this period, or disaster will certainly occur. Under natural conditions the fights seldom end fatally; but it is certain that the presence of a quarrelsome cock-bird in search of a mate seriously interferes with the pairing of the other birds in the vicinity. Observation in the field goes to prove that old cocks are more pugnacious than young ones, and as they are less valuable for breeding purposes, the object of every moor-owner is to reduce the number of old cocks by every means in his power.

[1] *See* pp. 29-32.

Nesting.

The nest, a slight hollow scratched in the ground and lined with a scanty layer of grass, heather, etc., is usually placed on the sunny side of a tuft of heather, and preference as regards its site seems to be given to an area on which the heather is moderately well grown rather than where it is rank. Birds will always nest in a place where they can see all round, if possible, hence their avoidance of long heather.[1]

Dry ground is always preferred; birds will not nest on boggy or damp ground, and are more likely to leave their nests on account of wet than for any other reason.

On some moors where the heather has been very closely burnt or the stock is unusually large, the Grouse appear to be unable to find nesting ground exactly suited to their requirements, and on these occasions they will boldly depart from their usual habits and will nest in short heather, flat dead bracken, or even on a bare unsheltered piece of burnt ground, leaving the nest as open as that of the Lapwing. It is important to note that in all cases open sites devoid of all covering are preferred to really long overgrown heather.

The time of nesting varies according to the season and the latitude. As a rule most of the eggs are laid by the latter end of April and the beginning of May; but a case has been reported of eggs being found as early as March 28th, and the Rev. W. B. Daniel records that "on the 5th of March, 1794, the Gamekeeper of Mr Lister (now Lord Ribblesdale), of Gisburne Park, discovered on the Manor of *Twitten*, near *Pendle Hill*, a brood of Red Grous seemingly about ten days old, which could fly about as many yards at a time. This was an occurrence never known to have happened before so *early* in the year."[2] Macdonald

[1] Macdonald in "Grouse Disease," makes the following statement: "The happiest condition in which a nest can be found is in growing heather of about a foot in length, and in the immediate proximity of short young heather." (Macdonald "Grouse Disease," p. 23. London: W. H. Allen & Co., Ltd., 1883.) And in another place he writes: "Grouse never nest amongst old, rough heather, always in a little tuft at the side or among the bent." (*Ibid.*, p. 26.) Macpherson, in the Fur and Feather Series, states that "It is a fallacy to suppose that Grouse like to nest in *very* old heather." (Fur and Feather Series, "The Grouse," p. 22. London: Longmans, Green & Co., 1894.)

[2] Daniel, "Rural Sports," vol. iii., p. 108. London: Longmans, 1812.

states that the hen begins to lay at the end of March,[1] while Macpherson, writing in the Fur and Feather series, says that "In the Island of Skye April 24th is a decidedly early date for a full clutch of Grouse eggs."[2] It is an interesting fact that, from the evidence obtained from many moors, of varying altitudes ranging from the south of Wales to the north of Sutherland, there is a difference of only two or three days in the dates when the earliest eggs are found; March 30th in Yorkshire and Perthshire, and April 1st on high moors in Inverness and Sutherland are dates frequently recorded for the first nest. The date at which the first clutch is completed varies by a full fortnight on high and low ground and on north country and south country moors. In Yorkshire by the end of April many birds have begun to sit, while in central Scotland from April 25th to May 20th would probably cover the dates by which the full clutches are complete on most moors. The intervals between the laying of each egg vary greatly in captivity, probably also in nature, depending upon the weather; for example, at the Committee's observation area in Surrey it was noted that one hen took twenty-nine days to lay ten eggs—an average of one egg every three days; another laid only four eggs in twenty-six days, or an average of one egg every six and a half days.

Eggs.

The clutch varies from seven to ten, and rarely reaches twelve. Macdonald states that the hen lays eight to fourteen or sixteen eggs,[3] while Macpherson gives seven and eight as the most usual number of eggs, and states that "more than ten is quite exceptional."[4] Seebohm, who speaks with authority on all questions of British oölogy, states that the number of eggs laid would seem "to vary with the propitiousness or otherwise of the season. In very wet and cold springs the smallest clutches contain four or five, and the largest eight or nine; whilst in very favourable seasons the small clutches are six

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[1] "Grouse Disease," p. 99.
[2] Fur and Feather Series, "The Grouse," p. 21.
[3] Macdonald, "Grouse Disease," p. 99.
[4] Fur and Feather Series, "The Grouse," p. 22.

or seven, and the larger ones from ten to twelve, or even fifteen and seventeen; but in the latter cases it is probable that the eggs may not all be the produce of one bird. In an average year most nests will contain seven or eight eggs. Birds which breed late on the high grounds do not seem to lay fewer eggs than those which breed early in the more sheltered situations."[1] A correspondent of the Committee in Forfarshire has reported a case of two Grouse hens sitting side by side—each on six eggs in a double nest; and the Committee's field observer has seen two hens sitting on one nest with twelve eggs.

For the following descriptive notes on the eggs of the Red Grouse in his "Birds of Europe," Dresser states that he is indebted to Seebohm: "The ground colour of the eggs of the Grouse is usually a pale olive, spotted and blotched all over with dark red-brown. The spots are frequently so confluent as almost entirely to conceal the ground colour. In fresh-laid eggs the brown is often very red, in some instances almost approaching crimson. It appears to darken as it thoroughly dries, and sometimes almost approaches black. When fresh laid the colour is not very fast, and before the eggs are hatched the beauty of the original colouring is generally very much lessened by large spots coming off altogether, no doubt from the friction of the feathers of the bird when sitting. If the weather is wet when the bird begins to sit this is much more the case. When the colour has once become thoroughly dry it will bear washing in water without injury."[2] In his most recent work Mr Dresser adds: "When blown and kept for some time, the ground colour fades to buffy white, and the spots and blotches darken in some cases to blackest brown. Those in (Mr Dresser's) collection measure from 1·60 by 1·14 to 1·82 by 1·32 inches. Mr Jourdain gives the average measure-

[1] Seebohm, "British Birds," vol. ii., p. 430. London: R. H. Porter, 1885.

[2] Dresser, "Birds of Europe," vol. vii., p. 170. London: published by the author 1871-1881.

ment of thirty-six eggs as 45·56 by 31·8 mm., and the average weight of eight eggs as 1·845 g."[1]

There is no truth in the belief that disease will follow if the eggs are not well coloured. Very often the uncoloured part of the egg whitens at the same time as the coloured part fades or is washed off, thus making an egg of "bad colour."

It is interesting to note that a bird of five years old lays fewer eggs and of a smaller size than a bird of one or two years old.

The net yield of the nesting season greatly depends upon the weather in spring; frost before sitting, snow after hatching, heavy rain following a drought when the birds have nested in low-lying ground liable to submersion, are some of the principal dangers to which early broods are exposed. The eggs also may be lost by a long spell of wet weather, even up to the point of hatching. This is probably not a matter of common occurrence, but in the spring of 1906 the Committee's field observer saw nest after nest deserted owing to rain. The nests on the low ground fared worst; in some the eggs did not hatch at all, in others only one half, or even fewer, were productive.

Nesting in snow.

The parent birds seem to defy the elements at all times, and during the period of incubation the hen will continue to sit upon her eggs apparently oblivious of the fact that a snow-storm is raging which has driven every other living creature off the moor. During such a storm hens are sometimes completely covered with snow as they sit upon the nest, for in hard weather instinct teaches them not to desert the post of duty. Observation of the bird at these times is difficult, for even the most enthusiastic naturalist is not often tempted to explore the higher ranges of the ground in the face of a blinding blizzard. We must to some extent form our conclusions by observation of after-results, and certainly there is little doubt that the effect

[1] Dresser's "Eggs of the Birds of Europe," p. 623, Pl. LXVII., Fig. 1. London: published for the author at the Office of the Royal Society for the Protection of Birds, 3 Hanover Square, 1905-1910.

of a heavy snowfall while the birds are sitting does not appear to produce the number of unhatched clutches of weather-bleached eggs which might be expected. Sometimes, no doubt, matters reach the limit of endurance when, urged by the pangs of hunger, the hen is forced to wander away in search of food and grit, and on her return finds all trace of her nest buried beneath a smooth, white drift. Even in this case all is not lost; the snow fortunately does not lie long in the months of April and May, and in due time she recovers her nest and resumes her domestic duties. It is recorded that in 1908, on a Midlothian moor, a heavy snowfall during laying-time covered the nests to a depth of 9 inches for a period of ten days; many eggs were lost, some even being laid on the top of the snow; in many cases the hen bird returned to her nest after the snow had gone and laid more eggs beside those which had been covered—some of these birds hatched out every egg. Other cases have been reported where the eggs were covered with snow for so long that their colouring matter had disappeared, and yet they produced a healthy brood.

Effects of wet.

From observations made upon Grouse in captivity it appears that during the period of incubation the hen will often leave her nest for several days at a time, for no apparent reason, and will return again and hatch out the whole clutch—this power of absenting herself without disaster to her eggs must under natural conditions stand her in good stead when the severity of the weather makes the task of incubation unendurable; but it is only in the earlier part of the sitting season that her absence is unattended with risk, for once circulation has commenced in the embryo chick the eggs must not be allowed to become cold. Only when the hen is forced to leave the nest on account of heavy rain is there a danger of her deserting the nest permanently—three days of incessant wet will suffice for this.

Effects of frost.

Another danger to which the eggs of Grouse are liable is that of being destroyed by frost while the hen bird is off the nest. This danger is greatest during the period before the full clutch has been laid, for after incubation has commenced the hen will not readily leave her nest during frosty weather for any length of time. Before the hen commences to sit she will often cover up the eggs in the nest with twigs of heather, grass and bracken, and this must save many of them from the effects of frost.

The Committee has had an exceptionally good opportunity of studying the effects of frost upon the eggs in the spring of 1908, when an extremely severe frost was reported from every district of England, Scotland and Wales. For three days in the third week of April the thermometer registered from 10 to 27 degrees Fahrenheit. The Committee requested its local correspondents to make careful observations on the resulting damage, and the replies received brought to light several interesting facts. In general it was stated that the effects of the frost had been disastrous ; but when the evidence came to be analysed the proof seemed strangely incomplete for very few reporters were able to state from personal observations that eggs laid before the frost had failed to hatch. On the other hand, several accurate observers reported that they had marked down eggs so frozen into the materials of the nest that it was not possible to lift them out or to separate them from each other, yet it was afterwards found that these eggs hatched out healthy chicks. On April 13th six Grouse eggs were found in a nest amongst heather when the temperature was 25 degrees of frost—and all six hatched out. On another occasion, when it happened that some Pheasant's eggs had been laid in a Grouse's nest, the Pheasant's eggs were the eggs which failed, while the Grouse's eggs were successfully hatched. Many observers went so far as to say that unless the frost was sufficiently severe to split the egg there was no danger of their fertility being affected, and of all the gamekeepers to whom the question was put very few could state that they had actually seen a Grouse's egg split by frost.

Actual splitting of the eggs by frost does occur, but it is exceedingly rare when the nest is in its customary position in heather. When placed in the open probably the eggs are liable to suffer just as Plover's eggs did in 1908, and an extra hard frost will sometimes split them. Even very scanty heather-growth retains the warmer air, and so shelters the nest and eggs from frost and winds. Moreover, if sitting has not begun the eggs are generally more or less buried in the material of the nest, so that they are to a great extent protected.

The effect of frost upon the eggs of Grouse has been fully discussed in the Committee's Report, and an analysis is given of the Reports of nearly 200 observers in different parts of the country.[1] The deductions to be drawn from this analysis, though negative, are nevertheless of considerable interest. They may be summarised as follows :—

1. Frost in the breeding season does not cause universal destruction to eggs.
2. In some cases it seems to do little or no harm, even though severe.
3. In other cases it seems to do more harm even though relatively less severe.
4. The effects of a hard frost in the breeding season are apt to be exaggerated especially if from any other less obvious cause there happens to be a shortage of young birds in the shooting season.

How it happens that eggs in one district seem to be better able to withstand frost than those in other districts must remain a subject for conjecture. Acclimatisation appears a more probable solution than any other, for it is clearly brought out by the Reports that in the more rigorous climates of the north and east the eggs were less effected by frost than in the milder climate of the west. Possibly it may be that in the colder districts instinct teaches the parent birds to take greater precautions, *e.g.*, to nest under the shelter of long heather rather than in open situations. Many cases are recorded of Grouse protecting their eggs from frost by covering them with loose twigs of heather.

[1] *Vide* "The Grouse in Health and in Disease," First Edition, vol. ii., pp. 132-136.

Enough has been said to emphasise the statement that the eggs of the Grouse are wonderfully tolerant of adverse weather conditions; the fact is not sufficiently well recognised, and because occasional losses occur there is a tendency among gamekeepers to put down every failure of stock to some sharp frost or heavy snowfall in the months of April or May. They often do not inquire whether as a matter of fact any eggs were laid at the date when the frost occurred, they seldom support their statement by pointing out nests deserted by the hen after being buried in the snow, they keep the plausible explanation ready for use if required, and if the stock after all proves to be up to the average, they feel secretly rather surprised, but say nothing about the adverse conditions in the breeding season, for the excuse may be required the following spring. Thus much valuable evidence is lost owing to the very natural desire of the gamekeeper to prove himself the innocent victim of circumstances.

Obviously, if the occasional snowstorms and moderate frosts of a normal April were really responsible for the damage so often attributed to them, it would follow that in a really inclement nesting season, such as occurred in 1908, the effects would have been disastrous throughout the length and breadth of the country. As a matter of fact, the bags in the autumn of that year, though unequal, were well up to, and in some places far above the average; and even where a shortage of birds was reported the failure could often be traced to other causes than the unfavourable weather-conditions in the spring.

While the evidence collected does not confirm the view that snow and frost in the nesting season are extensively destructive to the eggs of Grouse, there is some reason to believe that unfavourable weather, occurring immediately before the date of laying, has an injurious effect upon the breeding powers of the parent birds. In the spring of 1908, for example, it was observed that on many moors birds which had paired, and were about to nest, became packed again on the arrival of frost and snow, and postponed their breeding operations until some time after the return of favourable conditions. The result was that they nested several weeks later than they would otherwise have done, and not only were their broods late, but the number of eggs laid was smaller than usual—sometimes averaging only four and five in a nest. The resulting smallness of the coveys was often accounted for by the hypothesis that several eggs in each nest had been destroyed by the frost in April; but there was little direct evidence of this, and it seems equally reasonable to suppose that the power of egg production had been impaired by the enforced postponement of nesting. The data are insufficient to establish this theory, but the point is worthy of a passing mention.

It is certain that some of the eggs are lost owing to their having been dropped on the snow and not in a nest at all. After a certain stage of development the egg is laid wherever the bird happens to be, and it is not uncommon to find eggs dropped in this accidental manner lying on the ground or on snow.

During the nesting season the hen leaves her nest for a short time in the morning and evening to feed and drink, and her presence in any particular part of a moor may be known by the large "clocker" droppings peculiar to a sitting bird.

Loss of scent while sitting.

During the period of sitting the Grouse seems to be able to intermit its natural odour, and thus escape the notice of dogs and vermin. This point is noted by St John in "Wild Sports of the Highlands" when he states: "It is a curious fact, but one which I have often observed, that dogs frequently pass close to the nests of Grouse, Partridges and other game without scenting the hen bird as she sits on her eggs."[1] Probably the cause of the loss of scent is that when the bird is sitting still the air does not get amongst the feathers and so the scent is retained. The same remark probably accounts for the fact that at midday, when the birds are resting, they are very difficult to find with dogs.

Hatching.

The young Grouse are hatched after an incubation of twenty-

[1] St John, "Wild Sports and Natural History of the Highlands," p. 29. London: John Murray, 1878.

three to twenty-four days, and leave the nest soon after they are freed from the shell. They are anxiously guarded by the parents, the hen being more attached to them than the cock, who, when they are disturbed, is the first to fly from danger, though it may be only for a short distance. The hen, on the other hand, will risk any danger rather than leave her brood—be it only a single chicken or two. Often, too, like the Partridge and many other birds, she will feign a broken wing and flutter over the heather, apparently in a terribly damaged condition, until she has lured the intruder away from her brood. This fluttering action of the old bird should always be taken as a warning that the brood is young, that the squatting chicks are probably invisible, and that the danger of treading on them is great. It is most inadvisable when a cock or hen is flushed in the nesting season to walk about to see the size of the brood.

It is at this stage that the weather conditions become important, for the young chicks are liable to many dangers. It is true that they do not suffer from the cold, drizzly, sunless weather which destroys so many coveys of young Partridges, they are too hardy for that; but heavy snow, hail, or rain often takes its toll and leaves little trace behind beyond the fact that the coveys are found to be reduced in numbers when they come to the gun. Probably the half-grown chick runs more risk from weather than when it is newly hatched, for its size prevents it from being completely covered by the hen when cold weather or heavy rain sets in.

The period immediately following hatching, though so critical, is the period regarding which least is known. Few keepers like to disturb the ground at this time, and so the young bird's battle for life is fought unobserved, and only the closest and most patient observation would reveal the true conditions under which the chick's existence is passed.

The young Grouse, even although they may be squatting within a few feet of the observer, are very difficult to find; they seem to have the power of making themselves invisible at will, as they cunningly crouch by the side of a tuft of grass or heather, which often matches in colour the yellow, brown, and chestnut mottled down that covers their little bodies for the first few weeks. When at last a chick is discovered and lifted up in the hand, its first " cheep " is the signal for the others to scuttle away out of their places of concealment, or, if they are upwards of a month old, to make their effort at escape by a short flight, after which they are apparently incapable of a second attempt.

It is astonishing how little accurate knowledge we have of the principal dangers to which the young Grouse is exposed. The practical gamekeeper admits that many dangers exist, and without weighing them too closely in the balance he does all he can to mitigate each of them. He knows, however, that in spite of his care there must be a certain percentage of losses from one cause or another, and it is with some anxiety that he proceeds to the moor towards the end of July to inspect the condition of the stock. The result is sometimes unexpected, often he finds the birds have safely survived the perils of youth, and that the moor is well stocked with unbroken coveys; at other times he is perplexed to discover that the well-filled nests and successful hatchings are represented by a few ragged broods of two or three birds, and a large number of barren pairs. He endeavours to account for the disappearance of the young birds, and in his search for a reason he eventually hits upon something which has some appearance of plausibility, and frequent repetition soon places theory in the realm of established fact.

Migration is one of the commonest theories, and is supported by the fact that few, if any, dead bodies are found on the ground. The migration doctrine presents some difficulties, for the Grouse in its earlier stages is not by nature a wanderer, and a brood is usually found, at all events up to the end of July, not very far from where it was hatched out. Then, again, it is difficult to explain how on a large moor the young birds have departed before they are capable of sustained flight, especially if none of the neighbouring moors have received any noticeable addition to their stock. Lastly, it is permissible to ask how is it that when the young birds emigrated to more congenial surroundings they omitted to take their parents with them? Each of these points presents a difficulty, and the combination of them renders the migration theory untenable as an explanation for the absence of birds at any time up to the beginning of August.

Another favourite theory is that all the young birds have been drowned, and if it so happens that there has been a severe thunderstorm in June the theory becomes a certainty—though not a single drowned chick may have been found on the moor.

There is no doubt that many young Grouse are destroyed by drowning, either as a result of being caught in a drain by a heavy shower, or by the flooding of low-lying ground. It is impossible to estimate the loss occasioned by drowning in sheep drains, owing to the extreme difficulty of detecting the small corpses in the swollen stream. One of the Committee's correspondents, a gamekeeper, who makes it a rule to inspect all the drains upon his ground several times during the nesting season, states that on one occasion only has he found a drowned chick in a drain. This evidence is, of course, only negative, and against it has to be reckoned the fact that many observers have spoken definitely as to the damage arising from this cause. On many moors the sheep drains have been scoured by floods into deep chasms, from which it would be difficult for the chick to emerge on the approach of danger, and any one who has seen a hill drain immediately after heavy rain, when it is running bank high in a miniature torrent, can picture the risk which might attend any attempt on the part of the mother bird to lead her brood over the obstacle. Much may be done to minimise this risk by forming little backwaters in the drains, with shelving banks by which the young Grouse may escape in time of danger. With regard to flooding, it is necessary to speak with more reserve. Flooding is a gradual process, and the instinct of self-preservation, which teaches the young Grouse to hide from his foes, will doubtless also teach him to retreat before the rising waters. In one case, however, flooding is a real menace, for if the nesting season is a dry one Grouse have been known to nest in very unsuitable places, such as the beds of burns and dried-up pools and water-courses—often with disastrous results when the weather breaks.

But, if there has been no rain, the drowning theory must be discarded, and its place is taken by the drought theory; in other words, the fine, dry, warm, sunny weather which is credited with producing a healthy stock in a good year is the cause of their wholesale destruction in a bad year.

Nor do we know exactly what proportion of Grouse meet their fate from vermin; that a certain number are killed by foxes, ravens, hoodie crows, stoats, weasels, and even gulls, may be admitted; but when we come to apportion the blame we again find ourselves without sufficient evidence to amount to proof. The subject of vermin is dealt with more fully in a later chapter.[1]

Occasionally it is found that old birds as well as young have disappeared, and when this happens it is customary to ascribe the cause to "Grouse Disease" amongst the adult birds, for it is well known that if a parent bird dies from disease or any other cause there is little chance of her brood surviving.

At a very early stage of the Inquiry it became evident that the loss of young stock on a large scale had never hitherto been properly accounted for, and required further investigation by the Committee.

The Committee were able to offer a solution of this problem. During their Inquiry into the causes of mortality in Grouse they discovered a certain unicellular intestinal parasite, one of the Protozoa, a Coccidium, known as *Eimeria avium*, which in certain cases is most destructive to the young chick, but is rarely fatal to the adult bird; this Coccidium is fully described in chapter ix.[2] The discovery of the disease caused by this pathogenic organism and known as Coccidiosis justifies the view that when there has been extensive mortality amongst the young stock which cannot be accounted for in any other

[1] *Vide* chap. xiv. pp. 403 *et seq.*

[2] *Vide* chap. ix. pp. 246 *et seq.*

way, it is almost certain that the chicks have met their fate by this infantile complaint.

Coccidiosis as a disease of game birds and poultry is now being rapidly recognised in this country, and the disease is also being investigated in America.

Still there remains the difficulty that the dead bodies are not found in any numbers; it must be remembered, however, that the infant Grouse is a small object, and any one who has searched in vain in the heather for a full-grown bird which has fallen to his gun can realise the difficulty of finding a tiny chick upon a moor where the whole stock does not average more than a bird to several acres. Coccidiosis chiefly attacks the birds when they are very small; the chicks die in the heather, the little carcasses are rarely found, and in a short time they disappear altogether for, even if they have not been devoured by vermin or removed by heat, wet, flies, maggots, or burying beetles, the small bones do not make lasting skeletons, and would not be discovered even if the moors were searched.

In spite of difficulties the field observer and other members of the Committee's scientific staff have by diligent search been able to find a certain number of small dead chicks on the moors; in almost every case the cause of death has been found to be Coccidiosis. Many other cases of Coccidiosis have been received for examination from various parts of Scotland and Yorkshire, or from the Committee's observation area in Surrey.

Fortunately it is only in exceptional cases that we have to consider the question of a wholesale disappearance of the young stock from pathogenic causes. Under normal circumstances the Providence that watches over all young things brings to maturity a large percentage of the birds that are hatched; but Providence may be assisted, and the methods by which it may be assisted are fully discussed in another part of this volume.[1] Suffice it to say that in the earlier stages of the life of the Grouse the state of the moor is of great impor-

[1] *Vide* chaps. xi., xii., xiv., xv.

tance to the welfare of the birds. If the heather has been well burnt in a systematic manner the chicks have access to shelter in time of danger, yet are not lost in a wilderness of rank growth should a shepherd's dog scatter the brood in all directions; vermin is kept down, and, most important of all, there is easy access to a plentiful supply of suitable food in the strips or patches of heather which are available in various stages of growth.

The place above all others where we may be sure of finding a brood of young chicks, if there are any on the ground, is amongst rushes and long grass in the more swampy parts of the moor; this is specially noticeable in very dry seasons. Whether the chicks seek these damp spots for the sake of shelter from the heat or in quest of insect life is not known.

Food of young Grouse.

Flies, spiders, beetles, and greenish caterpillars about $\frac{3}{4}$-inch long, as well as slugs and chrysalides, have all been found in the crops of chicks. Fresh *Calluna* heather shoots, moss capsules, and tender blaeberry leaves just opened, if they are to be had, are also generally present; and as the young birds grow older heather becomes more and more their staple food.[1]

In a chick of a few days old, where the food consisted of small caterpillars, there was no grit to be seen in the gizzard; and, in another, the muscles of that organ, with its toughened lining, seemed sufficient to crush the soft blaeberry shoots. But it is the rule to find even in the youngest chick's gizzard a certain small quantity of fine quartz-grit and sand.[2]

When half-grown the crops of those examined contained a large percentage of heather, and the gizzards contained about half the amount of grit that is usually found in old birds, but in smaller fragments.

Water, as supplied by streams and pools, does not appear to be necessary in the earlier stages where there is plenty of young heather; insects, the succulent juices of the young heather shoots, and dew seem to provide all the moisture necessary. Broods are often hatched out far from any stream or pool, and they can generally be found within a few yards of the same

[1] *Vide* chap. iii. pp. 101 *et seq.*

[2] *Ibid.*, p. 108.

spot till they are able to fly. On this point, as it affects the hand-rearing of Grouse, a well-known moor-owner writes: "I have never noticed that the young Grouse, when half-grown or older, require more water than what they pick up in the grass in wet weather, and what is sprinkled on the grass or heather at meal times, in dry weather. Old Grouse go to drink two or three times a day at most; they seem to know how much is good for them; whilst young Grouse, if allowed access to water, are apt, or almost certain, to drink too much, and scour. This, of course, refers to tame birds." Another of the Committee's correspondents (a gamekeeper on a large moor in central Perthshire) says: "Regarding water, I have known several broods fetched out 600 yards from the nearest water of any kind, in a dry season; and they continued to thrive without water for at least three weeks after hatching."

As the Grouse grows older, the parent birds relax their anxiety for the brood when disturbed, and, although they lie very close, the hen bird no longer flutters along the ground endeavouring to distract attention.

Every keeper knows too well the danger that attends the needless disturbance of his beat at this time, especially in a high wind, which may carry the flushed birds hundreds of yards from their home. Instinct and the call of the parents may guide them back; but it is better that they should be kept quiet. It has been noticed that when a young brood are once upon the wing, in anything like a strong breeze, they appear to be unable to alight with safety; at the end of the flight they dash headlong into the heather, or on to the ground, and frequently come to an untimely end.

With the arrival of August 12th the Grouse comes into the glare of publicity, and there is little relating to his life history between this date and the end of the shooting season that is not known to the average sportsman; but even so there are variations in their habits in different localities which still remain a mystery, and it may be worth while to mention some of these.

While in the majority of cases the birds appear to be wild in proportion to their growth, this does not seem to be the only factor in the case, for in some districts on the west coast, notably in Skye, Grouse will sit close throughout the shooting season. It has been said that the reason for this is that in the districts in question birds of prey survive in larger numbers than elsewhere, and that the Grouse has not lost its instinct to sit close when in danger of attack by its natural enemies. This may be true, but is not altogether convincing, for it is well known that to sit close is no protection against the Eagle, though it may be against the Falcon. The Grouse instinctively knows this, and the appearance of an Eagle, or even a Heron, is the signal for all those on the alert to fly in terror to some distant place of safety.

Feeding habits.

Grouse feed off and on throughout the day; but it is only in the evening that the crop retains the food which is then required for use during the night.

It is often stated that Grouse feed only in the evening, but the observations of the Committee make it quite clear that this is not the case though it is true that at midday the Grouse appear to feed less, and towards evening far more than at any other time. Midday is given up to rest, and, in summer, to shelter from the heat of the sun, and the evening is devoted to the complete filling of the crop with food for digestion during the night. Colquhoun in "The Moor and the Loch" refers to this habit as follows: "In sultry weather they lie quite still except at feeding time, and not having stirred perhaps for hours the dogs may come within a yard or two before winding them."[1]

In the early part of the day and at dusk Grouse are found looking for grit on the rough moor roads and tracks, or along the burn-sides, where every fresh spate washes down a new supply.

Grit.

The attraction presented to the Grouse by a suitable supply

[1] Colquhoun, "The Moor and the Loch," p. 184. Sixth Edition. Edinburgh, William Blackwood & Sons, 1884.

of grit is most marked. Good grit is to the Grouse what raisins are to Pheasants, and salt to Deer. They often fly long distances to obtain it, and in districts where it is scarce they will congregate in numbers along the railways and roads that traverse the moor, in order to avail themselves of the supply thus artificially introduced.

Towards midday Grouse are generally found on the "tops" and higher grounds, and especially amongst broken moss-hags; or, if the weather be very hot, they may be flushed from the burn-sides and shaded places; in very rough weather they do not scorn the shelter afforded by a ledge of rock or bank of peat, and may then be best approached down wind. The best shooting is often got late in the afternoon on the low ground, to which the Grouse have descended to feed before "jugging," with crops crammed with heather shoots.

When moving from one part of a moor to another Grouse usually fly low, and as their principal time for shifting their ground is in the early morning or at dusk they run a serious risk of death by collision with the wire sheep fences so common on many moors.

This danger can be to a great extent averted by having all wire fences carefully "bushed" with bits of brushwood. Small branches of larch are best for this purpose, as they can be easily twisted between the wires, and do not readily blow out—a fair-sized branch every 5 yards is sufficient. Spruce branches are also used. Telegraph wires are not so common on a moor as fences, and not nearly so dangerous, while the cost of protecting the birds from them by game-guards makes it hardly worth while to consider them.

The Grouse, like the Domestic Fowl, the Pheasant, and the Partridge, is a "dusting" bird, and wherever a peaty or sandy bank has a sunny exposure, a "scrape," with a feather or two half embedded in the soil, is to be seen. The fine particles of impalpable dust, by getting into the breathing apertures of the troublesome insects which are found on the birds, afford the latter temporary relief. Grouse also like to sun themselves on a warm bank or slab of rock—often resting with one wing extended.

The practice of "becking" has been thus described in a note by Mr Alston in Dresser's "Birds of Europe":[1] "Early on frosty mornings the cocks are fond of perching on a knowe or hillock and uttering their clear-ringing *er-eck, kek-kek! wuk, wuk, wuk.* At such times they may often be seen to rise perpendicularly in the air to a height of several feet, and then drop again on the same spot." "Becking" is fully described by the Rev. H. A. Macpherson in the Fur and Feather Series, where it is pointed out that the practice is in the nature of an amorous demonstration by the cock Grouse with the object of attracting his mate,[2] and it may be compared to the peculiar antics adopted by the Blackcock and Capercailzie from a similar motive. "Becking," however, is not confined to the breeding season, indeed it is more usual during the autumn and winter months than in the spring. Mr Macpherson describes in a most interesting chapter the manner in which Grouse may be shot by taking advantage of this peculiar habit.

Grouse, when fully grown, do not pass the night huddled together like Partridges, but "jug" singly amongst the heather, taking care not to be far apart. From the traces left in time of snow it is found that they usually lie about a foot or two apart, so that a pack of a hundred may be contained within an area of a dozen square yards.

In the words of a Highland gamekeeper: "Grouse glory in their 'hardiness,'" and it is almost incredible how little they are affected by wet, cold, and snow. It may indeed be said that so far as the adult Grouse is concerned it matters not what the weather is so long as his food supply is not affected. They will never desert high ground for low ground merely on account of a heavy fall of snow, provided that there is sufficient wind to keep the exposed ridges clear, and thus give access to the heather; and even if the whole moor should be covered

1 "Birds of Europe," vol. vii. p. 168.
2 Fur and Feather Series, "The Grouse," pp. 65-72.

they will burrow in the soft snow to reach the heather underneath. It is quite common to come upon birds in holes a foot or two under the loose snow. It is only when the snow has become covered with a hard, icy crust that the Grouse begin to feel the pinch of hunger. On these occasions they may be seen in large packs following in the track of a herd of deer or a flock of sheep in order to take advantage of the broken surface. They have even been known to eat the old unburnt stick heather which on all other occasions they reject as unfit for food; but this is probably the last resource of the famine-stricken stock, and hardly justifies the practice of leaving a large amount of this unwholesome old heather as a food reserve in time of snow, for such a practice must greatly reduce the available supply of food at the critical period of early spring. A better practice is undoubtedly to burn all the more exposed ridges and knolls with careful discrimination, so that in whichever direction the snow may drift there is a good chance that some good feeding heather will be left bare.

It might be thought that where a heavy snowstorm occurs during the night there would be a risk of whole packs of Grouse being covered up and smothered by the drifts as the birds were jugging in a sheltered hollow. Sheep are often lost in large numbers by such misadventure, but Grouse never, for as they jug in the lee of a peat-hag or a moorland dyke they tread the snow under them as it falls, and are found next morning safely collected on the surface, though their fresh droppings several feet below show the level at which they began their night's repose.

It has been said that Grouse often avail themselves of the shelter of woods and plantations in time of snow; but the evidence on the subject is contradictory. In some districts it has been found beneficial to plant trees as a shelter for Grouse; in other districts, especially in the north of Scotland, they never use woods for shelter.

It is generally believed that a hard winter with much snow is beneficial to the health of the stock in the following spring, and the reason commonly given is that the hard weather kills off the weaklings. There is no evidence to support this theory. Grouse are seldom found dead during the winter months, and when they are the cause can never be ascribed directly to the effects of weather. If the belief that snow is beneficial is well founded, some other reason must be sought; perhaps the fact that the weather has caused the stock to shift, and so introduced new blood where required, may have something to do with the improvement: more likely, however, the solution is connected with the question of food supply. Ground which has been covered by snow for a period of several months provides better and more wholesome food than ground which has been heavily stocked, for when birds return in the spring they find the food supply still untouched by Grouse or Sheep, and the fact that it has been out of reach for so long has prevented it from being so heavily infected by the larvæ of *Trichostrongylus* as the lower moors which were crowded with Grouse throughout the winter. The melting of the snow may also have the effect of washing the Strongyle larvæ out of the heather.

Packing.

If the birds are well matured by August 12th they often begin to "pack" after the first few days' shooting, and will not then readily lie to dogs. Packing may at times take place so early as to make shooting over dogs an impossibility. On this account the poor results formerly obtained on most English moors led to the introduction of "driving." In Caithness and some other districts the Grouse, being more backward, do not pack except under exceptional conditions.

This custom of packing is worthy of study, for it may be found to have a direct bearing upon the questions of disease, migration, interbreeding, and the preservation of the stock.

In the first place, it may be stated that it is the young birds rather than the old birds that tend to form into packs in the earlier months of autumn, though the older birds will follow suit as the winter advances. Consequently, when packing first begins, it is the older birds that suffer the greatest loss in a day's Grouse driving, for they come up to the line of butts in twos and threes, and are "mopped up" to a bird, whereas the larger packs of younger birds merely yield a percentage of their numbers to swell the bag. To this cause may perhaps be ascribed some of the beneficial results which attend the introduction of driving on many moors.

Another important fact connected with packing is the tendency of the stock to separate into sexes—there are hen packs and cock packs, or at least each pack contains a large majority of one sex. It has been noted that certain hills in a range of moorland are frequented by hen packs, others by cock packs.

The normal time for packing is in the autumn and winter months, and the more severe the weather the more marked is the tendency. Hens pack more readily than cocks; the old cock does not appear to be of a sociable disposition, and often throughout the winter he will remain in solitary state, and only join the pack temporarily during a period of unusual storm. This tendency is often taken advantage of by those moor-owners who regard the old cocks as a menace to the health of their stock, and on many well-managed moors a rigorous crusade is carried on against the old single birds that frequent the bare tops, while their younger relatives occupy the lower ridges.

During the winter months the advent of mild weather will often break up the packs for a while, and many cases have been reported of birds being scattered over the moor in pairs even in the months of November, December, and January; but with the return of wintry conditions their gregarious habits assert themselves even up to the commencement of the nesting season.

The reason why Grouse should pack in winter has often been discussed. The most favourite explanation is that they combine with a view to obtaining food in time of scarcity. Another theory is that, like many other birds and animals, the natural instinct of the Grouse is to congregate in flocks, and that this instinct is only departed from to meet the requirements of the breeding season. It is probable that various motives induce the birds to congregate in packs. Some of these motives may be briefly mentioned. (*a*) To get on to the high bare tops out of the wet—it is observed that Grouse are always more packed after wet weather. (*b*) To go down to feed on the cornfields; Grouse are seldom found feeding singly on the stooks; this may be due to the natural timidity of the wild bird, which makes it fear to resort to the unwonted feeding-ground unless supported by numbers. The same rule applies with even greater force to the case of birds leaving their own ground and wandering far afield in search of food; such migrations never take place except in large packs. (*c*) Owing probably to the same cause, Grouse invariably tend to pack after they have been much disturbed, especially by driving; on moors which for some reason have not been shot over for a season the birds do not pack until late in the year. (*d*) In dry weather small packs of two or three coveys are found at or near the springs even on August 12th.

Undoubtedly, the most common cause of packing is scarcity of food. It has already been remarked that during the winter months the feeding area on every moor is restricted to those parts where the heather is of such a character as to resist the effects of frost and cold; hence the birds tend to concentrate upon these food centres.

The habit of packing is probably indirectly connected with the question of disease. If we admit that the congestion of a large number of birds upon small areas of moor is conducive to the deposit in dangerous numbers of the larval worms which cause disease on the favourite feeding-grounds of the birds, then it follows that the pack formation is in itself a danger to the health of the stock. This view is supported by the fact that where packing is the exception rather than the rule, as in the west coast of Scotland, disease is of rare occurrence. It is obviously impracticable to induce the Grouse to abandon this dangerous practice of congregating in packs; but in another chapter suggestions are offered for minimising the risk of disease by distributing and increasing the areas to which the packs may resort for food.[1]

In autumn, where a moor is near arable land, the birds will often come to feed on the stubbles and corn stooks; they sometimes come in hundreds, and from long distances. This is not, however, the universal rule, for in some districts Grouse feed very little upon the corn, and in some seasons they appear to frequent the arable land more than in others. It has often been observed that by improving the heather on a moor Grouse may be induced to feed less upon the stooks. The change is often accompanied by an improvement in the health of the stock, and this has given rise to the view that corn is an unwholesome diet for Grouse.[2]

In very severe weather the Grouse leave the high grounds entirely, and remove in packs many miles to the lower moors where they can find "black ground," or to a hill plantation where they can pick up a bare sustenance in the shape of various seeds. When they are very hard pressed, as in the winter of 1894, they even flock to the turnip fields, and instances of their alighting on thorn hedges to pick the haws are recorded in the *Field* of that year. In Argyllshire they have been known to feed on birch twigs during the winter—settling on the trees to reach the woody buds. Migratio

The subject of the migration of Grouse is one which has engaged the attention of many naturalists; but there has been a tendency among observers to note only the abnormal cases, and from them to deduce a general rule. One great obstacle in the way of accurate observation is the difficulty of identifying the original point of departure of the wandering packs. In spite of the confident statements of gamekeepers that they can tell by the size and plumage of a bird that he has come from a certain district many miles away, it is more than probable that the newcomer has always had his habitation within a few miles of the neighbouring march, or even that he has never left his home, but has disguised himself by a sudden

[1] *Vide* chap. xii. pp. 343 *et seq.* [2] *Vide* chap. iv. pp. 146 *et seq.*

moult. In some districts undoubtedly the birds shift annually in vast packs from the high ground to the lower moors, and return again in the spring to breed.

On rare occasions migration takes place upon a much more serious scale, when the whole Grouse population of a district, driven by hunger, rises in huge packs and works its way southward in search of food; this never happens unless a heavy undrifted snowfall has been followed by a hard frost, whereby a whole district is covered with an impenetrable sheet of frozen snow, thus cutting off all access to the heather. Such wholesale migrations often result in a complete loss of the stock, for the birds appear to lose their bearings, and though they may sometimes find a haven on some distant moor, where weather conditions are more propitious, several cases have been recorded of the packs being seen on the low ground 20 or 30 miles from the nearest hill, or even flying out to sea, whence presumably they never return.

In the case of normal annual migrations many opportunities have occurred for observing the power of flight of the Grouse. The following passage may be quoted from Macpherson in the Fur and Feather Series: [1]

"When snow and sleet have driven them down from the hills they will then fly long distances. It is not at all unusual for Red Grouse to cross the Solway Firth at a point where the estuary measures two miles in breadth, and I have known them fly longer distances. They often cross the valley of the Tees, flying about a mile from one hillside to another." Millais also writes: "I have twice seen Grouse on the wing when they were crossing the 'Bring,' a wide channel which separates the islands of Hoy and Pomona, Orkneys. The fishermen told me this distance . . . was quite four miles across, and the birds must have come at least another mile on the Pomona side from the point where they left the moor." [2] In Millais' "Game

[1] Fur and Feather Series, "The Grouse," p. 36.

[2] Millais, "Game Birds and Shooting Sketches," p. 53. London: Henry Sotheran & Co., 1892.

Birds" it is stated that Grouse have been observed flying from Thurso to Hoy, a distance of over 11 miles.[1] The following instances are vouched for by the Committee's own correspondents. A gentleman in Banffshire, writing in January 1907, says: "Packs of Grouse are continually flying across the valley during stormy weather, some 5 or 6 miles between moors;" while in Cumnock, in Ayrshire, there are "two ranges of hills divided by a valley about 2 miles wide, with a moss lying in between. In the pairing season Grouse often fly at a considerable height over the valley between the hills." Even during a Grouse drive a pack has been observed to leave the hill where it had been flushed, and not to rest until it had reached another moor 6 miles distant. Longer flights are more difficult to authenticate; Harvie Brown states that: "in the severe winter of 1878-1879, a pack of Grouse was seen crossing the Moray Firth in December, making for the Banff coast, as we were informed at the time by Sheriff Mackenzie of Tain. Much snow was lying at the time in East Sutherland and Caithness";[2] and Macpherson (*loc. cit.*) says also that "The Rev. M. A. Mathew records that a solitary Red Grouse was shot by Mr C. Edwards on the Mendips near Wrington, Somerset, in September 1885, and this he suggests must have crossed over the Bristol Channel, migrating from Breconshire."[3] Other records in "Birds of Essex," are quoted in Macpherson.[4]

We are indebted to the same writer for the following information upon the general habits of migration among Grouse.

"Their principal time for shifting about is in the evening after feeding, and again after 'becking' in the morning. But they are particularly restless on many moors about the end of September and in October, especially the female birds, and the

[1] Millais, "Natural History of British Game Birds," p. 54. London: Longmans, Green & Co., 1909.

[2] Harvie Brown & Buckley's "Vertebrate Fauna of the Moray Basin," vol. ii. p. 152. Edinburgh: David Douglas, 1895.

[3] Fur and Feather Series, "The Grouse," p. 37.

[4] *Ibid.*, p. 39.

first strong gale brings many of them off the hilltops, looking for more sheltered and genial situations.

"Birds of both sexes will fly a long distance to a patch of black heather during a prevalence of severe frost and heavy snow, but the hens shift about in packs more irregularly than their male companions, and they are less partial to the high grounds, but seek the lower portions of the moor, and such as are most screened from the east winds. Grouse netters say that in fine open weather the birds fly very long distances when shifting about the hills." [1]

Observations upon the wandering habits of individual Grouse have also been made where some peculiarity in the bird has made identification possible. An Ayrshire gamekeeper has told the Committee's field observer of a pure white Grouse which was seen and freely shot at on Glencairn and Upper Cree. It then disappeared, and was seen and shot at many times on a shooting 12 miles away. It was eventually killed by a gamekeeper 9 miles away from either of these moors, and now forms a stuffed specimen in a case in his cottage. All this happened in one season.

The question of the annual movements and migrations of Grouse are important as a guide to the best methods to be adopted for the regulation of stock. The fact that Grouse annually shift from place to place over a wide area forces one to the conclusion that co-operation is necessary rather than individual effort. For the same reason it is doubtful whether the benefit of introducing fresh blood (either in the form of eggs or of living birds) is confined to the moor on which the fresh blood is introduced. This remark would not, of course, apply to an isolated moor, or one in which for any reason the shifting habits of the birds are not fully developed.

Weight.

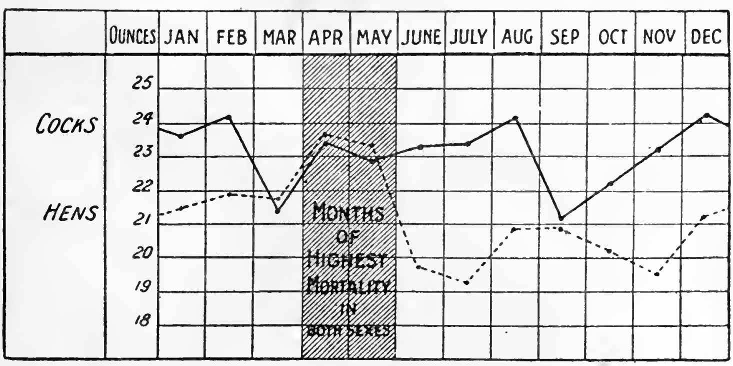
The weight of Grouse is a subject on which little has been recorded, yet it is one of great interest to the naturalist, for many facts in the life history of the bird are associated with the normal change of weight from one season to another.

[1] Fur and Feather Series, "The Grouse," p. 77.

From a practical point of view the weight of Grouse is a most useful indication of the health of a moor, this aspect of the subject is fully dealt with in a later chapter,[1] and in the present chapter it is proposed to describe only the seasonal fluctuations in the weight of healthy adult birds.

It is found that sex is a primary factor in determining the weight of an individual bird. An adult cock Grouse is as a rule heavier than an adult hen when both are well grown and in really good condition. This is true all the year round, except in spring, for at this time when the hen begins to sit she is heavier and in better condition than at any other time of the year, while the cock is not at his best. There is, therefore, at this season, a tendency for the average weight of both sexes to approximate, and even for the advantage to be on the side of the hen. The difference in the fluctuations of weight between the cock and the hen bird is shown in the Table given below.

SEASONAL VARIATION IN AVERAGE WEIGHT OF HEALTHY GROUSE.



The immediate reason for this difference in spring is probably the one which naturally suggests itself; viz., that the exigencies of courtship have a precisely opposite effect upon the male and female.

In December, the adult cock Grouse's weight averages 24·22 ounces compared to 21·07 ounces for the hen, while in

[1] Chap. viii. p. 215.

January it is 23·58 ounces compared to the hen's 21·52 ounces. These may be considered normal averages, the difference at this time of year being dependent wholly upon a sexual difference of size and build, body and bone. In other words, when the birds are all living under healthy conditions, and when the sexual instincts are in abeyance, the hen being less in all her measurements than the cock has a weight correspondingly less by 2 or 3 ounces.

It is, therefore, essential that average weights, to be of use, should include the sexes separately; and also if the weights be taken in August, September, and October that every bird taken for an average be adult.

As winter proceeds, we may assume that, unless the weather is unusually open, food becomes less abundant, or, at any rate, less easily obtained and less nutritious; "the sap goes out of the heather," as it is generally expressed, and there is a large proportion of dry, dark, woody, weather-bitten shoots.

Data are elsewhere given to prove that the quantity of such food, both by weight and bulk, found in the crops of full-fed birds in winter, is much in excess of what is usually found in the crops of similar birds in summer. In winter, the crops of Grouse often contain five times as much food-stuff as they ever contain in summer.[1] And, although several factors are at work to produce this difference, one of the most important is the necessity of eating a greater bulk of winter heather in order to arrive at the same total of food value.

It might be expected that the weight of Grouse would suffer from the shortage of nourishment contained in the winter food: but, as a matter of fact, the average weight of both sexes gradually increases during the winter months until March, the worst and most trying month of the whole year for Grouse. February, March, and April must be considered months of greater or less starvation every year, since the winter food has been picked over, not only by the Grouse themselves, but by cattle, sheep, deer, and hares, and often, too, the whole moor has long

[1] *Vide* chap. iii. Table I. p. 80.

been buried deep in snow, or the heather has suffered badly from frost or from the dry parching effect of north-east winds. Although the hen appears able to remain in good condition, the cock always loses weight to some extent — often far too much — at this time and in consequence suffers from a diminished power of resistance to "Disease." When thus half-starved, and long before he has any chance of recuperation, the exhausting necessities of courtship force themselves upon him.

In February and March he commences to live an exhilarated but exhausting and unsettled life. He becomes bold, noisy, aggressive, jealous, excitable, pugnacious and magnificent to see. He struts, becks, flies constantly about from one hillock to another, defies all comers, fights viciously, eats little, and constantly attends his mate. The result of the nervous and physical strain of the breeding season shows its effects upon the cock by a sudden and rapid drop in weight from over 24 ounces in mid-February to about $21\frac{1}{2}$ ounces in March.

With the hen, however, it is very different, for at this time she leads an even quieter life than usual. She feeds constantly, takes no part in the warfare of her mate, and becomes to a greater or less extent "broody." When in this condition she does not readily take the wing, and puts on flesh and fat. By the time she begins to lay she has a large store of surplus fat deposited throughout the body and in masses under the skin; and from this reserve she draws during the three weeks of incubation. For the twenty-three days during which she "sits" she leaves the nest only for a few minutes night and morning to eat and drink, and her tracks and "clocker" droppings are to be found always at the springs or drinking-places which happen to be nearest to her nest.

At the beginning of the nesting season the hen Grouse weighs as much as a heavy cock, sometimes even up to 27 ounces; but this holds good for a short time only. It is just during these two months of the year, April and May, that she suffers most from "Grouse Disease"; an inexplicable fact, did we not know that for various reasons, which are given elsewhere, March is to be considered the most dangerous month of the whole year for infection with Strongylosis.

As the hen sits, her weight, even in health, rapidly diminishes. She is living largely upon her reserve material, and has, in addition to produce from eight to ten eggs. This must be a considerable drain upon her system, since each egg weighs about an ounce, and each ounce so lost to her is an ounce of her " flesh and blood," the whole amounting sometimes to nearly half her eventual total weight. By the end of June, thanks also to the trials of a family, she reaches an average weight of less than 20 ounces, and by the end of July sometimes falls to 19·5 ounces, whereas the cock, benefiting daily by the improving food and weather, gradually rises from 19 or 20 ounces in March to an average of 24 ounces in August.[1]

It will perhaps throw light on the cause of the marked changes which appear in the Table if an attempt is made to account for them month by month.

The sudden drop in the weight of the cock in February and March, for example, must be due to courtship rather than to shortage of food, for though food is scarce at this time the shortage makes no difference worth noticing in the case of the hens. This argument is borne out by the almost equally sudden rise as soon as the mating is over.

The post-nuptial moult in the male takes place in April and May. It is complete in June, therefore any loss of weight in the replacing of new feathers would make itself felt in the earlier of these three months. From April to August the food supply is improving daily, and the weight of the cock Grouse gradually increases. And it is by no means easy to see why there should be a sudden drop in September unless it is due to the complete (male) moult to the winter plumage. As there is no corresponding drop in the hen, and, as we know, no similar moult, we are probably right in thus attributing the September fall in the weight of the male to this autumn moult.[2]

In June the hen undergoes a complete post-nuptial moult,

[1] *Vide* p. 33. [2] *See* chap. ii. pp. 42 *et seq.*

changing from the now faded breeding or nuptial dress, to the autumn or summer plumage, and this she cannot do without an appreciable drain upon her resources, which is clearly reflected in her weight.

In changing the winter plumage for a nuptial breeding dress in April she differs radically from the cock, who retains his winter plumage until the breeding season is over. The two sexes moult at different seasons, and each twice within the year. The details of the changes have been dealt with in another chapter.[1]

It has been pointed out that the cock bird begins to grow new feather in April and in August, whereas the hen bird begins to grow new feather in February and July; and each of these moults appears to have a definite effect upon the weight of the bird. There are, therefore, fluctuations in the weight of the healthy Grouse which are partly due to the moult, and are therefore seasonal, while others are purely sexual; it must be noted that the seasonal fluctuations differ as to date in each sex. Both seasonal and sexual changes occur in normal healthy birds. These fluctuations must be fully recognised before any useful deductions can be drawn regarding the changes of weight in birds that are or have been diseased.

The following list includes most of the conditions which commonly affect the weight of Grouse:—

I. In Health.

- (*a*) *Sex*, generally in favour of the male, but in April and May rather to the advantage of the female.
- (*b*) *Late hatching*, producing birds of both sexes unready for the winter; birds which have missed the best growing months of summer, and which therefore remain permanently undersized and of a poor physique though not actually diseased.
- (*c*) *Moult*, in the male taking most effect in March and in September; in the female in July and

[1] *Vide* chap. ii. p. 42.

November ; probably always leads to some loss of weight in either sex.

(*d*) *Courtship*, in the male always apparently a cause of loss of weight : in the female, owing to increased rest, with some change in the general metabolism and extra opportunities for feeding prior to incubation, seems to lead normally to a very considerable increase of weight.

(*e*) *Egg laying and incubation*, gradually lead to a loss of weight, which becomes more marked when the hen has had the care of a family of chicks. These cares, notwithstanding the abundance of summer food, often result in producing the lowest possible weights in hens, such loss of weight being in some cases due to an attempt to rear a second brood.

During the hen's incubation the cock recovers his weight, because the food supply is rapidly improving, and because his energies are no longer exhausted by courtship.

(*f*) *A shortage of good food* in a bad winter must often be responsible for a great reduction in weight. Similarly the abundance of food in summer, autumn, and early winter must serve to counteract some of the other causes of loss of weight.

It would be interesting, were it possible to collect sufficient figures, to compare local variation in the average weight of healthy males or females with local differences in the geographical situation, climate, height above sea-level, or the character of the subsoil. Particular districts have been credited with the production of birds distinctly above the average in size and weight. Midlothian, Caithness, and the west coast of Scotland each claim to produce exceptionally heavy Grouse.

To establish this a much more extensive series of weights should be taken than has hitherto been possible. So far as the Committee have been able to ascertain, it is difficult to say with certainty that any one district produces birds of a definitely heavier type than any other. The result of the evidence collected may be shown in the form of an abstract:—

TABLE SHOWING AVERAGE WEIGHT IN OUNCES OF ADULT GROUSE IN DIFFERENT COUNTIES DURING THE MONTH OF AUGUST.

SCOTLAND.

	Cocks.			Hens.		
County.	Number Weighed.	Average Weight.	Heaviest Bird.	Number Weighed.	Average Weight.	Heaviest Bird.
Argyllshire main-land . . .	76	24·3	27·5	58	21·3	23
Mull . . .	1	25	25	...	...	...
Caithness . . .	14	23·6	...	...	...	...
Sutherland . .	174	23·9	...	174	21	...
Ross-shire . .	15	25·0	...	14	21·4	...
Inverness . . .	98	24·35	...	...	...	...
Moray . . .	4	23·37	...	...	...	...
Banffshire . .	10	24·1	...	10	20·8	...
Aberdeen . . .	48	25·0	...	48	21·4	...
Kincardine . .	32	23·23	...	25	19·9	...
Forfar . . .	12	25·3	...	12	21·3	...
Perthshire . .	73	23·5	28	46	20.2	24
Stirlingshire . .	33	23·8	...	31	20·4	24
Fife	43	23·27	...	...	...	...
Dumbarton . .	12	23·0	...	12	21·0	...
Haddington . .	14	23·78	...	...	...	...
Peebles . . .	1	...	30·0	...	...	...
Ayrshire . . .	10	24·0	...	10	20·0	...
Berwickshire . .	12	24·0	...	12	21·3	...
Average for Scotland	680	24·0	...	452	20·8	...

ENGLAND, WALES, IRELAND.

Northumberland .	12	25·25	...	12	21·0	...
Durham . . .	5	25·6	...	4	20·0	...
Cumberland . .	...	...	28·6	...	...	...
Westmorland . .	10	22·97	...	...	...	...
Yorkshire . .	62	24·2	...	62	21·5	...
Derby . . .	15	24·5	...	15	21·3	...
Wales . . .	20	23·7	27·0	20	21·25	24
Ireland . . .	1	25·5	...	...	...	...
Average for England, Wales, and Ireland	125	23·92	...	113	21·3	...

From the foregoing figures it will be seen that there is remarkably little difference in the average weight of Grouse from widely different districts, the extent of the variation being only 2½ ounces in the case of cocks and 1½ ounces in the case of hens. In the specimens weighed the cocks from Scotland showed a slightly higher average weight than those from England, whereas the hens were distinctly lighter. This might have been due to accident, but it is more probable that the birds in England, being earlier, might have reached a more advanced stage in their seasonal variation than in Scotland, and we have seen that in August the cocks have a tendency to drop rapidly in weight, whereas the hens are attaining a comparatively high average which they steadily maintain for a month or more. Had the weights been taken in September the hens from Scotland would probably have shown as high an average as the hens from England; while the cocks from both countries would have shown a universal drop.

The foregoing comparisons seem to indicate that Grouse throughout the British Isles are of very uniform weight, and that any fluctuations that may be noted are probably merely temporary variations due to the abundance or shortage of the food supply in a particular district.

The heaviest cock Grouse which came before the notice of the Committee was one of exactly 30 ounces from Peebles.

Macdonald, in "Grouse Disease,"[1] says: "The Grouse in Scotland is a larger and finer bird than that met with in England," a remark which the above figures do not altogether uphold.

Macpherson, in Fur and Feather Series, says: "The cock birds not infrequently weigh 28 or 28½ ounces in the north of England, when in first-rate condition in every respect. Anything over 30 ounces is noteworthy, but a weight of 32 ounces is not unprecedented."[2]

In Yarrell's "British Birds,"[3] Red Grouse are said to be

[1] Macdonald, "Grouse Disease," p. 103.

[2] Fur and Feather Series, "The Grouse," p. 64.

[3] Yarrell, "British Birds," vol. iii. p. 77 (edited by Howard Saunders). Fourth Edition. London: John Van Voorst, 1882-1884.

at their best, both as regards weight and plumage, in November; but this is only partly true. Their best months are February, August, and December; and one may say they are at a fair level of condition in those months.

Age of Grouse

Various opinions have been expressed as to the age which a Grouse can attain, and a few observations on the subject may be quoted. On a Yorkshire moor a cock Grouse, which was recognisable owing to its having a broken leg which stuck out prominently at right angles, was known to have lived for nine years in a wild state. An Ayrshire gamekeeper, one of the Committee's correspondents, can vouch for a Blackcock living twelve years, and is of opinion that Grouse live as long. Another correspondent, a Forfarshire gamekeeper, is sure that many of the old cocks on the tops are ten years old, and if appearances go for anything the black old cocks so often killed on the high tops of many moors must have reached this patriarchal age. In view of the many dangers to which they are exposed the wild Grouse seldom gets the chance of dying of old age, and the duration of its life depends more on the severity of the shooting and the numbers of vermin than upon the bird's own longevity.

Observations on Grouse in captivity tend to support the view that they can live to a considerable age. Unfortunately, in every case reported to the Committee where a tame Grouse has reached the age of ten or twelve years the bird has died an accidental death.

CHAPTER II

THE CHANGES OF PLUMAGE IN THE RED GROUSE IN HEALTH AND IN DISEASE

THE subject of the plumage of the Grouse has already been briefly referred to, and the chief object of the following chapter is to describe in greater detail the somewhat complicated series of changes which occurs each year in the normal Grouse, and to show to what extent a departure from the usual rule may serve as an indication of the health of individual birds or of the stock as a whole.

PART I.—PLUMAGE CHANGES OF THE COCK GROUSE

When a large number of skins of the cock Grouse are arranged together, side by side, according to the month in which the birds were killed, it will be found that, even taking into account the differences of well-marked local variations in plumage, the series can readily be divided into two very distinct sets.

Seasonal changes.

There is first a very marked uniformity in the plumage of the cock birds killed from the middle of November to the end of June; and likewise amongst those killed from the end of June to the middle of November.

These two periods, November to June and June to November, mark the two seasonal changes of plumage in the cock Grouse.

The first is a plumage worn throughout the winter and during the courting and breeding season of the spring.

The second is a plumage worn throughout the late summer and early autumn.

It is necessary to lay stress upon this general broad division of the cock Grouse's plumage, and if a large number of skins can be arranged as suggested the time at which the Grouse has definitely changed from the one plumage to the other cannot possibly be overlooked. The birds obtained at the end of May are definitely in the darker and redder winter plumage, and those procured at the end of June are definitely in the paler and more buff-coloured summer plumage; those killed at the beginning of October are still partly in the paler summer plumage, and by the end of November all are in the darker winter plumage.

It must, however, be added, that there is hardly a month in the whole year, or a Grouse skin in a collection of many hundreds covering every month of the year, in which one plumage only can be found unmixed with the other. This fact accounts largely for the misunderstanding which at one time existed, but which has now, we hope, been satisfactorily settled, in respect of the vexed question of moult and plumage changes in the Red Grouse, and their proper interpretation.

Without referring in detail to the points upon which differences of opinion have before now arisen, it may be shown that much misunderstanding upon this difficult subject is based upon a different rendering of facts into words, facts which were recognised and perfectly well explained by Mr Ogilvie-Grant in 1893.[1] Both he and Mr Millais have made the subject of plumage changes in the game-birds, and especially in the Grouse, a special study, and it must be admitted that there are very few points upon which they have touched which seem to require further explanation and still fewer points, if any, which can be brought to light for the first time in connection with the plumage changes of the Red Grouse. A monograph on the Red Grouse would, however, be obviously incomplete without an account of the plumage changes of the bird itself; and it so happens that during the six years of the Grouse

[1] (1) "Annals and Magazine of Natural History" (6), xii., July 1893, pp. 62-65; (2) "Catalogue of the Birds in the British Museum," vol. xxii., November 1893, pp. 36-38; (3) "Annals of Scottish Natural History," July 1894, pp. 129-140, Pl. v. and vi.

Disease Committee's existence the collection of some six hundred Red Grouse skins, representing every age, phase, and change of plumage in that bird, has given a unique opportunity for an independent revision of the work already done—an opportunity such as has never occurred before in the study of any single species of British bird for observing the effect of disease upon moult and feather growth. And although the work as it stands has been so nearly completed by the labours of the two ornithologists already mentioned, there are still points of interest to which attention may be drawn, especially in connection with the marked effect which parasitism and other wasting diseases have upon the moult and growth of feathers, and it is to this influence of disease that attention will be particularly drawn in the present chapter.

It is important to note the extraordinary irregularities which so commonly occur in the plumage of the Red Grouse owing to disease, whereby the deferred moult becomes in some years almost the rule, and the rule of health becomes almost the exception. Diseased conditions often entirely mask the normal plumage changes, and it is far more important to realise this than to examine thousands of more or less healthy birds shot in the ordinary course of events in the shooting season.

It is almost incredible that a moult should be deferred from one season to another, or even to a third, and that the right plumage should eventually be produced if the bird, by means of good food and good weather, is at last enabled to recover its health and grow any new feathers at all. It is interesting to know that bare featherless legs and feet, which have so long been considered a sure sign of disease in the Red Grouse, may, in certain months of the year, be a natural accompaniment of really good health, while thickly feathered legs in the same month are a sure sign of deferred moult and of sickness. It is only when the proper season for the moult of the leg and foot-feathering is completely understood that we can attach an unfavourable prognosis to heavy leg-feathering when the legs should have been featherless, and an equally favourable prognosis to bare legs when the legs should certainly have been bare.

To return, however, to the two plumages of the healthy cock Grouse. They are distinguished by Mr Ogilvie-Grant as the *autumn plumage* and the *winter-summer plumage*, and he says further that the cock "has no distinct summer plumage."[1] It is perfectly easy to see what is meant by this, and also by the statement which follows, that the cock "retains the winter plumage throughout the breeding season."

Mr Millais also, in speaking of the cock Grouse, makes use of the expression *autumn plumage* which, he says, appears late in June; and he adds that the autumn plumage, together with the "*spring feathers*" (or what Mr Ogilvie-Grant considers the first beginning of the autumn plumage on the Grouse's neck), remain till the main moult in August and September.

Mr Millais makes the following statement, which appears to be based on a misinterpretation. He says: "as a matter of fact the male Grouse sheds in September and August a plumage which is a mixture of its winter, spring, and eclipse feathers."[2]

These so-called "spring" and "eclipse" feathers are no doubt, as Mr Ogilvie-Grant holds, the commencement of the plumage which is completed gradually during the summer months, and which he has described as the *autumn plumage.* It is naturally a little misleading to find the autumn plumage beginning to appear in early summer, but so long as the term is understood to mean the paler, more buff-coloured plumage with bolder bars of black, which begins to appear first on the neck of the cock at the end of May or early in June, and is eventually cast for the winter plumage in October, there need be no real misunderstanding.

That feathers of the previous winter plumage should be mentioned in speaking of the *moult* of this autumn plumage

[1] "Handbook to the Game Birds," p. 28. (Allen's Naturalists' Library). London W. H. Allen & Co., Ltd., 1895.

[2] *In lit.*, "British Birds," for April 1910, vol. iii. p. 382. London: Witherley & Co.

is also quite intelligible, since the old winter plumage of the breast and abdomen is being quickly shed and replaced by a similar new winter plumage at the time when the autumn plumage on the rest of the body is being cast. There are in addition very frequently a few feathers of the copper-red plumage on the chin really belonging to and remaining over from the previous winter plumage.

Instead of going into further details, however, with regard to the two moults and plumages of the cock Grouse, it will be simpler at this point to take its plumage changes in detail, successively month by month, explaining as nearly as possible what can be gathered from the examination of a series of skins, including a number of specimens in all stages of disease as well as in health.

The specimens illustrate every month of the year and most of the local variations to be found in England, Scotland, and Ireland; and there are a sufficient number of sick as well as healthy birds to show the very great influence that disease has in altering the individual capacity for feather growth. Unless this effect, which results as a rule from excessive parasitism, is fully recognised, there will always be misunderstandings upon the moult of this bird, for almost every Grouse in the country is to some extent infested with parasitic worms, and there are years when irregularity of moult is the rule rather than the exception. Moreover, it so happens that in autumn, when birds are being shot in large numbers, the survivors of the two worst months of the year for "Grouse Disease" mortality, that is, the survivors of May and June, are all convalescing; but they are convalescing with their plumage changes all retarded and put completely out of order and routine. In this way it is possible in September to kill two birds on the same day, both of which have the chestnut-coloured feathers of the winter plumage on the chin and throat; but upon examination it may be seen that in one bird the edges of these feathers are frayed and worn and the colour faded, showing that they have survived from the *previous* winter plumage;

whereas in the other bird they are hardly free of the scaly sheaths in which they grew, and are really precocious feathers of the *coming* winter plumage.

In each sex the general change from winter to summer may be described as a change from a more richly-pigmented, darker, black and chestnut, or rufous-chestnut plumage with rather fine transverse black markings, to a less richly-pigmented, paler, buff or rufous-buff or tawny-buff plumage with characteristically broad black bars and transverse markings.[1]

In each sex, moreover, the characteristic buff and black broad-banded summer plumage in its special appearance on the dorsal aspect is given by the growth of feathers with large black centres and a few buff or tawny-buff subterminal bars of considerable width, and a terminal border or spot of the palest buff, which is a very conspicuous feature on the back of most hens, and often little less conspicuous in the cock. In the cock, however, this plumage appears just two months later, and is less beautifully developed than in the hen.[2]

There is without doubt a general broad resemblance, firstly between the cock and the hen Grouse when the former is in its "winter plumage" and the latter in its "autumn plumage"; and, secondly, between the cock and the hen Grouse when the former is in its "autumn plumage" and the latter in its "spring plumage."

The perplexing fact is that these general resemblances are not synchronous in the two sexes, for there is an interval of two months between the moult of the cock and hen.

Cock Grouse in January.

Beginning now with the cock Red Grouse in January, and looking at the breast first, the uniformity of the series is a very conspicuous feature. Every healthy bird is chestnut or rufous-chestnut and black, with fine, almost vermiculate black cross-lines over it.

Even in the blackest birds the throat and fore-neck are always of a rich copper-red colour, with very little or no black edging at the borders of the feathers, which are usually barred

[1] *See* Plates II. to V. and VII. to X. [2] *See* Plate I. (Frontispiece).

with black only on the actual chin. Here there may be also more or less of white tippings, even to the formation of two white moustachios leading downwards from the gape, sometimes an inch in length. This may be a feature either of the black type or of the red[1] (Pls. II. and III.). In some very red and black Red Grouse the abdominal feathers are also freely and broadly tipped with white; and this may sometimes be seen even on the feathers of the upper parts. The legs and feet in this month are thickly feathered, and are white, or white with brownish barring. The claws are usually very long and strong. Occasionally a pale bleached feather of the preceding "autumn plumage" is to be found on the flanks, middle of the breast, or neck, and may be recognised by its frayed edges; and in a very backward bird, where there are many such worn and faded feathers on the chest and flanks, this is invariably the result of sickness. Turning now to the back we find a general uniformity of chestnut, bright or dark, or of blackish feathers, with fine black transverse markings; but again in almost every bird there may be found a considerable number of the old black-centred "autumn plumage" feathers remaining, with their frayed and faded edges of whitish-buff (Pl. IV.). On the lower back and rump the more worn and faded feathers predominate. The primary and secondary quills are complete, but only a few months old, having been renewed between June and August; and the same may be said of the tail feathers.

The following points in the cock Grouse of January are characteristic:—

(1) The rich copper-red, generally unbarred feathers of the throat and fore-neck.

(2) The fine barring of the chestnut, dark rufous-chestnut, or blackish-brown of the back, with the scattered back-centred feathers of the last "autumn plumage."

(3) The thick white feathering of the feet and legs, which

[1] The whole chapter deals with the Red Grouse (*Lagopus scoticus* Lath.). The terms "black Red Grouse" and "buff-spotted or white-spotted Red Grouse" must not be confused with similar terms for other species of Grouse.

Pl. II.
(P.Z.S. 1910. *Pl. LXXIX.*)

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MALE GROUSE, BLACK TYPE, IN FULL WINTER-PLUMAGE.

Pl. III.

(P.Z.S. 1910. *Pl. LXXX.*)

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MALE GROUSE, RED TYPE, IN FULL WINTER-PLUMAGE.

soon becomes blackened and worn by the "burrens" or charred stalks of old burned heather.

(4) The perfect flight-feathers of the wings and tail.

(5) The very large claws.

In *February* the cock Grouse is still in the darker winter plumage. Young feathers of this "winter plumage" may still occasionally be found on the hind-neck, nape, and head in backward birds. **February.**

In *March* the cock Grouse normally shows no change; but towards the end of the month in exceptional instances individual birds may be found with a few precocious feathers of the autumn plumage making their appearance on the back of the head and neck. These are very probably feathers irregularly developed to take the place of those which have been lost during encounters with other males. **March.**

In *April* the cock Grouse still shows no change. In this month there are often greatly increased opportunities for the addition of skins to a collection, because it happens to be a month of very high mortality from "disease." The birds are found not only by the keepers who are out early in the month in search of fox-earths, and who are generally also burning heather about this time, but also later by the shepherds when ranging the moor in the lambing season. Thus a very large proportion of males are badly diseased, and comparatively few birds are in perfect health. It follows that in the series of skins of cock birds representing the month of April, the great majority are very backward. Healthy birds have still the old, rich, red, copper-coloured throat of the winter plumage and fresh-looking "autumn" feathers round the neck, upper back, and mantle, while the winter and old autumn plumage of the rump and back is bleached and faded. The backward birds are easily picked out, as they have not yet assumed their "winter" plumage, and are still mostly clad in old, worn autumn plumage of the previous year. If an April bird has newly and thickly feathered legs and feet, it means, almost certainly, that the "winter" plumage has been put on very late. The healthy Grouse should now be moulting the **April.**

feathers of the feet and legs, so that bareness or lack of feathers in April becomes a sign of health, and thickly feathered legs a sign of sickness ; this is the precise contrary of the proverbial saying that bare legs indicate disease ; though at other seasons the saying may be applicable.

ay. In *May* the preponderance of cock birds found dead, and therefore of skins of cock birds showing belated moult, is again a large one. The healthy cock is still in his much-worn winter plumage, but on the head and neck more feathers of the new autumn plumage have appeared (Pl. v.).

une. In *June* as a rule, the mortality amongst adult birds, due to Strongylosis, is coming to an end. Late in June the healthy cock Grouse can at last be said to have changed into his complete "autumn plumage." The winter plumage persists only on the abdomen and lower breast, on the actual chin which is blackish with a few white spots, and on the throat, where a few red feathers still remain. The moulting of the quills and tail feathers commences towards the end of the month. The rump and back are now completely covered with new black-centred feathers carrying broad-barred buff and black bands, and a few have a whitish terminal spot, similar to that found in the female. The head and neck, breast and throat, are now clothed in broad-barred buff and black feathers, quite distinct from the more chestnut and more finely black-marked plumage of the winter. It is impossible on seeing a series of the birds showing this distinctive change to avoid noticing how closely this autumn plumage of the cock approximates to the nesting plumage of the hen, but it has arrived in the cock just two months later than it is normally due in the hen—far too late to be a breeding plumage. It appears almost as though the pathological postponement of the moult, a postponement which is, after all, nothing but a sign and a symptom of disease, has gradually developed into a normal habit in the life of the bird, and one is led to think that this habitual disability in the cock Grouse, which results from Strongylosis during the nesting, courting, and breeding season (a disability which causes the death of

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MALE GROUSE, RED TYPE, IN FULL WINTER-PLUMAGE WITH A FEW BLACK-CENTERED FEATHERS OF THE PREVIOUS AUTUMN-PLUMAGE.

Pl. V.

(P.Z.S. 1910. *Pl. LXXXIV.*)

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MALE GROUSE CHANGING FROM WINTER- TO AUTUMN-PLUMAGE.

about eight cocks to every hen in April and in May), may have caused the alteration in the season of the moult, simply because the *vis vitæ* of the cock bird, insufficient as we now know it to be at the close of winter for the ordinary calls of reproduction, would be still more disastrously insufficient if preceded by an early moult.

At the present time the cock undoubtedly breeds in the old winter plumage, without any acquisition of a new breeding plumage, and, as has recently been pointed out by Mr Ogilvie-Grant, what have been regarded by Mr Millais as new "spring feathers" on the neck are in fact the *old* autumn feathers, which on that part of the body do not become worn and faded.

It is unlikely that any feather of the Grouse is altered in pattern, tone, or any other character, when once it has completed growth and has been cut off from the circulation, for once the circulation has ceased beyond the entrance to the base of the shaft, and once the feather is cut off from the circulation in the deeper living layer of the skin, it is no more likely or able to change the pigment which is responsible for its pattern or its colour than would be the same feather had it been plucked out and kept entirely separate from the bird.

If there are, as has been held, distinct pigments, such, for example, as buff, black, and orange-red, in the various colour tones of the Red Grouse, it becomes easier to see that the loss of the red pigment, which is utilised for the eggs, leaves the buff and the black in greater quantity for the nesting season plumage. In the winter all three would once more be available.

The whole question of pigment production and pigment distribution, intimately connected as it is with the question of the excretion of waste products and the deposition of fat, both in health and in disease, has not reached a stage which admits of dogmatic statement upon the subject of pattern change in feathers without moult.

That the cock bird should moult the feathers of the legs and feet between March 30th and June 17th is no longer difficult to understand when the prevalence of Strongylosis is fully grasped. No bird is safe from the nematode infestment, and we have now reason to believe that the majority of cock birds are so badly infested that they are forced to defer the moult which in the hen takes place before nesting begins. It is, therefore, obvious that between March and June there will be every stage of good or bad leg and foot-feathering from the newly acquired thick, white winter stocking of the sick cock, and the naked featherless clean moulted leg and foot of the really healthy male bird in June. In July, again, the healthy cock bird will be found beginning to produce white feather tips over the legs and feet.

ly.

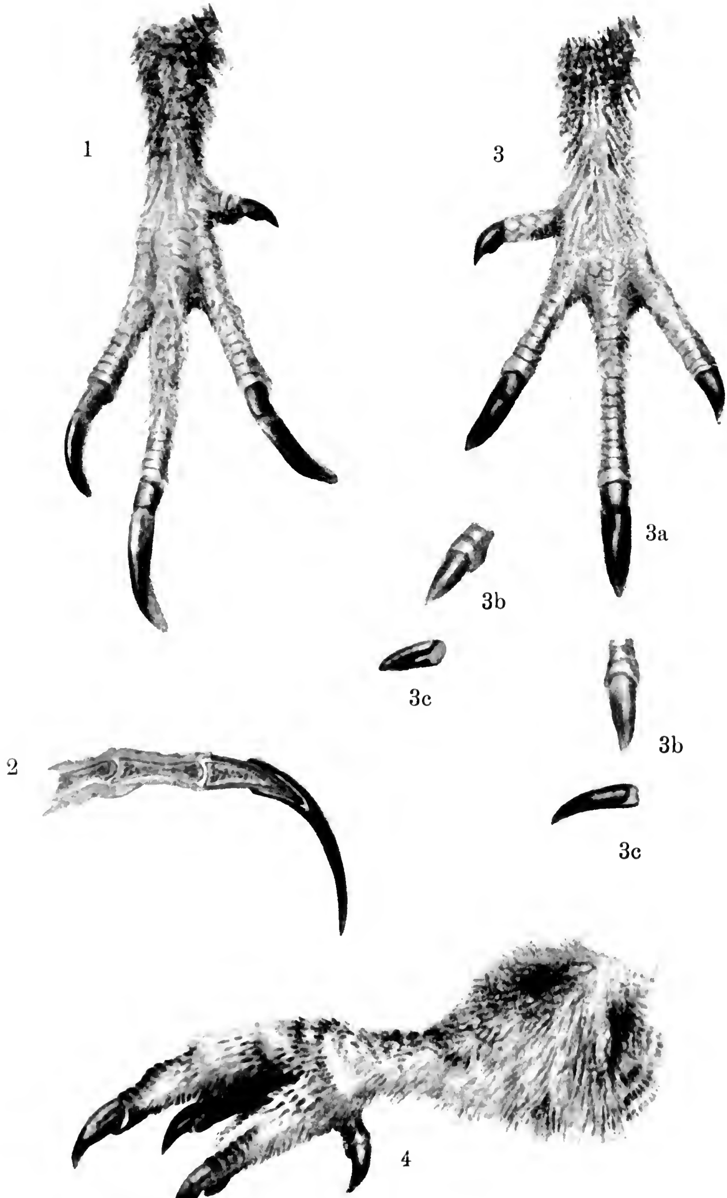
In *July* the general appearance of the healthy cock is much lighter in colour-tone, and much more broken and mottled in pattern-character than that of the same bird in the winter. The claws are in many cases now ready to be shed, and the primaries, secondaries, and tail feathers are in moult. Some six or eight new clean-grown primaries are often to be found in July, and the long tail coverts are broad-barred buff and black.

igust.

In *August* the cock Grouse has, of course, the appearance of full summer or autumn plumage, but it requires very little examination to see that he has already begun to put on feathers of the winter plumage. He now rapidly sheds the old feathers of the last winter's plumage which remained throughout the summer upon his breast and abdomen, and replaces them with the exceedingly handsome narrow cross-barred red or brown or blackish feathers of the coming winter plumage. There is no second moult or replacement of these feathers of the breast and abdomen in the cock. Once in the year is enough for this special area, and the feathers that "carry through" are wholly of the winter plumage. They are often broadly tipped with white. The chin feathers which survived with those of the breast and abdomen are now also replaced by new ones. It is noticeable that in the Ptarmigan it is also the white feathering of the chin and of the breast and belly, as well as

Pl. VI.

(P.Z.S. 1910. *Pl. XCIII.*)



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FEET OF RED GROUSE: SHOWING STAGES IN MOULTING OF NAILS.

of the wings and tail, which is changed once only in the year.

In August, as has been said, the cock Red Grouse has begun to put on his winter plumage. The feathers of the breast and abdomen are full of sheaths and sheath-scurf, the growth of these feathers being very rapid and often scarcely noticeable. On the rump, back, and to a less extent on the shoulders, new rich red-brown feathers finely marked with black lines are showing here and there. Primaries, secondaries, tail feathers, and coverts are now replaced by new and blackish feathers with perfect and unbroken outlines. Even a few new rich copper-coloured feathers are appearing as isolated touches of bright colour amongst the faded broad-barred autumn feathers of the upper breast. The feet and legs are bare, save where new white feather tips are just appearing through the skin, and the claws of all the healthy birds are being shed (Pl. VI., Figs. 1, 2, 3, 4).

In *September* the chin and throat of the cock Grouse contain a mixture of many pale autumn feathers much worn and faded, and a few new copper-red ones. Most of the frayed "autumn plumage" feathers are now falling out. The breast and abdomen, wings and tails, are clothed with entirely new winter feathers, while the head and neck, back, shoulders, rump, and coverts of the tail are in a transition state, the "autumn" feathers frayed and bleached at the tips, contrasting with the new rich chestnut and darker brownish winter feathers with their fine black transverse markings. The feathers of the legs and feet of healthy birds are rapidly growing to form thick, white stockings for the winter. Bare legs in September are a sign of belated moult or, in other words, a sign of sickness. September.

In *October*, for the first time since the preceding winter, the red and black varieties of Red Grouse become once more conspicuously distinct. This result is due to the new growth of fully pigmented feathers, either red or black, upon the under surface of the body. The upper neck is rapidly becoming copper-red. The chin and throat still show a proportion of October.

the faded buff "autumn" feathers among the red, the former looking spotty and pale. On the back the new chestnut and black feathers are rapidly replacing the faded autumn feathers. The flight feathers which were moulted in June have now been replaced thus accounting for the fact that the adult birds as well as the young ones are stronger on the wing than at the beginning of the shooting season. Some perfectly healthy cocks still look as if in "autumn plumage," while others, on the contrary, have nearly completed their winter dress. The legs and feet are thickly covered with white feathers, and the nails are uniformly small, as the old claws have all been shed. Their growth, however, is extremely rapid.

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cember.

In *November* and *December* the cock Grouse drops most of the remaining "autumn plumage." By the end of the latter month his moult is complete, but on the neck and back a greater or lesser number of these autumn feathers are retained till the following summer.

The most striking characteristics of the winter plumage are the rich copper-coloured neck and throat, and, in the darker varieties which are common in the Scottish Highlands, the contrasting blackness of the upper breast and abdomen often broadly flecked with pure white tips.

Amongst the cocks there are several well-defined and easily recognised varieties, which seem to have a certain regularity of distribution geographically. These will be considered later.

Part II.—Plumage Changes of the Hen Grouse.

The two changes of plumage in the hen Grouse are completed, in the one case by the end of April or the beginning of May, and in the other case by July and August.

The actual feather changes in both cock and hen are really very comparable in character, notwithstanding the difference of two months already referred to, they may be described and explained in very much the same terms.

Mr Ogilvie-Grant was the first to draw attention to the exceptional want of agreement in the seasons chosen by the two sexes of the Red Grouse for their moult, and as in the cock's plumage he makes use of the terms "autumn" and "winter-summer" or "winter" plumages, which have therefore been used here, so in speaking of the hen's plumages it will be well to adhere similarly to the expressions used by him, and to call them "summer" and "autumn-winter" or "autumn" plumages.

Exception may be taken, and indeed has been taken, to these names, as being inappropriate and inexact, but they are sufficiently exact for all practical purposes, and so long as moults and plumage changes are not completed in a week, but are spread over a period of several months, so long will there be some inexactitude in the terminology of these moults and plumages if they are named according to the months or seasons. It is immaterial so long as the term is sufficiently defined, for it is obviously impossible to use a term so exact as to require no definition.

The hen Grouse moults twice in the year, and wears her "summer plumage" as the breeding dress from April to July, and her "autumn" or "autumn to winter" plumage from August to March. These changes may be expressed in terms of comparison with the cock, as a case of plumage change in which the hen has two annual moults, exactly as has the cock, but both moults occur two months earlier in the hen than in the cock.

Breeding plumage.

The hen's "summer" or breeding plumage is a very beautiful dress, variable to a considerable extent it is true, but yet having a general uniformity which becomes the more obvious as a greater series of skins in any particular phase of plumage is examined.

Opportunities for even seeing the hen Grouse, to say nothing of obtaining her skin, in the full breeding plumage are rare; and thus it happens that, even in the large series of Grouse skins at South Kensington and at Cambridge, this phase is only poorly represented.

The Committee has been to some extent more fortunate, and has obtained a great many skins of hens in the summer plumage, so that points of resemblance can be noted at sight, and individual variations perforce take their proper places. It has been a marked feature in the whole collection of six hundred skins that as the series grew, and the general uniformity became more marked, the individual variations which were so noticeable at first, became gradually relegated to their subordinate position.

Uniformity, albeit with endless minor variations, is the rule in the Grouse as it is in every other creature that leads an unprotected existence under natural conditions. How long it will continue in the protected, often over-protected, Grouse remains to be seen. It is possible that such variation as already occurs is to some extent a modern development; but on this point there is at present insufficient evidence to amount to certainty.

ary. Beginning once more with *January*, it may be said that in this month some hens, when examined on the under side, are hardly distinguishable by their plumage from some cocks (Pl. VII.). On the back it is different, and a healthy hen in January is unmistakable owing to the terminal spots of buff which appear almost invariably, though occasionally in limited numbers, on the feathers of the back. In some healthy hens the chin is sometimes still pale buff in colour, owing to the persistence of summer-plumage feathers of the preceding year. The throat and fore-neck, on the other hand, are copper-red, but rarely so uniformly red as in the cock (Pl. II.). The copper-red feathers seem to begin on the fore-neck and proceed towards the chin, so that the chin often remains buff and black when the throat is already red. Except in very backward birds, which have been sick, the old and faded broad-barred feathers of the flanks are never found in January. The legs and feet are white and thickly feathered, and the claws are long and strong.

uary. In *February* the bird is still in the same plumage as in January. In a few forward birds the feathers of the summer

Pl. VII.
(P.Z.S. 1910. *Pl. LXXXV.*)

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FEMALE GROUSE, BLACK TYPE, IN AUTUMN-PLUMAGE.

Pl. VIII.

(P.Z.S. 1910. *Pl. LXXXVII.*)

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FEMALE GROUSE, RED TYPE, CHANGING FROM WINTER- TO SUMMER-PLUMAGE.

dress begin to make their appearance on the back of the neck about the middle of the month.

In *March* the change from autumn plumage to spring breeding plumage is, in healthy birds, now quite unmistakable, though many birds are very backward owing to disease. All doubt as to the sex of healthy birds, whether seen from above or below, is now removed. The broad-barred buff and black feathers of the flanks are now appearing, and are most conspicuous and characteristic, while the whole of the lower breast and abdomen covered by the red brown or red-black finely barred feather of September growth are still in excellent condition and remain unchanged. The feathers of the chin, throat, neck, and upper breast are now mixed with broad-barred black and yellow feathers in forward birds; while in backward birds the throat and fore-neck may still be clad in copper-red feathers. The legs and feet are already looking worn and less well feathered, but the claws are long. March.

In *April* and in *May*, for the simple reason that many hen Grouse are infected with "Grouse Disease" in these months, the proportion of skins of backward hens is large. The birds thus picked up dead carry one immediately back again to winter, for although they ought by this time to be putting the finishing touches to their spring plumage, they are, in fact, but just succeeding in the belated effort to put on the autumn dress. They are thus a clear six months late, and afford the most misleading seasonal characters imaginable. Their legs and feet, instead of being worn and almost moulted clean, are at last, after a winter spent with almost naked legs, well-clothed with thick white feathers. The appearance of the legs therefore in the hens, as in the cocks, is totally misleading to the keeper or to the sportsman who considers bare unfeathered legs to be a sign of "Grouse Disease," for in April, May, and June none but healthy birds have naked legs and feet. The general character of advanced and healthy birds towards the end of April and in May is that of a complete spring plumage. The whole of the upper parts are broadly barred with buff April and May.

and black, and marked with conspicuous terminal whitish buff spots or bars (Pl. IX.). The under parts, again, are broadly barred with buff and black, from the chin to the throat and neck, over the breast and down the flanks, while the central lower breast and abdomen are still in the autumn plumage of the previous September. White terminal spots may, of course, be present on the breast and abdomen. These are a local or an individual character which will be mentioned later in dealing with varieties of feather pattern and coloration. The flank feathers of the hen in the full spring plumage show much diversity of pattern.

The legs and feet of the healthy hen Grouse in April and in May are very poorly feathered, but the claws are very long (Pl. VI., Figs. 3, 5).

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In *June* the legs and feet are almost bare, and the claws begin to drop off (Pl. VI., Figs. 3, 4, 5). The precise date of this shedding of the claws is again really a part of the moult, and is, in consequence, equally dependent upon the health of the bird. Sick birds which have survived the spring mortality are always late in the shedding of their claws, and equally late in the changing of their feathers. The claws are shed, both in health and in disease, but once a year, and the casting is synchronous as a rule with the disappearance of the autumn dress. The figures (Pl. VI.) by which this process is illustrated require but little explanation. The whole of the year's growth of horny black nail becomes loose on the soft and growing vascular matrix, and when quite ready to be cast can be easily pulled off like a little cap. The young nail beneath is at first soft, pink and vascular and very short, but soon hardens and deepens in colour, and in a month or two has grown to be a useful nail of horn. The transverse or circular groove which is left at the point of detachment of the old nail is quite a useful indication of age in cases where there is a doubt as to a bird being over twelve months old or of the year. The presence of the groove showing that the claws have once at least been shed is conclusive proof that the bird is more than twelve months old.

edding
claws.

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FEMALE GROUSE IN FULL SUMMER-PLUMAGE.

In *June* there is another characteristic appearance in the hens, namely the bare patch of abdominal skin which results from the shedding of the abdominal feathers, grown in the previous September. The loss of these feathers leaves a naked patch of skin on the abdomen of a hen that has been sitting, and this patch remains naked for the next few months. The general character of a June hen in health is that of the completed summer-nesting plumage, broad-barred buff and black over all the upper and under parts, excepting the abdominal area, the lower breast, wings, and tail. But it looks already somewhat faded and worn; and it is quite probable that in acquiring so perfect a plumage for sitting unnoticed on a nest built amongst the heather, the economic absence of the redder pigment in the feathers is in part a result of the acknowledged fact that for longer and more trying use, and for wear and tear in feathers, darker pigments are required, whereas for the short-lived and less exacting requirements of the summer plumage in the hen Grouse from April to June the buff and black feathers, with very much poorer wearing qualities, are found to be sufficient. The black pigmented parts of the feather stand wear and tear far better than the yellow parts. Certain pigments have a value, therefore, of a very practical nature apart altogether from the æsthetic point of view of attractiveness, or the rather hypothetical view of assimilation to surroundings for the purposes of safety or to assist in obtaining food.

It very occasionally happens that the hen Grouse, instead of retaining the redder plumage of the previous autumn's growth on the abdomen until it drops off during incubation, grows an almost universal spring plumage of buff and black broad-barred feathers covering the lower breast and abdomen as well as the remainder of the body from head to tail. A skin showing this condition is preserved in the National Collection, and there is an almost equally perfect specimen in the Committee's Collection.

The more usual procedure is that the abdominal patch of autumnal plumage is lost during incubation, and is then quickly replaced by a renewal of the autumnal feathers when the spring plumage is also being shed. There remains, however, in the majority of birds, a very quaint growth of belated spring plumage, consisting of buff and black-barred feathers in two lines down each side of the centre of the naked patch, as though, for some occult reason, the intention to grow "spring-plumage" feathers upon this area had never been altogether lost. This peculiar persistence of belated intention shows itself as a patch of yellow feathers made up of the two lines of feather growth in the midst of a much broader area of the autumn red pigmented feather which one would expect to find all over the abdomen.

In *July* the summer plumage of healthy hens is much worn out, frayed at the edges, and very definitely faded, and the feathers are already dropping out. On the chin, throat, and fore-neck, new red feathers of the autumn plumage, looking rich and dark, are already making their appearance. The back is as it was, but faded, and the flanks are still conspicuously broad-barred with buff and black; but the abdominal bare patch is now growing new autumn plumage feathers with great rapidity from the centre outwards. The primaries and secondaries have now commenced to moult. There may be in July, in the hen, as many as six or eight old primaries in each wing with frayed tips, still to be renewed.

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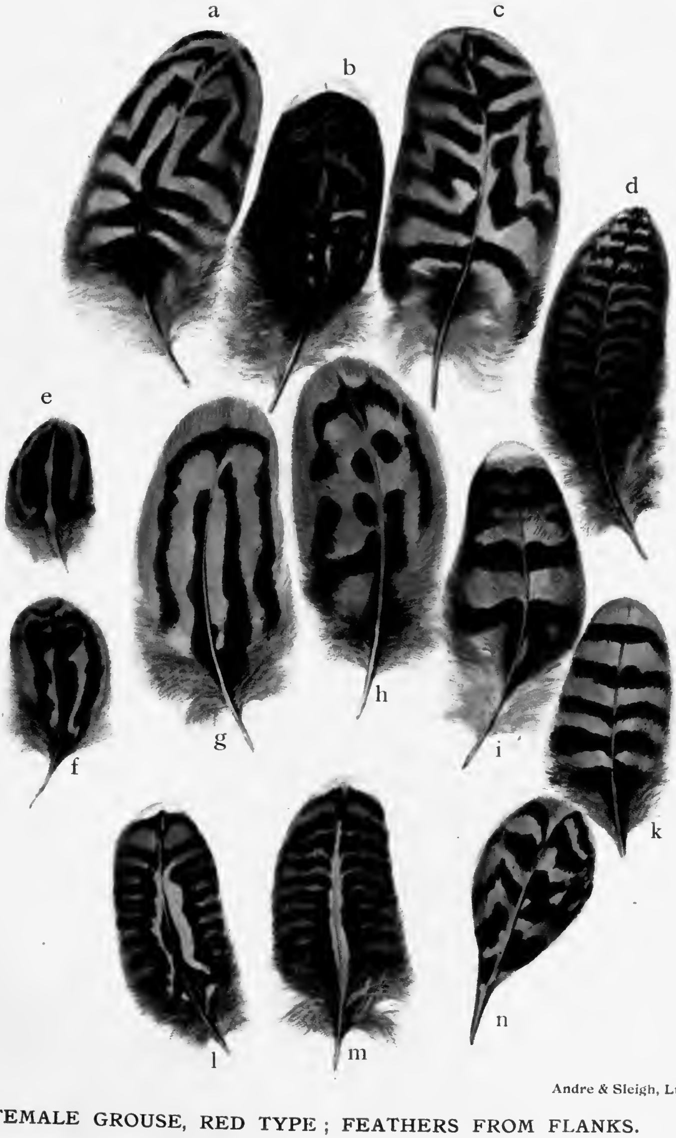
Precocious young birds of the year can still at once be distinguished from hens in moult, because in the former the dark red-brown, black-lined autumn plumage is on the flanks, while the broad-barred buff and black, and rather worn-out chicken feathers are in the centre of the abdomen. In the adult the distribution is reversed. The broad-barred buff and black feathers of the spring plumage are on the flanks, and the redder fine-barred autumn plumage is appearing in the centre (compare Pl. x., Figs. *a*, *c*, *g*, *h*, *k*, and *n*, with Fig. *d*.).

The legs and feet in July are naked, and the claws are very small; but the feathers are already showing through as small

Pl. X.

(P.Z.S. 1910. *Pl. XC.*)



Andre & Sleigh, Ltd.

FEMALE GROUSE, RED TYPE; FEATHERS FROM FLANKS.

white points, not to be confused with broken shafts, which occasionally result from wear and tear in woody heather.

The plumage of the hen Grouse in *August* is well known. August. There are probably fewer diseased birds on the moor in August than there are in July. In July, however, they are never shot, and are therefore not observed, but in August they are carefully picked out of every bag, and, owing to the general interest in the question of disease, are almost always noticed, and in some cases are publicly notified. Hence the idea that disease makes a new start in August and September. As a matter of fact, these wasted birds are almost certainly convalescent. They have been diseased, and they are still suffering from disease, but they have avoided actual death in the two highest mortality months, April and May. Once tided over these fatal months, the food and general conditions of life improve, the weight of the cock goes up, and the balance is again in favour of recovery for him; and although with the hen the exigencies of incubation and the cares of the family continue to handicap her until June and even July, she then rapidly begins to put on weight, and in August and September is once more on the way towards complete recovery. Many sick-looking "piners" are shot upon the moors in August, but in September many that were not up to the average weight the month before are practically normal, and would probably be indistinguishable from healthy birds, were it not that their serious indisposition of the preceding months has put them behind their fellows in the matter of feather change.

In August, therefore, a collection of skins contains a large number of examples of hen birds showing deferred moult and belated growth of the autumn feathers. The normal healthy hen Grouse in August has already put off most of the broad-barred spring plumage feathers of her nesting dress, and is very much like the cock bird in appearance, with the same dark, red-brown vermiculate or fine-barred plumage underneath, white-flecked or not as the case may be, and with a mixture of old and new feathers above. The legs and feet of a forward hen are already showing quite a fair growth of white feathers, and the nails have all been shed. The claws are therefore short and rather soft, and the transverse sulcus or groove at the point of detachment is clearly marked. In the wings there may still be a number of primaries to be changed.

In the convalescent "piner," on the other hand, the case is often very different. She has still a most deplorably bleached and weathered breeding plumage, with worn-out feathers, frayed or ragged, often with saw-toothed edges, showing the unequal effect of wear and tear on the pale buff pigmented and black pigmented parts. The bird in this belated plumage has quite naked legs and feet and long unshed nails, or may at the most be just showing the points of a new growth of feathers through the skin; and in this state she is conspicuously shabby and ill to look upon in comparison with the splendid plumage recently acquired by her healthy sisters, and by the now almost universally healthy cocks. But the point above all others to be remembered in this connection is that this hen is convalescent, and still has a couple of months of good food and good weather in which to complete her convalescence before the winter comes.

If the spring outbreak of disease has been severe—that is, if the general conditions of the preceding winter and early spring months have been such as to conduce to a heavy and widespread infection of the Grouse with the larval *Trichostrongylus*—then both cocks and hens will have been equally infested in April and May. But the breeding season and the concomitant needs of the two sexes are, from April onwards, quite distinct from one another.

The result of this is that there is often a large mortality of cocks in April and in May, and a much less marked mortality of hens, probably in the proportion of seven or eight cocks to one hen, but definitely occurring in the same two months.

There is no great mortality from Strongylosis in any other months of the year, and after May the cocks are suddenly relieved and rapidly recover, so that by August there are almost no sick cocks; the hens, on the other hand, have still two very trying months to face on account of the strain of laying, sitting, and rearing their broods, and although, thanks to the abundance of food, probably most of them succeed in struggling through, yet by August they have only just been freed of their more pressing cares, and a great number are still to be found in very poor condition. The recovery commenced, however, at the moment when the strain is removed, and it is this point which has so constantly been overlooked. Sick birds in August are convalescent, and however many there may be, they are not a sign of a new outbreak of disease, but a sign that the past spring infection was a heavy one, though less fatal than it might have been.

At the end of their own specially critical periods, the cocks have at any rate June, July, August, and September in which to pull themselves together by means of good food assisted by good weather; whereas the hens, at the end of *their* own specially critical period, have August and September. Hence the preponderance of sick-looking hens when the shooting begins, and the widespread, but erroneous, belief in a recrudescence of disease in autumn.

To return to the further consideration of the hen's change of plumage in *September*, her finest feature is now undoubtedly the clean new growth of bright red, or dark red, or black and white-flecked feathers of the breast and abdomen, with their narrow but even blacker markings. The whole of the old feathers of this tract have now been shed, but they grow again so quickly that no bare skin is visible save in the middle area of the abdomen quite low down, where, as has been already pointed out, the new growth is of belated feathers coloured as in the spring plumage, and therefore quite different from those around them. There is still, as a rule, no accession of new red feathers on the chin or throat of the healthy September hen, or at the most but a feather or two. But in the sick hen there is still often a sprinkling of the old red feathers of the preceding autumn plumage, very faded, amongst the faded buff and black feathers of the belated spring plumage. On the back of even

September.

forward hens there is still a mixture of old and new plumage, and the scapulars are often faded to something like black and white, and are badly frayed at the ends. The wings have now almost completed their moult, but there may still be a primary or two to change, even in very forward birds. The legs and feet are rapidly becoming feathered for the winter, though in backward birds which have been sick they are still quite bare, and now, of course, this feature may truly be taken to be a sign of sickness and disease, though in a convalescing bird.

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In *October* one may find a very backward bird with as many as three worn-out primaries in either wing to change; but, as a rule, the wing is perfect, the primaries and secondaries and their coverts all completely new, and in the tail the rectrices are full grown. The legs and feet are now also fully feathered, though the thickness of the growth increases as the winter cold comes on. On the back the bird now looks fresh and richly coloured from head to tail, but a close search will always disclose a number of spring-plumage feathers which have still to be thrown off. Underneath, the rich red-copper colour is gradually replacing all the previous buff on the chin and throat. The change " hangs fire " a little on the neck and upper breast, but it is still progressing, whereas on the lower breast and belly the rich red or darker winter plumage with its beautiful fine black crosslines and pure white flecks is a very striking feature.

There are, in the Committee's collection of skins, a number of examples showing the result of disease in deferring the moult; many of these birds, even in October and November, have failed to get rid of the old, faded and completely worn-out spring plumage. The majority of these birds have been so diseased in spring that they have not bred at all. The ovaries have throughout the season shown no development, and there are no signs, even in the earlier months, of the shedding or development of ova or of any increase in size of the oviduct. They have been true barren hens. In some cases there appear, in October, feathers of three separate plumages. There are the faded spring-plumage feathers of the current year, but mixed up with them here and there are new feathers of the autumn plumage coming, and here and there exceedingly old worn feathers of the autumn plumage of the year before. One example, an October hen, shows exceedingly well how the bare, broody patch of the abdomen grows delayed broad-barred buff and black feathers instead of the fine-barred darker autumn-plumage feathers which surround the patch. These broad-barred feathers appear in two parallel rows, breaking through the skin of the broody patch on either side of the medial line; this growth is also well shown in a specimen at the British Museum of Natural History.

In *November* the chief alteration is the completion of the autumn moult and the assumption of the autumn plumage. The feathers of the upper parts have black middles, and are barred with rufous-chestnut and ornamented with the characteristic white or buff-coloured terminal spots. November.

In *December* the hen is in full autumn-winter plumage. On the legs and feet she is well and thickly feathered; and on the under side the chin and throat are dark red, as well as the fore-neck, marked with broader black bars than upon the lower breast and abdomen, where the marking is of the finer type, and the colour distinctly of the redder and darker autumn plumage. December.

The following is a brief summary of the principal changes in the plumage of Grouse from January to December:—

The Cock Grouse.

January.—Full winter plumage. *Breast,* chestnut or reddish-brown and black with fine black crosslines. *Throat and fore-neck,* rich copper-red with little black edging to the feathers, white moustachios, abdominal feathers often broadly marked with white. *Legs and feet,* thickly feathered and white with (sometimes) brownish barring, claws very long and strong (*see* Pl. II. and III.). *Back,* uniform bright or dark chestnut or blackish-brown with fine black transverse markings (*see* Pl. IV.). *Wings,* flight feathers perfect, primary and secondary quills and retrices (tail feathers) complete.

A few paler feathers of the preceding autumn plumage still remain (*see* Pl. IV.). When these autumn feathers are numerous they may be regarded as a result of delayed moult caused by sickness.

February.—Full winter plumage. Autumn feathers are still present, but are only numerous in very backward birds.

March.—Full winter plumage but very forward birds may show a few new autumn feathers; some old autumn feathers are still present even in healthy birds.

April.—Winter plumage is still the main character, but new autumn feathers are beginning to appear on the neck and mantle. The feathers of the feet and neck are beginning to moult, and bareness of legs in this month is a sign of health (*see* Pl. V.). A few old autumn feathers still remain on the back and rump.

Nearly all birds picked up dead in this month and in May are very backward, and have not yet assumed the full winter plumage which they should have completed in December.

May.—A larger number of autumn feathers have appeared, but the winter plumage is still predominant, though by now it has become worn and dingy.

June.—Late in this month the autumn plumage begins to prevail, though winter feathers still remain on the abdomen, lower breast, neck, and throat. In this month the quills and tail feathers commence to moult.

The autumn plumage may be described as follows: Head and neck, breast and throat, broad-barred buff and black feathers not so rich or finely black-marked as the winter plumage. Back and rump black-centred feathers with broad-barred buff and black bands, a few with a whitish terminal spot.

July.—Full autumn plumage, the general appearance is much lighter in colour tone than the winter plumage. The wing and tail feathers are in full moult, the claws also are ready to be shed; but the feet and legs are beginning to grow new feathers. It should be noted that even in this month the winter plumage is still retained on the abdomen and lower breast; there is no second moult or replacement of these feathers.

August.—Autumn plumage is still predominant, but the new winter feathers are appearing, the old feathers of last winter's plumage remaining on the abdomen are rapidly shed and replaced. The new wing and tail feathers are completed. The claws are being shed, and the legs are still bare.

September.—The autumn feathers, already very worn and frayed, rapidly fall out, the breast and abdomen, wings and tail have grown new winter feathers, but the upper parts are still in transition; the legs are beginning to get their winter feathers.

October and November.—Winter plumage almost complete in forward birds; flight feathers perfect; legs well feathered; claws small.

December.—Full winter plumage with a few autumn feathers on neck and back, which are retained till following summer.

The Hen Grouse.

January.—Autumn or autumn-winter plumage. Throat and fore-neck copper-red, but not so red as in the cock. Breast, bright or dark red or black, flecked with white (*see* Pl. vii.). *Back*, chestnut, with black markings similar to the cock, but with terminal spots of buff. The old broad-barred feathers of the flanks are only found in backward birds. Legs and feet well feathered, claws long and strong.

February.—Full autumn-winter plumage in forward birds, a few spring feathers are appearing on the back of the neck.

March.—The spring or breeding plumage begins to appear in healthy birds. On the flanks broad-barred buff-and-black feathers are conspicuous, the lower breast and abdomen still retain the red-brown or red-black finely barred autumn-winter feathers; but on the chin, throat, neck, and upper breast forward birds show the broad-barred black-and-yellow feathers of the summer plumage. In backward birds these parts are still copper-red. The legs are less well feathered, but the claws are long (*see* Pl. viii.)

April.—Full spring plumage; on the back broad-barred buff-and-black with terminal whitish spots or bars, the breast flanks, chin, throat, and neck are similarly barred except on the lower breast and abdomen which still retain the autumn-winter plumage (*see* Pl. IX.). The legs and feet are poorly feathered, but the claws are long. Sickly birds are still in full autumn plumage with well-feathered legs.

May.—Full spring plumage.

June.—Full spring plumage, but now beginning to look faded and worn; the bare nesting patch is noticeable in hens that have been sitting.

July.—The spring plumage is now much faded, and the feathers are dropping out. The rich dark autumn plumage is beginning to appear on the chin and throat. The back and flanks remain as before; but the bare nesting patch is becoming covered with new feathers. The wing feathers are beginning to moult. The legs and feet are bare except in backward birds, and the claws are mostly shed.

August.—The autumn feathers, dark red-brown with fine transverse markings, has replaced the nesting plumage on the under parts, but on the back there is still a mixture of spring and autumn feathers. The legs and feet are beginning to show new feathers. The claws have been shed, and the new nails are small and soft. The wing feathers are still being moulted. Backward birds are very noticeable owing to their faded spring plumage, bare legs, and long claws.

September.—The breast and abdomen is in complete autumn plumage, but on the chin, throat, and back there is still a mixture of old and new feathers. The wing feathers have almost completed their moult, and the legs are beginning to be well feathered.

October.—The autumn moult is almost complete though a few old feathers remain on the back neck, and throat; the wing and tail feathers are perfect and the feet well feathered.

November.—Autumn moult completed.

December.—Full autumn or autumn-winter plumage.

Part III.—Local Variation in the Plumage of the Grouse.

The following notes are the outcome of an attempt to find some broad differences between Grouse from the Highlands, the Lowlands, the east coast and the west coast of Scotland, and from English, Welsh, and Irish moors.

It seemed possible that, with a large series of skins of a species peculiar to the British Isles, and at the same time so variable, one might discover points in the coloration of the plumage or in the size of the birds which could be attributed to the varying physical conditions under which they live.

The artificial transportation of Grouse from one country to another, generally from the southern moors to the northern, often far removed from one another, with different food and climate, has no doubt to some extent confused the issue. But this is a difficulty which will increase rather than decrease, and it is also possible that the purity of the British breed (at present the only species of bird peculiar to our islands), may before long be impaired by the introduction of a foreign species, the Willow Grouse, on the mistaken supposition that the latter is freer from the parasite of "Grouse Disease." This foreign species has already been introduced here and there, and has to some extent interbred with our own Red Grouse.

The Committee's collection contains five hundred and eighty skins of the Red Grouse, including five hundred and forty adult birds of both sexes and forty chicks and pullets. These, however, cannot be taken all together in one series. It is essential, for purposes of comparison, that the male birds in their two plumages should be taken separately in two lots, and the females in a similar manner. Therefore the skins have to be divided as follows :—

	No. of skins.
Male birds in winter plumage . . .	241
Male birds in autumn plumage . . .	120
Female birds in autumn plumage . .	108
Female birds in summer plumage . .	71
Immature birds of the first six months .	40

The largest series of skins is therefore that of the male birds in winter plumage, and it so happens that this set, both as regards sex and plumage, is best adapted by its general uniformity to give some result when arranged map-wise over a large outline of Scotland and England.

Having arranged the skins into lots which are sufficiently uniform to allow of comparison, and having arranged one of these lots, the cocks in their winter plumage, for instance, according to the localities from which they were obtained, it becomes possible to make the following deductions :—

(1) That the general uniformity is very much more marked than might have been expected considering the character for variability which has always been attributed to the bird; the variability is lost in the mass, though it is visible in individuals.

(2) That, allowing for a good many exceptions, there is certainly a greater tendency to blackness in the birds of the northern Highlands than in those of the south. Or, one may say that in passing from the north of Scotland southward and westward, there is an increasing tendency to the bright red and dark red types of Grouse, which culminate in the very characteristically bright red bird of Wales and of the Midlands of England, in which the predominating colour of the feathers of the breast and under parts generally is red with fine broken black cross-lines, while these cross-lines are sometimes almost absent.

(3) This gradual change from north to south of black, or red and black to dark red cocks, and farther south to bright red cocks is accompanied (speaking very broadly, for there are many exceptions) by a loss of the white terminal borders which characterise the feathers of the abdomen.

There is no doubt that the blacker birds of the Highlands of the north of Scotland are more frequently white spotted beneath than the birds obtained farther south. Nevertheless, the white spotting is not entirely confined to the blacker or to the darker birds, though in the lowlands and in the north of England, especially in Yorkshire, it is only exceptionally met with.

Mr Ogilvie-Grant, in his "Handbook to the Game Birds," 1896, says: "The ordinary varieties of the *male* may be divided into three distinct types of plumage: a *red form*, a *black form*, and a *white-spotted form*."[1]

The *red form*, he says, "is mostly to be found on the low grounds of Ireland, the west coast of Scotland, and the Outer Hebrides";[2] and this statement is borne out not only by the Committee's collection of Grouse skins, but by the interesting collection made by Mr T. E. Buckley now in the Cambridge Museum. Similar birds have been obtained in some numbers from Caithness, Sutherland, the Lewes, and Inverness-shire. From Stirling, Selkirk, Northumberland, and Wicklow only one or two have been examined, but in Wales the red type is almost always met with. Welsh birds are often most typically and uniformly very bright red. Dumfriesshire also undoubtedly produces a large proportion of the same red type.

Bright red birds are not commonly characteristic of Ross-shire, Stirlingshire, or Northumberland notwithstanding the fact that an occasional example of this type may be found in these counties. Dumbartonshire, however, and Argyllshire are said to produce more birds of a bright red type than other counties, and both these counties fall in with Sutherlandshire as forming part of the west coast of Scotland.

Examples of the red type of the cock Grouse are given in Pls. III. and IV.

The second or *black form* of cock Grouse is, according to Mr Ogilvie-Grant, rarely met with, most of the black birds being mixed with the red or white-spotted forms. In the Committee's collection there are a few very good examples of the really black type, and they come from the following areas:—Caithness, Sutherland, Perthshire, Dumbartonshire, and

[1] "Handbook to the Game Birds," p. 27. [2] *Ibid.*, p. 28.

Yorkshire. More or less typical examples have also been obtained from Ross-shire, Aberdeenshire, Morayshire, Kincardine, Stirling, Fife, and Lancashire. At Newcastleton the low-lying grassy moors are credited with the production of the black type of Grouse, while the other types are found on the higher heather ground.

An example of the black type of cock Grouse is given in Pl. II.

"The third or *white-spotted form* has the feathers of the breast and belly, and sometimes those of the head and upper parts, tipped with white. The most typical examples of this variety are found, as a rule, on the high grounds of the north of Scotland."[1]

This statement is again confirmed by the Committee's collection, although an occasional white-spotted bird makes its appearance farther to the south. The most marked examples of this white-spotted form have come from Caithness, Sutherland, and Inverness, while Dumfries, Perthshire, and Yorkshire have each provided one or two very fair examples. In Easter Ross birds are said to be most commonly dark red or black with white beneath. At Scrafton, Middleham, the majority have white beneath, and all are dark red or bright red; still the predominance of white beneath is quite conspicuous in a geographical arrangement of a large number of skins, as a character of the north of Scotland, especially throughout the Highlands.

Turning next to the female Red Grouse, no less than five distinct types are described by Mr Ogilvie-Grant: *a red form, a black form, a white-spotted form, a buff-spotted form, and a buff-barred form.*

The difficulty in arranging hen Grouse into these classes is that a single bird may fall under three headings at once. A hen Grouse may be at once buff-spotted, white-spotted, and red or black, for the white spotting is an independent character and may occur on any type in the autumn plumage of the breast

[1] "Handbook to the Game Birds," p. 28.

and abdomen, and this may also be definitely of the red or the black type.

In the Committee's collection, the first or *red form* is well represented from all parts of the country, and follows very much the same distribution as the red type of the cock Grouse.

Red examples were procured from the following areas:—Sutherland (3), Argyll (9), Arran (1), Dumbarton (1), Cumberland (1), Westmorland (1), and Wales (3), all bright red birds; Ross-shire, all dark red; Inverness-shire (3), very bright red and (3) very dark red birds; Aberdeen (3), very dark red birds; Stirling (4), red birds, with very fine black markings on the breast. Perthshire, Moray, Kincardine, Dumfriesshire, Kirkcudbright, Northumberland, Durham, and Yorkshire were all represented by red hens, generally of the dark red type.

An example of the red type of hen Grouse is given in Pl. VIII.

The second or *black form* of hen is certainly, as Mr Ogilvie-Grant says, extremely uncommon, and only one or perhaps two of the Committee's birds should be included under this heading. Two others are, however, so dark as to come with difficulty under the category of red birds.

Caithness produced a really black hen bird, the sex of which could not possibly have been determined from its plumage. It appears to be an old hen, which has assumed male plumage. A specimen from Inverness is almost as dark a bird, and another is a very dark reddish-black bird. A specimen from Dumbartonshire is similarly a case in which there seems to be more black than dark red.

An example of the black type of female Grouse is given in Pl. VII.

The third or *white-spotted form* is less rare, and, according to Mr Ogilvie-Grant, occurs as often as in the male. In the Committee's collection it is well represented by birds from Sutherland, Ross-shire (a bird of the red type), and Inverness. It was less to be expected that examples should have been met with in Yorkshire, Lancashire, and Westmorland. Single examples were procured in Dumfries and Kincardine. There is a fine Irish example from co. Mayo in the British Museum (Natural History), No. 99 12.1.1.

The fourth or *buff-spotted form* of hen Grouse, said to be "much the commonest and most usually met with, has the feathers of the upper parts spotted at the tip with whitish buff."[1] This type is generally distributed, and the Committee's collection includes examples from Caithness, Sutherland, Ross, Perthshire, Ayrshire, Kincardine, Dumfries, Northumberland, Yorkshire, Westmorland, and Lancashire.

The fifth or *buff-barred-form*, according to Mr Ogilvie-Grant, "is met with in the south of Ireland, and resembles in winter (autumn plumage) the ordinary female in breeding plumage, having the upper parts coarsely barred with buff and black. Very little is known of this last variety, owing to the difficulty of obtaining birds except during the shooting season."[2] The repeated endeavours of the Committee to obtain specimens resulted in one hen only being obtained from Donegal. This bird was a very typical example of the buff-barred type, and it certainly differed from anything procured either in Scotland, England, or Wales. The nearest approach to it was to be found in four hens from Selkirkshire, and in hens from Inverness-shire, which might be more accurately described as buff-barred than as buff-spotted. Single examples from Lanark, Mid-lothian, Roxburgh, Haddington, and Northumberland might be classed in the buff-barred type, and the females from Yorkshire were all rather of the buff-barred type, but none of these birds had quite the same markings as the Irish example.

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Two points in connection with the practical distinction of old Grouse from young, and of cock Grouse from hens, are of perennial interest both to the gamekeeper and to the sportsman. No discussion is more apt to produce different opinions than that which arises upon the age or the sex of Grouse in certain stages of moulting. It must be admitted that there are individual cases in which it is almost impossible to tell the sex

[1] "Handbook to the Game Birds," p. 28. [2] *Ibid.*

until the bird has been cut open and the internal anatomy examined. In these doubtful cases the only way to settle the point is to cut the bird open down the middle of the abdomen, carefully turn over the whole of the intestines from the right to the left—that is, from the bird's left side to the bird's right side—without tearing the attachments, and then, having exposed to view the flattened reddish kidneys which lie closely packed into the inequalities of the backbone and pelvis, to see whether an ovary or a testis is revealed overlying the uppermost portion of them.

It may be said that there is no other infallible means of arriving at the sex of a Grouse at certain times of the year, for it has so often happened that experienced and careful gamekeepers, who have handled Grouse for a lifetime, have certified a specimen as a cock, when the specimen has turned out to be a hen, and *vice versâ*. The mistake is unavoidable and excusable, for in certain individual Grouse in the autumn-winter plumage there is no reliable characteristic in the feathering or in the supraorbital comb, or in any external part of the bird, by which the sex can be distinguished. In most Red Grouse, however, the confusion of sex is not possible, for it is a matter of common knowledge that for a great part of the year the cock and the hen are so wholly unlike one another as to make it difficult for any one who did not know the birds to believe them to be of the same species. Even in the summer months, when the cock puts on a plumage closely simulating the breeding plumage of the hen, there is a difference in the general tone and colour. It is only in the autumn and winter that it is possible to mistake the sex of individual birds.

Generally speaking, the feathers of the head and neck give the best indication as to sex in the autumn-winter plumage. In the male the red colouring is, as a rule, far more uniform than in the female. In the male also there is, as a rule, an absence of black markings on these red feathers, except on the upper part of the head, on the crown, and nape of the neck. The cheeks are generally a clean bronze or chestnut-red colour; so are the feathers of the chin, throat, fore-neck, and upper breast, giving the bird a very rich uniform red colour all over the head and neck. In the hen, as a rule, the whole of the feathers of these parts are crossed by narrow black bars, giving her more of the mottled and broken colouring which the cock bird only begins to assume in the early summer when he puts on the first feathers of his autumn plumage.

The feathers of the chin are a very useful indication of sex from August to November, practically throughout the shooting season, for the chestnut-red feathers which can be found on the chin of the cock Grouse in every month of the year will be sought for in vain in the hen at this time. Even in December and January they are so imperfectly red as compared with the same red feathers in the male that one may almost say that red feathers are to be found on the chin of the hen only from February to July, when they become conspicuous on account of the contrast in colour with the increasing yellowness of the breeding plumage. These red feathers persist from her previous autumn-winter plumage exactly as do the feathers of the lower breast and abdomen.

This persistence of winter-plumage feathers on the chin, lower breast, and abdomen is common to both cock and hen; but in the cock they remain, as a rule, until replaced by the following winter plumage, persisting throughout the autumn plumage change; whereas in the hen they are persistent only to June or July, and are entirely replaced during the autumn change. Even when the autumn plumage is put on, the yellow feathers of the preceding breeding plumage are almost always to some extent persistent, and they are to be found in the chin of the hen bird even though the throat and neck may be unusually red and therefore unusually like those of a cock bird.

From January to May there is no possibility, as a rule, of confusing the sexes. In June and July confusion is unlikely, but in August and onwards to December the differentiation of the sexes by the plumage is sometimes a difficult thing, and the best guide is the persistence of feathers of the preceding plumage such as occurs upon the chin in particular. We must recollect that the dominating plumage of the male is the winter plumage, while that of the female is the summer or breeding plumage.

In the autumn, especially from September and October onwards, there is the additional difficulty of distinguishing old birds and young.

Distinction between old and young birds.

To quote Mr Ogilvie-Grant, "Young birds in July resemble the adult female in breeding plumage in their general colour, but the flank feathers of the adult plumage begin to appear about this time. By the month of November the young are generally not to be distinguished from the adults."

Groove on claw.

There is one sign of age in the majority of birds in the shooting season, if it has not become obliterated—namely, the mark across the claws of recent shedding. Very often one may find the nails or claws still adhering to the toes, though ready to drop off, so that a gentle application of force removes them like small caps, leaving the new shorter claws beneath, each marked by a groove where the old claw was attached. This groove persists often for some little time, and is an infallible sign that the bird is over a year old at least. Young birds of the year do not shed their claws, and therefore never have this groove.

Wing feathers.

There is another method of determining a bird's age which is often used as a rough indication upon the moor, namely, to pull out the third primary feather of the wing at its distal end. If blood can be squeezed from the quill it is considered as a sign that the bird is of the year. If no blood can be squeezed, and the feather is old and dry, it is considered as a sign that the bird is more than a year old.

This sign of blood in the quill of the third primary is not, however, an infallible sign of youth, for it is evident that as soon as the feather finishes its growth the quill becomes as hard and dry and bloodless as all the others. The only indication will then be a slight difference in the shape and contour of the two last feathers as indicated above.

Moreover, in September it is easy to find birds obviously adult with claws attached but on the point of being shed, and having all the primaries moulted except the two most distal ones. The third then will be found to be a short feather actively growing, and if it is pulled out the growing root will be full of blood. Therefore not every bird that gives this sign is necessarily a bird of the year.

ower bill.

Another sign often used to test the age of a bird is the strength of the lower mandible. The weight of the bird is allowed to hang without support by holding the tip of the lower bill only. The bone of an old bird's jaw easily stands this test, but the soft jaw of a young bird of three or four months cannot carry its weight, and the jaw either bends or breaks.

ull.

Yet another test often used is that of trying to crush in the skull with the finger and thumb; in the young bird the soft skull gives way readily, in the old bird it requires very considerable force.

In dissection, the age of an old bird is apparent, perhaps as plainly upon the table as elsewhere. The fibrous tissues all toughen with age and use, and the bones become harder. The grits of the gizzard in an old bird seem to be larger and more worn into rounded pebble shapes—the reason for this has been discussed elsewhere.[1] The question, therefore, of deciding whether a bird is less than a year or more than a year old, is possible, but it seems almost impossible to judge more exactly of the age of an older bird by any sign to be discovered either externally or internally.

[1] *Vide* chap. iii. pp. 107 *et seq.*

CHAPTER III

THE FOOD OF THE RED GROUSE

Part I.—Observations on the Food of Grouse, based on an Examination of Crop Contents.

During the period of the Inquiry the contents of three hundred and ninty-nine specimens of loaded crops have been examined by the Committee with the express view of ascertaining the various foods eaten by Grouse; the percentage of compositions have been tabulated, as well as the total weight of food in the crops at the various hours of the day, and by this means the Committee have come to several unexpected conclusions. In addition to those tabulated some eleven hundred other crops were examined, these were obtained chiefly from diseased birds in April and May, and from shot birds in August and September. The results correspond closely to those obtained from the tabulated specimens.

The three hundred and ninety-nine specimens of tabulated crop contents are well distributed as to locality and as to date. It is natural that by far the greater number should have been supplied during August and September; but the other months are fully represented, and no fewer than thirty-three counties have contributed specimens.

Table I. (p. 80) is drawn up to show the average weight of the crop contents of birds killed at different hours of the day, from 6 A.M. to 6 P.M. Time of feeding.

In the last right-hand column of Table I. will be found a general average for the twelve months, and it will be seen from the figures given that Grouse feed from morning until night,

TABLE I.—WEIGHT IN GRAINS OF CROP CONTENTS, IN WHICH THE HOUR OF COLLECTION WAS GIVEN, IN SUMMER AND WINTER RESPECTIVELY.

Hour of Collection.	Weight of Crop Contents of each Bird in Grains. (April to November.)	Weight of Crop Contents of each Bird in Grains. (December to March.)	Average Weight, in Grains. Apr. to Nov. Average.	Dec. to Mar. Average.	Combined Average for 12 Months.
6 a.m.	1	10, 10 . .	1	10	$5\frac{1}{2}$
7 „	8	No specimen .	8	No specimen	8
8 „	No specimen . .	20 . . .	No specimen	20	20
9 „	1, 8	10 . . .	$4\frac{1}{2}$	10	$7\frac{1}{4}$
10 „	3, 18, 19, 4, 4, 20, 9 .	No specimen .	11	No specimen	$5\frac{1}{2}$
11 „	18, 2, 16, 27, 20, 14, 3, 13, 24, 40, 28, 36, 43, 34, 11	5 . . .	22	5	$13\frac{1}{2}$
Noon.	12, 14, 2, 11, 18, 6, 7, 15, 21, 7, 1, 6, 15, 24	120, 10 . .	$11\frac{1}{3}$	65	38
1 p.m.	18, 36, 62, 29, 32, 2, 3, 5, 13, 13, 18, 12, 19, 0	No specimen .	19	No specimen	19
2 „	26, 45 . . .	70, 60, 20 . .	$35\frac{1}{2}$	75	$55\frac{1}{4}$
3 „	50, 173, 98, 213, 334, 27, 7, 12, 17, 26, 18, 14, 2, 6, 8, 28, 52, 24, 48, 31, 1, 5, 68, 31, 32	110, 100, 80, 180, 358, 200, 369, 50, 380, 250, 320 . .	53	217	135
4 „	15, 1, 4, 4, 246, 50, 17, 32, 50, 43, 50, 46, 8, 4, 2, 43, 3	339, 429, 239, 369, 429, 599, 280, 280 .	36	$370\frac{1}{2}$	$208\frac{1}{4}$
5 „	8, 1, 1, 2, 1, 254, 66, 18, 5, 32, 23, 17, 7, 23	150, 210, 200 .	$32\frac{1}{2}$	$186\frac{2}{3}$	$109\frac{1}{2}$
6 „	37, 93, 114 . .	10, 349, 290, 20, 409 . .	81	214	$147\frac{1}{2}$

but that full crops are more commonly found in birds killed in the afternoon and evening, both in winter and summer, than in the morning and forenoon.

When a Grouse is in health the gizzard invariably contains food undergoing a grinding process throughout the hours of daylight, even in the longest summer day. The crop is often found very full towards evening, and rarely so before noon; but this is only because in the evening the bird feeds more heavily in order to store up food for the hours of darkness, while during the daytime he seldom eats more than the digestive processes can deal with at the time. Hence during the early part of the day the food passes rapidly from the crop to the gizzard and on to the digesting tracts of the gut proper, and the crop is left almost empty. This has given rise to the view that Grouse only feed once a day, and that in the evening.

Heather (*Calluna vulgaris*), as is well known, is the ordinary food of the adult Red Grouse. But twenty or thirty other plants are also eaten, often in great quantities, and it is a well ascertained fact that Grouse that have never set eyes upon a sprig of heather will live and flourish for years.

Yet the importance of heather in building up the birds for the approach of winter cannot be exaggerated, and there is little doubt that in a bad heather year all the young birds suffer, while even in a good heather year the later broods will be permanently handicapped as regards physique and disease-resisting power if they have missed the best food months.

The most noteworthy fact brought out by Table I. is that Grouse appear to require a larger quantity of food in the winter months from December to March, than in the spring, summer and autumn months from April to November.[1]

It is, of course, true that in a bad heather year Grouse may find substitutes for their staple diet. Of these substitutes blaeberry is undoubtedly the most valuable, as may be seen by reference to Tables II. and III.;[2] but in many districts blaeberry does not grow upon the moors, and in no case is it so

[1] *Vide* also p. 34. [2] *Vide* pp. 82 and 89.

reliable a winter food as good heather. Other substitutes for heather are rush-heads, crowberry, bog myrtle buds, seeds of *Potentilla tormentilla,* fern leaves, bog cranberry leaves, flowers of *Erica tetralix* and *Erica cinerea,* moss spore capsules, sheep

TABLE II.—Showing the Percentages of Various Foods found in Crop Contents of Grouse from April to November inclusive.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Calluna (Heather) shoots, fresh and green	47	69½	82	31½	59½	63¼	31	24
Calluna (Heather) shoots, brown but living	46 } 93	12 } 82	0 } 82	21½ } 53	1 } 66	0 } 79½	11 } 70	15 } 72
Calluna flower-buds, flower and seed-heads	0	½	0	0	5½	16¼	28	33
Blaeberry (*V. myrtillus*), stalks and leaves	4	6	6	20	0	4½	9	22
Various, including Erica, Crowberry Fern, Sorrel, etc.	3	12	12	27	34	16	21	6

sorrel leaves and seeds, insects, and oats. On pp. 97-101 will be found a list of the vegetable foods eaten from time to time by the Red Grouse, with illustrations of some of the plants referred to.

The summer substitutes for heather, while interesting as showing the wide range of the Grouse's diet when many varieties of food are available, cannot be considered of great importance to the health of the adult bird, for if the heather is good, and the supply sufficient, the stock will be well nourished and healthy even on a moor where there are no berries or other miscellaneous kinds of food.

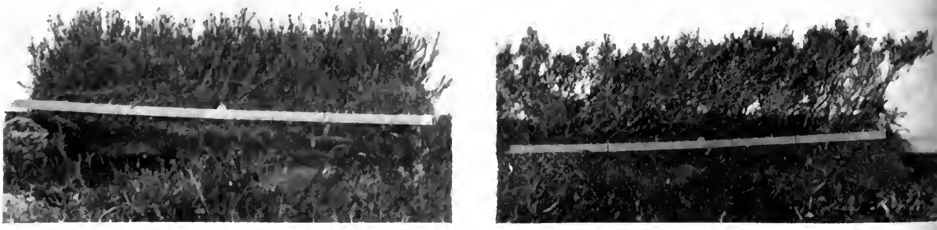
Heather, then, is the essential basis on which the Grouse depends, and the importance of the plant is so great that it may be permitted to give a short description of the phases through which it passes during the seasons of the year.

Beginning with the months of early spring, it will be seen from Table II. that in April the Grouse's diet consists of an equal quantity of fresh green heather and of brown "winter" heather. The former is more nutritious than the latter, but

PLATE XI.

TYPES OF HEATHER.

Old Heather valueless as food for Grouse.



Young short Heather valuable as food for Grouse.

Opposite p. 83.

even the brown winter heather is better than nothing, and is to be distinguished from withered dead heather which Grouse never eat.

Short *versus* long heather.

The fresh green heather so desirable for the food of Grouse does not necessarily represent the young shoots of the spring growth, for these do not generally appear till May, but rather the evergreen foliage which the plant carries upon its lower branches throughout the winter. No one who casually examines a Grouse-moor in mid-winter can realise that the dull brown weather-beaten scrub conceals on its more sheltered twigs a luxuriant growth of vivid green shoots: these green shoots are far more numerous on short close heather than on the long overgrown heather so common on many moors, for as the plant increases in height it becomes more open in its growth and more susceptible to the blighting effects of frost and cold winds.

In cases where the heather has attained a height of several feet the shelter is so greatly reduced that it is sometimes difficult to find any green shoots at all in winter unless the weather has been unusually mild; such long overgrown heather is of practically no value as winter food for Grouse (*see* Pl. xi., Fig. 1). This type of long and apparently luxuriant heather is very common on the west coast of Scotland, and in many districts in the central Highlands, and probably accounts for the fact that these districts carry a comparatively small stock of Grouse. In other districts the heather seems to have developed a short, close habit of growth—to the uninitiated it would appear to be stunted and poor; yet it is in the districts where this dwarf type of heather is common that Grouse appear to thrive in the largest numbers. The hills are covered with a close carpet of vegetation having a smooth level surface which may be compared to a well-clipped yew hedge—this level surface forms a canopy of shelter from frost, while the stems of the heather are so short and stiff that they are little affected by the wind. If this type of heather is examined, it will be found that immediately below the weathered canopy there is a rich growth of bright green shoots even in the most severe winter (*see* Pl. XI., Fig. 2).

There is no doubt that it is on the moors which have a large proportion of this short, close-growing heather that the largest stock of birds can be carried over the winter. But it is only on a special class of ground that this type of heather is found to grow naturally; it is usually associated with dry, hard soil, good natural drainage, a rocky subsoil, and only a shallow layer of peat on the surface; it is uncommon in districts with a heavy rainfall.

Even on the best ground there is a tendency for the heather to grow too long and bushy; but this tendency can fortunately be controlled by artificial means. In a later chapter the subject of heather burning is fully described,[1] and it is only necessary here to state that, for purposes of food, heather ceases to have any value after it has been allowed to become rank.

With the advent of May comes a great change in the condition of the heather plant. In this month every twig breaks out into green shoots, even the oldest and most ragged stick heather will produce young growth of the kind most valuable as food for Grouse; but it is now too late for this tardy recovery to be profitable, for the days of famine are past, and there is sufficient food to feed ten times as many birds as there are upon the ground. Even in this month of plenty, however, the close, short heather of from 4 to 8 inches in height is superior to the straggly forest of overgrown plants, for there is an ever present risk of late spring frost when the tender young shoots will require all the shelter they can get.

The appearance of the young growth is marked by an immediate change in the diet of the Grouse. On referring again to Table II., it will be seen that in May the consumption of fresh green heather shoots rises suddenly to 69½ per cent., while that of the dry winter heather drops to 12 per cent. At the same time the proportion of miscellaneous foods is more than doubled, owing doubtless to the fact that every moorland

[1] *Vide* chap. xii. pp. 343 *et seq.*

plant is throwing off its winter sleep and bursting into appetising young buds.

Just as the first flush of early pasture is more nourishing than the later growth, the first heather shoots of spring probably contain a larger percentage of nutritive food than at any other time of the year, and it is doubtless due to this cause that Grouse make such rapid growth in size and strength between the date of hatching in May, and the opening of the shooting season some ten or twelve weeks later.

It is in the month of May also that the young heather plants first begin to appear on the black ground where the old heather has been burned. The length of time that elapses between the date of burning and the growth of the new heather varies. If the roots are not too old, and have not been destroyed by the fire, the new growth will spring from them within a year; on some ground this always occurs. If, however, the roots have been burnt out, or are too old to send forth new shoots, the ground must lie waste for years, until a fresh growth of heather springs from wind-blown seed or from the seed lying dormant in the soil.[1]

It is usual to suppose that the first shoots of the young heather as they appear above the ground are greedily eaten by Grouse. Observation has shown that this view is not strictly correct, for the adult birds will never feed on the immature plant so long as they can find plenty of close-growing heather of the type described on p. 83. This is fortunate, for otherwise the first growth might be very severely checked on a moor carrying a heavy stock of birds. Sheep, on the other hand, are very fond of the tender young shoots, and are often most destructive to seedlings which have not had time to secure a firm roothold.

While the adult Grouse does not eat the very young heather, there is no doubt that the chicks prefer it to the shoots of the more mature plant; but the amount eaten by them in the days of their infancy is so small that

[1] *Vide* chap. xii. p. 352.

they cannot make any material impression on the growth of the plant.

In June there is a continuance of the favourable food conditions which commenced in May. It will be seen by reference to Table II. that in this month the consumption of fresh green shoots of heather rises to 82 per cent., while that of brown winter heather drops to zero.

In July the consumption of heather drops to its lowest for the year—only 53 per cent.; this is doubtless partly due to the ripening of blaeberries which occurs in this month. The consumption of blaeberry stalks and leaves has risen to 20 per cent., while the quantity of berries eaten is shown by the increase of "various" to 27 per cent. The unexpected increase in the consumption of brown winter heather is puzzling, but might be accounted for by an abnormal period of cold weather or blighting wind causing a "set back" in the new growth, and driving the birds to feed more largely on the old shoots. This view is supported by the fact that the birds have also eaten an abnormal quantity of blaeberry stalks and leaves, whereas in the following month, when the heather has presumably recovered from its temporary blight, the consumption of brown winter heather and blaeberry leaves and stalks drops at once from 47 per cent. to 1 per cent. The figures for July shown in the Table are probably exceptional, and do not represent the normal proportion of foods eaten in that month; but they are interesting as showing the elastic manner in which the Grouse can adapt himself to varying conditions.

In August the figures for the consumption of heather appear to have become normal, and the fact that this is the great berry month of the year is shown by the increase of "various" to 34 per cent., the largest amount in any month. Berry feeding is, of course, irregular, for berries only grow in certain localities, their consumption cannot therefore be gauged by the examination of specimens obtained from moors where no berries are obtainable. Berries are not an essential item in the diet of the Grouse; but it is well known that where they are to be obtained Grouse will flock to them in large numbers often deserting the heather altogether for a while and congregating in vast packs upon the berry ground. The blaeberry fruit does not as a rule grow in such profusion as that of the clusterberry or Scottish cranberry, and does not seem to be so attractive to the Grouse, though its leaf and bud are much more generally eaten at all times of the year.

Heather flowers and seeds.

The August figures are interesting as showing the first indication of heather blossom in the diet. First in the bud, afterwards in full bloom, and lastly in the form of fully ripened seed, the flower of the heather is an important item of food. There is an old saying that when the "stoor" (*i.e.*, pollen dust) is on the heather in August a good Grouse season is sure to follow, and the experience of the Committee tends to confirm this belief. In a year when the bloom is early and luxuriant the pollen rises in clouds when disturbed, covering boots and gaiters with a soft yellowish dust, and sometimes even interfering with the breathing of the dogs. This condition is usually followed by a fine harvest of well-ripened heather seed, and the importance of heather seed as a form of food may be seen at a glance from the figures given in Tables II. and III.

It is often stated that in seasons when the corn has ripened well and early, the stock of Grouse in the following spring is healthy and vigorous, and the breeding season a good one; from this it has been argued that the same weather which has resulted in a good crop of grain has also produced a good crop of heather seed. This factor, too, may have something to do with the difference in the numbers of Grouse which moors in different parts of the country are capable of carrying. It is well known that the number of Grouse on a moor does not depend upon the area of heather land, for in the thinly-stocked moors of the west of Scotland the heather growth is stronger than in the south of Scotland, where in many districts there is a larger stock of birds. Even in Yorkshire, Lancashire, and Derbyshire the ground does not appear to be better suited for the growth of heather than in Scotland, yet in these counties the stock of birds is proportionately much greater. The difference is partly to be accounted for by the fact already noted, that the heather in the north of England is of a better quality, that is to say with many more stalks to the square yard, than the rank growth of the west of Scotland, but it has also been suggested that in the former country the normal weather conditions are more favourable to the ripening of the heather seed. Again, in Caithness, where the grain always ripens well on account of the long hours of daylight in the summer months, the stock of birds which the ground can carry is unusually large.

In September, October, and November, the tendency to revert gradually from summer to winter diet is well exemplified by the figures in Table II. Throughout these three months the consumption of the heather seed increases steadily, while " various " drops from 16 per cent. in September to 6 per cent. in November. In October we find the item of " brown winter heather " reappearing in the list, and in November we have a sudden increase in the consumption of blaeberry stalks and leaves, due probably to some temporary check suffered by the heather similar to that indicated by the figures for July.

Winter food.

Turning to Table III. (p. 89) we find that in the four winter months the diet becomes more restricted. " Various " practically disappears, and its place is taken by a larger quantity of heather shoots, while heather seeds and blaeberry stalks still keep their place in the list.

One or two points are worth noting. In the first place, the sudden drop in the consumption of heather seed from $20\frac{1}{4}$ per cent. in January to $2\frac{1}{2}$ per cent. in February and $2\frac{1}{3}$ per cent. in March is interesting as showing that once the seed has fallen to the ground it is no longer eaten by Grouse, though it may be valuable for the reproduction of the plant.

Another point is that, both in this and the preceding Table, the figures relating to the consumption of blaeberry stalks and leaves are misleading because they are the result of averaging the crop contents of a large number of birds—many of them sent from localities where blaeberry is unknown. Were the crops of individual birds recorded it would be found that those coming from moors where blaeberry is common would show almost as large a consumption of that plant as of heather. Blaeberry forms as much as 30 per cent. of all foods taken by Grouse in Derbyshire, 22 per cent. in Yorkshire, 11 per cent. in Inverness and Dumfriesshire, and very little in any of the other counties.

TABLE III.—Showing the Percentages of Various Foods found in Crop Contents of Grouse from December to March inclusive.

	December	January	February	March
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Calluna (Heather) shoots . .	$59\frac{2}{3}$ } $86\frac{2}{3}$	64 } $84\frac{1}{4}$	$75\frac{1}{2}$ } 78	97 } $99\frac{1}{3}$
Calluna (Heather) seed-heads .	27 (more than $\frac{1}{3}$ ripe)	$20\frac{1}{4}$ (more than $\frac{1}{6}$ ripe)	$2\frac{1}{2}$	$2\frac{1}{3}$
Blaeberry stalks and buds (*Vaccinium myrtillus*) . . .	10	$13\frac{1}{4}$	15	...
Various, including Cowberry leaves (*Vaccinium vitis-idæa*), Bog Cranberry leaves (*Vaccinium oxycoccus*), Crowberry leaves (*Empetrum nigrum*), *Erica*, sorrel, fern, and other green leaves	$3\frac{1}{3}$	$2\frac{1}{2}$	7	$\frac{2}{3}$

In special cases these averages are departed from, especially when the heather crop has been a failure. Thus, some December specimens from Lancashire showed the remarkable average of 80 per cent. of blaeberry stalks and buds, with only $17\frac{1}{2}$ per cent. of heather shoots and $2\frac{1}{2}$ per cent. of heather seed, but in this case the heather-seed crop in Lancashire was reported as very bad. In the same year the heather seed crop in Peebles and Merioneth was reported as exceptionally good, and the December specimens from both these counties showed the proportion of 50 per cent. of heather shoots and 50 per cent. of heather seed, but *no* blaeberry.

Probably the consumption of other foods, which are classed under "various," and have already been enumerated, varies in the same way chiefly with local relative abundance, as, for example, in Perthshire, where "various" rises to 53 per cent.; Ayrshire, where it reaches 47 per cent.; and Derbyshire, where it reaches 40 per cent. of all foods taken.

Individual taste plays a large share in the food statistics of Grouse. One may find, for example, one bird eating largely of fern leaf, another of bog myrtle buds, another of nothing but rush-heads or *tormentilla* seed. In one case, where two birds were killed with a "right and left" in a Grouse drive it was found that one had filled his crop with heather shoots, the other with blaeberry leaf buds, yet both birds had come off the same beat. Occasionally one finds that even an adult bird has eaten scores of small black gnats. The flower of *Calluna* is varied occasionally by the flower of *Erica tetralix*, or ripe cluster berries, or spore-capsules of several mosses, or leaves of the cloudberry.

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The interest of Table III. centres on the first item, "Heather Shoots," for the figures prove conclusively, if proof were required, that, except on favoured moors where blaeberry abounds, heather shoots and nothing but heather shoots constitute the diet of the Grouse during February and March—the fact that the February column shows 7 per cent. of "various" was due to one bird's crop being almost entirely filled with crowberry leaves, a quite unusual diet; the "various" consumed by other specimens examined for the month only amounted to $\frac{1}{3}$ per cent.

It is obvious, therefore, that in February, March, and April the question of food becomes a critical one, for if the heather fails the Grouse must suffer either by direct starvation, or what is more dangerous, by being forced to crowd too closely on to the few small areas where good winter heather is to be obtained.

Although we have no evidence from any one of the hundreds of Grouse crops examined that true frosted heather is ever eaten, the heather which actually filled the majority of the winter crops varied greatly in its value as a food. It could often be seen that the birds had been hard put to it to fill their crops at all, perhaps from stress of weather, or more probably because of excessive or deficient burning or an overstock of sheep, or for some other less obvious reason.

The mere fact that the crops of many birds contain old heather is enough to prove that birds sometimes find great difficulty in collecting a meal of wholesome food. The vast majority of winter crops contain, as we have already said, good dark green or dark reddish brown winter heather, sound wholesome food with a minimum of dead woody tissue. But now and again one finds a crop full of old woody growth of which the food value must be very small. This is probably due to the fact that the moor has been left long unburned, and that all the heather within reach is old and rank. Or the moor may have been over-burned from every point of view except that of the grazing tenant. In such a case large tracts of young heather are burned again and again, often by runaway fires, to bring the land to grass and kill the heather. In this the grazing tenants of parts of the borderland and of the north of England have been very successful, and heather in many places is a thing of the past, the moors being now almost all white land. Scattered through this, where the tussocky grass has had its way for many years, is a thin growth of useless straggling heather of little value as food for bird or beast.

For the purpose of drawing up Tables II. and III. two hundred and eighty-seven specimens of Grouse were examined, and the specimens were fairly evenly distributed over the months from April 1906 to March 1907. The specimens represented birds from no fewer than twenty-seven different counties, so that the results may be regarded as conclusive, so far as concerns the particular period under review.

In case, however, of the period selected being abnormal, Table IV. (p. 92) was prepared to show the crop contents for two complete years, viz., 1906 and 1907. In this Table the figures for the corresponding months are placed together, and an average is struck for each month. It will be seen that these averages show the same general tendencies as are seen in the former Tables, and confirm the view that the figures given in Table II. for July and November 1906 were abnormal, and probably due to exceptional circumstances.

The total number of specimens examined for the purpose of drawing up Table IV. was four hundred and thirty-six, including the two hundred and eighty-seven already included in Tables II. and III.; but in 1907 the specimens were not quite so well distributed as in the earlier period.

TABLE IV.—Comparison of Monthly Averages of Crop Contents covering Two Years.

		Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Calluna heather shoots . .	1906	64	$75\frac{1}{2}$	97	93	$81\frac{1}{2}$	82	53	$60\frac{1}{2}$	$63\frac{1}{4}$	42	39	54
	1907	89	72	81	64	100	100	95	38	63	51	$70\frac{1}{2}$	$59\frac{2}{3}$
	Av.	$76\frac{1}{2}$	$73\frac{3}{4}$	89	$78\frac{1}{2}$	$90\frac{3}{4}$	91	74	$49\frac{3}{4}$	$63\frac{1}{8}$	$46\frac{1}{2}$	$54\frac{3}{4}$	$56\frac{5}{6}$
Calluna heather flower and seed-heads . .	1906	$20\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{1}{3}$	0	$\frac{1}{2}$	0	0	$5\frac{1}{2}$	$16\frac{1}{4}$	28	33	23
	1907	10	9	2	0	0	0	0	14	21	24	$19\frac{1}{2}$	27
	Av.	$15\frac{1}{8}$	$5\frac{3}{4}$	$2\frac{1}{6}$	0	$\frac{1}{4}$	0	0	$9\frac{3}{4}$	$18\frac{5}{8}$	26	$26\frac{3}{4}$	25
Blaeberry stalk, bud and leaf.	1906	$13\frac{1}{4}$	15	0	4	6	6	20	0	$4\frac{1}{2}$	9	22	21
	1907	$\frac{1}{2}$	19	15	21	0	0	0	12	0	1	10	10
	Av.	$6\frac{7}{8}$	17	$7\frac{1}{2}$	$12\frac{1}{2}$	3	3	10	6	$2\frac{1}{4}$	5	16	$15\frac{1}{2}$
Various . .	1906	$2\frac{1}{2}$	7	$\frac{2}{3}$	3	12	12	27	34	11	21	6	2
	1907	$\frac{1}{2}$	0	2	15	0	0	5	36	16	24	0	$3\frac{1}{3}$
	Av.	$1\frac{1}{2}$	$3\frac{1}{2}$	$1\frac{1}{3}$	9	6	6	16	35	$13\frac{1}{2}$	$22\frac{1}{2}$	3	$2\frac{2}{3}$

The results of this Table have also been given in the form of a chart for purposes of comparison.[1]

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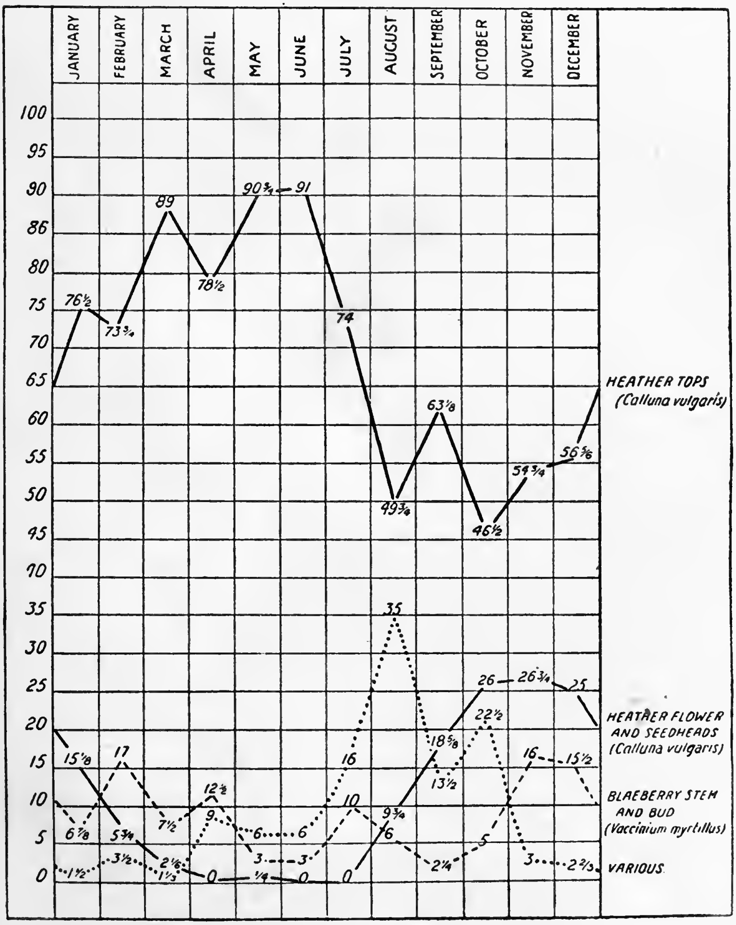
The strain upon the vitality of the Grouse in the winter months is intensified by the fact that a greater bulk of food is required by each bird per day than is required during the summer.

[1] *Vide* p. 93.

But few would have rated it at five times the quantity, and yet, from a comparison of the afternoon crops of the winter with those of the summer, this appears to be the case. Thus the average weight of food found in a Grouse crop from

CHART SHEWING
PERCENTAGE CONSUMPTION OF VARIOUS FOODS EATEN EACH MONTH BY THE RED GROUSE



December to March, between 3 P.M. and 6 P.M., is 250 grains, whereas the average weight of food found in a Grouse crop from April to November, between 3 P.M. and 6 P.M., is only 50 grains.

The fact that more food is required in winter to maintain the body temperature would, of course, partly account for this increase, even if the heather had the same food-value. But as heather certainly has an inferior food-value in winter, the amount taken must be increased in a far greater proportion. No doubt the necessity for provision during the longer hours of night-time has some effect in the overfilling of the crop in winter, but this would not account for crops being heavier in March, when the days are comparatively long, than in November when they are short.

The interesting fact remains, and is amply proved by the figures, that more food is required by the Grouse in winter than in other seasons of the year; and as in winter the proportion of *Calluna* to all other foods is as seven to one, it is obvious that a very great advantage accrues to a Grouse on a moor in which young and comparatively nourishing heather is abundant during the winter months, *i.e.*, on a well-burned moor, well covered with short close heather of a varying number of season's growth.

To put this conclusion in other words; whereas in summer a certain area of heather will support a bird comfortably, many times this area will be required for the same bird in winter, so that the capacity of a moor, as regards the question of stock, must be gauged mainly by its Grouse-feeding value during the winter months.

If we consider this generalisation with reference to moor management we shall see that a moor carrying its full tale of birds in the summer becomes automatically and unavoidably overstocked in the winter unless the stock is heavily reduced by shooting, for not only is there less food available, but the birds require a much larger quantity of food to keep them in health.

Migration of birds in winter obviously complicates the question. In the case of a moor on high ground, which often loses all its birds in winter, probably natural conditions regulate the stock of birds automatically during spring and summer. But on the adjacent low-lying moors the case is more serious; for the ground has to supply not only more food than is needed for its own stock in summer, but in addition an increased seasonal demand made upon it during the winter months by hundreds of undesirable immigrants from the higher ground. Such low-lying moors must always run the risk of being dangerously overstocked in the winter.

In certain parts of the country oats form a regular seasonal change in the dietary of Grouse, and this form of food must now be considered.[1] Oats.

Very few birds with corn in any part of the alimentary canal were submitted for examination; but so far as these specimens show, oats are an unsuitable form of food for Grouse. As is well known, Grouse often visit the stubbles and corn stooks in very large packs in the autumn—in September, October, or November, according to the season and locality. They seem to know that they are out of place, and finding themselves with a wealth of food all round, away from their normal surroundings, are eager to fill themselves as full as possible in a very short space of time, aware, by instinct or experience, that they may be disturbed at any moment. One consequence is, as the examination of birds has shown, that they eat as much husk as grain, instead of picking and choosing, as Partridges do, in a quiet and leisurely manner. This difference in the crops of Grouse and Partridges that have been feeding on the same ground is very noticeable. The one is filled to repletion with indigestible and exceedingly irritating husks and a comparatively small amount of grain, while the other (the Partridge's crop) contains grain only.

The result in the Grouse is that the whole alimentary canal, from one end to the other, is soon in an irritable and inflamed

[1] *Vide* also chap. i. p. 29, and chap. iv. pp. 145 *et seq.*

condition. The gizzard does what it can to work up the husks and grain into a milky paste, but the microscope shows that this paste is to a large extent composed of siliceous spicules and small spines of an almost glassy hardness. This damages the delicate mucous lining of the intestine. The result of the passage of this irritating food is, first, an extra flow of digestive juices, secondly, an increased activity on the part of the walls of the intestine, both as to movement (peristalsis) and secretion from the stimulation produced by this form of food. Thirdly, comes a point at which mucus is thrown out in large quantities to protect the gut, and this continues and increases until the actual cells themselves are shed, and the protection breaks down. Finally, the intestine becomes inflamed to the extent of ulceration, and this state will continue and increase so long as the cause continues to act.

Such irritation to the intestine of even a healthy Grouse, which already has to deal with worms of at least two kinds, is bound to have an evil effect if continued for any length of time; moreover, in places where the corn is left out owing to bad weather, or for other reasons, there is the additional aggravation that the birds may be filling themselves with wet and sour grain, not one whit the less irritating as regards the husk, which cannot be softened by wet; and no doubt the consequence of this is in some seasons noticeably bad.

Corn in moderation is probably not unwholesome as a food, and were it possible to feed one set of Grouse with clean grain, and another with such stuff as the birds pick up for themselves on the stubbles, there is no doubt that the former would rapidly improve in condition, and the latter go steadily downhill. Such an experiment is not practicable.

To recapitulate, the following may be given as a fairly accurate account of the monthly dietary of the Red Grouse for the year:—

January, *Calluna* shoots (64 per cent.) and *Calluna* seed-heads (27 per cent.).

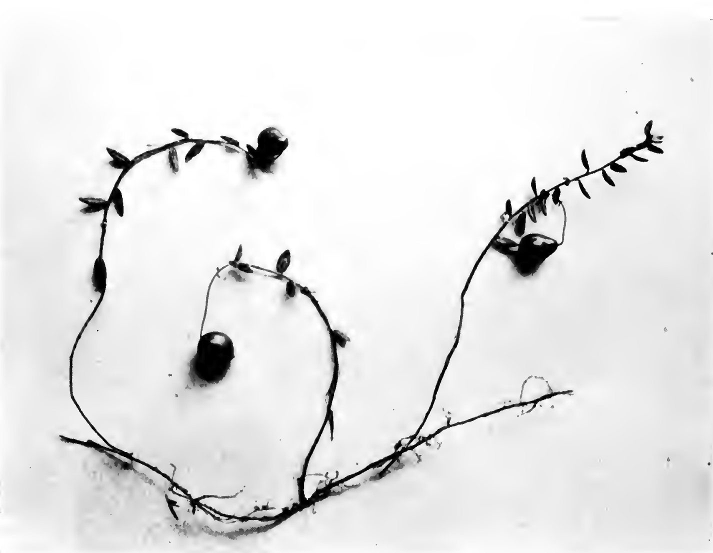
February, *Calluna* shoots (75 per cent.) and the stalks and buds of blaeberry and leaves of cowberry.

PLATE XII.

PLANTS EATEN BY THE GROUSE.

C. G. M.

Fig. 1. *Vaccinium myrtillus* (Blaeberry—Whortleberry—Bilberry—Whorts—Whinberry).



C. G. M.

Fig. 2. *Vaccinium oxycoccus* (Cranberry—Mossberry).

March, *Calluna* shoots (97 per cent.) and blaeberry stalks and buds.

April, *Calluna* shoots (93 per cent.) and very little besides.

May, *Calluna* shoots (82 per cent.) and rather more "various."

June, *Calluna* shoots (82 per cent.) and "various."

July, *Calluna* shoots (53 per cent.) and an increasing amount of "various."

August, *Calluna* shoots (60 per cent.) and some *Calluna* flowers and "various."

September, *Calluna* shoots (63 per cent.) and 16 per cent. of *Calluna* flowers and "various."

October, much less (42 per cent.) of *Calluna* shoots, and nearly 30 per cent. of *Calluna* flowers, and some "various."

November, still less (39 per cent.) of *Calluna* shoots, and 33 per cent. of *Calluna* flowers and seed-heads, and the rest "various."

December, a rise in *Calluna* shoots to 60 per cent., but still 27 per cent. of *Calluna* seed-heads.

List of Vegetable Food eaten from Time to Time by the Red Grouse.

Heather or Ling (*Calluna vulgaris*), the staple food of Grouse. Grouse eat the shoots, flowers, and seed-heads. *See* Pl. xi., p. 83.

Blaeberry (*Vaccinium myrtillus*), known also as Whortleberry, or Whorts Bilberry, Whimberry, Blueberry, or Blue Whortleberry. A low branched shrub 6 to 18 inches high, growing often in large green patches The flowers which appear in April, May, and June are flesh-coloured, and the berries, which are black with a purple bloom, ripen in July and August; they are agreeable to the taste. Grouse eat the stem, buds, flowers, and berries. *See* Pl. xii., Fig. 1.

Cranberry (*Vaccinium oxycoccus*) known also as Bog Cranberry, Mossberry, Moorberry, or Fenberry, a very low plant with a prostrate straggling slender stem and small leaves. It is found creeping on the surface of the moss in boggy places. The flowers which appear in June, July, and August are solitary and bright red, and the dark red fruit, which ripens in August, is pleasant to the taste. This berry is common in many parts of England, but is little known in Scotland, though the plant without the berry is sometimes seen. The leaf and the berry are sometimes eaten by the Grouse. *See* Pl. XII., Fig. 2.

Red Whortleberry or Cranberry (Scotland) (*Vaccinium vitis-idæa*), also called Clusterberry, Cowberry, Nutberry, or Nubbery, Craneberry, and Crawberry, a low, straggling shrub with leaves resembling those of the box. The pink flowers, which appear from June to August, grow in terminal drooping clusters, and the bright red berries ripen in September. Its leaves are to be distinguished from those of *Arctostaphylos uva-ursi* by the dots on the under surface and the rolled back edges. Grouse eat the berry eagerly, and will occasionally feed on the leaf. *See* Pl. XIII., Fig. 3.

Red Bear Berry (*Arctostaphylos uva-ursi*), also called Grassack or Graashacks, a small trailing evergreen shrub which grows in dry heathery and rocky places. The leaves are finely reticulated, and the berries are red, and inside are mealy with hard angular seeds. The rose-coloured flowers appear from June to August in terminal clusters. *See* Pl. XIII., Fig. 4.

Cloudberry (*Rubus chamæmorus*), also called Averine and (in Cumberland) Noops, a small herbaceous plant belonging to the Raspberry family with large green leaves resembling those of the Geranium. It grows amongst the heather and grass on the mountain tops and high ridges. Its flowers, which appear in June and July,

PLATE XIII.

PLANTS EATEN BY THE GROUSE.

C. G. M.

FIG. 3. *Vaccinium vitis—Idæa* (Red Whortleberry—Clusterberry) Cranberry (*Scot.*)

C. G. M.

FIG. 4. *Arctostaphylos uva-ursi* (Red Bear Berry—Graashacks).

p. 98.]

PLATE XIV.

PLANTS EATEN BY THE GROUSE.

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FIG. 5. *Rubus chamæmorus* (Cloudberry—Averine).

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FIG. 7. *Erica cinerea* (Bell Heather—Fine-leaved Heath).

Opposite p. 99.]

are white or rose-coloured, and grow on short erect stems, they are not unlike the flower of the Blackberry or Bramble, and its bramble-like fruit is red, turning to orange yellow as it ripens. The leaf and berries are eaten by Grouse. *See* Pl. XIV., Fig. 5.

Bell Heather (*Erica cinerea*), also called Fine-leafed Heath, has leaves three in a whorl; it grows on dry places and in similar situations to common heather. It flowers in July and August, and the bloom appears before that of the common heather. The flower bells are purple. The taste of the leaves is more bitter than that of common heather. The flower alone is eaten by Grouse, but while it is out it is eaten in fair quantities. *See* Pl. XIV., Fig. 7.

Crowberry (*Empetrum nigrum*), also known as Crakeberry, Singberry or Blackberried Heath, a small prostrate plant with the habits of a heath. The purplish flowers, which appear in May and June, are very small and are placed in the axils of the upper leaves. The ripened berries are black. The top shoots, tight leaf buds, and berries are eaten by Grouse. *See* Pl. XV., Fig. 6.

Cross-leafed Heath (*Erica tetralix*), has leaves, four in a whorl, and placed crosswise. It has rose-coloured flowers and grows in similar situations to common heather. Flowers in July and August. The flower-heads are eaten in quantities by the Grouse, but the leaf-shoots are avoided. *See* Pl. XV., Fig. 8.

Dwarf or Creeping Willow (*Salix repens*), a low, straggling shrub from 2 inches to 1 foot in height. Foliage and young shoots more or less silky white. The plant has small oblong leaves, and bears small catkins in spring, followed by silky seed vessels. Found on sandy ground. Where it occurs the leaves and young shoots are greedily eaten by Grouse.

Bog Myrtle (*Myrica gale*), also known as Sweet Gale, an erect shrub, 2 or 3 feet high, fragrant when rubbed.

It has long, narrowish pointed leaves, slightly toothed near the tip, and often downy beneath. It bears small catkins before the leaves are out. Always found in boggy places. Grouse eat the buds in winter and early spring, but sparely.

Cotton Grass (*Eriophorum*), also called Cottonsedge, two or three species of similar habit. A rush-like plant, bearing in summer, after the flowering period, conspicuous, white, cottony tufts, either solitary or in clusters of two or three or more. Grouse are very greedy for the flower of this plant in spring, and the tender shoots are also said to be useful when they first appear. The plant is then known by gamekeepers as "Blackhead" or "Moss-crop." It is found in marshy ground.

Sorrel (*Rumex acetosella*), Common Red or "Sheep" Sorrel. A slender plant, from 3 or 4 inches to 1 foot high, often turning red. It has long, more or less arrow-shaped leaves, very acid to the taste. The red-tinged green flowers are in terminal clusters on an erect stem, and are seen from spring to autumn. The plant grows in dry pastures, and on open heaths. The seeds are greedily eaten by Grouse.

Heath Rush (*Juncus squarrosus*), a small rush about a foot high, growing in drier situations than most rushes. The flower and seed-heads are very freely eaten by Grouse.

Field Wood Rush (*Luzula campestris*), a small rush with soft, flat, grass-like leaves, fringed with silky hairs. It grows in dry places. The flower- and seed-heads are eaten by Grouse.

The following additional list of plants, upon which Grouse are said to feed, is given in a pamphlet on "The Improvement of Grouse Moors," by the Rev. E. A. Woodruffe Peacock, who has examined the contents of many crops and gizzards of the Grouse.

Tormentil (*Potentilla tormentilla*).

Suckling Clover (*Trifolium minus*).

PLATE XV.

PLANTS EATEN BY THE GROUSE.

C. G. M.

Fig. 6. *Empetrum nigrum* (Crowberry—Crakeberry).

C. G. M.

Fig. 8. *Erica tetralix* (Cross-leaved Heath).

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Heath Bed-straw (*Galium saxatile*).
Marsh Lousewort (*Pedicularis palustris*).
Heath Lousewort (*Pedicularis sylvatica*).
Yellow Violet (*Viola lutea*).
Bracken Fern (*Pteris aquilina*).

The seeds of the following plants are greedily eaten, and are most useful as late autumn and winter food :—

Mouse-tail Grass (*Alopecurus myosuriodes*).
Purple Melio Grass (*Molinea cœrulea*).
Common Orache (*Atriplex patula*).
Chickweed (*Cerastium triviale*), and other moor cerastia.
Persicaria (*Polygonum aviculare, and P. persicaria*), and Knot Grasses of all species. The flower-heads are also eaten.

In their season, too, Grouse are very fond of capsules of the moor mosses, such as the Great Golden Maidenhair Moss (*Polytrichum commune*), and the smaller fungi.

Part II.—The Insect Food of Young Grouse based on an Examination of Crops and Gizzards.

The Committee have devoted special attention to the question of the food of the Grouse in the earlier stages of its existence, and have examined the crop contents of many chicks with a view to ascertaining the nature of their diet. Their dietary is extraordinarily varied, and probably we have as yet by no means exhausted the list of what they eat. It was observed from the commencement of these investigations that young Grouse were much more addicted to insect food than were the adult birds, and in order to complete the Committee's knowledge on the subject it was found advisable to obtain the services of an entomologist.

In the months of June and July 1908 the moors in Inverness-shire, Morayshire, and Banffshire, and at a later period those in Yorkshire, were visited with the following objects.

(1) To obtain a number of young Grouse chicks and to

examine the contents of their crops and gizzards, with a view of ascertaining both the nature of their food, and also, if possible, the intermediate host (supposed to be some insect or mollusc) of the Cestode parasites which infest these birds.

(2) To identify exactly the various fragments found in the crop, proventriculus, and gizzard of Grouse by the careful collecting of insects on the feeding grounds of the young birds. In many cases the remains in the crop or intestine were so broken up and crushed that it was only possible to determine and name them after careful comparison with whole specimens obtained on the same spot.[1]

(3) To collect and put into spirit large numbers of insects and spiders for the purpose of dissection and microscopic examination for possible cysts of tapeworms.

The birds were captured by hand and immediately killed by chloroform, dissected the same day, and their crops and gizzards transferred to methylated spirit. The contents of both crops and gizzards were afterwards examined, and the fragments carefully compared with whole pinned insects obtained on the same ground as the chicks. A detailed list of the contents of the crops and gizzards of the chicks was published in the Final Report of the Committee.[2]

The list of insects collected was most interesting, and included many rare species. Most of the specimens were collected on the actual feeding grounds of the young Grouse, and the list is therefore useful as showing the variety of diet possible during the first few weeks of the chick's life.

On a typical Grouse moor by far the greatest variety of insect-life is found in the marshy ground around the sources of the streams. *Diptera* largely preponderate, but small Tineid Moths, May-flies, Stone-flies, and Spiders are also plentiful. On the higher and drier ground many other insects were

[1] A complete list of the insects obtained on the moors during the course of this Inquiry has been published in the "Annals of Scottish Natural History," pp. 150-162, July 1910.

[2] "The Grouse in Health and in Disease," vol. ii. pp. 86-90.

found, including Crane-flies, Bees, and the larger *Lepidoptera*, as well as a few others which must be regarded as of mere casual occurrence, such as *Syrphidæ* or Hover-flies, the *Bombus* or Humble-bee, etc.

The commonest insects in the crops are undoubtedly *Diptera* of the family *Limnobiidæ*. Seventeen crops contained specimens that could be referred to this family, and of these no fewer than fourteen contained the curious little species known as *Molophilus ater*. In one case there were over one hundred specimens of this fly. This bird was from eighteen to twenty days old, and its crop was gorged with the remains of the fly besides a few tips of heather. Other crops from the same moor, belonging to chicks a week old or less, contained fifty-six, fifty, thirty-four, and eleven examples respectively of the same fly. We may therefore conclude that the species is attractive to the eye and taste of the young chick. It was found plentifully in certain marshy spots where the chicks were known to feed. Insects most commonly eaten.

Although the results have been tabulated in various ways, it has been found difficult to trace any outstanding feature regarding the insect food of Grouse chicks. It is sufficient for the present purpose to state that the food of young Grouse is largely made up of insects, that these insects present a great variety of species, and that the species most commonly found in the crop is probably that which is most numerous in the area where the chicks are accustomed to feed. But it is also evident that the number of insects eaten shows a considerable falling off towards the third week of the chick's life. We should not expect the chicks to show much discrimination in the catching of their prey, and as *Diptera* undoubtedly are the most numerous in individuals of all the insects on the moors, it naturally follows that they head the list in the table of crop contents.

An attempt was made to ascertain to what extent the quantity of insect food decreases as the chick grows older, and a table was published in the Final Report which brought out the fact that after the second week of the bird's life there is a marked falling off of insect food and a proportionate increase in the vegetable diet.[1] The crops are arranged, so far as possible, in order of age, beginning with the youngest. The ages of the birds are estimated by the length of the keel of the sternum or breast-bone.

Vegetable food of chicks.

This table also showed that the crops of young chicks in the first week or two contain, in addition to insects, the following vegetable food-stuffs in varying proportions:—*Calluna* shoots; only the very fresh young green shoots are eaten. *Calluna* flowers, in full bloom, and flower-buds. Moss fruit-capsules, or spore cases. Blaeberry flower-buds, and ripe blaeberries occasionally (*Vaccinium myrtillus*). Blaeberry leaves and young stalks. Fern leaves (*Blechnum* and *Pteris*). Rush-heads, in flower and seed (*Juncus sq.*). *Tormentilla* seed-heads. Shoots of *Empetrum nigrum.*

Of these the most constant are the fresh young shoots of *Calluna;* then the fresh blossoms of *Calluna*, and then the spore capsules of moss. While insects are commonly eaten, many crops of the youngest chickens contained no trace of them. It is practically certain that by eating some such animal food the cystic stages of the intestinal worms which infest young birds even in the first weeks of their existence are introduced. Until this matter has been further investigated, it is needless to say more here.[2]

Part III.—Water.

There are various opinions regarding the Grouse's requirements in the way of water. The majority of moor-owners and naturalists are firmly convinced that Grouse require water, and quote in support of their view the undoubted fact that when springs and drains are periodically kept open the stock is more healthy and numerous. Others state that water is not necessary, and that the fact that drains and springs are not allowed to become choked may have beneficial results

[1] "The Grouse in Health and in Disease," vol. i. p. 91.
[2] *See* also chap. vii. pp. 190 *et seq.*

apart altogether from the maintenance of the water supply. The evidence on the subject is somewhat conflicting.

As already stated, Grouse do not appear to require water from springs or burns in the earlier stages of their life;[1] this fact is established from observations on both wild and hand-reared birds. On this subject, a well-known moor-owner in Banffshire writes: "Grouse never seem to want water except in a very dry season; a shower is sufficient to last them for a long time. The less water they have in hand-rearing, I find, the better they do." And, again, "I have never noticed that the young Grouse, when half-grown or older, require more water than what they pick up in the grass in wet weather, and what is sprinkled on the grass or heather at meal times in dry weather. Old Grouse seem to know how much is good for them; while young Grouse, if allowed access to water, are almost certain to drink too much, and scour. This, of course, refers to tame birds." Another correspondent of the Committee, a gamekeeper near Pitlochry in Perthshire, writes: "Regarding water, I have known several broods fetched out 600 yards from the nearest water of any kind, in a dry season, and they continued to thrive without water for at least three weeks after hatching, when rain would no doubt relieve the old bird, which I am of opinion had nothing to drink but dew all that time; at least I never found young chicks without the parent bird along with them."

On the other hand, a gentleman in Yorkshire, who successfully reared twenty-four Grouse out of twenty-eight eggs set, says: "They were watered three times a day." And a gamekeeper, whose experience of some of the largest moors in Perthshire has lasted for a lifetime, says: "There must be water, and, where a moor is blest with good springs, there will the Grouse be also. One cannot have too many springs on a moor in dry weather."

When full-grown there is little doubt that Grouse do drink; hand-reared birds are seen to drink frequently on a hot day

[1] *Vide* chap. i. p. 20.

from the supply of fresh water provided for them, and the droppings of nesting birds are always found near water. Wild birds, in the hot weather of July and August, and in the dry, frosty days of winter, often congregate near running water and open streams when other drinking-places are dried up or frozen hard. It is well known that in the summer Grouse often shift entirely from the drier beats of a moor to the well-watered ones, and, on a certain dry, sandy moor near the sea, even the young birds die if the artificial drinking-pools are allowed to run dry.[1] The almost unanimous opinion expressed by correspondents favours the view that under natural conditions the adult Grouse go to drink two or three times a day.

In support of the view that Grouse either never drink, or at least are not dependent upon a supply of drinking water, several arguments are brought forward. It is said that no Grouse has ever been seen to drink, but when we consider how wild the bird is in its natural state this is not surprising; indeed, only very few observers have succeeded in seeing the bird in the act of feeding. Another argument used is that from an examination of the alimentary canal no trace of water can be found, and the contents of the crop are always found to be dry. This may be sufficient to prove that the bird does not drink when the crop is full, but does not dispose of the possibility of its drinking during the long periods of the day when the crop is empty. Then, again, cases are quoted of moors which carry a large and flourishing stock of Grouse where the ground is by no means well watered. On one of the best stocked Grouse moors in Britain, the only water comes from about a dozen springs and one deep burn which runs through the middle of the ground. Grouse are seldom observed to resort to the burn, and it is difficult to see how several thousand birds can all water at the springs. While it cannot be said that this entirely disposes of the question, it seems to justify the view that Grouse are not dependent upon a large water supply.

How far dew forms a substitute for water is a matter which

[1] *See* note on p. 317.

has received considerable attention without any results being arrived at sufficiently definite to be worth reporting. There is a curious lack of information available regarding the fall of dew, the districts in which dew is most prevalent, etc. There is probably a close connection between dew and the infection of Grouse by the nematode worm *Trichostrongylus pergracilis.* In view of the fact that the larvæ of this worm can only climb the heather shoots, or indeed exist on them, when they are slightly damp, it would appear that this is one of the questions which might be further investigated with advantage.[1]

Part IV.—Grit.

The health of Grouse and of other game-birds is greatly dependent on the nature of the grit they take to assist in the assimilation of their food. During the autumn of 1906 the Committee made a collection of the grits from the gizzards of Grouse and other game-birds. These grits were obtained from the gizzards of Ptarmigan from Ben Mohr in Sutherlandshire; Grouse from Ross-shire, Inverness-shire, Aberdeenshire, and North Wales; Blackgame from Ross-shire and Exmoor; and Partridges and Pheasants from various counties in England and Scotland.

The gizzards of Grouse naturally received most attention; but for purposes of comparison those of other game-birds were also examined. The quantity of grit found in a single gizzard varies very slightly. Samples taken from adult cocks were each found to be equal in bulk to an ounce of shot, although, of course, much lighter, and the number of grains in each ranged from three hundred and fifty to five hundred and fifty. It was also noticed that, especially in the case of Pheasants, the cock birds have a larger quantity of gritty material, while the individual grains also appear to be larger. This is doubtless correlated with the larger size of the bird, for in the smaller varieties of game-birds and in immature individuals it is

[1] *Vide* chap. viii. p. 235.

invariably found that the grains of grit are fewer and smaller than in the larger and full-grown specimens. The gizzard of a Grouse chick of fourteen to twenty days old was examined, and the grit was found to weigh 3 grains. It consisted of fragments of quartz, smooth and water-worn, and evidently picked up in the bed of a stream. *Two* minute but perfect prisms of quartz, were also found. All the grains were decidedly smaller than in an adult. In a half-grown chick the grit weighed 58 grains, while in adults the average weight is 118 to 120 grains. Grits are present even in very young birds; in one case they were found in a chick only forty-eight hours old.

The grit of an old bird can be at once recognised by the large size of the grains, and by the excessive polish and smoothness of the well-worn surfaces, suggesting that the larger grains are in use for a considerable period of time. Between extreme youth and old age all stages of wear and polish may be found, as well as every gradation in point of size.

Constituents of grit.

A full analysis of the petrological character of the specimens is contained in the Interim Report of the Committee; it is unnecessary to repeat all the details here, but a short summary of the general conclusions may be given. As would naturally be expected the constituents of these samples are nearly always hard rocks and minerals. Minerals or rocks softer than quartz, flint, or felspar are hardly ever found; this may be due partly to selection by the bird, but it must also be borne in mind that soft substances would soon be ground up by the action of the gizzard, and disappear. To this also is probably due the almost complete absence of any calcareous matter, which is both soft and comparatively soluble. The only really abundant constituents in the gizzards of Grouse are quartz and felspar, and small fragments of various rocks composed of one or both of these minerals, such as granite, gneiss, quartzite, etc., with occasionally grains of shot and crystals of garnet, and other minerals. Felspar is chiefly found in specimens from Scotland and North Wales, where rocks consisting largely of this mineral are specially abundant. The specimens from Ross-shire are of interest from the geological point of view, since in some cases they contain a representative collection of the gneissose and schistose rocks of the north-west Highlands.

A comparison of results shows that in the gizzards of Grouse quartz is nearly always present, although no quartz may be found on the moor where the bird was shot. Two cases of this may be mentioned. On one part of an extensive shooting in North Wales there is excellent feeding and sheltering ground for Grouse, but no quartz grit, yet the gizzards of the birds always contain quartz; in order to obtain it they have to fly across a wide valley to another hill, and then return again to their feeding-ground. Again, on a Ross-shire moor no quartz could be seen on the moor, yet all the gizzards of these birds contained quartz; this quartz was probably obtained from the burns, for on examining them small pockets of quartz were found in many of the pools and eddies.

The quartz is not always angular and sharp, but is frequently water-worn; in these cases it is probably picked up out of burns—in fact, in low-lying moors the water courses are almost sure to be the source of this quartz.

The grits found in the gizzards of Yorkshire Grouse are very similar to those of the Scotch birds except in one case, where the grit is chiefly composed of small black pebbles. In one gizzard out of every three of the Grouse examined shot were found; but shot were rarely found in the gizzards of Pheasants.

It may be noted that whereas Ptarmigan and Grouse seem unable to exist without quartz, Partridges, and still more Pheasants, are more adaptable; they prefer quartz if they can get it, but failing quartz, Pheasants will content themselves with flint, sandstone, and even coal. Doubtless the tough and fibrous nature of the food eaten by Grouse makes it necessary for him to confine himself to the hardest and most angular descriptions of rock, and even when quartz grits are found in the gizzard the angles are often rounded and smooth from the nature of the work which they have been called on to perform.

Flint grit may serve for Pheasants, but it does not fracture into serviceable shapes for Grouse. Sharp points and cutting edges are not wanted, but sub-angular and roughly rounded pebbles of small size for the breaking up and pulping of the comparatively hard foliage of *Calluna*.

In another part of this Report it is suggested that when quartz is scarce it might be artificially introduced with a view to the welfare of the stock. This expedient has met with some success, but has not been very extensively adopted. The artificial introduction of quartz grit has frequently been tried with Pheasants, and always with success. In the Committee's collection there are several specimens of gizzards from Pheasants shot on estates both before and after the introduction of quartz, and in every instance it can be seen that the quartz is preferred to the natural grit found on the estate.

Observations have been made with a view to finding out how long quartz or other hard grits normally remain in the gizzard of a Grouse, and it has now been proved by experiment that if none are supplied to make good the normal and presumably accidental loss, the bird whose gizzard may on the first day have allowed about a hundred grits to pass, becomes exceedingly careful on the second and third day, and allows no such loss to occur again. In a case in which no grits were supplied to a Grouse at all, and in which the Grits passed in the droppings were carefully washed out and collected every day for twenty-one days, the greatest daily loss after the second day never exceeded thirteen small pieces, even though a hundred and sixty pieces had been passed on the first day, and twenty-seven pieces on the second. This bird died unexpectedly on the twenty-first day, and upon dissection the gizzard was found to contain still no less than half of the original contents, all of which had been in the gizzard for at least three weeks. That this apparent control of the gizzard over the loss of grits was not merely accidental was proved by the occurrence of a precisely similar series of losses day by day in another bird; but when its companion died, apparently as the result of losing half its grits, the second bird was not pressed to a similar finish.

It is therefore probable that in the ordinary course of a Grouse's life the daily loss of small grits is considerable, and that this loss is replaced by an equally regular supply picked up day by day upon the sides of moor roads, or in "scrapes," or along the channel of a burn.

But, in the event of a heavy snowfall it appears very probable that the Grouse soon recognise that the loss is exceeding the amount which can be made good day by day, and that in such a case they can, in some unexplained way, place a check upon further loss. It cannot for a moment be imagined that the bird has any sort of voluntary control over the passage of grits from the gizzard. But it is quite conceivable that the gizzard itself will allow a certain careless loss of any surplus number, especially of the smaller pieces, so long as there is still a sufficiency of larger grits in the gizzard.

When the supply, however, is straitened, and the bird fails to find more grits to swallow, it may be that less food is eaten as well, and thus the loss of grits is automatically reduced. This is probably the explanation which comes nearest to the truth, and it is a significant fact that a bird not only loses weight, but may actually die when only half of its normal supply of gizzard grits has been lost, and when the dejecta show that this amount of grit is still capable of grinding up the food given to it.

Under normal conditions the character of the grit required differs with the nature of the food that is being eaten. Heather, oats, and oat husks are all efficiently dealt with by the quartz grit normally found in a Grouse's gizzard, but large hard seeds are not, and are passed undigested. These seeds are sufficient in themselves to pulp fruits so long as fruits only are being eaten. But as soon as heather or other fibrous vegetable matter is eaten, quartz or other stone grit becomes essential.

In the Blackcock the gizzard with its quartz pebbles can crush hawthorn pips, but the Grouse apparently cannot crush any of the pips of even much smaller berries, such as

Clusterberry, Blaeberry, or Crowberry. They all pass through intact.

The possibility has been suggested that the replacement of quartz grits by hard seeds of fruit, and the passage of the former through the intestine may act as a vermifuge. So often has a diet of berries apparently arrested a case of Helminthiasis that it is a question to be seriously considered whether enough attention is given to the encouragement of berry-bearing plants upon a moor. In many cases the sheep keep them so closely cropped that except where there are woods or enclosures it is difficult to find a visible trace of them. It would perhaps repay the trouble and expense to fence off enclosures from the sheep where any tendency is seen for the growth of Blaeberries, Cranberries, Crowberries, or the like, and the Grouse would quickly find and make use of them.

It is particularly unfortunate that during deep snow, when Grouse have great difficulty in replenishing their stock of gizzard grits, they are compelled by hunger to feed upon the very foods which most rapidly evacuate their entire stock of grits. The hips and haws whose large, hard seeds, as has been said, quickly replace the quartz in their gizzards, are comparatively useless to them for dealing with heather or Blaeberry shoots, yet the bush and tree fruits are amongst the first emergency rations used in a heavy fall of snow, since they come within reach as the ground foods become more deeply buried.

The strongest evidence that quartz is the most suitable form of grit is its universal presence in all the vegetable feeding birds that can obtain it. Red Grouse, Ptarmigan, Blackgame, and Capercailzie, as well as Pheasants and Partridges bred on the moor borders, and Scandinavian Willow Grouse, all collect quartz, and nothing but quartz, if it is by any means to be obtained.

PART II.—THE GROUSE IN DISEASE

CHAPTER IV

CAUSES OF MORTALITY IN THE RED GROUSE

In classifying all diseases it must be remembered that before a disease can be scientifically named it is necessary to ascertain whether the disease in question has an individuality which can be specifically described and recognised by definite characteristics and symptoms.

It is an accepted rule of medical science that the primary cause of a disease should be sought for as the first step towards the discovery of a remedy. Yet this important rule has been almost wholly ignored by the majority of writers upon "Grouse Disease," with a few notable exceptions.

Hardly a writer on the subject but dwells on vague generalities, hopelessly mixing up observed facts with speculative theories, and primary with predisposing causes; for instance, if the chief object of the writer of the following paragraphs had been to confound an already almost hopeless confusion, he could hardly have been more successful:

"What I still maintain is that the unwholesome food which Grouse have been compelled to eat has occasioned both the worms with which they have been infested and at least one type of the disease."

"The disease appeared in all its virulence after the heather had been damaged by hard frost; but the crying evil is undoubtedly the overstocking of the moors with sheep."

"Grouse have materially suffered from cold late springs which have blighted the heather."

"Granting as I do that this nasty little parasite Strongylus does occasion disease in Grouse, is there anything illogical in attributing the cause of the worm to the bird being compelled to eat unwholesome food, from its natural food the heather being damaged or destroyed from continued blighting east wind? And thus the blight of the heather is really at least one cause of 'Grouse Disease.'"

"Insufficient or unwholesome food is the cause at least of one type of disease amongst Grouse."

Or the following:—

"'Grouse Disease' is caused mainly by overstocking, over-preservation, and the complete and indiscriminate slaughter of certain species of so-called vermin, notably the Peregrine Falcon; also by the state of the young and old heather after severe and late frosts which do much more harm now that heather-burning is done systematically. Also by greed for big stock. Unnatural and rapid burning of heather and a wholly artificial state of Grouse farming; also interbreeding."

In the above quotations, which may be perfectly sound so far as they go, we have a very fair summary of possible predisposing causes; but the immediate cause of "Grouse Disease," whether we consider the disease to be Pneumonia, or Strongylosis, or Coccidiosis, or Enteritis, or any other sickness in the world, is not touched.

Until, therefore, we have discovered the active agent in a disease we cannot say that we know its cause. This is a fundamental rule, and to be satisfied with predisposing causes is to be satisfied with less than half the truth, though that half is, of course, very important if our intention is to proceed further in the attempt to discover a remedy for the disease in question.

The primary or acting cause of Klein's acute infectious pneumonia was believed to be a bacillus known as the *Bacillus coli;* the primary cause of Cobbold's Strongylosis is the thread-worm *Trichostrongylus pergracilis;* the primary cause of Grouse Coccidiosis is *Eimeria* (*Coccidium*) *avium*, and so on; not east winds or the absence of the Peregrine Falcon.

The consequences of what has appeared to be epidemic disease amongst Grouse have been so disastrous from time to time in the past that it is not surprising to find a very widespread tendency amongst sportsmen and gamekeepers to attribute every death and every case of sickness on the moor to the so-called " Grouse Disease."

It has been the object of the recent " Grouse Disease " Inquiry to investigate this question, and to find out amongst other things :—

Objects of "Grouse Disease" Inquiry.

(1) Whether the sickness described universally as " The Grouse Disease " in all the literature of the past century which deals with the subject is, in truth, a single disease with individual characters peculiar to it alone ? (2) Whether a distinction can be discovered between various recorded outbreaks of the so-called " Grouse Disease " which will justify the opinion held by many writers that two distinct forms of disease, due to two distinctive causes, are confused under the one term ? (3) In the event of a finding in favour of the belief in two or more distinct epidemic diseases, what are their respective causes and effects, and by what distinctive titles and characteristics should they be known ? (4) In the other event of a finding in favour of the belief that only one epidemic disease exists, is Professor Klein's view right, that the only serious disorder amongst Grouse, to which all past records of disease refer, is the one which has for its cause a *Bacillus*, and for its chief characteristics the appearance of acute pneumonia in the lung, and " all the characters of an acute infectious epidemic disease " ? Or, (5) is Dr Cobbold's view right, that there is a pseudo-epidemic disorder amongst Grouse, answerable for all the recorded outbreaks of disease, which has for its cause a thread-worm, and for its chief characteristics certain damage to the gut, due to chronic irritation, leading to extreme emaciation ? (6) Is there any other form of " Grouse Disease " capable of causing extensive mortality, which has hitherto been overlooked ?

These are questions which have to be answered before it can be said that we understand the forms of " Grouse Disease "

Results of Committee's investigation.

sufficiently to classify them systematically. With a view to defining the main divisions under which the next chapters are arranged, it may be well at this stage to give in anticipation a brief summary of the conclusions at which the Committee has arrived.

The Committee is of opinion :—(1) That the sickness which has in the past caused "Grouse Disease" among the great majority of adult birds is a single disease with clearly defined characteristics of its own ; (2) and (3) it follows that if the two forms of "Grouse Disease" hitherto described as distinct diseases are, in fact, one and the same disease, there is no longer any need to differentiate between them ; (4) that "Grouse Disease" is not due to an acute infectious pneumonia caused by the presence in the lung of Klein's Bacillus ; (5) that adult "Grouse Disease" is caused by the presence of Cobbold's *Trichostrongylus* in large numbers in the cæca ; (6) that another form of disease in Grouse exists which has hitherto escaped notice. This disease is caused by the presence of *Eimeria* (*Coccidium*) *avium* in the alimentary tract, and is referred to in the following pages by the name of "Coccidiosis." It is improbable that Coccidiosis can have been responsible for any of the outbreaks of so-called "Grouse Disease" in the past, for, so far as the Committee's experience extends, it is only the chicks that succumb to this disease, whereas the records of "Grouse Disease" refer only to mortality among adult birds.

The grounds on which the foregoing conclusions are based form the subject of several long and technical chapters in the Final Report of the Committee, but in the present volume it is not proposed to do more than give a general description of the two principal forms of "Grouse Disease," viz., Strongylosis or "Grouse Disease" proper which kills the adult birds, and Coccidiosis which kills the chicks.

Minor diseases of Grouse.

We have still to discuss the less important diseases of Grouse, of which quite a considerable list may be given, though their interest is greater from an academic point of view than as a serious menace to the well-being of a moor: indeed, with one or two possible exceptions, there is not much probability that they will ever give cause for much anxiety. The exceptions occur most commonly in consequence of the proximity of Grouse moors in certain districts to low ground shootings heavily stocked with Pheasants and Partridges. It is well known that these latter birds are often the victims of various forms of Enteritis, and cases have been reported of Grouse dying of disease apparently contracted from Pheasants which have strayed on to the moor.

Amongst other causes of death may be mentioned diseases connected with the reproductive functions, diseases connected with the seasonal moults, and diseases caused by deficient or unwholesome diet.

Other causes of mortality.

But apart altogether from mortality due to disease, a large number of deaths are directly or indirectly due to accident or to artificial causes. Many of these causes may be traced to the agency of man, and it will be shown elsewhere to how great an extent some of them are avoidable by attention to the details of moor management.

Shooting, in all its forms, is responsible for a great deal of unrecorded damage amongst Grouse; and the examples of "pricked" birds which have come to the Committee's notice, generally sent as "diseased" birds for examination, show amongst other things how extraordinarily active is the recuperative power of an animal in a state of nature. Bones are fractured and reunited, even those of the wing, allowing the bird to survive, to be shot again the following year.

Peritoneal adhesions may shut off a perforation of the intestine, and even result in a short circuit of the gut before leakage has caused sufficient general peritonitis to result in death.

The present chapter deals with the mortality and damage due to accidental causes or to natural causes other than true "Grouse Disease," and thus clears the way for the proper consideration of the more important subject dealt with in the subsequent chapters, viz., death due to "Grouse Disease."

The causes of death and damage to Grouse not due to "Grouse Disease" may be classified as follows :—

(*a*) Those referable to artificial conditions, such as accidental consequences of sport, wire-fencing, telegraph-wires, sheep-drains, vermin-traps, poison, etc.

(*b*) Those referable to natural conditions, such as

Extremes of climate ; cold, heat, wet, snow, etc.

Destruction by birds and beasts of prey, so-called "vermin," and by the pugnacity of the Capercailzie and Blackgame.

Exigencies of reproduction : fighting of cocks, over-sitting of hens, egg-binding, gastro-uterine gestation, etc.

Exhaustion due to moult, and to skin disease affecting the growth of feathers.

Deficient diet and starvation, due to frosted, blighted, and over-age heather or to heather-pests ; deficiencies of grit and water ; excessive or injudicious burning ; and feeding on unwholesome foods, *e.g.*, corn-stooks and sour grain.

A.—Causes of Death and Damage resulting from Artificial Conditions.

Under this heading there are some causes which may be passed with a mere mention.

One might do so with all, perhaps, were it not for the interest attaching to some of the cases which have come under observation, and the light which they throw on the recuperative power of birds in the wild state. Some of these cases occurred in birds which had died naturally ; in others the specimen had been shot, and forwarded for examination as a possible case of disease.

The following accidents are within the experience of most game preservers : collision with wire fences and telegraph wires, accidental damage from vermin traps, snapping by sheep dogs, drowning in sheep drains or moss-cuttings, etc., and wounding by shot.

And of these no one can doubt that the "pricking" of birds due to bad shooting is the most frequent cause of damage.

The following examples illustrate a number of these points :—

A hen Grouse whose wing had been cut off clean at the shoulder, presumably by collision with a wire fence, not only survived to be shot the following season under suspicion of being a sick bird, but actually succeeded in rearing a brood of five healthy young Grouse. **Collision with wire.**

Another instance of precisely similar nature is recorded, in which the bird, a hen Grouse, had successfully raised a brood of healthy chicks notwithstanding the loss of a wing. In the first of these cases the wing was cut off so close to the body that no vestige of a stump was left. The cicatrix in the skin was adherent to the tissues about the rounded end of the broken humerus, of which only the head and neck were left. There was every appearance that the wound had healed well and quickly, probably some four or five weeks before the bird was shot, and soon after the nesting time. In feather and in condition the bird was not appreciably the worse for her mishap. The shoulder-blade, which had been broken in two pieces at the time of the accident, had made a strong though irregular union (*see* Fig. 1). For the purposes of comparison a drawing is given of the bones of the undamaged (right) side of the same bird (*see* Fig. 2).

The sternum or breastbone is another bony part also liable to injury, but sometimes without immediately fatal results; in such cases damage is most probably caused by collision with wire fencing.

A hen Grouse was picked up alive on a Berwickshire moor in August. She weighed only 14½ ounces, and was very thin and in very poor feather; but upon dissection it was found that, perhaps a month or two before, she had broken her breastbone right across by collision with something—probably a wire fence. The smaller hinder portion had been displaced forwards and upwards, riding upon the larger portion, and there becoming fixed firmly by osseous union, but with a considerable amount of displacement and shortening. This accident must have completely disabled the bird for six weeks or a month,

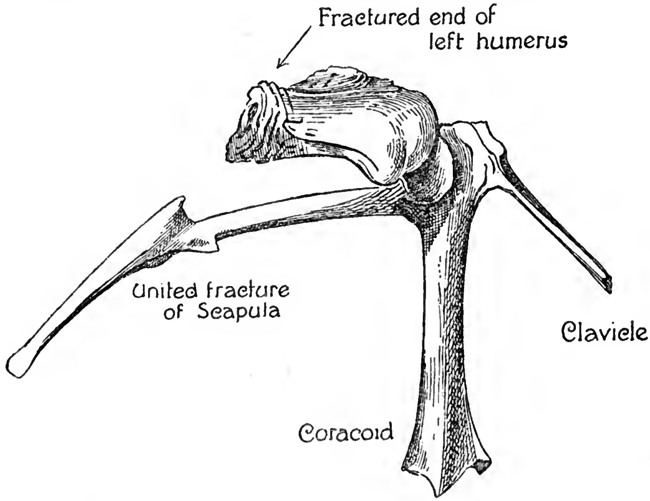

FIG. 1. A permanently fractured left humerus and a fractured and re-united left shoulder blade.

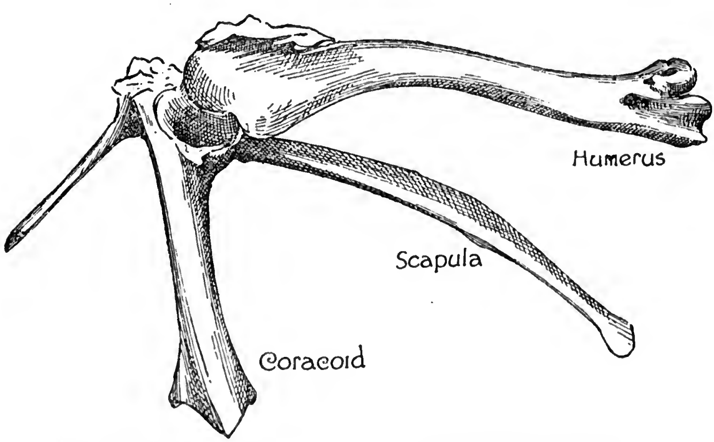

FIG. 2. The same bones uninjured from the right side of the same bird.

rendering her quite unable to fly. Yet she had lived, and the broken bone had united. The only apparent disability remaining was the infestment with parasites, the tapeworms, *Hymenolepis*, and *Davainea* and the round-worms *Trichostrongylus* having all established themselves in excessive numbers in the various portions of the gut. Thus Strongylosis would have eventually killed the bird, but only indirectly and as an after result of the injury, which in itself was cured.

A young Grouse chick, 11½ ounces, very plump and well feathered, was found dead in Argyllshire, in August 1908, and was forwarded for examination. There was no sign of disease, the bird was in excellent condition, and death had resulted from collision, probably with wire fencing, which had broken the breastbone right across. There was hardly any external sign of damage in this case; but on removing the skin the bruising and bleeding which overlay the more serious damage beneath at once indicated the cause of death. It is easy to distinguish between damage before and after death, when it is remembered that the circulation is active in the former case and inactive in the latter. Any violence done before death is accompanied by bruising and bleeding. Damage done after death may be accompanied by *post-mortem* staining due to the leakage of bloody serum; but will never show blood-clots lying under the skin or amongst the muscle-sheets or other organs.

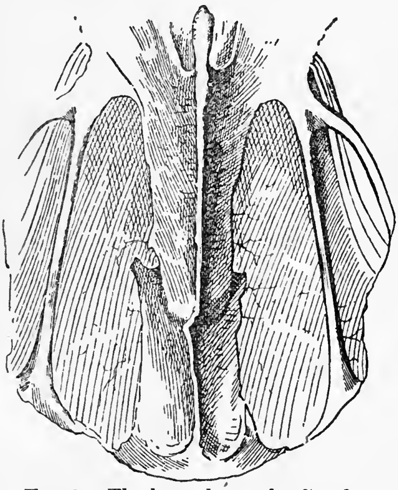

Fig. 3. The breastbone of a Greyhen fractured and reunited.

Two cases of fractured sternum have occurred in Blackgame, forwarded for examination. The first represents a recent fracture of the sternum in a Blackcock. The second (*see* Fig. 3) represents almost exactly the same damage reunited, owing to the fact that the Greyhen, in which it occurred, did not die until some months after the accident. The exact method of overriding and union of the broken bone in this example is shown in Figs. 4 and 5 which give a view of the breastbone from each side. Both cases occurred in a very curious series of six deaths in Blackgame which were forwarded for examination as cases of "Grouse Disease," all coming from the same locality.

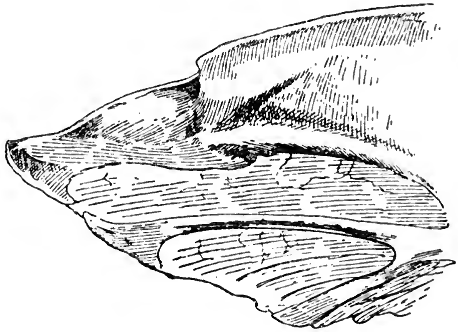

Fig. 4. View of the right side of Fig. 3.

The facts were as follows :—

(No. 1.) A Blackcock, October 16th, 1907; weighing 45 ounces; was found dying; in excellent condition. Had been feeding on corn.

(No. 2.) A Greyhen, October 26th, 1907; found dying, thin, in poor condition, dirty beneath, and much bedraggled; had evidently been squatting for a long time on the ground, unable to fly. This bird was forwarded by train for examination, and on arrival was still living. She was kept alive, feeding freely on grapes, until November 2nd, when she was killed with chloroform, as there appeared to be some internal damage with a complete absence of any sign of disease. On *post-mortem*

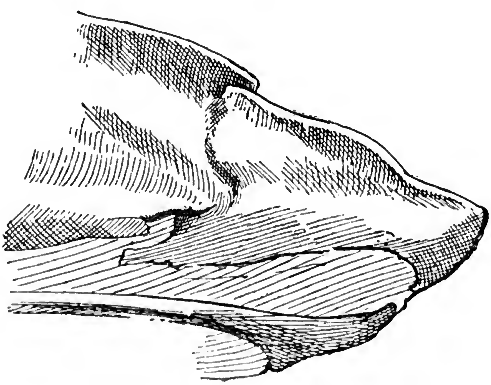

Fig. 5. View of the left side of Fig. 3.

examination the breastbone was found to have been broken right across near the abdominal end; but it had since become firmly united again with a little displacement due to overriding of the hinder fragment (*see* Fig. 6). Clearly this bird was unable to fly because the wings from long disuse had become weak, and adhesions about the pectoral muscles probably made the attempt to use them painful. The joints of the legs too were stiff and difficult to straighten, the result of long squatting on the ground amongst wet undergrowth. She must have led a sedentary existence for some time, and would probably have died without regaining the power of flight.

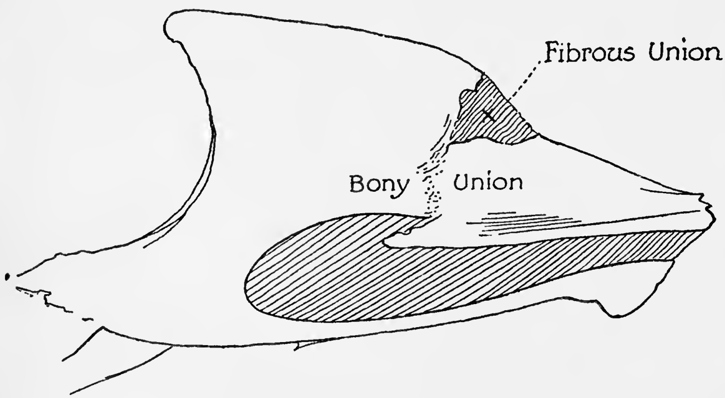

FIG. 6. Showing method of union of broken breastbone.

There can be no doubt that the cause was collision, probably with a wire fence. The organs showed no sign of disease.

(No. 3) A Greyhen, weighing 34 ounces, was found dead in good condition; had been feeding on corn. Examination showed that an old wound had produced extensive bleeding in the abdomen, but so long previously that the clot was semi-organised and formed a series of concentric blood-cysts. A more recent damage had caused extensive bleeding around the base of the heart and into the lungs, and this had killed the bird; but not until several hours had elapsed since the accident, which almost certainly resulted from collision with a fence. There was no sign of disease.

(No. 4) A Blackcock, weighing 41 ounces, was found dead on November 1st, partly picked by crows or mice, but in fair condition. It had been feeding on hawthorn berries. This bird had a deep wound in the breast, from an accident which had broken the lower end of the sternum. The damage was undoubtedly the result of collision with a fence, or something of the kind. It was exactly comparable to that in the Greyhen, No. 2, but more severe, so that the bird died shortly after the accident. No sign of disease was discovered.

(No. 5.) A Blackcock, weighing 39 ounces, was found dead in good condition on November 4th. There was no food in any part of the gut. This bird had its back broken, and the bone splinters had torn the lungs and the smaller air passages, so that they gradually filled with blood. The hinder part of the bird's body and its legs must have been paralysed, so that it could not search for food, and the drowning of the bird in its own blood took so long to kill it that all the food, eaten before the accident, was digested and the remains passed. The whole body was full of venous blood, showing that twelve or twenty-four hours may have elapsed between the accident and the bird's death, which was due again almost certainly to collision with a fence. Once more there was no sign of disease.

(No. 6.) A Greyhen, weighing 31 ounces, was found dead on November 4th in good condition ; again the back was broken, but this time lower down at the level of the last rib instead of at the fifth rib as in No. 5. The left lung was compressed and rendered absolutely useless by a large blood-clot which had collected in the thorax owing to internal damage caused by the splintered bone. This bird had evidently lived for some hours after the accident, and had previously been feeding on corn. There was no sign of disease, and every reason to suspect collision with a fence as the cause of the accident.

Obviously this series of deaths was not due to an epidemic of disease, though it is difficult to understand why so many birds should have collided with fences in the same locality, where no new wires or other obstructions had been recently erected. The gamekeeper's view at first was that they all had disease, and outward appearances to some extent supported him. Later on, however, the Blackgame began to leave the valley where they had been feeding on corn, and where the accidents occurred, and once more took to the moors. The keeper reported that the Blackgame on the moors were quite healthy, and continued: "I have been among Blackgame and Grouse for over forty years, and I never saw Blackgame affected the same way. If eating green oats is killing them, they have eaten them for over forty years and were not a whit the worse. I have known Blackgame eat oats from September to December, and not a single bird die from it. What puzzles me is why they are not dying in the next valley (3 miles off). When the Blackgame light on the ground they tumble on their heads. If there is a fence hard by they sometimes fly into it. I have seen many birds (recently) showing the same symptoms."

All this suggests some form of intoxication, and it is just possible that the sodden and half rotten grain eaten by the birds might produce sufficient alcohol by fermenting in the warmer process of digestion, to act upon them in this way. There is, of course, also the possibility that grain soaked in spirit had been purposely put down, but in this case it was improbable.

It was certain, at anyrate, that the epidemic was an epidemic of accidents and not of disease, however suggestive appearances may have been to the contrary.

Sometimes a collision or other accident may cause fracture of the vertebræ or internal injury.

A hen Grouse, of 20 ounces, was "found dead, but quite warm, about a mile from the nearest part of the moor, and at a place to which Grouse never go unless driven off the moor, by storm, which very rarely occurs." This was in Cumberland in March 1909. The bird was quite healthy, in good condition, well feathered, and of a fair weight, and having been found dead with feet and legs well feathered, was just the kind of bird to be classed as a case of " the acute form of ' Grouse Disease ' which kills off birds in splendid condition before they have time to waste." But there was some blood in the mouth, and when this clue was followed up by further dissection the root of both lungs was found to have been torn to pieces by splinters of bone from the fracture of two or three vertebræ. There was a fair number of *Trichostrongylus* in the cæca, but no sign of disease and no tapeworms.

A cock Grouse of 26 ounces was forwarded from Scotland with the correspondence quoted below. The case affords an excellent example of the evidence upon which the idea of an acute and very rapidly fatal form of " Grouse Disease " has been founded.

The gamekeeper writes as follows :—

" I am herewith sending you a Grouse cock which, I think, must have ' gapes ' or something. His neck is very much swollen. This is the third bird of the kind I have seen during the season. We are now seeing diseased Grouse, at least birds having all the appearance of such. In fact, taking all over I never saw worse feathered birds than those we get here. They are especially poorly feathered on the legs."

This was written at the end of September when the birds were in full moult. This particular bird had still the old claws on, and two primaries of each wing to shed ; and the feet, though apparently unfeathered, were on closer inspection just beginning an excellent growth of feathers. One of its eyes was damaged. Attached to the bird was a note saying that it was a diseased Grouse, notwithstanding that it was making a healthy moult for the winter, and weighed 26 ounces. On dissection the swelling of the neck was found to be due to a mass of loose blood-clot ; the thorax also was full of blood-clot, and the bruising and tearing of the blood-vessels about the root of the neck left no doubt that the bird had met with an accident. There were no tapeworms in the bird at all, and no sign of disease of any sort. And though the cæca contained a good many *Trichostrongylus*, there was no redness, and the mucosa was quite healthy.

A cock Grouse of 21 ounces was " watched for ten days " in March 1908. During that time he was flushed regularly every day by the gamekeeper at the same place. But during the last few days he could not be flushed " without the help of a dog as he was becoming every day the weaker " ; so he was shot, and forwarded as a case of " Grouse Disease." This he was, but only to a very slight extent. The real reason why he objected to being flushed regularly every day was because he had retired to a certain retreat to be away from other birds and remain quiet while a wire-fence wound healed. It was found that the wire had torn through the skin of his breast, and had rent the pectoral muscles, which are the muscles of flight. Had he been left alone he would have recovered in a few weeks, and would have rejoined the healthy birds on the higher ground as soon as he was fit to hold his own. This retirement of a sick or damaged Grouse to a place where he can recruit his health in solitude is in accordance with the habit of almost every animal that lives.

Damage to crop.

Damage to the crop is sometimes responsible for accidental death or injury.

A cock Grouse of 21 ounces was caught and killed, July 1908, in Argyllshire. There was very great dilatation of the crop, which was filled with an old blood-clot and with heather, the crop contents had been there for a long while, and had become dry and mildewed. There were two or three cicatrised wounds through the skin and crop ; but these were all closed except one, which remained open and suppurating. The passage to the œsophagus downward was free, and the bird might possibly have recovered in time. The crop was adherent everywhere to the subcutaneous tissues, and so to the skin, and there were numerous enlarged blood-vessels wandering over the crop wall and also in the adhesions caused by the diffuse inflammation. It is extraordinary that the bird should have maintained its weight so well—21 ounces ; *Davainea* was absent, *Hymenolepis* and *Trichostrongylus* were both present, but with no redness in any part of the gut.

Damage to wing.

Figure 7 represents an example of recovery from a fracture of one of the wing-bones in a cock Grouse. The radius in this case had been broken in two at the junction of the middle and lower thirds, probably from a shot wound. The bird must have lived for at least a month or six weeks during the winter without flying, but made a perfectly sound union notwithstand-

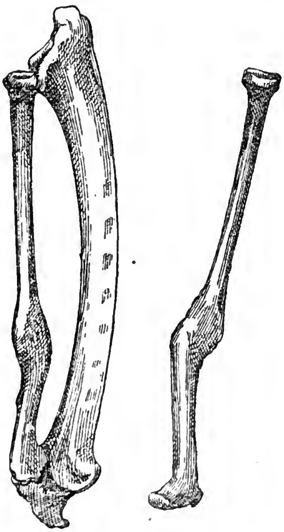

Fig. 7.

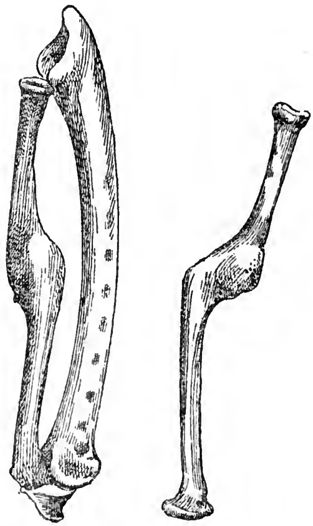

Fig. 8.

Broken and re-united wing-bones.

ing. It survived to be shot dead on the wing in April as a healthy bird killed for purposes of crop analysis.

Another instance may be quoted of the radius being broken in two pieces at about its centre, probably by shot. In this case the union was incomplete when the bird was killed; but, though some movement was possible between the broken ends, the formation of callus and new bone had made a considerable advance towards effecting a firm union.

Figure 8 represents a firmly united fracture of the radius which had been broken in two about the centre. There was no evidence of damage to the ulna. A shortening of 2 mm. (from 50 mm. in the sound bone to 48 mm. in the damaged one), occurred in the united radius, and the union was effected irregularly with a large boss of new bone. This bird was an undersized hen, killed as a "piner" on August 15th, 1906,

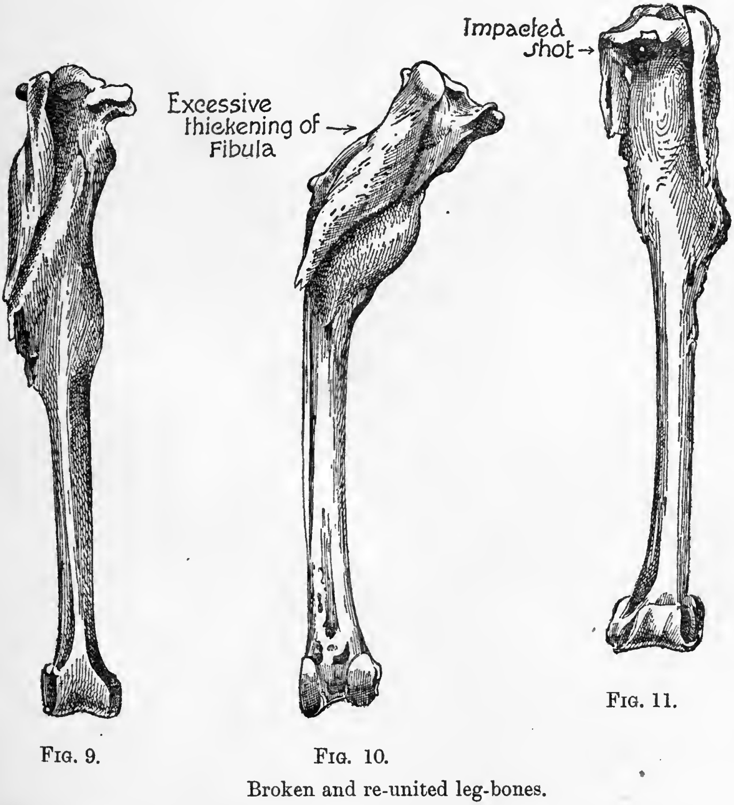

Fig. 11.

Fig. 9. Fig. 10.

Broken and re-united leg-bones.

and suspected of disease. She was shot on the wing, but was in very poor condition and badly infested by *Davainea*, *Hymenolepis*, and *Trichostrongylus* within, and by innumerable bird-lice and other parasites without.

Damage to leg-bone.

Figures 9, 10, and 11 all resemble one another in representing united fractures of the upper third of the tibia and fibula.

I

In each case the fracture was comminuted. The shortening in one leg was from 83 mm. to 76 mm. The union in each was effected by an irregular and immovable mass of bony matter thrown out to include the fibula which is also greatly thickened.

The first case (*see* Fig. 9), was that of a cock bird which lived to be shot on January 7th, 1907, weighing 20 ounces.

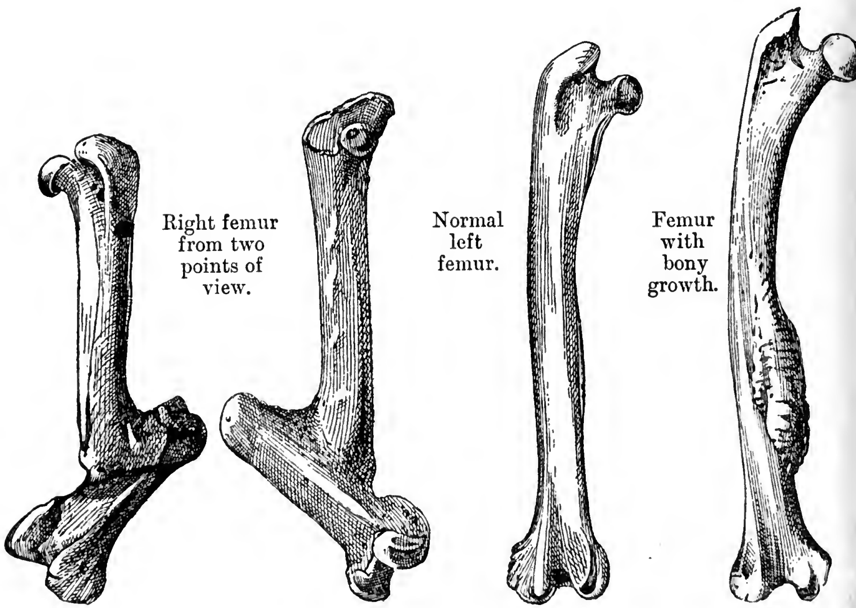

FIG. 12. FIG. 13. FIG. 14. FIG. 15.

Broken and re-united thigh bones.

The fractured end of the bone had been rendered smooth by absorption, and the deformity caused by overriding of the lower fragment had been partly obliterated. In another case (*see* Fig. 10), the upper fragment was united to the lower at an angle of 30 degrees. Figure 11 was obtained from a cock, found dead in November 1907, having succumbed to Strongylosis. The shot which caused the damage can be seen to the left impacted in the bony mass.

Two cases of damage to the femur may be mentioned:—

Figures 12 and 13 show a united fracture with shortening from 55 mm. to 43 mm. owing to the excessive displacement of the lower portion of bone. The upper fragment forms an angle of 45 degrees with the lower. The bird was a hen found dying from Strongylosis in April, but the fracture must have taken place at least six weeks before. From the complete union effected the bird must have been healthy at the time, but the accident may have been the starting-point of sickness, which resulted eventually in its death. Fig. 14 shows the undamaged femur of the same bird.

Figure 15 shows a bony outgrowth of the femur due to periostitis resulting probably from some violence which was insufficient to break the bone.

Internal shot wounds.

Damage from internal shot wounds also occurs. An adult cock Grouse of 16 ounces only was found in Nairnshire in September 1909, sick and unable to fly. It was a bad case of Strongylosis; but the original cause of its sickness was a number of lead pellets which had some time previously passed through the pectoral muscles, the sternum, and the liver.

In another case an adult cock Grouse of 18 ounces, in good feather, was found in Yorkshire on September 5th, 1908, sick and unable to fly. The bird was suffering from Strongylosis; but there were also healed scars of shot wounds. The lungs were somewhat stained *post-mortem*, but one of them was thick and solid. It was in part a dark, rich, reddish black all through, and in part normal pink. A line of adhesions joined up the second and third lung-lobes, and there were cicatricial puckerings showing where a shot had passed through. The solidification was due to old bleeding. A shot had also recently passed through the neck, traversing the muscles, and tearing a small hole in the trachea, which had remained unhealed. There was bloody fluid in the mouth and trachea. The skin wound had nearly mended, but bits of feather were found in the tissues of the neck, and the scar outside was matted up with broken feathers. The wound made by the shot which passed between the ribs and entered the lung had completely healed, and its position was shown under the skin only by a small blood clot which persisted. This bird must have survived its most recent wounds for a week or two at the least.

In October 1909 a cock Grouse of 20 ounces was sent for examination from Perthshire in very good condition.

The following information was sent with the bird:—

"I enclose a Grouse which I picked up to-day. I put up a pack of Grouse. This one rose a little after the others, and after flying about 200 yards dashed to the ground, and when I got up to it it was quite dead and blood flowing from its mouth."

Examination outside before opening revealed the fact that the bird had been pricked by shot. One of the quill feathers was cut through, evidently by a pellet, and there were marks of shot in other quills. Blood was flowing from the mouth, and an examination of the lungs showed that one of them had been torn by shot so that many of the air-passages were full of blood. But the blood liberated by the original wound had clotted in the lung and saved the bird from immediate death. Had the bird been allowed to rest until this lung and its clot had healed and become firmly cicatrised it would perhaps have recovered. Instead, however, it was flushed and forced to take flight. This broke down the freshly formed clot, and the bird died of secondary hæmorrhage. There was in addition to this a very large clot round the liver, showing that a pellet had entered this organ also. This case is a very good example of what has certainly been described in former years as the sudden death of birds from acute disease, a disease which strikes them down in the pride of health in full flight and excellent condition. It is also a very remarkable case of long survival after serious damage caused by shot wounds.

Another case was that of an adult cock Grouse of 19 ounces, found dead on January 3rd, 1908, in Argyllshire.

This bird had been badly sprinkled with shot some time before its death—at least a couple of months, judging by appearances. That it should have survived at all is extraordinary.

Three shot pellets were found lodged in the tissues of the neck; two ribs had been broken on each side, and had firmly united again. There were small caseous masses in the lung, the remains of small localised abscesses which had been caused by the passage of the shot. The pleura were fastened to the ribs by traumatic adhesions; and as the result apparently of some obstruction or damage to the usual set of veins there was a great enlargement of what are generally quite insignificant veins in the wall of the proventriculus.

On February 17th, 1908, a cock Grouse of 23 ounces was found dead in Inverness-shire. It was in excellent plumage and condition, and although an abundance of Strongyles was to be found in the cæca there was no redness and no engorgement of the villi.

The cause of death was apparently collision in flight, and the chief damage was that suffered by the heart, which was much enlarged and swollen out to twice its normal size by a great extravasation of blood in the muscular tissue of the walls, both of the auricles and ventricles. The veins running in the wall of the proventriculus were much engorged. The lungs were unhurt, and otherwise the bird was perfectly normal.

Tumours caused by shot wound.

A hen Grouse of about 17 ounces was found on July 23rd, 1909, in Sutherlandshire, sick and unable to fly. She was in very poor condition, and heavily worm-infested. But the chief cause of distress was a very large tumour caused by rupture of the vessels in the inner walls of the gizzard. The gizzard was enormous, and occupied nearly the whole of the abdominal cavity, causing complete compression of most of the intestines intensified by the formation of adhesions due to peritonitis and the stretching of the normal mesenteries over the tumour. The tendinous and tougher portion of the gizzard had retained its normal size and shape, but the fleshy part had become greatly distended. The tough lining membrane was the part which had given way.

Cases have been occasionally observed of dermoid cysts and fibroid tumours in the neck; these may sometimes be the result of shot wounds.

Damage to feet.

Various accidents may happen to the foot and metatarsus of the Grouse, ranging from complete loss of the foot at the tibio-metatarsal joint to the loss of toes at the metatarsophalangeal joints, or at the various inter-phalangeal joints.

Steel vermin traps will perhaps account for some of these cases, but in one case the appearance of the stumps of toes on both feet, to a different extent on each foot, suggests frost-bite as the cause; or at any rate some form of gangrene rather than steel traps. A possible explanation is the strangulation of toes, sometimes even of feet, which sometimes occurs in infancy by the tightening of strands of sheep's wool accidentally wound round them. This is a common accident with Lapwings.[1]

An instance of the death of Grouse in a vermin trap may be recorded. Two healthy cocks fighting in the spring accidentally came together into a "Samson" trap, and were simultaneously killed.

Damage to bill.

Damage to the bill may sometimes be a cause of death. A cock Grouse of $18\frac{1}{4}$ ounces was found dead on July 13th, 1908. There was a very little *Calluna* heather and Blaeberry leaf and stem in the crop. The bird had probably found difficulty in obtaining sufficient food for the lower bill was split and curved, forming an unhandy instrument for plucking heather. Death by starvation, however, had been hastened by Helminthiasis. *Davainea* was abundant; *Hymenolepis* filled the duodenum, while *Trichostrongylus* was present in great numbers. This bird would very probably have recovered during the summer but for the additional handicap of its damaged bill. It had survived the two months of highest mortality, April and May.

[1] A similar case, occurring in a hen partridge, shot when flushed with the covey, is described in the "Field," September 12th, 1908.

Many interesting cases have also been recorded of recovery from flesh wounds, either by shot or by barbed wire, and the following have come under the notice of the Inquiry:—

One case represented a long standing leakage of the crop, due to a wound through the skin and crop-wall. Owing to constant use of the crop, and to the alternate distention and contraction of the overlying skin, the adhesions between the edges of the skin and crop-wall had become permanent before there was any chance of the openings in either being closed. Bits of heather pressed constantly between the lips of the wound had prevented healing, and had defeated the efforts made by the crop to pass all the food into the gizzard. The bird had therefore to eat more than the normal amount to make good a chronic wastage, and this accounts for the very abnormal distention of the crop which often characterises cases of the kind. Such cases may have resulted from shot wounds, or from rents made by barbed wire. The latter is probably the cause in the majority of cases.

It is fairly common to find shot pellets loose among the contents of the crop or in the gizzard. They have sometimes been lodged there when the bird was killed, but have more commonly been picked up and swallowed as grit, or out of simple curiosity. In one case a shot pellet was actually encysted in the thin wall of the crop. It would have found its way eventually into the crop without any damage; but it is curious that a pellet having entered the bird with sufficient impetus to get through the skin and half way through the wall of the crop should not have gone right through into the contents.

Danger of sheep drains.

The danger to young chicks in sheep drains and in moss cuttings for "peats," or for general surface draining, has already been mentioned. It is greatest during a "spate" after a spell of dry, hot weather in June or July, when young broods have been led by their parents to take shelter from the sun in dry drains with steep sides. The sudden filling of these drains is responsible for the loss of many chicks before they find a place to scramble up into safety. This danger is well recognised, and the best method of avoiding it is dealt with elsewhere.[1]

Accidental poisoning.

Accidental poisoning is a rare cause of death in Grouse. A few cases have been brought before the Committee as cases of "Grouse Disease." It is not easy to guess how poisoning occurs, for poison used in killing vermin is administered mainly in eggs, and in the carcasses of fur-bearing animals, neither of which are likely to be tampered with by Grouse. Poisonous sheep-dip has been blamed in some cases; but it is difficult to believe that it can be more than the rarest cause of accident.

The theory that many Grouse are poisoned by lead pellets, whether swallowed as such, or in solution as carbonate of lead in drinking water, has been ingeniously upheld by an elaborate calculation of the amount of shot scattered over a moor in a shooting season; but though the crops and gizzards of Grouse do occasionally contain a lead pellet or two, they are sufficiently uncommon to be a matter of curiosity to the finder rather than a cause of sickness to the birds.[2]

The following is an account of what was supposed to be accidental poisoning of Grouse by sulphate of Barium. It is given by Macpherson in the "Fauna of Lakeland."[3] Quoting John Borrow as writing from Alston in 1837, he says: "In consequence of the Grouse in some parts of this neighbourhood having been unable to procure sand (owing to the depth of snow), they have picked up particles of the sulphate of Barites, which appears to have been the cause of a very great mortality among them. A person whom I can depend on assures me he saw not less than forty brace dead upon the moors a few days since."

One may, I think, legitimately wonder whether this mortality was not due rather to grit-starvation, accompanying and augmenting the evils of food starvation, which is always present to some extent with deep snow.

[1] *Vide* chap. i. p. 17, and chap. xii. p. 369.

[2] *Vide* Macdonald, "Grouse Disease," p. 160.

[3] *Vide* Reverend H. A. Macpherson, "A Vertebrate Fauna of Lakeland," p. 323. Edinburgh: D. Douglas, 1892.

No case of poisoning in Grouse can be attributed to the consumption of any plants found growing upon a moor.

Several cases of abscesses and septic poison of the leg, which resembled " bumblefoot " and " whitlow," were sent up for examination during 1908. A young cock Grouse that was shot purposely on August 25th, on account of the condition of its body and feet. The foot of another Grouse was affected in the same way though to a less degree. The latter weighed 15½ ounces, and its condition was fair. Both feet were much swollen with collections of caseous pus. It was killed " on an exceptionally dry juniper hill " in Inverness-shire. There were no abnormalities in any other part of the bird, except the usual infestment of *Trichostrongylus ;* but the organs were all apparently healthy. Several similar specimens were obtained upon the same moor.

Abscesses and septic poison.

It is evident that in Grouse, and in poultry affected with " bumblefoot," we have the result of localised suppuration from septic infection following upon some small and unnoticed wound or damage such as a scratch or bruise. A " whitlow " is exactly comparable to this affection in the toes, and a whitlow may be a septic affection of the superficial or deeper tissues, and if of the latter, the infection may spread to tendon sheaths, or even into the joints themselves, or between the muscles.

B.—Causes of Death and Damage resulting from Natural Conditions.

Nearly all the causes of death and damage due to purely natural conditions have from time to time been so well described that it will here suffice merely to recapitulate them.[1]

[1] In connection with the effect of weather conditions upon Grouse, much additional evidence has been collected by the Committee, and is referred to in other chapters of this book. In view of the information now made available for the first time, it may become necessary to reconsider some of the opinions of recognised authorities referred to in this chapter.

Climatic extremes.

1. Climatic extremes are well known and well recognised. They may occur from the time the eggs are laid to the end of the bird's life. At every age, in every season, and every year, the welfare of the bird is threatened by unusual climatic conditions in one direction or another.

Excessive heat and its usual accompaniment, water famine, are both somewhat uncommon at the time of year when they would be most dangerous to Grouse life. They are referred to in chapter i.[1]

The following abstracts sum up the harm ascribed in the past to wet and cold. Macdonald in "Grouse Disease" has no doubt about the matter when he writes that "Damp and cold never fail to produce diarrhœa, cramp, and disease"; and again, "Excessively cold or wet seasons are succeeded by great mortality among birds, and Grouse suffer more in wet than in dry seasons, however cold—this was strikingly demonstrated in the wet season of 1872-1873"; and again, "Cold wet causes bad hatching seasons."[2] So also Macpherson in the Fur and Feather Series says that young Grouse "do best in fairly dry seasons."[3] And for the bad effect of cold and wet on the food supply Macdonald, again, in "Grouse Disease," says: "We can also connect the disease with wet seasons. The heather does not quite ripen, particularly the small tops on which Grouse chiefly feed."[4]

There seems, in fact, to be a consensus of opinion amongst those who have had the best opportunities for judging, that the hatching season can hardly be too dry so long as there are dewy nights. The chicks can supply their needs by drinking dew in the morning, and beyond this they find sufficient moisture in the insects and young succulent moss-capsules and heather shoots which form their staple diet, and which contain something like 60 to 80 per cent. of water. The sitting hens want water and must have it, and their bulky droppings may always be found

[1] *Vide* chap. i. pp. 104-106.
[2] Macdonald, "Grouse Disease," pp. 24, 40.
[3] Fur and Feather Series, "The Grouse," p. 24.
[4] Macdonald, "Grouse Disease," p. 40.

on the edges of the burns and springs nearest to their nests. They are reported to suffer seriously in a drought. But when all is said, excessive heat and drought are far less to be feared in the British Isles than excessive wet and cold. Sunstroke, "staggers," and "splanders" in wild birds of any kind are extremely rare when compared with the results of an excessively wet hatching season, especially if it happens to be accompanied by cold. Too much wet is undoubtedly more harmful both to the sitting hens, to the eggs, and to the young birds when hatched, and for a month at least after hatching, than any other climatic extreme to which Grouse are subject. Excessive rainfall is said to account for the scarcity of Grouse on the moors of the West of Scotland and of the Western Isles, and to this John Colquhoun adds that "Grouse are never so plentiful on the west coast, from the wet springs addling so many of the eggs." And again, "Protect as strictly as possible, and kill every rapacious bird and beast on the ground, there never could be half as many Grouse reared in the west as in the north or centre Highlands; and the reason is the humid climate prevents it. Every sportsman knows that the Grouse in the north or centre Highlands of Scotland are immensely more numerous than in the watery west." [1]

The nesting season of 1906 was most typically a bad wet season everywhere, and in walking over some of the Scottish moors, south of Perth at any rate, nest after nest was found to be deserted with a full clutch of eggs in which the chicks had died just before the time of hatching. Second broods are in such cases no doubt produced, but if an early winter sets in, or if the autumn turns wet and cold, these late-hatched broods swell the ranks of the poorly-feathered, undersized birds which appear next spring as "piners," and are liable to succumb eventually to disease of one sort or another. The question of the diminished value of second broods is fully discussed in a later chapter.[2]

[1] Colquhoun, "Moor and Loch," vol. i. pp. 194-198.
[2] Chap. xv. pp. 335 *et seq.*

In every way, except in checking the growth of the heather, hard frosts and heavy snow do less harm than excessive rains. A certain number of hens may be occasionally frozen to death upon their nests, as has been recorded by Stuart-Wortley (Fur and Feather Series). Eggs, too, may be "frosted" when late frosts are sufficiently severe,[1] or young Grouse may be killed by late snowstorms, as in 1864 on Glenshea; but such occurrences are very rare. The power of resistance of the egg to frost is dealt with in another chapter.[2]

Still, however little direct harm excessive cold may do to Grouse, the indirect harm is often very great, and there is no doubt that late frosts in the north of England and in the south of Scotland, catching the heather after the sap has begun to rise, often reduce the available supply of food.

"Frosted heather."

It may be well to review what has been written from time to time as to the effect that "frosted heather" is supposed to have upon the Grouse.

In Macdonald's "Grouse Disease" a Scottish forester is quoted as having stated that during a certain epidemic there was no "Grouse Disease" all along the sea coast where the heather does not suffer by frost, while ten miles or so inland, where the sea ceased to exercise its influence, "Grouse Disease" began. It is there stated that the dissection of Grouse that had died of the disease proved that their crops contained frost-bitten heather.[3] And, again, in a quotation from Colquhoun's paper, it is stated that in Perthshire, in 1852 and 1853, the heather was excellent, and in consequence there was no disease, while in 1854, 1855, and 1856 the heather was frosted without snow, and there was bad disease. Again in 1857 the heather was excellent, and there was no disease; and so on.[4] Speedy, however, says: "Heather which has been killed by frost and entirely divested of its nutritive qualities

[1] W. A. Adams, "Twenty-six Years' Reminiscences of Scotch Grouse Moors," p. 94. London: Horace Cox, 1889.

[2] *Vide* chap. i. pp. 10-14.

[3] Macdonald, "Grouse Disease," p. 40.

[4] *Ibid.*, p. 122.

is about the most unlikely thing for Grouse to feed upon."[1] He says, too, that after bad disease there are more survivors on the high exposed heather-frosted parts of the moor than on the lower sheltered localities, and that "'Grouse Disease' has not been peculiar to those seasons when the heather was most generally frost-bitten, or when it had not been covered and protected by snow. . . . Some of the most fatal visitations have been preceded by winters more remarkable for mildness than severity."

The statements contained in the above quotations from Macdonald and Colquhoun are probably due to a misuse of the term "frosted heather," for there is a condition of heather which is *not* rightly called "frosted heather," and it will prevent misunderstanding if the meaning of the term is clearly defined. To begin with, young, fresh, green heather of the early summer may be caught by a late black frost which sweeps over the moor and literally "scorches" it red. This is a comparatively frequent occurrence in the north of England, and was well exemplified on a certain Yorkshire moor in the early summer of 1907. The countryside was green one week, and "as red as a fox" the next. Every leaf that was turned red by the freezing winds (there was no snow) died, and eventually dropped off without recovering. But the plant was not killed; it very soon put out fresh leaves from the lower stalks, and the moor in a few weeks was as green as ever. Still, the fact remains that the birds of that moor were suddenly reduced from a very abundant to a very limited supply of food, for in no case will a Grouse eat such useless stuff, nor has a Grouse's crop ever been found to contain this fox-red frosted heather. It is dead, and the birds know it and will not eat it, but forthwith proceed to look for something that is not dead, therefore any harm that accompanies its appearance is due, not to the presence of unwholesome food, but to the sudden shortage of wholesome food. Such fox-red frosted heather must on no account be

[1] Tom Speedy, "Sport in the Highlands and Lowlands of Scotland," p. 202. Second Edition. Edinburgh and London: William Blackwood and Sons, 1886.

confused with the dark, red-brown, winter heather, which is secure from any ordinarily severe frost, and is merely the resting condition of the healthy living plant. The two are totally distinct in colour, the former being, as has been said, brick-red or fox-red, and the latter a deep brown, or dark reddish brown often associated in the leaves of the other side of the twig, with a deep or vivid winter green. Such heather is alive and healthy, and forms perfectly wholesome food for the Grouse; it is, in fact, their staple winter food. The only point is that being somewhat dry and sapless (in which lies the whole reason of its immunity to frost), and lacking in food-value when compared with fresh, young, summer heather, about three or four times as much has to be eaten by the bird to get the same amount of nourishment. This dark, winter heather cannot be correctly called "frosted," since the change in it is merely due to a seasonal alteration in the chemical condition of the cell contents, while it remains in the healthy resting winter state. With certain modifications it may be stated generally with regard to the two forms of "frosted" heather that in one case the heather is dead—having been killed by even a moderate frost—and that in the other it is living, and is proof against even a severe frost.

The presence or absence of snow on the ground makes a great difference in time of frost. Snow acts as an efficient protection to the heather, and only the extra long twigs that protrude beyond the snow are affected by frost. Hard frost after snow trims the heather by cutting off and killing all the longer pieces, so that the leaves bleach whitish grey, and eventually drop off. This may happen even to straggling pieces of dark brown winter heather if the frost is severe enough; but it requires a very low temperature and a prolonged exposure to affect real winter heather to any great extent. There is no other condition of heather which can with any show of reason be called "frosted"; and it may be urged that no heather should be so named except that which has been nipped and killed beyond all chance of recovery. To call the resting condition of winter heather "frosted" is as unreasonable as to call any evergreen shrub "frosted" because its winter leaves are darker in colour than those which it produces in early summer.

Closely simulating the fox-red, frosted heather, however, is the heather damaged by a certain beetle known as *Lochmœa suturalis.* This pest has long been recognised in Argyllshire, Ayrshire, and Dumbartonshire, and its ravages were described by Mr Grimshaw in 1898.[1] This subject has been fully dealt with in a later chapter.[2]

Heavy snow.

Before leaving the climatic causes of death and damage to Grouse, something remains to be said about heavy snow. Its most obvious danger lies, of course, in starvation, since a heavy snowfall, unaccompanied by wind, and not followed by a thaw for many weeks, reduces the available food supply to a minimum, and drives the Grouse to travel far and wide over cultivated lands, into gardens, town outskirts, and even to the seashore for a scanty living.

It is recognised that one of the best ways to help Grouse under such circumstances is to lay bare patches of heather by breaking through any hard crust that may have formed on the surface of the snow. This may be done either by rakes or harrows, and the spots chosen should be those where there is known to be the best supply of good feeding heather. As a rule there is sufficient wind with the snowfall to ensure that large tracts of ground remain uncovered on exposed ridges, and on the weather side of hill faces. When this is so, the Grouse collect on them; but as these exposed tracts are always on the weather side, and almost always on the shoulder of a hill, it is usually the worst heather which is exposed; the lee side is probably buried deep in snow.

Attention has already been drawn to the benefit derived from sheep and deer in time of snow, owing to the surface of the snow being broken by their tracks. But although the

[1] "Annals of Scottish Natural History," vol. ii. p. 27.
[2] *Vide* chap. xiii. pp. 370 *et seq.*

heather may be exposed, and even though oats and corn may have been put down in abundance for the birds, the most important step has often not been taken to relieve the necessities of starving Grouse. They must have grit, for without grit it is almost useless to put down corn. This was realised and put into practice in the snowstorm of 1881, but only by very few. Corn was put down here and there for the ravenous birds, and though some of it was eaten it was evidently not what they were most eager to obtain. On one moor, at any rate, men were sent out with shovels, not merely to expose the heather, but to open up the "scrapes" along the road sides all over the moor, and thus to expose fresh grit. Every day new grit was laid open and rotten quartz and sandy rock were broken out, and each day a fresh supply was needed. Grit, therefore, was what the birds were really starving for, and it was the want of it that rendered them incapable of dealing with hard corn or winter heather. With good quartz grit they can deal with almost anything, even the very woody heather that appears above the snow; without grit they will starve. Any one may assure himself of this by examining the winter crop-contents of the white-winged Willow Grouse or "Rype" of Scandinavia—the bird which decorates our poultry shops as "Ptarmigan" in winter. It is quite wonderful to see how excellent is the condition of these birds, living as they do on hard wooden alder twigs and buds, woody dwarf willow twigs and old rank heather. Their crop contents are extraordinarily hard and uninviting in appearance, and yet with good quartz grit everything is ground up and utilised.

Another cause of death to Grouse is the ravages of birds and beasts of prey. This subject is dealt with elsewhere.[1]

Deaths also occur amongst Red Grouse owing to the antagonism which exists between the male birds of Blackgame and Capercailzie, and those of the Red Grouse. The two former have been blamed for the disappearance of Grouse from certain parts of the country. John Colquhoun, speaking of the decrease

[1] *Vide* chap. xiv. pp. 405 *et seq.*

of Grouse in some districts says: "This may in part be attributed to the advance of cultivation; but I cannot help thinking the Blackgame have a good share in driving off the Grouse, as I know of one instance where the former were killed off, and the latter again returned to their old haunts. I believe it is also more than suspected that the Capercailzie, wherever they are introduced, have a great inclination to dispossess both."[1]

Corn feeding.

Corn feeding is a habit which has become general among Grouse and Blackgame wherever the lie of the land permits, or the condition of a moor facilitates it. It is often mentioned as an accompaniment, or a cause, or a forerunner, or a consequence, of "Grouse Disease." The opinion of gamekeepers on the subject is about equally divided; some say that it does the birds more good than harm, and others say exactly the reverse. Occasionally yet another suggestion is made which appears on the whole to meet a certain proportion of cases, namely, that in certain districts the weaklings alone are to be found upon the stooks and stubbles, or, in other words, that corn feeding is a consequence of sickness, not a cause. Generally speaking, in districts where large packs habitually come upon the stubbles, it is probably because they have insufficient food upon the moors. Grouse when feeding on the stooks are generally not only healthy but wild, until they have filled themselves with corn, when their habitual wariness often seems to leave them. This has long been recognised, and in Adam's "Reminiscences," for example, we find the statement that "Grouse, when they get on the plough are sometimes very stupid."[2] A case in point occurs in the extraordinary series of deaths to Blackgame caused by collision, which has been described above.[3]

Corn feeding is customary with healthy Grouse on some moors much more than on others; but the evidence seems to show that when *sick* birds appear on the cornfields they are

[1] John Colquhoun, "Moor and Loch," p. 202, note.
[2] Adam, "Reminiscences," p. 25.
[3] *Vide* pp. 119 *et seq.*

there because they are sick—not that they become sick because they have been upon the corn. St John notes that on August 12th, 1847, during a severe epidemic of disease in Morayshire, Grouse were feeding in numbers on unfilled green oats in the small fields near the moor. This, he says, he had never seen before, though he was accustomed to see Grouse flocking to the stubbles in the autumn.[1]

Sickly birds found feeding on the stooks were forwarded for examination in 1908, birds seriously diseased with Cobbold's Strongylosis, wasted piners that could hardly fly. These were probably sick birds that had been crowded out from the good feed on the moor by the healthier birds which live there in packs, the latter only occasionally make a raid upon the corn.

The following extracts support the opinion that over-much corn-feeding is a precursor of disease:—

Macdonald quotes as follows from a pamphlet written by Mr William Colquhoun of Ross-shire in 1858:—"The Grouse have fed a great deal on the stooks during the disease (1854-1856); and on the stubbles after the corn was stacked; and also in spring on the sown corn. This year (1858) the Grouse did not come to the corn as in former years." (The disease had then quite disappeared.)[2]

Again Colquhoun says that Grouse thrive in confinement when fed on corn; but allows that their greed for corn increases in disease years. He thinks that possibly they are upset by eating damaged and unwholesome heather, and are driven to stook and stubble for a sufficiency of food.[3]

Speedy, too, writes as follows:—

"An excessive consumption of corn by the Grouse species, particularly in wet seasons when the harvests are late, has been assigned as a cause of the 'Grouse Disease.'"[4] But he goes

[1] Charles St John, "Natural History and Sport in Moray," p. 202. Edinburgh: David Douglas, 1882.

[2] Macdonald, "Grouse Disease," p. 123. William Colquhoun, "Remarks on the Decrease of Grouse and the Grouse Disease," p. 29. Edinburgh: Edmonston and Douglas, 1858.

[3] Colquhoun's Pamphlet, p. 30.

[4] Speedy, "Sport in the Highlands and Lowlands of Scotland," p. 200.

on to say that hand-reared Grouse can live for several years in perfect health without seeing anything but corn; and that whereas on the Dalnaspidal and Rannoch moors the birds were too far from cultivation ever to see corn, yet they suffered badly from disease in 1873.

As with theories based on the belief that Grouse feed on frost-bitten heather, so with those that are based on their feeding upon corn, *post-mortem* examinations produce little evidence to show that they suffer any serious harm from the latter food, or that they ever under any circumstances fill their crops with the former.

Risks of reproduction processes.

Turning now to the dangers and risks attendant upon the natural processes of reproduction and moulting, we find that the exigencies of courtship, mating, and moulting in the male, of moulting, the laying of eggs, and the hatching out and rearing of a brood of chicks in the female, constitute the sequence of a taxation which bears heavily upon the Grouse. It is worth while to look at these in detail to see how far each may fairly be burdened with responsibility.

If an inquiry is made into the cock bird's life he will be found engaged in constant vigilance and warfare from the time of pairing, generally about the end of February or March, onwards for a month or two at least. The battles are more bloody and more disastrous to the weaklings than is generally supposed, and many of the half-starved and parasite-infected cocks, the so-called cases of "disease" found dead along the burns, have really been killed in fighting. It is a fact, testified by more than one reliable gamekeeper, that two or more healthy cocks will sometimes set upon and kill a weakling before they settle their own dispute; and of the urgency of their own dispute the following quotation by Macpherson in the Fur and Feather Series affords a good example. He quotes a Perthshire keeper, who "saw two male Grouse engaged in combat, so completely blinded by fury were the birds that they dashed against the wall of a stone building, one of them killing himself with the impetuosity of his flight "[1] In the same work Mr Stuart-Wortley writes: "In the pairing season the old warriors come down from the heights, fight with and vanquish the younger ones, and absorb the young hens."[2] Such efforts combine to bring to an end a very large proportion of cock birds which are more or less exhausted after the winter by poor feeding and the loss of strength due to the presence of intestinal parasites.

Then follows the moult, an exhausting process under the best conditions, and one for which nature generally makes provision by laying in a stock of subcutaneous fat. All this is consumed during the growth of the new feathers.

But in the case of an ill-conditioned Grouse the moult commences with an insufficient supply of fat from which to draw for the growth of new feathers. The result may be a complete failure to rise to the occasion; or, if the failure be only partial, the old feathers, but only to some extent, are retained, and the new feathers will come slowly, poorly, and sparsely. Bare legs and a poor-looking mixture of old and faded feathers, with a more richly coloured new one here and there, produce a seedy, chequered-looking bird, and to this must be added an air of exhaustion and *malaise.* Occasionally in the male the summer change of plumage is not completed even by autumn, and feathers of three different plumages may then be found on a single individual. But as the season advances, and good food becomes more abundant, by degrees the moult is completed in a more or less satisfactory manner. The chief troubles are then over for the cock, and he gradually improves in condition, and is prepared to meet the ensuing winter.

The lot of the hen is certainly less enviable than that of her mate. She also may have struggled through the winter, and while the cocks fight over her is quickly putting on fat for an early moult. She makes an almost complete change of plumage before laying her eggs in April; and in this she must consume

[1] Macpherson, Fur and Feather Series, "The Grouse," p. 32.
[2] *Ibid.*, p. 147.

a portion of her strength. She recuperates in sitting, but feeds only scantily the while. Then her troubles begin to be more pressing, especially if by any mishap she loses her eggs and has to lay and sit a second time. If, however, by the end of June, she hatches off, she must still be constantly on the watch for danger to her chicks. In July she has to moult again. Little wonder that by August she is sometimes reduced to the condition of a "piner," or that, when the shooting season comes, she is discarded from the day's bag, to be submitted for examination under the suspicion of "disease."

It is the same story precisely as in the case of birds handicapped for life through having been hatched late in a second brood. In the one case the birds are full grown and healthy to begin with, but have been unable to stand the strain of breeding and moulting. In the other case they have never had a chance to become full grown. In either case the course of natural taxation is the same, the parasitic infestment is the same, and the final result to the bird is the same. The only thing which differs is the primary cause of weakness, and this may be one, or several, of a very considerable number of causes that lie in wait for the life of the Red Grouse on every moor.

Of accidents which may happen in the process of laying, there is one which is well known in captive birds, but is rare in nature, namely, a shortage of lime rendering the eggs deficient in shell. Soft-shelled eggs not only fail to stimulate the muscles of the oviduct, but give them no purchase upon which to act. The consequence is that the egg is not expelled, but is broken in the duct, and is followed by other eggs until the bird dies either from exhaustion or from a rupture of the oviduct involving the peritoneum. Soft-shelled eggs in wild birds generally appear in a second clutch laid shortly after the loss of the first nestful.

Gastro-uterine gestation must always be rare, but one well-marked case in a Grouse was sent up for examination. The egg, when shed by the ovary, failed to enter the open upper end of the Fallopian tube, and so passed into the body cavity. By causing irritation there it became adherent to the peritoneal covering of three portions of the gut. The adhesions formed a firm support, and presumably the egg was for a short time carried safely. Eventually, however, it was broken in the peritoneal cavity, and the bird was shot, and owing to her unwillingness to take flight was forwarded as a case of suspected disease.

Diseases of the skin.

Disease of the skin is a very rare thing in wild Grouse, and generally results from the irritation produced by innumerable ectozoa or external parasites, such as ticks and lice.

An example was furnished in an adult hen Grouse of 20 ounces, shot on August 12th, 1908, in Lanarkshire. The bird was very unprepossessing in appearance, as the feathers had failed to make their way through the skin of the head and neck especially, and to some extent all over the body. The skin was of a very deep yellow colour, and there were sebaceous cysts of varying sizes scattered all over the bird, and so thick on the head and neck that hardly a feather appeared. The gamekeeper's view was that it looked "like a hen that had sat herself out on frosted eggs." There was no other abnormality discovered except the large size of the spleen which measured 20 mm. in length and 11 mm. in thickness.

Another case which resembled the last occurred in a Grouse where *Ixodes* and *Goniodes* had again produced a great number of scabs and sores and warty excrescences all over the face and head, and especially in the neighbourhood of the ears and eyes.

CHAPTER V

"GROUSE DISEASE"

History of "Grouse Disease" with an account of the work of the "Grouse Disease" Inquiry, in respect of previous work done by Professor Klein, Dr Cobbold, and others.

"Grouse Disease" in its epidemic[1] form has become a serious matter only since the Grouse has come to be of importance in the economic management of estates in England and Scotland. Careful protection, improved conditions of food caused by heather-burning and drainage, and the removal, as far as practicable, of all animals that seriously threaten the lives of the birds, are some of the artificial means by which moors have become more heavily stocked with Red Grouse than was the case under more natural conditions. To this heavy stocking, combined sometimes with unfavourable natural conditions, but oftener with injudicious management, have been attributed the outbreaks of epidemic disease which have periodically visited the majority of Grouse moors. In other words "Grouse Disease" has always been considered to be intensified by artificial conditions.

It is doubtful whether this view is correct. As early as the end of the eighteenth century we have records of serious mortality amongst the Grouse in certain districts, and "Grouse Disease" undoubtedly occurred in the earlier part of the last century, long before the artificial conditions had become established.

Amongst the earliest recorded outbreaks of disease about

[1] The familiar word "epidemic" is used throughout these volumes to signify outbreaks of specific diseases among Grouse in place of the more correct term "epizootic."

the beginning of last century, Macdonald, in "Grouse Disease," says: "It is now (1883) eighty years since the alarm of 'Grouse Disease' was sounded in this country."[1] Speedy says: "The first time 'Grouse Disease' attracted special attention was in 1838. Prior to that date it was not unknown in Scotland; but it had not assumed the proportions of a malignant epidemic. Even in 1838 and for several years afterwards, it was much milder in its results than it has latterly become. In 1867 it seems to have developed a most destructive form, attracting very general attention. Prior to that it was comparatively local, decimating the birds in certain districts, and leaving other districts untouched."[2] Howard Saunders says: "As long ago as 1815 a severe outbreak in the Reay country, Sutherland, was on record."[3] Mr Woodruffe Peacock in a pamphlet on "Grouse Disease" writes: "Old Moor Keepers have told me that their elders knew it as a slight and local trouble quite 50 years before 1847," *i.e.*, in 1797.[4] And finally, in the MS. Records of Bolton Abbey, it is specifically mentioned as a "fatal disorder" in 1882; though as early as 1809 and 1811 there are records of "no shooting"—accountable in all probability to disease.

It is therefore probably not correct to say that the first predisposing cause of "Grouse Disease" was protection leading to overstocking. The question is really of academic interest, since the artificial conditions are now firmly established.

It might be profitable to consider the other theories which have been put forward as to the predisposing causes of disease.

Such theories are numerous, and every one of them has at one time or another been promoted to the rank of "the real cause," the acting and primary cause, that is to say, of so-called "Grouse Disease."

The subject has long held the attention of many observers. Macdonald, Macpherson, Stuart-Wortley, Adams,

[1] Macdonald, "Grouse Disease," p. 112.
[2] "Sport in the Highlands and Lowlands of Scotland," p. 184.
[3] "Zoologist," 1887, p. 302.
[4] Rev. E. A. Woodruffe Peacock, "Grouse Disease," p. 12.

Speedy, Teasdale-Buckell, and a host of other naturalists and sportsmen have supplied a large collection of interesting facts and observations, and an almost equal number of hypotheses and theories to account for them, while Cobbold, Klein, Farquharson, Colquhoun, Andrew Wilson, and Young have all contributed towards an understanding of the pathology of "Grouse Disease." It is proposed first to discuss the conclusions at which various writers have arrived, and as the work of Cobbold and Klein stands out pre-eminently the simplest course will be to take their conclusions first.

Dr Cobbold's conclusions.

Dr Cobbold's view, was that "Grouse Disease" was entirely due to a threadworm known by the scientific name of *Trichostrongylus pergracilis* found in the intestines of the bird. In his opinion "the irritation, probable distress and subsequent emaciation of the birds are readily explained by the presence of hundreds and thousands of strongyles; and the mere circumstance that these parasites are very small, is quite sufficient to account for the fact that investigators have hitherto overlooked them."[1] He considered that the difference observed in the intensity of the disease during various epidemics might be partly accounted for by the presence of tapeworms and threadworms in varying proportions in the same Grouse, but that the strongyles were "sufficient by themselves to cause the death of the host" without the "assistance of a second kind of parasite."[2] He also thought that the intensity of the attack might vary with the strength of the individual victim. "A strong bird," he says, "will overcome or resist the irritation set up by the presence of hundreds of entozoa; while a feeble bird, or one attacked before it is perfectly grown, will more or less rapidly succumb to the invasion.

Professor Klein's conclusions.

Professor Klein came to the conclusion that there was a disease amongst Grouse which took the form of an acute infectious pneumonia, and was characterised by the presence

[1] T. Spencer Cobbold, M.D., F.L.S., F.R.S., "The Grouse Disease," p. 15. London: The *Field* Office, 1873.
[2] *Ibid.*, pp. 24, 25.

in the lung of a specific bacillus of the *B. coli* group. The disease had, he believed, two classes of victims, one which died rapidly in plump condition and fine plumage, and another which died slowly with emaciation. He puts on one side the whole question of parasitic intestinal worms as having no particular connexion with this epidemic pneumonia, and no casual connexion with the mortality.

Cobbold differed from Klein in one important respect, viz. :—that he distinctly indicates that he did not observe any example of a Grouse dying in good condition and without loss of flesh.

Neither Klein nor Cobbold suggest that they had any suspicion that they were dealing with two distinct diseases.

Taking all these facts and opinions into consideration, the Committee at an early period adopted the provisional view that Klein and Cobbold had before them Grouse dead from two distinct diseases—(1) plump and well-conditioned birds which had died of an acute infectious pneumonia, *i.e.*, the acute form of Klein's "Grouse Disease"; and (2) emaciated piners which had died of the results of extreme parasitism, *i.e.*, of Cobbold's Strongylosis.

The view that two distinct forms of disease had in the past been confused under one term was supported by the literature on the subject, for all previous writers on Grouse and "Grouse Disease" had referred to a difference in character to be noticed between the disease outbreak of one year and that of another and between the appearance of the victims at one stage and another of the same epidemic.

The following abstracts serve to illustrate the point :—

William Houstoun of Kintradwell, Brora, says: "At that time it took the tapeworm type, but, when the disease next appeared, it had a different form, and I fear we are as far as ever from a solution of the cause."

These later cases were presumably cases of Cobbold's Strongylosis, for the writer proceeds to describe that the intestines were distended "with a yellow feculent matter" suggesting the appearance characterising the cæca in that disease, and the victims were all piners.

Again, Macdonald described the earlier stages of the epidemic as being much more virulent, the birds being found dead and dying in numbers by the water-courses, "which latterly was not the case." The plumage in the earlier attacks looked different, the feathers were dirty and draggled—an appearance which was "latterly not seen in diseased birds."[1] And again, quoting from "Land and Water" (1867), he says that "one striking difference between the disease of 1867 and that of former years was that the dead birds . . . picked up this season were so plump and in such excellent plumage that they had the appearance of healthy birds; whereas in former years the diseased birds were most characterised by disordered plumage and attenuated bodies."[2]

In another place he writes: "We have ourselves frequently picked up dead Grouse perfectly plump, and in excellent plumage one season, and in the next season found diseased birds with attenuated bodies and dull disordered plumage."[3]

From this the Committee surmised that the disease which occurred in 1867 was Klein's pneumonia; while in the previous records the birds had been victims of Cobbold's Strongylosis. This provisional view was again borne out by a letter written by Mr Macdonald to the *Times*, May 12th, 1873, which ran thus: "It seems that disease of an exceedingly virulent kind prevails in all parts of the Highlands, and in a form hitherto unknown. . . . In 1847, 1856, and 1865 the infected Grouse exhibited a 'dull disordered plumage and attenuated bodies.' . . . In June 1867 they showed good plumage, a healthy appearance, and were perfectly plump, although the liver was soft and discoloured. This year (1873) they are beautiful in plumage, but wasted to skeletons . . . and with full crops."[4] This occurred evidently in later autumn, since mention is made of the large quantities of berries in their crops.

[1] Macdonald, "Grouse Disease," p. 127.
[2] *Ibid.*, p. 155.
[3] *Ibid.*, p. 131.
[4] *Ibid.*, p. 155.

All these quotations seem to point to the fact that in 1856 and 1865 there was an excessive mortality from Cobbold's Strongylosis; whereas in 1867 there was an epidemic of Klein's acute infectious pneumonia.

Again, in Adam's "Reminiscences" we find: "Disease in this attack (Dalnawillan, 1882) was very different in its aspects from former attacks. It came on very suddenly, sharp and decisive."[1] The distinction is markedly contrasted by Adams in his book, and the incidence in each case is well described.

Tom Speedy in "Sport in the Highlands and Lowlands of Scotland" writes: "The epidemic assumed two different forms. In some cases the birds were draggled, wasted, and emaciated, bare about the legs, and indicating . . . a long continued or fatal disease. At a more advanced period of the season they were found dead in beautiful plumage, with fine feathery legs; and the red above their eyes unsullied and as bright as vermilion. In many cases they were seen the one day seemingly in perfect health, and the next day stiff and cold in excellent condition."[2]

Enough has now been quoted to show that in the minds of many observers there has been for years the suspicion that the differences observed were not merely two phases of one form of sickness, but two distinct diseases. And it was on this assumption that the Committee at first commenced their investigation.

On following up this provisional hypothesis, however, it was found difficult to reconcile the opinions of former writers with the facts observed.

One thing was quite certain, that whereas the Committee had seen during the first three years of the Inquiry extensive mortality amongst Grouse caused by some agent which acted slowly and produced "piners" only, they had not seen anything at all like an epidemic of acute or infectious pneumonia. It followed therefore that if the rapid death of birds in good condition was typical of Klein's disease no case of Klein's disease had yet been seen.

[1] Adam, "Reminiscences," p. 75.

[2] *Op. cit.*, p. 185.

During the whole investigation the only form of disease observed among adult birds was a widespread mortality of "piners" owing to what appeared to be a form of starvation caused by an excessive number of the threadworm known as *Trichostrongylus pegracilis* in the cæca. This form of disease is quite comparable to the form of "Grouse Disease" described by Cobbold.

Tapeworms a possible cause of disease.

The widespread idea that tapeworms are at the root of one form of trouble is perhaps natural, considering that it is common knowledge that in some animals they are the cause of serious wasting. Moreover, the very first thing that appears when a Grouse is opened up, whether purposely or accidentally, is a mass of large white tapeworms. What could be more natural, since the bird is wasted to skin and bone, and tapeworms are found in large numbers, than to consider the one to be the cause of the other. But if only threadworms were as conspicuous as tapeworms, outnumbering them as they often do, to an almost incredible extent; or if some distinction had been earlier recognised between the main gut of the Grouse and its cæcal appendices, there would before now have been a strong following of Dr Cobbold, and the pining form of disease would be more readily associated with the presence of the smaller worm.

All birds dying from Strongylosis must be "piners," because their death results mainly from an inability to absorb nourishment owing to the cæcal lining or mucosa being damaged. The consequent emaciation is a *sine quâ non* in the diagnosis.

It is hardly necessary here to quote the accounts of dissections which have been recorded from time to time (many unfortunately in the most cursory manner), with a view to ascertaining what pathological lesions were found to account for death. The subject is fully discussed in the original Report of the Committee, and may be found at greater length in the published works of Dr Cobbold, Professor J. Young, John K. Lord, F. Buckland, Tom Speedy, Professor Klein, and Dr Andrew Wilson.

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The foregoing *résumé* is necessary in order to show the position of the controversy when the Committee of Inquiry was beginning its work. It explains many of the unavoidable errors into which the Committee was led by the inaccuracy of much that had been published on the subject. Even Professor Klein's work, accurate and painstaking as it was, and clear as were his published descriptions of whatever he himself saw, was misinterpreted by him for the sole reason that bacteriology (a science of which he was one of the most honoured founders) was still in its infancy. His deductions as to the disease being an acute infectious pneumonia due to a specific bacillus have now been shown to be founded upon a misconception; but, in the days when he was working at the subject, no one could have arrived at other conclusions than those to which he himself came. It is due to so great and careful a worker to say that at that time he was years ahead of any other bacteriologist in this country. That he should since have been found to be in error merely shows how dependent is science upon the methods available at the moment, and how impossible it is for any one at any time to be certain that even the most probable explanation of observed facts is the right one.

The doubts of the Committee were confirmed when their bacteriologist, Dr Seligmann, found that the bacillus which Professor Klein considered to be the specific cause of Grouse pneumonia was in fact only to be discovered in the lungs some twelve to twenty-four hours after death. It became gradually clear that not only the grosser appearances in the lung which Klein considered to be due to pneumonic congestion, but the microscopic appearances of the lung-tissue in section, as well as the colonies of bacilli which he described and figured in the lung, were in fact only to be found some hours or days after the death of the bird. They were undoubtedly due to a *post-mortem* migration into, and colonisation of, the tissues in question by numbers of *Bacillus coli* which had escaped from their proper sphere in the intestine at the moment when the normal defence had broken down.

It gradually began to dawn upon the Committee that the appearances in the lung upon which Klein had relied in making a diagnosis of acute infectious pneumonia differed in no way from the appearances which had been observed by the Committee in the lungs of hundreds of birds found dead from all causes, including Cobbold's Strongylosis, general Helminthiasis, accidents, or even shot wounds.

This discovery undermined the faith which the Committee were prepared to place in the existence of Klein's acute infectious pneumonia, and it soon became evident that in birds obviously dying of "Grouse Disease," there was no dangerous *ante-mortem* infection of the lung or other tissues with the bacillus in question, and no recognisable lesion in any organ of the bird except in parts of the intestine. All the appearances which were previously attributed to Klein's pneumonic disease, were now found to be due to *post-mortem* change alike evident in diseased and in perfectly healthy normal birds.

The point was further tested by taking a number of healthy pigeons, and killing the whole of them at the same time with chloroform. The birds were numbered and opened on consecutive days and the change in the appearance of the viscera was noted. It was evident that in every case where there had been extravasation of blood or serous fluid owing to rough handling, or damage by the knife in dissecting the pigeon, the tissues of the lung became black, and took upon themselves precisely the same appearance that is seen in a Grouse found dead upon the moor, or examined some days after being shot. The appearance of pneumonia was evidently due to a soaking of the lung-tissue in decomposing blood and serum, and the *post-mortem* colonisation of the tissues by *Bacillus coli.*

Once this fact became clear, the Committee was no longer burdened with the task of recognising and investigating the type of "Grouse Disease" described by Professor Klein, for it now became impossible to accept his explanation of the disease. It then became necessary to set on foot more detailed investigations to determine the following points :—

1. To prove that the amended view of Klein's work was the right one, and that the " Grouse Disease " which he saw and described as a form of infectious pneumonia was in reality not different from the " Grouse Disease " which the Committee were seeing constantly, and were describing as Cobbold's Strongylosis.
2. To make a complete investigation of the life history of the *Trichostrongylus pergracilis* or the Strongyle of Cobbold, with a view to ascertaining its mode of infecting Grouse, its action in the cæcum of the Grouse, its method of reproduction, its dissemination, and the conditions which enable it to hatch from the egg, to pass through the stages of development, to survive on a Grouse Moor, and to enter a bird at a stage when to be swallowed means completing the cycle of parasitic life, instead of being merely digested. The life history of this threadworm was obviously required in its smallest details, in order that Strongylosis might be understood.
3. To discover whether this or any other form of " Grouse Disease " was caused by bacterial infection or not. For convenience this may be called the bacterial theory.
4. To investigate the blood of the Grouse in health and in sickness, and especially to try and discover whether death was caused by toxins introduced by parasites in the intestine. This might be known as the " blood-poisoning " theory.
5. To make certain that " Grouse Disease " did not result from the presence in the intestines, or in the blood, of any protozoal parasite. This might be called the protozoal theory.
6. To complete the investigation of the Grouse parasites, ectozoa as well as entozoa, with a view to determining whether " Grouse Disease " could be considered attributable to some of them, or even to one of them.

The last four years of the Committee's work were devoted mainly to the study of the foregoing questions. The detailed results of their investigations are given at length in the original Report, and, though their conclusions may be subject to modifications in detail, it may be claimed that these have gone far to elucidate the main points involved. These conclusions may be summarised as follows:—

1. So far as the observations of the Committee were concerned Klein's infectious pneumonia is not a separate and distinct disease from Cobbold's Strongylosis. In fact, to be more precise, Klein's disease was never observed.
2. The life history of the threadworm *Trichostrongylus pergracilis* was satisfactorily traced.[1]
3. The investigations failed to establish any connexion between "Grouse Disease" and bacterial infection due to the presence of parasites or any other cause.[2] It was not found that the bacilli which find their way into the organs did much harm. Some harm no doubt they do; but how much cannot be accurately ascertained.
4. It was not found that mortality was due to toxæmia caused by parasites in the intestine.
5. It was not found that extreme mortality among adult Grouse was caused by the presence of parasitic protozoa in the intestine.[3] It may, however, be noted that in the course of investigating this point the Committee discovered a hitherto unobserved disease among immature Grouse, which was caused by the presence in large numbers of the protozoal parasite *Eimeria* (*Coccidium*) *avium* in the intestine.[4]
6. The ectozoa and entozoa of Grouse were carefully investigated, but no extensive mortality could be traced to any of them with the exception of the *Trichostrongylus pergracilis* of Cobbold, and to some small extent to the smaller tapeworm *Hymenolepis microps*.[5]

[1] *See* chap. viii. pp. 219 *et seq.* [2] *See* chap. viii. pp. 215 *et seq.*
[3] *See* chap. ix. p. 244. [4] *Ibid.* pp. 244 *et seq.* [5] *See* chap. vii. p. 198.

The question has frequently been asked whether there is an epidemic form of " Grouse Disease " which in spite of minute inquiry and search has eluded the vigilance of the Inquiry during the last six years, and whether the Committee never came across the genuine epizootic " Grouse Disease " at all.

Apart from the question of whether Klein's pneumonia has any existence in reality, all the outbreaks of disease amongst Grouse which have come under the observation of the Committee can be ascribed either to Strongylosis or to Coccidiosis, the only two diseases which are now recognised as causing widespread mortality amongst Grouse. And the principal sign of both these forms of disease is loss of weight.

Yet one of the most persistently quoted observations, which some sportsmen and gamekeepers still maintain to be true in fact, is that in some epidemics there is a certain proportion of birds which succumb to so acute and virulent a form of " Grouse Disease " that they die before any loss of flesh or weight can have time to show itself, and before any change in the appearance of the feathers becomes manifest.

This view is founded not on actual measurement of weight, but on the bird's general appearance of good feather and normal weight, *as estimated by the observer* who takes the bird in his hand when it is found dead on the moor.

In most alleged outbreaks of " Grouse Disease " the birds have been collected and burned, or buried by the score in a moss-hag or under a rock. They were never weighed, and never carefully examined. Yet without careful weighing and examination it is impossible to come to any reasonable conclusion as to their condition or the cause of their death.

The Committee's field-observer has himself been present on several occasions when such birds have been picked up and passed from one to another of the keepers and the gillies; full-feathered, richly-coloured hens, perhaps found almost warm but dead upon their nests. And these birds have been weighed in the hands and their weight guessed as fully normal, notwithstanding the condition of the breast, yet the spring balance has invariably proved appearances deceptive, except in the cases where accident has been the cause of death.

In the case of a hen whose feathers have been recently donned for nesting, a most misleading impression of good condition is given even in a wasted bird. In the cocks it is different, for the feathers have not been changed for the nesting season, and the plumage is often worn and faded in comparison with the new nesting plumage of the hen.[1]

It is often hard to believe that a hen Grouse which has died in full nesting plumage, however thin and poor, is not actually heavier than the dingy cock bird of the same month. And if no rain has fallen on the hen since her death the comparison between her and the cocks which are found in all stages of disease, decayed, weathered and bleached, is even more misleading.

The point has now been too often tested to allow of doubt. No bird dies of Strongylosis without loss of weight. That some birds waste more and some less before succumbing to the disease is certainly true, the difference in this respect depends mainly upon the season, but sex and individual strength also make a difference.[2]

On this point the Committee can speak with entire confidence. During the whole period of the Inquiry, from 1904 to 1910, there has not been a single outbreak of "Grouse Disease" in which the birds died without loss of weight.

While, therefore, it is possible that a virulent and sudden form of disease does, in fact, sometimes occur, it is also possible that the belief in it is entirely without justification, and is the result of inadequate method and inaccurate observation.

[1] *Vide* chap. ii. p. 42.

[2] *Vide* chap. i. p. 33.

CHAPTER VI

ANATOMY AND PHYSIOLOGY OF THE RED GROUSE

As a preliminary to the proper understanding of the method of infection in the forms of " Grouse Disease " known respectively as Strongylosis and Coccidiosis certain facts concerning the functional activities of the different parts of the Grouse's alimentary canal should be explained.

By the alimentary canal is meant the whole tract of the digestive apparatus from the mouth to the anus or vent; and the following is briefly a history of the experiences undergone by a morsel of food after it has been swallowed by a healthy bird.

In the case of the Grouse it is reasonable to take a small sprig of heather, *Calluna vulgaris,* with a somewhat woody stalk and a number of very small greenish or brownish green leaves, and perhaps a few small pink flowers or shrivelled flower heads containing a considerable number of very small seeds. Other foods, of course, are frequently eaten, but all the vegetable stuffs may be considered as partly composed of soft, alterable, and digestible material, such as starch, protoplasm, chlorophyll, and sap solutions, and partly of indigestible woody fibres. The animal foods, whether they consist of insect or mollusc, worm, crustacean or spider, can also be considered as composed partly of soft, digestible material, and partly of indigestible matter, such as chitin.

And further, the function of the grit must be considered, since it is as essential to the well-being of a herbivorous or graminivorous bird as are teeth to the higher mammals.

The sprig of heather is partly plucked, partly cut from the growing plant by the beak of the bird In captivity it is found necessary to fix the bunches of heather either by tying them to the wire run or by placing a heavy weight upon the roots; should this precaution be neglected the bird, having no notion whatever of using its feet to steady anything, drags the loose heather all over the ground in unsuccessful efforts to pluck off the tips.

There is sometimes to be seen quite a free flow of watery saliva from the beak of a feeding bird, and in the mouth of birds killed there is always a certain amount of saliva. This saliva serves to coat the rough hairy heather tip with mucus, and thus to facilitate its passage down the œsophagus or gullet to the crop (Pl. XVI.). The food is, of course, swallowed whole but in very small pieces, and there is no mastication. The length of the œsophagus (Pl. XVI.) from the pharynx to the proventriculus or first part of the stomach[1] is $5\frac{1}{2}$ inches, when the neck is normally outstretched; but before passing down the whole length of this tube the food finds its way into a thin-walled sac or diverticulum of the œsophagus, at a point 3 inches from its entrance at the pharynx, and commonly called the "crop" (Pl. XVI.). Here the food collects, and remains for a longer or a shorter period according to the rate at which the gizzard can dispose of it. The lower portion of the œsophagus measures 2 inches in length, and the opening of the crop occupies over half an inch of its length.

The proventriculus (Pl. XVI.) forming the thick-walled glandular part of the stomach has a cavity of very small dimensions, and a length of $\frac{3}{4}$ inch. It is lined with large mucous glands having prominent mouths. These secrete a thick, tenacious, opaque white fluid, wherewith the morsels of food on their passage from the crop to the gizzard are coated.

In this respect there is a very great difference between the condition of the food as it leaves the crop, and its condition in the gizzard. In the crop the food is almost invariably dry,

[1] The stomach of a bird is divided into two portions, the proventriculus and the gizzard.

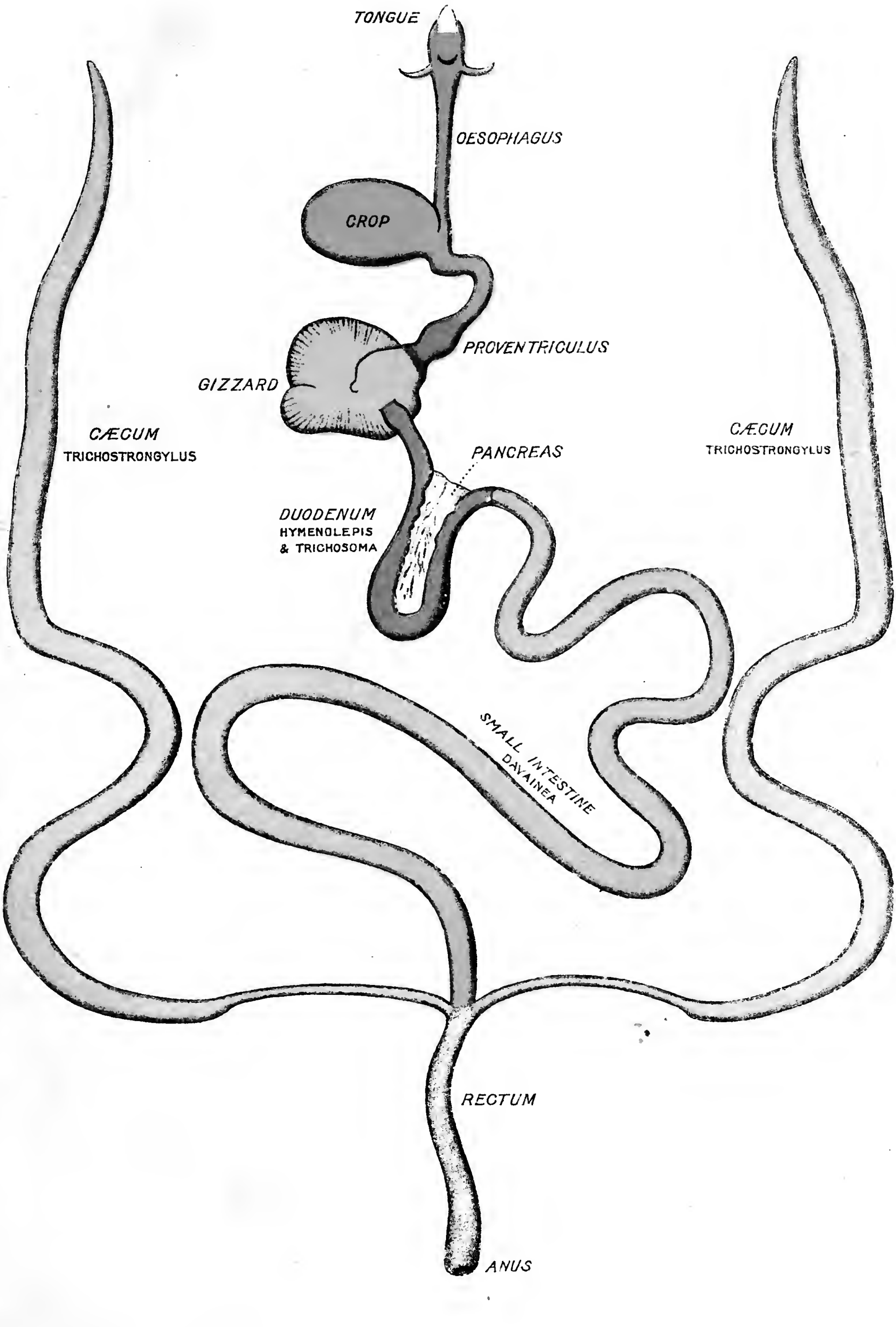
almost exactly as it is plucked from the living plant, and it is found thus in masses fresh and green, or greenish brown, with no appreciable admixture either of mucus or of water. Probably when there is food in the crop, no water is drunk, for there is never any wetness either in the crop, proventriculus or gizzard, all of which are occupied in turn by the morsels of food in process of digestion.

From the proventriculus the bits of food, coated now with a tenacious and slightly acid mucus, are passed into the muscular gizzard (Pl. xvi.), a familiar object in the anatomy of the common fowl, and an organ of very similar shape and of equal muscularity in the Grouse. Its walls are very thick, and the muscles which compose them act from tendinous sheets, into which they are firmly fixed. The cavity of the gizzard is comparatively small and contains about a teaspoonful of small hard subangular or rounded grains of hard rock. The substance almost universally chosen as grit by the Red Grouse is quartz, and although on the moor, as in captivity, the bird will swallow any small portion of hard material which comes in its way, quartz is most suitable, not only for the Grouse but for every other graminivorous bird in health. The subject is more fully dealt with in chapter iii.

The food having reached the gizzard with a free admixture of slightly acid mucus, is now thoroughly mixed up with the grits of quartz, and ground with their assistance to a pulp, the harder woody fibres soon showing up as whitish bits in a brownish, greenish, or reddish mess. This vegetable pottage has now to be separated from the quartz grits, and to be passed little by little into the duodenum.

The separation is effected by the sphincter or ring-like muscle at the exit from the gizzard, and the digestible food, including our particle of heather, now sufficiently pulped, is separated as it leaves the gizzard from most of the harder and larger grits, and enters the duodenal loop of the small intestine.

The duodenum (Pl. xvi.), $6\frac{3}{4}$ inches in length, begins at the exit of the gizzard and is U-shaped. It consists of two



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parallel "limbs" of about equal length. These two limbs are supported and held together by a mesentery which contains the pancreas (Pl. XVI.), a pale pink, flattened glandular mass filling the space between the descending and ascending limbs. This gland pours its alkaline and digestive pancreatic juice and ferment into the upper end of the descending loop.

The liver (Pl. XVI.) also pours its alkaline, biliary secretion into the upper end of the descending loop, so that it is intimately mixed with the pulped food as it passes into the duodenum little by little. The shape of the loop assists this admixture, since it checks the immediate passage of the contents into the small intestine.

Digestion is now ready to go on apace. The food, when being macerated and pulped in the gizzard, is distinctly acid; but, when mixed with the alkaline pancreatic and hepatic secretions from the liver, becomes gradually neutralised until it is of the right reaction as well as at the right temperature for the action of the digestive ferments.

In the duodenum the contents are normally almost fluid, when there are no tapeworms or threadworms present. The duodenum is, however, the common habitat of the tapeworm *Hymenolepis microps*,[1] and of the threadworm *Trichosoma longicollis*;[2] and the former of these is frequently present in such large numbers as to appear like a soft, semi-solid, creamy mass completely filling the whole length of the duodenum. It is only when this worm is absent, as it generally is during the winter months, that one appreciates the fact that the duodenum seldom contains at any one moment more than a very small amount of solid food pulp mixed with the digestive fluids. The passage of the food through it is slow and gradual, and the admixture with the alkaline digestive juices is proportionately complete.

Normally the outward appearance of this part of the intestine is a pale creamy white, and the mesenteric vessels which

[1] *Vide* p. 197. [2] *Vide* p. 199.

ramify over the peritoneal surface are almost invisible. The pancreas also should be pale creamy white or faintly pink.

The alkaline mixture now passes from the duodenum into the convoluted upper portion of the small intestine (Pl. xvi.). This extends from the lower end of the duodenum to the upper end of the rectum (Pl. xvi.), where the two cæca enter it. The small intestine measures in all 35 inches, but there is a distinction to be made between the upper convoluted portion and the lower straighter portion (Pl. xvi.), for the convoluted portion is freely movable, whereas the straight portion is so intimately folded with the long cæcal appendices, and so closely bound together with them in a common mesentery as to be very limited in its movement. The various parts of the lower intestine are shown laid out in the accompanying diagram (Pl. xvi.).

Returning, however, to the changes which are being experienced by the particle of food in question, as it passes from the duodenum into the convoluted portion of the main gut, it is first noticed that the duodenal tapeworm, *Hymenolepis microps*, wholly disappears, and that its place is taken by the much larger and more conspicuous tapeworm, *Davainea urogalli*, often in such quantity that the outward appearance of the small intestine is altered to a swollen, bulky gut of a creamy white colour due to the enclosed mass of white tapeworms shining through its thin and distended walls.

It has already been noticed that the neutral or faintly acid reaction of the contents of the duodenum has gradually changed to a more and more markedly alkaline reaction. *Hymenolepis* affects a neutral medium, and *Davainea* an alkaline medium.

These changes in the character of the intestinal contents can, of course, be easily tested by the use of litmus papers; but when a Grouse, which has been feeding upon ripe Blaeberries, Cranberries, or Crowberries with coloured juices, is examined, the contents of the alimentary canal of the bird itself are found to be coloured within from end to end, in such a way as to make litmus unnecessary. The juices of the berries are red, and stain the tissues red wherever the acidity is not overcome by alkaline digestive juices. But wherever there is a slight alkalinity in the juices there the tissues are stained bluish.

In the convoluted intestine the food is in a somewhat fluid state; and as the mere presence of convolutions in the intestine of any animal are evidence of the necessity for a retarded passage, the function of the convolutions in this case is obviously to hold the mixture for a sufficient length of time at a certain regular temperature to enable the active digestive ferments to complete their work upon the food-pulp. The heather fragments are thus altered into a solution of digestible food and indigestible refuse of woody fibre. The former is now ready for use by the tissues of the body as soon as it can be brought to them by the agency of the circulating lymph and blood. Certain harmful and poisonous products will also unavoidably appear in the Grouse's intestine as they do in the human intestine and in the intestine of every living animal from time to time, even in the ordinary course of digestion. These, as in the human body, having been absorbed with the soluble food supply into the blood are then eliminated, chiefly in their passage through the liver, before the mixture of good and evil products can be thrown upon the general circulation. The liver in man is the great eliminator of poisons produced in the intestine, and the liver in the Grouse almost certainly acts in a similar way.

By the time the food reaches the lower and straighter portion of the small intestine it is seen that much of the fluid has disappeared, the contents are becoming more and more thickened, and are now converted into a semi-fluid paste intermixed with woody particles. By the time that the contents reach the junction of the small intestine with the rectum they have been still further prepared for separation. At this point the cæcal appendices or cæca (Pl. xvi.) open into the main gut. Each cæcum measures from 30 to 36 inches in length. Their colour in health is a dull drab grey, while that of the small intestine is greenish. All that is soft of the food is now squeezed into the narrow openings of the cæca, while all that is hard, including the indigestible part of the heather fragment, the indigestible woody fibres, and the refuse of the cellular tissues, is compressed into a firm, dry mass, and passed straight into and along the rectum.

The exact method of separation is due to the action of the sphincter muscles which regulate the opening and closing, not only of the two entrances to the cæcal appendices, but also of the entrance to the upper end of the rectum.

Each cæcum at its junction with the main gut is guarded by a narrow tubular portion (Pl. xvi.) some 4 or 5 inches in length, which admits nothing to the cæcum except the softer parts of the pulpy mixture. The pultaceous, creamy-brown pulp must be squeezed into these cæcal back-waters by the pressure of the small intestine from above, while, at the same time, the rectum remains closed and refuses to admit anything at all.

In this way all the nourishing contents of the main gut pass into the cæcum, and are there absorbed into the blood and system generally of the Grouse, any portion still remaining undigested passes out again by the same orifice. Yet the cæca always appear to be filled to some extent by material from one end to the other. It is only after a prolonged starvation, say for twenty-four hours or more on a railway journey, that the cæca are found to be partly empty, and it is obvious from observation that the riddance begins by contraction of the blind end, and that it gradually works toward the open end. It would appear from this that there must be a pause in the entrance of material to the cæca while the waste matter is being evacuated. The muscles of the small intestine seem thus to act intermittently but without any long period of rest. The cæcal muscles, on the other hand, must have long periods of rest when the cæcum is full and actively absorbing, and then a period of activity to empty itself. But these periods of rest and activity must be of very different length. It is probable that after full feeding in the evening the Grouse jugs in the heather, and the process of digestion and the action of the intestine proceed until there is a large quantity of hard and soft food in the lower part of the small intestine ready for selective absorption and separation. This separation probably proceeds all night, the soft material constantly passing *into* the cæca, and the harder waste matter passing on as constantly into the rectum and out at the vent. Then, early in the morning the action is reversed, the passage of food down the main gut ceases because the supply from above has stopped during the night when, of course, nothing has been eaten. The useful part of the cæcal contents has now been absorbed, and is circulating in the blood, and the cæcum therefore contracts downward and expels all the waste matter that is in it. This is confirmed by what one sees upon the moor, by the absence of cæcal excreta amongst the heap of formed droppings passed in the night, and by the appearance of cæcal excreta either on the top of these heaps, or more frequently in their near neighbourhood or near the early morning drinking and feeding resorts. It has already been stated that the Grouse feeds more or less all day; but, as a rule, the crop is found fullest in the evening. Probably digestion is sufficiently rapid during the day to deal with the food almost as fast as it is picked and swallowed. It may be that the cæcum receives matter both by day and by night, and discharges its contents only in the early hours of the morning; but these details are not easy to determine in the wild bird.

It is easy to see how indispensable it is to the well-being of the Grouse that the cæca, whose combined length nearly equals that of the rest of the alimentary tract, and which are responsible for the absorption of most of its food, should be in good working order. It seems impossible to exaggerate their importance in the bird's economy, for if they are put out of action the bird may eat as much as ever and yet rapidly lose flesh by sheer starvation.

One portion of the alimentary canal remains to be mentioned, namely, the rectum (Pl. XVI.). This measures $4\frac{1}{2}$ to 5 inches from the point of entrance of the cæcal appendices to the anus.

The rectum appears to empty its contents almost immediately after receiving anything from the main gut or the cæca. When examined by dissection it is generally empty; but there is one marked exception to this statement. In the hen Grouse, during the laying of eggs and incubation, but especially during incubation, the want of exercise, and the necessity for keeping the nest clean, leads to an excessive accumulation of fæces, always of the harder, formed kind, in the lower part of the rectum. This accumulation of fæces results in an enlargement and distention of the lower part of the rectum and the cloaca, which recover themselves only after incubation and hatching are completed. The massed and bulky droppings of a sitting hen Grouse, or "clocker" as she is called, afford useful information concerning the number of nests upon a moor.

As these "clocker's" droppings are only to be seen in the nesting season, it is perhaps not surprising that the keeper alone recognises what they mean. They are usually to be found along the side of burns and springs. Such places are used habitually by sitting hens when they leave their nests, perhaps once or twice a day, for food, grit, and water, and these droppings supply far more satisfactory evidence of the season's prospects than could be gained by disturbing the birds on their nests.

This then is, as briefly as possible, the normal course of the digestion and absorption of food by the Red Grouse, and it remains now to speak of the more common variations and disturbances which affect this process and which upset the health of the bird.

Many such variations have come to light during the past seven years in the course of dissecting something like a couple of thousand Grouse: of these some were healthy and some unhealthy; but in this chapter no account is given of damage resulting from shot wounds, collision with wire fences or similar accidents. This subject has already been dealt with.[1]

By far the more important pathological changes which are to be found in the Red Grouse are those which result from excessive parasitism, and they are therefore discoverable as a rule in the intestines, and above all in the two blind cæca, which afford a habitat to thousands of the round-worm *Trichostrongylus pergracilis.* The particular damage caused by this threadworm resulting in the fatal Grouse disorder which is now called Strongylosis, will be dealt with in chapter viii.[2]

It will best serve the purpose in view to take again the alimentary tract from end to end, and to mention the lesions to which the various parts are liable.[3]

It is a very rare thing to find any disturbance in the upper reaches of the alimentary canal. The mouth, the œsophagus, the crop, the proventriculus, and the gizzard as a rule carry no parasites, and are very seldom the seat of any pathological trouble. But it may happen that a bird gets hold of some irritant poison with its food, and this probably accounts for one or two otherwise unaccountable cases of inflammation of the crop walls, with engorgement and enlargement of all the vessels ramifying over it.

In the duodenum it is comparatively common to find the lining intensely inflamed, showing a bright red surface to the naked eye, sometimes all over, and at other times in patches. This is apparently the result sometimes of the presence of the tapeworm *Hymenolepis microps,* in large numbers; sometimes of the presence of the threadworm *Trichosoma longicolle.* But although in many cases the lining is thus reddened and *Hymenolepis* and *Trichosoma* are abundant, it is also quite as frequently found that the worms are present without any reddening, and in some cases reddening is present without any sign of a worm.

It is probable that in many of these cases where there is

[1] *Vide* chap. iv. pp. 119 *et seq.* [2] *Vide* chap. viii. p. 204.
[3] *Vide* Diagram, p. 165.

inflammation of the duodenum and smaller intestine, Coccidia have been the cause and have been overlooked, and that the more obvious threadworms (*Trichosoma*) have really little or nothing to do with the engorgement.

It may exonerate the tapeworms *Hymenolepis* and *Davainea* to some extent, that both may be present in masses without any accompanying inflammation, but the association of a large number of the threadworm *Trichosoma* in the duodenum with the symptoms referred to is too frequent to allow this nematode to escape blameless. *Trichosoma* is probably a harmful worm, but as it only occurs occasionally, the damage done by it is comparatively trifling.

Typically the duodenum when badly infested by *Hymenolepis* looks bulky and translucent, swollen and soft, and is of a pinkish yellow colour, with thin walls. The upper end of the ascending limb is often deeply stained by contact with the liver. The fluid contents, always small in amount, are generally yellowish, and may be blood-stained if *Hymenolepis* and *Trichosoma* are present in excessive numbers.

It is not a rare thing to find that in a sick bird the control of the lower sphincter of the gizzard is lost at the point of death or somewhat earlier, and that the grits have passed out of the organ in large quantities into the duodenum. Normally the grits are retained in the gizzard for a considerable time, certainly for months, if they are of any size. Much depends upon the nature of the food, and, as already explained, the presence of hard, woody seeds may lead to the loss of most of the gizzard grits, in which case they are passed with the dejecta.[1]

Passing now to a consideration of the small intestine, and its pathological manifestations, the first noticeable point is its external appearance when really full of the large tapeworm *Davainea urogalli*, as is so frequently the case; the gut is distended, and appears fatty, thin-skinned, whitish-yellow in colour, and rather translucent. Within, there are

[1] *Vide* p. 112.

often great masses of *Davainea,* but no redness of the mucous membrane.

The only pathological appearance which is commonly seen in the rectum of the Grouse is a reddening along the glandular ridges, due to villous engorgement. The cause of this villous engorgement is obscure. It does not appear to be dependent upon disease or sickness, though apparently sometimes it has some relation with an excessive number of tapeworms in the main gut.

In the cæca of the Grouse lies the whole origin and cause of "Grouse Disease" in the adult bird. In these blind guts live *Trichostrongylus pergracilis,* and these, when present in enormous numbers, produce an excessive amount of irritation and congestion of the vessels, and so much disturbance of the proper functions of this portion of the gut that the contents, consisting of food, mucus, nematode worms, and nematode ova in a pasty and decomposing mess, not only become useless as food, but may be a grave danger to the bird owing to the amount of toxins produced and absorbed into the circulation.

With regard to other organs of the body of the Grouse there is more to be said of the lungs than of any other. On this subject the reader may be referred to chapter xii. of the Committee's Report, where Dr Cobbett and Dr Graham Smith have described in detail the appearance of really fresh lungs, exposed in birds just dead, and their appearance after being more or less stained by *post-mortem* fluids and decomposing blood.

It is unnecessary here to repeat the discussion upon the question of "Grouse Disease" and pneumonia. For this reference must be made to chapter v., where reasons are given for the belief that Klein's explanation of "Grouse Disease" as an acute infectious pneumonia is not the correct one.[1]

The normal colour of quite fresh healthy lung is a very

[1] *Vide* p. 159.

clear pink, almost a whitish pink until the organ is cut into, when it is found to exude bright red blood, and the cut surface therefore immediately becomes bright red.

The appearance of fresh lung in bad cases of *Strongylosis* does not vary at all from the appearance of the lung in a healthy bird, and there is no sign of solidification or of the earlier stages of pneumonia, congestion, or infiltration in the lung as a symptom of the disease.

Pneumonia proper must be an exceedingly rare disease in the Grouse, and probably ninety-nine out of every hundred diagnoses of it are the result of a failure to realise that *post-mortem* staining and infiltration give an appearance which may be mistaken for pneumonia. It is exceedingly difficult to find even a very small piece of this so-called pneumonic lung which will not float in water, and this is a fairly reliable rough-and-ready test for consolidation.

With regard to the liver there is very little to be said. It is an organ which changes perhaps more rapidly *post-mortem* than any other, both in appearance and in consistence, and yet more has been deduced from its *post-mortem* appearance than from any of the more reliable indications of disease in Grouse. If the liver be examined fresh, even from a bad case of Strongylosis, it will be found to present a normally firm consistence and a healthy red colour. It is true that it may, and probably always will, partake of the general congestion which characterises Strongylosis. But this alters its normal appearance very little *when it is fresh*; it may be a darker red, and it may be more friable, but the change is hardly noticeable. The "black" and "tarry" livers may be ignored, unless they occur in birds that have only quite recently died, as being indications of no value from the diagnostic point of view. Discoloration even in a fairly fresh liver will often be found upon section to be very superficial and to be creeping towards the centre from the surface of the interior. Hence the first portion to show the change right through is always the edge of the anterior lobes.

The spleen of the Grouse varies very much in size, and this fact appears to have some connexion with Strongylosis. It is comparatively large in young and healthy birds, and is large, as a rule, and of a fresh, red colour in healthy adult birds; but in cases of Strongylosis it becomes very small and very dark, an appearance which is noticeable in fresh, dead cases of disease, and even more noticeable as *post-mortem* changes advance.

The kidneys appear to suffer very little from the general congestion which must be considered a symptom in Strongylosis. The colour of the kidney in a freshly killed healthy bird is a reddish brown, a good deal paler than the colour of the liver. Normally the lobes lie very flat against the dorsal wall of the abdomen, fitting into the inequalities of the skeleton.

In the breeding season, and in a breeding bird, there can be no doubt whatever as to the sex, for the ovary is a conspicuous bunch of more or less developed ova in the hen; and in the cock the testes are conspicuous round white objects as large as the kernels of good-sized hazel-nuts on each side of the backbone.

There is but one ovary, and it lies always on the left side of the backbone of the bird. There are two testes, one lying on each side of the backbone, the left one generally at a slightly lower level than the right. This development of the ovary only on one, the left side, is the reason for advising the examination to be made as described above, on the left side always. One testis or the ovary cannot then be missed.

If the bird examined thus is not breeding, as may often be the case with birds found dead of disease in April and in May, the discovery of the ovary is still a matter of comparative ease, and the discovery of the testes even easier. The testes are always somewhat enlarged in the spring months, whether the bird be diseased or not, and they may be the size of a pea or larger, and will generally be white. The ovary may be small, but will always be like a portion of hard cod's roe, in which the ova, though no bigger than a pin's head, are distinct and numer-

M

ous. The undeveloped ovary of an adult female Grouse would about cover a threepenny piece, but is long and triangular in shape rather than circular.

The oviduct in a breeding hen is a large and conspicuous duct, and may, of course, contain an egg with the shell in course of formation and being pigmented in preparation for laying. The oviduct in a barren bird, or in a hen at other times than the breeding season, is a very much less conspicuous object, and is less easily found than the small and undeveloped ovary.

If no ovary is seen, but a very small blackish, or whitish, or parti-coloured object is found in its place which is suspected of being a testis, the intestines must then be gently separated from their attachments about the middle line of the back, and the other testis must be sought for about in the same position on the opposite side. Even in a young bird the ovary shows ova with sufficient distinctness to make doubt as to its sex an impossibility; but in a very young male bird the testes may be so small, and, being very often black, may look so unlike what is expected that both should be sought for and found before arriving at a certain conclusion as to sex.

It is easy, if the intestines are roughly handled, and the attachments torn carelessly away, to carry away the testes or the ovary from their proper position, and to remove them with the intestinal attachments. The peritoneal folds are delicate and require careful handling, and they overlie the generative organs and the kidneys; but a very little practice will enable any one to do the necessary dissection with certainty, and to arrive at an irrefutable diagnosis as to sex.

The testes appear often to run a normal course of development as the breeding season approaches, however seriously the bird may be diseased. The first sign of any increase in the size of the testes is to be found about the third week of February, at least in the northern half of Scotland. Further south it is found a little earlier. In May the testes have increased in size to twenty or thirty times the bulk they had during inactivity, and they are then white and fatty, whereas in winter they are generally small and black and deeply pigmented.

Occasionally a very emaciated cock bird will be found with testes only half the normal size during the breeding season; but, as a rule, the effect of disease on the development of the hen's generative system, both ovary and oviduct, is far more noticeable than is the case in the male.

It is very noticeable that in sick Grouse hens there is no development of the ovaries or enlargement of the oviduct and cloaca such as takes place in spring in every healthy hen. The ovaries remain small and undeveloped as in midwinter. Such birds are barren if they pair, for as a rule they cannot lay an egg, but they pair nevertheless, as every gamekeeper knows to his cost.

This difference between the male and the female Grouse is significant. It seems that, in the male, appearance may be sacrificed to efficiency, for in cases of disease the generative organs may be fully developed while the plumage is backward; whereas in the female, appearance comes first, and the nuptial plumage is donned at any cost, often to the undoing of the hen herself, at any rate to the complete undoing of her power to produce an egg.

There are, of course, many sickly hens that not only don the breeding dress but also lay a modicum of eggs. They appear later in the shooting season with every sign of disease and exhaustion upon them, but yet recovering.

Grouse that have survived the mortality of April and May do not usually die later in the year. They become convalescent through the summer and autumn, owing to good food and better weather. There is, in fact, no autumnal outbreak of disease; but there is an increased opportunity for the collection of birds that have been sick and are convalescent. These birds can fly, and are shot in August and September; it is only when they are discovered in the bag, in the process of inspection later in the day, that they are suspected of disease, and are forwarded to the laboratory for examination.

Such birds are not at the point of death, but are, in fact, convalescent. They are not the birds that will be killed off necessarily in the coming winter, but may perhaps be still weaklings in the following spring. They are the birds that in the *previous* spring were badly hit by Strongylosis, but managed to survive April and May, and were then safe, with a supply of good and varied food assured to them for at least eight months to come.[1]

As we know much about these wasted autumn hens it is now safe to say that they may be placed in two classes:—

(1) Those that were too sick in the spring to breed at all, and so remained barren.

(2) Those that were not too sick to breed, but bred small clutches and reared from two to four or five young Grouse.

The first class has the best chance of recovery, for with them there is nothing to occupy their attention but food and rest and their own convalescence. Probably most of these are passably healthy birds in autumn, with no sign of having suffered very badly except in their backwardness as regards change of plumage. These birds usually show a great mixture of plumages, having feathers sometimes of the preceding winter plumage, mingled with an irregularly grown nuptial spring plumage and perhaps some new feathers of the already overdue autumn-winter plumage.

The second class is different. They also have a mixture of the same three plumages, but with more complete nuptial feathers, and fewer of the preceding winter plumage. They are the worst of all the sick birds seen in the autumn months. They may have been less sick in the spring than the barren birds but they have been completely worn out by the effort to nest, and by the cares of their family. They have nevertheless struggled through, thanks to the summer and autumn food supply and summer weather, and by the autumn they are convalescent. By January they will in all probability be once

[1] *Vide* chap. iii. pp. 84 *et seq.*

more comparatively strong and healthy, but not so well prepared to meet the critical conditions of early spring as those included in the first class. These, probably, of the second class are the birds that form the first class in the following year, or perhaps they cannot even rise to that, and fall victims to the spring mortality.

CHAPTER VII

THE ANIMALS WHICH LIVE ON OR WITHIN THE GROUSE

It is necessary to begin this short account of the animals which live on or in Grouse by apologising for the length of many of the words employed and in some cases for their technical nature. It has not been found possible wholly to do without them, but in most cases the scientific names of the various animals mentioned are given in footnotes, and an attempt has been made to explain the technical terms used.

Like other animals, the Grouse supports a number of parasites living on or in it which we can collectively call its "fauna." On the outside of its skin, amongst the base of the feathers, numerous insects browse, whilst beneath the skin in the spaces of the body, such as that of the alimentary canal, and in the cells and tissues, such as the epithelium or lining membrane of the intestine and in the blood, worms and unicellular animals (Protozoa) swarm. During the last four years these parasites have all been investigated, some more, others less, closely, according as they seem to throw much or little light on the health and disease of the bird. In the account which follows the members of the Grouse's fauna are numbered consecutively so as to give some idea of its wealth and variety.

The animals which live beneath the skin and within the body of the Grouse constitute the "Endoparasites" of the Grouse, whilst the animals that live on the outside of the skin are termed the "Ectoparasites." Amongst the last-named is included the Grouse-fly.[1] This fly is said to suck the

[1] *Ornithomyia lagopodis*, Sharp.

blood of the Grouse, at any rate it is so constantly associated with that bird that it seems to merit a place here.

At first sight the attention paid to the Ectoparasites, or animals which live outside the Grouse, mostly among the feathers, may seem superfluous, but the study was rendered necessary by the probability of establishing a connexion between these Ectoparasites and the more important internal parasites. Most of the internal parasites and all the tapeworms pass through a second host. For example, the tapeworms which live in the alimentary canal of the Grouse pass their younger or larval stages in the body of some lower animal. This lower animal, presumably an insect or a snail or a spider, must be eaten and digested by a Grouse, and the larval tapeworm must be thus set free before it can grow up into the adult tapeworm which we find in the intestine of the Grouse. In searching for this second host it was natural to begin with the Ectoparasites, which one would imagine were continually being snapped up by the bird. We have, however, up till now completely failed to find any tapeworm larvæ in the Grouse-fly or in the numerous "biting-lice" or "bird-lice"[1] which abound on the skin and amongst the feathers of the Grouse; and what is still more significant and still more remarkable, we have, in the hundreds of crop contents which we have examined, never found one of these insects amongst the Grouse's food.

During the course of the recent investigations many anatomical and morphological notes have been made which, though interesting to the zoologist, have no direct bearing on disease in Grouse, these have been published in another place.[2] Here, it is proposed to give as complete a list as possible of all the animals which infest the Grouse, but only to discuss at length such facts as have a direct—though perhaps at times a distant—bearing on disease in Grouse. For there is no doubt that the worms and unicellular animals (Protozoa) which live in various regions

[1] These form the group of insects called the Mallophaga, which is allied to the Anoplura or true lice of man and other mammals.

[2] *Proceedings of the Zoological Society of London*, 1909, pp. 309, 335, 351, 363. "The Grouse in Health and in Disease," First Edition, pp. 348ff.

of the alimentary tract cause very definite and often very fatal diseases, and to diminish this cause of death the parasites must be eliminated or their access to the body of the bird prevented. Consideration of the diseases thus set up will come elsewhere, and here it should only be remarked that the expression "*the* grouse-disease" is a misleading one. As if a Grouse or any other living creature suffered from only one disease! What is usually meant by "*the*" disease is a somewhat sudden and very virulent disorder which sweeps through a district and in a very short time carries off a very large percentage of birds. Such a disease was investigated by Dr Klein some twenty years ago, and it is proposed that this disease—if it be a distinct disease—be called Klein's Disease of the Grouse. Since the Committee was appointed there seems to have been no definite outbreak of Klein's disease, but innumerable Grouse have been examined which were said by the game-keepers and moor-owners to be affected with or killed by "*the*" disease, which further investigation has shown to have been done to death by worms or Protozoa. The symptoms of "*the*" Grouse Disease are not readily apparent, especially to the unclinical eye.

ECTOPARASITES

INSECTS.

A. Mallophaga.—Bird-lice or Biting-lice.

I.—*Goniodes tetraonis*, Denny.
The Broad Bird-louse of the Grouse.

The bird-lice comprise a number of forms, sometimes also termed biting-lice, which in the great majority of cases live on the skin of birds. A few, such as the dog-louse,[1] live amongst the hairs of mammals. As this is the alternate host of a common tape-worm,[2] which passes its

[1] *Trichodectes latus*, Nitzsch.

[2] *Dipylidium caninum* (L.).

adult state in the dog, there was some justification for our hope of finding the larval stage of at least one of the Grouse tapeworms in these insects, but so far we have not succeeded in doing so. The bird-lice form a rather isolated group of insects; but there is, apart from the fact that their mouth organs are adapted for biting and not for sucking, much resemblance between some of their organs and those of the true lice; with these but not so closely allied, are the fleas.[1]

Biting-lice are as a rule minute flattened little insects, with poorly developed eyes, a chestnut-brown body, and a generally well-groomed appearance. Five distinct species infest the domestic fowl, and unless the host be unhealthy, they seem rarely to do much harm.

In 1842 Denny[2] described and figured the broad bird-louse, which he calls the "Louse of the Black and Red Grouse." He states that it is "common upon both the Black and Red Grouse."[3] "Upon the Willow or Hazel Grouse[4] I find a similar but distinct species, rather broader in the abdomen, and of much darker colour."

Andrew Murray, in his book on Economic Entomology,[5] writing of the broad bird-louse, says: "This is the insect which sometimes, especially in the bad seasons, does so much harm to the young Grouse when they are feeble and unhealthy."

Goniodes tetraonis is the commonest of the insects which infest the skin of Grouse, crawling about amongst the bases of the feathers and on the vanes of the feathers themselves. It occurs more commonly than the narrow bird-louse of the Grouse,[6] which is often associated with it. It is comparatively rare to find a bird free from these "biting-lice," but perhaps 10 per cent. is about a fair estimate of the number of uninfested Grouse. The number on each bird is to some extent an inverse measure of their health. Careful search will discover but two or three on a healthy Grouse, but on a "piner" hundreds may be met with.

The broad bird-louse is usually found on the smaller feathers, crawling about half-way between their insertion and the tip of their vanes. When disturbed they hurry away into the brushwood of the small feathers, like small deer seeking cover, and they are by no means so easy to catch as one at first thinks. They eat the finer barbules of the feathers, which, accumulating in the crop, gives the dark, curved marking in their rather transparent bodies. On this meagre and arid diet they seem to flourish, actively produce young, and pass through several ecdyses or changes of skin.

The eggs are very beautiful objects; in badly infested Grouse they may be numerous, but as a rule they are none too easy to find. Usually

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[1] Bird-lice, true lice, and fleas are now placed together in the modern group *Anapterygata*.

[2] "Monographia Anoplurorum Britanniæ," published by H. G. Bohn, London, 1842, p. 161, Pl. xiii. Fig. 3.

[3] *Tetrao tetrix* and *Lagopus scoticus*.

[4] *Tetrao saliceti* (sic).

[5] Chapman and Hall, London, 1877.

[6] *Nirmus cameratus*, Nitzsch.

they occur in small groups attached to the base of the after-plume and between it and the shaft of the plume. The specimen figured was on one of the feathers from the flank. (*See* Pl. XVII. Fig. 4.)

The eggs are elongated, some three or four times as long as they are broad. They are fixed by some adhesive secretion at the end corresponding to the hinder end of the embryo they shelter. At the other end is a well-marked cap or operculum which always points to the free end of the feather. The beauty of the marking on the egg-case is shown best in another but allied genus,[1] and we figure one, which we found[2] on the feathers of a partridge. Under the pressure of a coverslip the egg-case gradually ruptured along a circular line below the well-marked thickened edge or rim of the cap. The contained egg then began to emerge, carrying off with it the cap. The resemblance of this structure to a cap was emphasised by the long process which stands out like a feather borne on its apex. The eggs of the broad bird-louse of the Grouse show the network markings less well, but they are conspicuous on the cap, which bears a long tapering filament, longer than the egg itself. These markings also occur just below the cap, but fade away towards the fixed end. The general appearance of the eggs on the after-plume is shown in Pl. XVII. Fig. 3. They were found on the 27th July 1908, and they seem to be laid throughout the summer.

There is no metamorphosis, the young leaving the eggshell as miniatures of their parents.

II.—*Nirmus cameratus*, Nitzsch.

The Narrow Bird-louse of the Grouse.

This insect seems to have been first named by Nitzsch[3] in the year 1818, but with no description. It is figured and described, and a bibliography is given by Denny[4] under the name of *Nirmus cameratus*. Denny found it on the Red Grouse, the Black Grouse, "and I expect also upon the Ptarmigan." Grube describes it in Middendorf's "Siberian Travels" as existing on the Willow Grouse[5] and the Ptarmigan,[6] thus confirming Denny's surmise.

This narrow bird-louse is mentioned in Giebel's article[7] on bird-lice at Halle, and described and figured in his great monograph.[8] Piaget in his "Les Pediculines," states his conviction that *N. cameratus* is specifically identical with the *N. quadrulatus* of Nitzsch, from the Capercailzie.[9] This opinion is also held by Kellogg.[10]

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[1] *Menopon.*

[2] This egg is almost certainly the egg of *Menopon pallescens*, Nitzsch.

[3] Germar's *Magazin der Entomologie*, Halle, iii., 1818, p. 291.

[4] "Monographia Anoplurorum Britanniæ," London, 1842, p. 112.

[5] *Lagopus albus.*, Lin. = *L. sub alpinus*, Nils.

[6] *Lagopus mutus*, Leach = *L. alpinus.*

[7] "Zeitsch. Ges. Naturwiss.," xxviii., 1866, p. 370.

[8] *Insecta Epizoa.*

[9] *Tetrao urogallus.*

[10] Wytsman's *Gerura Insectorum*, 66th Fasc. Mallophaga.

PLATE XVII.

GONIODES TETRAONIS.

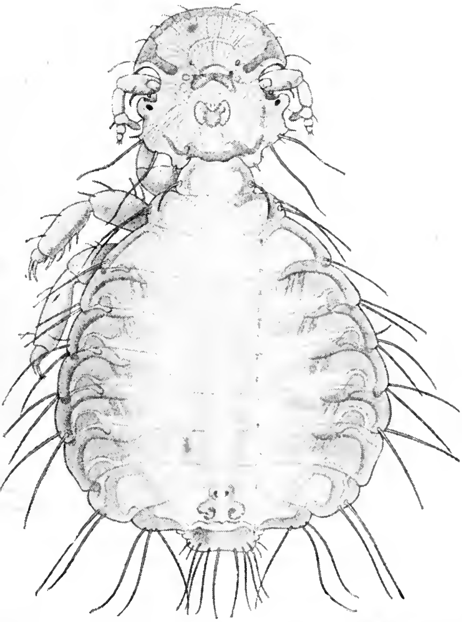


FIG. 1. *Goniodes tetraonis.* Denny. Male seen from above. The legs are shown on the left side only. The forked character of the antennæ of the male and the male genital plates in the abdomen are shown.

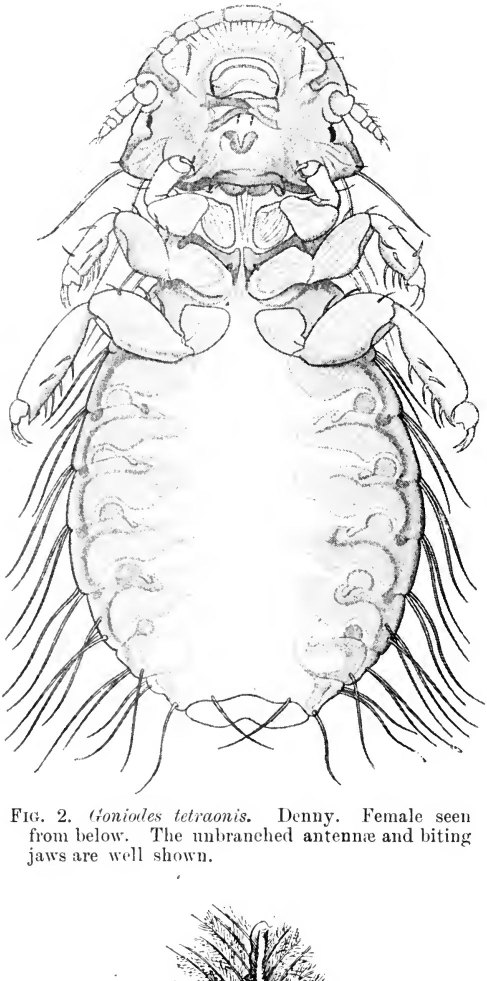


FIG. 2. *Goniodes tetraonis.* Denny. Female seen from below. The unbranched antennæ and biting jaws are well shown.

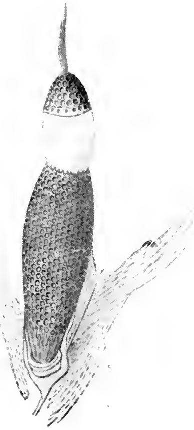


FIG. 3. Egg of *Menopon pallescens.* Nitzsch. Highly magnified. Under the pressure of the cover-slip the operculum has come away and the egg is squeezing its way out of the egg-shell.

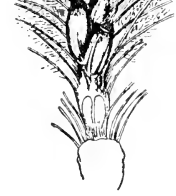
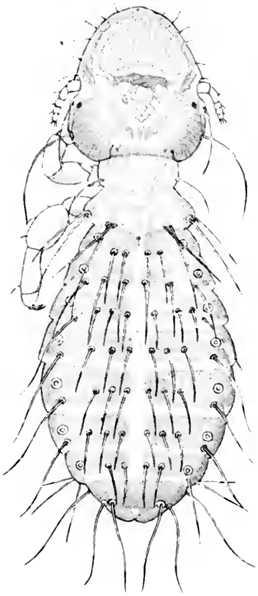


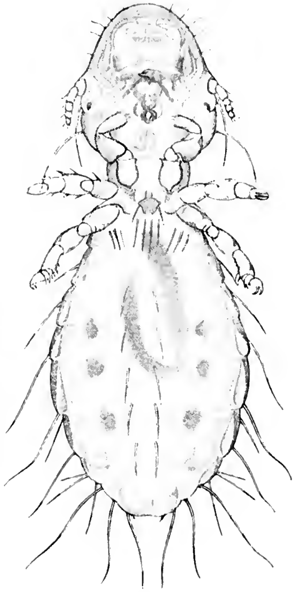
FIG. 4. Four eggs of *Goniodes tetraonis* attached to the base of an after-plume. The operculum has fallen off one of them.

site p. 186.]

PLATE XVIII.

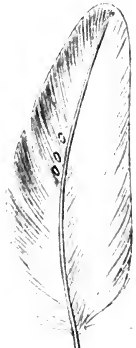
NIRMUS CAMERATUS.

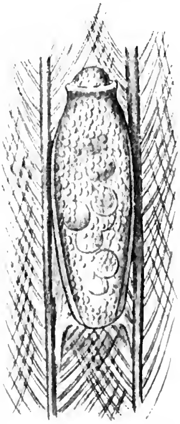




A B

FIG. 1. *Nirmus cameratus.* Nitzsch. Magnified. Female. A seen from above; B seen from beneath.





A B

FIG. 2. Eggs of *Nirmus cameratus* on the feathers of a young Grouse about three weeks old. A, very slightly magnified, three eggs on one of the wing-covers; B, very highly magnified to show reticulations.

[e p. 187.]

Nirmus is a more slender animal than *Goniodes*, and appears to be longer. It is rarer than the latter, though in the great majority of cases the two are found together. Most of what has been said above about the broad bird-louse applies also to the narrow form, as their habits are very similar, except that the latter lives more on the skin and upon the base of the shaft of the feather than does the former. It also seems to frequent the feathers under the wing, where the broader form is seldom seen. Both species appear to be able to wander all over the body; and though they seem rather more common upon the head, neck, and back, the old view that these biting-lice occur chiefly or exclusively on those parts of the body inaccessible to the beak has not been borne out by recent investigations (Pl. XVIII. Fig. 1).

Some eggs of this form have been found. These were for the most part empty, but from one or two full ones specimens of the insect have been hatched out. The eggs are white, and transparent when empty, just visible to the naked eye, 0·6 mm. in length, and about four times as long as they are broad. Each egg-case is beautifully marked with a network of ridges, the areas between the ridges being six-sided. At one end the egg has a cap which is pushed off when the young emerges. The eggs are laid between the barbules of the feather-vanes or near the bases of the filo-plumes or short hair-like feathers, and adhere to their supports by means of some sticky excretion (Pl. XVIII. Fig. 2).

The eggs appear to be laid during the summer; the first time they were found (some of them were empty) was on 2nd July 1907, they were found again later in the season.

There is no metamorphosis or change of the larva into a chrysalis, and then into the adult form, as for instance in butterflies. The young emerge from the egg-case as small miniatures of their parents. They seem to cast their skin several times, but the exact number of times is not known. Dead specimens and cast skins were frequently met with.

In no case were either of the two species found in the crop of the Grouse, though, as we have just stated, they are fully exposed to being snapped up by the bird's beak if the bird cared to notice them. It is not known exactly how clean birds get infected; probably the bird-lice simply crawl from one bird to another when the latter are contiguous. There is evidence, however, that in some cases, probably rare ones, they cling to the Grouse-fly and are by it transported to a new host.

B. SIPHONAPTERA.—Fleas.

(i.) Fam. PULICIDÆ.—Fleas.

III.—*Ceratophyllus gallinulæ*, Dale.[1]

We are indebted to Mr N. C. Rothschild for identifying this flea, which is here recorded for the first time from the Grouse. It is a

[1] N. C. Rothschild, *Ent. Mag.*, 2nd Ser., xiv., 1903. In the *Ent. Rec.* xiii., 1901, No. 10, Rothschild described this under the name—synonym—of *Ceratophyllus* (*Trichopsylla*) *newsteadi*.

well-known bird-flea, having been found in the nest of the hawfinch, in that of the dipper, in that of the blackbird, the moor-hen, and others. In the thousands of Grouse which passed through the hands of the Committee only one or two specimens of this flea were found (all in 1906), and none were found in the crop. Hence, although the dog-flea, *Pulex serraticeps Gerv.*, is said to be the intermediate host of the dog tapeworm,[1] it does not seem at present very possible that the Grouse-flea could play any part in the life history of the Grouse tapeworms. On the other hand a flea may easily escape notice in the crop contents, and this species is probably much commoner in the nests than on the birds when flying. It has been suggested that there may be a connexion between the seasonal occurrence of the transparent tapeworm and the life history of the flea. The view is strengthened by Minchin's recent discovery of the larval form (cysticercus) of a tapeworm[2] in an allied species of flea[3] which lives on the rat. As this species of Grouse - flea had not hitherto been accurately figured, Mr Edwin Wilson drew both male and female, and the drawings were reproduced in the original report. Now that the rôle of the flea in carrying certain human diseases is recognised, it is well to have them accurately delineated, as in a flea every hair tells. (Pl. XIX. Fig. 2.)

IV.—*Ceratophyllus garei*, Rothsch.

This second species of flea was found in a Grouse in 1907 ; but only one or two specimens were taken. It is recorded by Evans[4] from the nest of the lapwing, and of the ring-dove. Rothschild[5] has found it in the nest of a water-hen, and he records that it has been taken from the stoat, the weasel, the shrew, the vole, and the water - rat, and from hedge-clippings.

C. Diptera.—Flies.

(i.) Fam. Hippoboscidæ.—Horse-flies.

V.—*Ornithomyia lagopodis*, Sharp.—The Grouse-fly.

This family includes besides the Grouse-fly, the horse-fly, sometimes known as the forest-fly, the sheep-ked, which has lost its wings and burrows in the wool of the fleece, and a third species which infests red-deer. This last has wings when young, but when the flies find a suitable host they get rid of their wings and nestle among the fur. Most, however, of the members of this family live on birds, and they seem particularly to frequent the swallows and allied species.

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[1] *Dipylidium caninum.*

[2] Thought by Mr Nicoll to be *Hymenolepis diminuta* (Rud.), a tapeworm of the rat.

[3] *Ceratophyllus fasciatus.*

[4] "Ann. Scot. Nat. Hist.," 1906, p. 163.

[5] *Ent. Mag.*, 2nd Ser., xiii., 1902, p. 225.

PLATE XIX.

CERATOPHYLLUS GALLINULÆ, ETC.

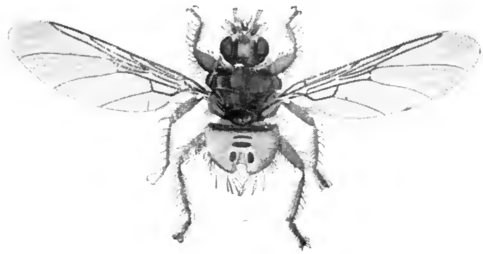

Fig. 1. The Grouse-fly *Ornithomyia lagopodis*. Magnified about nine times.

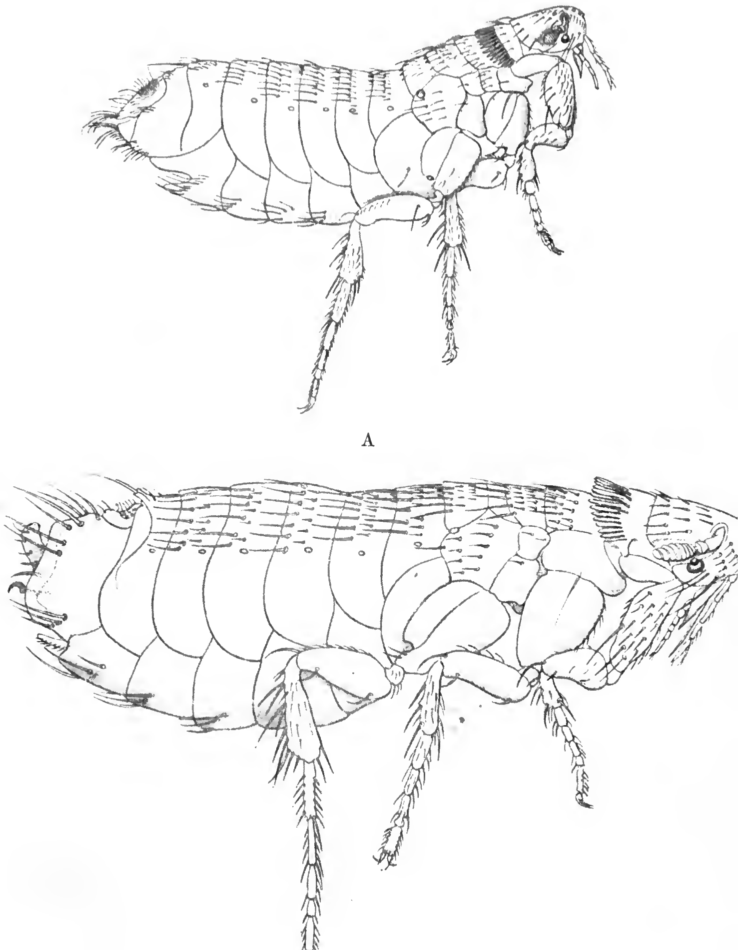

Fig. 2. Side view of *Ceratophyllus gallinulæ*. Dale. Highly magnified. A, Male; B, Female drawn to the same scale and showing the relative difference and size.

G. 3. Larva of *Scato-*
a stercoraria L. From a
se-dropping. Magnified.
anterior spiracle.
posterior spiracle.
hypostomal sclerite.
. pharyngeal sclerite.
viseral trachea.
transverse commissure.

site p. 188.]

Till recently it had been thought that the Grouse-fly was the same species as the common bird-fly,[1] but recently Mr D. Sharp has pointed out that it is a distinct species. It is distinguished from the common bird-fly by its "peculiar lurid blackish colour, without any trace of green even on the feet or legs," and by other characters which have been quoted in the more anatomical portion of the Committee's Report. Recently yet another species[2] has been separated off from the common bird-fly, so that we now have three species of *Ornithomyia* in this country, and probably more will be added as the group is further studied.

We do not know the exact relations of the Grouse-fly to the Grouse. It is believed to suck its blood,[3] and it certainly bites human beings. For a time it seems to burrow amongst the feathers of the bird, and any one handling Grouse during the summer is likely to disturb a fly or two. They come buzzing out, and are apt to crawl up one's sleeve. The feet, although large, are very beautiful. They are provided with a pair of very large hooks (Pl. XIX. Fig. 1). Altogether, these insects have a sinister aspect, and to people who do not like flies they are very repellent. They occur freely in larders where freshly killed Grouse have been placed, and after a short time they leave their dead host and accumulate upon the windows.

The earliest month in which the Grouse-fly has been found is in June, towards the latter end. The latest is in October. They are most plentiful in August.

The females seem to be commoner than the males, or, it may be that in August they are more readily caught. Like other horse-flies, forest-flies, and sheep-ticks, the Grouse-fly does not lay eggs, but the ovaries produce one large egg at a time, and this passes into a dilated oviduct which acts as a uterus, and here the egg develops. After attaining a certain stage of development, the larva surrounds itself with a pupa or chrysalis skin and is extruded. The chitinous or horny covering of the larva hardens and blackens with exposure to the air, and forms the so-called pupa-case ; in fact, one may almost say the young are hatched as pupæ. At no time is the larva exposed, though there is a larval stage free in the uterus of the mother wrapped first in the egg-shell and then in the pupa-case.

The pupæ were found during August and September. They are black, shiny, seed-like looking objects, and appear to be deposited amongst the feathers, from which they are easily detached. The few we have found either dropped on some paper over which we were handling birds, or lay loose at the bottom of the cardboard boxes in which Grouse travel. Probably they take some eight or nine months before they give rise to the adult fly, and the latter very likely disappear altogether from about October till June. Further research is needed to throw light on these questions.

Three specimens of the Grouse-fly, all of them taken from one bird,

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[1] *Ornithomyia avicularia*, Lin.
[2] *O. fringillina*, Bezzi.
[3] *Proc. Zool. Soc. Lond.*, 1910, p. 704.

were themselves markedly infested with an ectoparasite, a species of mite. Here we refrain from quoting Dean Swift. The mite[1] belongs to a sub-family all of which are parasitic upon insects; these are regarded as harmless. Our specimens existed in considerable numbers, clustered round the hinder end of the fly's abdomen on the ventral surface, with their snouts or proboscides plunged into the body of the insect. Many were laying eggs, and many cast-off cuticles were lying around them. Eggs from which the larvæ had escaped presented a spindle-shaped outline; others contained eggs in various stages of differentiation; others fully formed larvæ.

We have in no single case found a Grouse-fly in the crop of a Grouse, nor have yet found any cestode larvæ or cysts in the bodies of the flies which we have cut into sections or dissected.

(ii.) Fam. Scatophagidæ—Scatomyzidæ.—Dung-flies.

This family contains species many of which produce their larvæ alive and deposit them in the bodies of other insects, or on open sores, or in organic material. The Grouse dung-fly cannot be looked upon as an ectoparasite of the Grouse, but it lays its eggs in Grouse-droppings, and its maggots live on and in these dejecta. The maggots must therefore constantly be in close contact with and certainly eat the eggs of the tapeworms which exist in such vast numbers in the Grouse droppings; and hence it was thought a profitable object to investigate for the second state of the cestode. It may be recalled that each Grouse dropping consists of two parts—(1) the dejecta from the intestine strictly speaking, and (2) the more fluid dejecta from the cæca. The latter pass last and lie like a cap upon the former. The two lateral diverticula or pouches of the bird's intestine known as the cæca are unusually large in the Grouse, and in them the absorption of the digested food takes place. The fly-maggots are only found in numbers in the "cæcal" part of the dropping.

VI.—*Scatophaga stercoraria*, Lin.—The Grouse Dung-fly.

The Grouse dung-fly is first found commonly in April. In June it is not so common, owing perhaps to the rain having washed the cæcal part of the droppings away. A large number of the larvæ have been examined both by crushing them and by cutting them into sections, but no trace of tapeworm cysts have been found, although many weeks were spent in carefully searching through the tissues of this and an allied species of dung-fly.[2] No specimen of either dung-fly or of their larvæ has been found in the crop of the Grouse (Pl. XIX. Fig. 3).

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[1] Mr C. Warburton has kindly identified the mite as belonging to the genus *Canestrinia* and probably to a new species.

[2] *Scatophaga squatida*, Meigen.

ARACHNIDA.

ACARINA.—Mites and Ticks.

(i) Fam. IXODIDÆ.—Ticks.

The ticks are now known to carry certain unicellular animal parasites (Protozoa), capable of setting up virulent disease in man, cattle, dogs, etc. They may therefore be of importance in an inquiry into Grouse Disease. It is possible that their presence on the skin may be connected with some of the internal protozoal parasites mentioned below.

Severe outbreaks amongst fowls of a disease named "spirillosis" and of another obscure but very often fatal disease have been described by Balfour[1] in the Sudan. The organism which causes the former disease, a spirochæte[2] is transferred from one fowl to another by a tick.[3] The second, and as yet rather obscure, disease is recognised by the natives, and by them associated with the presence of the same or allied ticks. We have found little trace of such disease in Grouse, and the recorded number of ticks taken in the Grouse is, except locally, so small that they can hardly play any part in Grouse Disease.

VII.—*Ixodes ricinus,* Lin.—The Common Sheep-tick.

This species of tick (the "castor-bean tick," as it is called in America) is common in many parts of the world. It is reported from sheep, goats, cattle, horses, deer, dogs, cats, foxes, ferrets, hedgehogs, hares, rabbits, bats, birds, and man. It occurs most frequently during the spring and early summer, but disappears after the beginning of July.

The sheep-tick is one of the commonest and one of the oldest known ticks of Europe. In the British Isles it often occurs on hunting dogs, and is sometimes called the "dog-tick"; the adult stage is especially frequent on sheep, goats, and oxen; less common on horses, dogs, and men. On the other hand, the larvæ and the nymphs are common enough on birds, lizards, and small mammals—in fact, on animals which live among and brush through grass or heather. It is only in the larva and nymph state that we find these ticks on the Grouse. On each of the infested birds the specimens were fixed on the chin or round the eyelids—in fact, in such positions as the Grouse cannot reach with its beak. In parts of Ross-shire, especially in certain woods, these ticks swarm in enormous numbers, and the keepers declare that they kill large numbers of young blackgame. Hence there is nothing remarkable in finding this species from time to time

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[1] *British Medical Journal*, 9th November 1907, No. 2445, p. 1330.

[2] Probably *Spirochæta gallinarum.*

[3] *Argas persicus.*

on the Grouse, where its presence must be regarded as accidental. The larval stages emerge from the eggs and probably crawl on to the heather, and thence on to the Grouse or other animals which come in contact with the vegetation. Both larvæ and nymphs have been found amongst the feathers, but in small numbers and on rare occasions. The tick has never been found in the crop, and it can hardly play any part in infecting the bird with tapeworms.

(ii.) Fam. Tyroglyphidæ.—Cheese and Flour Mites.

VIII.—*Aleurobius farinæ*, de Geer.—The Flour Mite.

Synonym: *Tyroglyphus farinæ.* Gerv.

Mr C. Warburton has identified this small mite which was found in considerable numbers on several birds and at varying times of the year. Whilst very common at Easter time, they were less abundant in July. The flour-mite occurs in great numbers on all sorts of organic material—grain, straw, hay, tobacco, flour, cheese, dead bodies, etc. At times the workmen handling corn, horses, etc., have suffered much irritation and skin-eruption from the attacks of this mite. There seems no doubt as to the species of this mite, but the authorities on these animals express surprise that they should occur so commonly on the Grouse. They have, however, been found on a large majority of birds which were specially searched with the view of finding mites. The specimens, some of which were taken on freshly killed Grouse, contained some red substance in the stomach, probably blood from the bird. There seems at present little reason to incriminate this mite as the carrier of the tapeworm cyst.

ENDOPARASITES

PLATYHELMINTHES.—Flat Worms.

Cestoda.—Tapeworms.

In the alimentary canal of the Grouse are found three species of tapeworm, two of the genus *Davainea* and one the genus *Hymenolepis*.

Before describing the tapeworms of Grouse in detail it is necessary to refer once more to the method by which they are reproduced. As already stated, we know that all tapeworms, with perhaps the exception of one species, pass through two distinct and different animals known as hosts.

Unfortunately, little or nothing is known about the life-history of any species of *Davainea* which includes both the "large" and the "stumpy" tapeworm, or of *Hymenolepis*, the "transparent" tapeworm of the Grouse. The larval or cystic stages of the former have in some few cases been said to occur in insects and in molluscs; the larval host of the latter is thought to be an insect or a myriapod, or perhaps even more likely some "water-flea" or other fresh-water crustacean.

With regard to these possible second hosts. We have never found a myriapod in the crop of the Grouse, and so far we have not found any crustacea—though it must not be forgotten that these are probably so small as to escape notice in the crop contents. Specimens of slugs belonging to a species [1] which is common on the Staffordshire Grouse moors have been found in the crop of a Staffordshire Grouse. These slugs are very voracious and practically omnivorous; they will eat almost anything, especially decaying animal and vegetable matter, fungi, paper, weak and injured worms and slugs, and—what is interesting from the point of view of the Grouse tapeworms and round-worms—they devour the dejecta of other animals. They prefer the shady places in moors and fields, and emerge into the open only at dusk or when the day is cloudy or overcast.

These slugs have been cut into sections and diligently searched for cysts of tapeworms, but none have been found. This absence of infection, combined with the rarity of the slug in the Grouse's crop, seems to show that it is not the second or larval host of the Grouse cestodes.

Moorland streams have been tow-netted for crustacea in the spring and a certain number of the larvæ and adults of some of the water-fleas and other small crustacea [2] have been found.

[1] Mr W. E. Collinge has identified this slug as *Arion empiricorum*, Ferussac.

[2] Mostly belonging to the genus *Cyclops*. A list of species captured, for which we are indebted to Mr D. J. Scourfield, is printed in the Zoological Society's *Proceedings* for 1909.

The numbers were, however, meagre and tow-nettings later in the summer yielded an even more unsatisfactory "bag." None of the crustacea[1] when examined microscopically showed any cysts, and as they are few in number it seems improbable that the source of the tapeworm infection lies here.

We have thus with some degree of probability shut out as second or larval host of the tapeworms—at any rate for the present—the ectoparasites of the Grouse, the myriapoda and the slugs or snails and fresh-water crustacea, and this on the grounds (1) that on examination none of them reveal a cyst, and (2) that these animals are either not eaten by the bird, or so rarely eaten and in quantities so small as to render it highly improbable that any of these invertebrates could account for the almost constant presence of the tapeworms in large numbers in the Grouse.

Two rather striking facts seem to point to the normal insect food of the Grouse, which it picks up on the moor, as the more probable source of tapeworms. One is that two artificially reared Grouse which died during the early autumn of 1907, when carefully searched for tapeworms were found to be entirely free from them. The second fact is, that under natural conditions young Grouse often contain fully grown "large" tapeworms (*Davainea*) before they are three weeks old. They must certainly have swallowed the second host when very young, perhaps even the day they were hatched, or the worm would not have had time to grow. The young birds live very largely on an insect diet. Hence the best chance of finding this second host is to examine the crop contents of the very young birds, and to do this the observer must have a moor at his disposal, with leave to kill as many young birds as he may want, and this is a very difficult thing to obtain.

It has been stated over and over again by sportsmen and gamekeepers that the Grouse eats no insects, but this is far from the truth.

[1] A fuller report on the insects found in the Grouse-crop has been given by Mr J. C. F. Fryer.

Although the observations on the animal food of Grouse are necessarily incomplete,[1] enough has been done to show that it is fairly abundant and very varied. From the crop of a single bird there have been taken six saw-fly larvæ, eight caterpillars of a Geometrid moth, one caterpillar of a smaller moth, two small Tineid moths, a number of immature bugs resembling the " frog " or " cuckoo-spit," a fly, two specimens of the plant-lice, one small spider, and the remains of four specimens of the slug mentioned above. The gizzard of the same Grouse contained, in a more broken up condition rendering identification more difficult, two or three dozen larvæ of saw-flies and moths, some young bugs, and the pupæ of two true flies.

The segments of the Grouse tapeworms containing the ripe eggs pass away with its dejecta and lie on the ground or lodge on the heather and other plants, or in water. As already stated, the eggs of the two species of *Davainea* are believed to develop into larvæ inside the body of an insect or a land mollusc. They are excessively minute, and lying as they do in millions on the heather, may be readily consumed by the leaf-eating caterpillars and other insect larvæ which live on the moors. Doubtless many are eaten by the Grouse themselves, but these are digested and come to nothing, for they have not reached the larval stage and, as we have said above, the larval stage of a tapeworm must be passed inside an animal quite distinct from that which harbours the adult worm. To get at and eat the eggs seems an easier matter for caterpillars and other insect larvæ or for slugs than it is for the ectoparasites, which as a rule are not very likely to come across the dejecta of their host. For this reason, in continuing the search for the larval tapeworm, it was necessary to examine the insect larvæ and the slugs eaten by the Grouse. A common food of Grouse is the head of certain species of rush.[2] There is a very minute moth

[1] *See* pp. 101 *et seq.*

[2] *Juncus articulatus* v. *lamprocarpus*, *J. squarosus*, and *J. effusus* v. *conglomeratus* are all frequently eaten.

whose larvæ live in curious, white, papery cases inserted into each twig of this rush-head which they eat. When the rush is in its turn eaten by the Grouse, the larvæ of the moth pass into the alimentary canal of the bird and are there digested.[1] The case is whitish, semi-transparent, and with brown specks: it is formed when the larva is no longer young, but not at any very fixed time. At first its outer end is closed. The larva often leaves the case, burrowing into the rush-head for food, and at times fails to find its way back. Before pupating, the outer or anal end of the case is opened, and the case strengthened by a glandular excretion. In the Interim Report of the Committee it was recommended that these larvæ should be searched for cysts; but it has been pointed out that there would be little chance of the larvæ coming across the eggs of the tapeworm as they feed in and on the interior of the rush-head, and the search has yielded no results.

In following up this second line of research the insects which occurred most commonly in the crop of the Grouse were examined first. These were examined microscopically, both after teasing the body up in glycerine and by grinding it up—but not too finely—in a pestle; in some cases also sections were made and examined, but always without result.

In hunting for the cysts the observer meets with two great difficulties: firstly, it is not exactly known what the cysts of either of the tapeworms are like; and, secondly, the tissues of the insects and spiders which were examined are little, if at all, known, and more than once some organ proper to the insect has been taken at first sight for a tapeworm cyst, only to result in the disappointment of finding later that it was an egg or other structure belonging to the putative host.

A considerable number of the commoner insects found on

[1] It has not yet been possible to determine finally the species of the moth, but it is probably *Coleophora cæspititiella*, for this species frequents many kinds of rush; whereas the *C. glaucicolella*, the other inland species, is most partial to *Juncus glaucus*. The former is usually fully out by the middle of June and lingers on till the middle of July; the last-named moth issues about the middle of July, and flies for four weeks. J. H. Wood, *Ent. Mag.*, 2nd Ser., iii. (xxviii.), 1892.

the moors have also been examined in the hope of throwing some light upon the life history of the Grouse tapeworms. The specimens[1] investigated were collected by Mr P. H. Grimshaw, of the Royal Scottish Museum, but here again the investigation has not met with success.

We may now proceed to describe the tapeworms of Grouse.

Fam. Taeniidæ.

XI.—*Davainea urogalli* (Modeer, 1790.)—(The "Large" Tapeworm of the Grouse.)

Of the three tapeworms which are found in Grouse, this species, originally described from *Lagopus scoticus* in 1853, by Baird is the commonest and by far the largest. It occurs in many allied forms, *e.g.*, the blackcock, the capercailzie, and according to Krabbe in a partridge, and one of the Himalayan pheasants. It appears at an early age in the young Grouse: a specimen, 35 cms. in length, has been taken from the intestine of a bird about three weeks old. Curiously enough, it was an abnormal specimen, the worm having split; and

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[1] In the manner indicated, the following insects were examined in every case by looking through the débris of some four or five specimens.

Diptera.

(i.) *Monophilus ater*, one of the sub-family Limnobiinæ of the Tipulidæ. A very common constituent of the food of young Grouse. No trace of a cyst was found, but in one specimen an immature nematode was wriggling about.

(ii.) *Bibio* sp. This also proved a blank.

(iii.) *Cyrtoma spuria*, one of the Empidæ. This fly is small and seemed to have little interior; no trace of a cyst was found. In another small Empid fly a Gregarine was discovered.

(iv.) *Scatophaga* sp. *Scatophaga stercoraria* is perhaps the commonest fly in Scotland, and, owing to its larvæ living in the droppings of the Grouse, it can hardly fail to contain the eggs of the cestodes; but no *Scatophaga* has ever been found in the crop of a Grouse, and there is some reason to doubt if the tapeworm eggs develop in this fly. After searching for a long time through the tissues of many specimens of *Scatophaga*, only one ovum was found, apparently of *Davainea urogalli*, and that was no further advanced than when it was laid.

Plecoptera.

Similar gropings through the disjected membranes of an unknown species of Perlid produced no better results.

Arachnida.

The tissues of a spider very common on the moors, and of a phalangid were also investigated with a similar want of success.

although one end of the fork of the now **Y**-shaped worm dwindled and came to nothing, the other was already shedding mature "proglottides" or "segments" crowded with eggs.

The large tapeworm occurs only in the small intestine of the Grouse. Sometimes the number of specimens is small, two or three; at other times—and this is especially the case with weakly and diseased birds—the number of worms amounts to dozens, and they so fill the lumen of the alimentary canal that it seems difficult to imagine how the food can squeeze past them. In a badly infected bird worms of very different sizes are met with.

The anatomy of this form has been fully described in the Official Report: here we need only consider a few facts of more general interest. Both the "rostellum," or protrusible anterior end of the head, and the four suckers are armed with hooks. We shall consider later how far these hooks can act as inoculating agents. The number of proglottides or segments varies with the size of the worm. The medium-sized specimens possess some two hundred and fifty proglottides—the long worms may have four hundred (*see* Fig. 16). The posterior proglottides are continually breaking off, singly or in short chains of two or three, and, leaving the intestine of the Grouse with the dejecta, they come to lie about on the moors. Each proglottis contains, at a very rough estimate, some two hundred eggs, so that at any given moment a *D. urogalli* would contain nearly one hundred thousand eggs. But this is no measure of the fecundity of the tape-worm, because as fast as the proglottides break off at the tail end new ones are formed at the head end, and the animal goes on and on producing new proglottides like a recurring decimal. The ova are excessively small, and they must be disseminated in millions all over the moors. As already explained, they probably make their way into some insect spider or mollusc, and there turning into the cystic or larval stage await the moment when the insect is swallowed by a Grouse to assume again the adult characters. An enormous number of the eggs must perish without ever meeting with those conditions which alone permit them to develop.

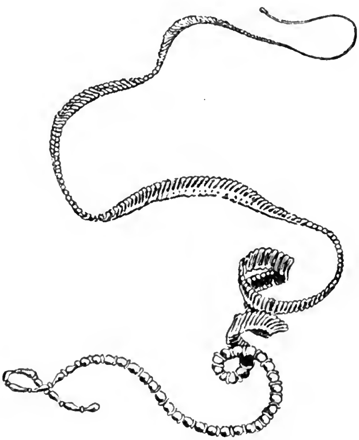

FIG. 16. *Davainea urogalli.*

X.—*Davainea cesticillus* (Molin), 1858.

(The Stumpy Tapeworm of the Grouse.)

A second much smaller form of tapeworm also belonging to the genus *Davainea* has only been recorded twice in the course of the investigations of the Committee. Once a few specimens were taken from the duodenum of a Grouse shot in Roxburghshire ; and it again was found loose either "in the small intestine or rectum" of a Grouse from Caithness. In both cases only young, immature specimens were met with. It is remarkable for its short, stout, stiff appearance, and for its small number of segments.

This tapeworm, common in chickens and turkeys, is only an occasional parasite of the Grouse, and in no case has its presence been associated with any lesions or ulcerations of the intestinal wall. As a factor in "Grouse Disease" it may be neglected. Its second host is probably some Coleopteran (beetle) or Lepidopteran (butterfly or moth), but at present this has not been proved.

XI.—*Hymenolepis microps* (Diesing), 1850.

(The Transparent Tapeworm of the Grouse.)

Specimens of a second genus and a third species of cestode inhabit the intestine of the Grouse. The same worm has been described from the capercailzie, and from the blackcock. The living specimens of this tapeworm have been found only in that part of the intestine known as the duodenum, but after the Grouse is dead they may wander into other parts.

It is an extremely delicate, transparent tapeworm which exists in almost countless numbers in the duodenum of the Grouse. On cutting open this part of the alimentary canal of a Grouse infested with these worms—and it is seldom that a bird is found free from them except in the winter months—they are not at first apparent. They are so fine and so transparent that they are invisible when alive, and the contents of this part of the alimentary canal appear very much like a thick soup. If we add some fixing agent such as corrosive sublimate this soup resolves itself into a mass of very fine, delicate, white threads inextricably tangled up together, and so numerous that there seems but little room left in the duodenum for the passage of the food. If, with great care—for they break at the slightest strain—we succeed in disentangling one of these worms we shall find its head embedded to a greater or less extent in the mucous lining of the duodenum, into which, to use a poetic phrase, "it nuzzles" whilst the body of the worm floats freely in the fluid contents of this part of the alimentary canal. If we also succeed in freeing the head we now have a complete worm, and can study its structure. (*See* Fig. 17.)

We have no information about the fate of the eggs and embryos of this transparent tapeworm, but as a general rule the cystic forms of this genus live in some insect or myriapod (centipede), as is shown by the fact that this genus of tapeworm occurs in bats, insectivores, rodents, and insectivorous birds. One species, *Hymenolepis nana*, occurs in man, most frequently in children, and is not at all uncommon in Italy. Sporadic cases of another species, *H. diminuta*, occurring in man, are also recorded. There is some evidence that the larval stage of this last-named species, which is common in rodents, occurs in the flea.

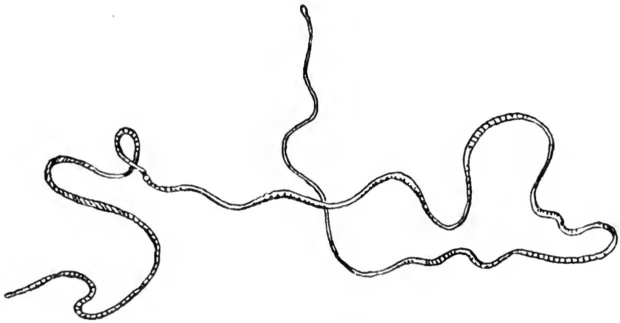

FIG. 17. *Hymenolepis microps.*

The injury caused by the presence of this tapeworm is serious, and when it is present in certain numbers it is associated with the occurrence of bacteria in the tissues, the number of which bears some direct proportion to the degree of infection of the tapeworms. That the latter should disappear during the winter is a curious fact which requires elucidation.

NEMATODA.—Threadworms or Round Worms.

(i.) Fam. TRICHOSTRONGYLIDÆ.

XII.—*Trichostrongylus pergracilis* (Cobb.[1]).

(The Strongyle of the Grouse.)

This is the second parasite worm discovered by Cobbold and described by him in 1873.[2] It belongs to a genus peculiarly destructive to birds. Some details of the harm caused by its near allies have been given in the Report of the Committee.

The strongyle lives in the opaque fluid contents of the paired cæca of the Grouse. It is very thin and fine, and is difficult to see when

[1] Synonym : *Strongylus pergracilis*, Cobb.

[2] The "Grouse Disease," *The Field* Office, London, 1873.

alive, owing to its transparency. On shaking up some of the contents of the cæcum in 75 per cent. alcohol to which has been added a few drops of corrosive sublimate and acetic acid, the worms become opaque and more visible, and they can be easily seen by compressing between two microscope slides a drop or two of the cæcal contents and holding them up to the light. The worms, if there be any present, then appear as thin, white transparent lines. The males are some 8 mm. in length, the females 10 mm.

No one has ever seen, and probably no one will ever see, this strongyle enter the body of a Grouse; but that it does so in the larval form, and that directly, *i.e.*, without the intervention of an intermediate host, seems clear. When swallowed the larvæ make their way along the alimentary tract and turn up into the cæca, where they rapidly develop into adults.

The serious injuries caused by the presence of *T. pergracilis* in the cæca, the accompanying symptoms, and the general pathology are described in chap. viii. To distinguish the disease from others which afflict the Grouse, it may be called Strongylosis.

(ii.) Fam. Strongylidæ.

XIII.—*Syngamus trachealis* (Von Sieb).

(The Red or Forked Worm.)

This common pest of the fowl-yard and pheasant-coop has been found but three times in the Grouse. Probably the free and unconfined life of the bird, together with the comparative paucity of earthworms in the moors, protects Grouse from "gapes," as the disease caused by the forked worm is called. There seems no reason at present to incriminate this worm of causing any trouble to Grouse. One of the cases observed was a young bird from Argyllshire.

(iii.) Fam. Trichosomidæ.

This family includes two human parasites, the whipworm of man and the worm which lives in the human intestines, and as larvæ migrate to the muscles, causing the painful and ofttimes fatal disease of Trichinosis in man, pigs, and rats. The genus *Trichosoma* occurs in all classes of vertebrates, especially in mammals and birds. It includes some seventy different species.

XIV.—*Trichosoma longicolle* (Rud.).

(The Whipworm of the Grouse.)

This round worm is far less common than the Strongyle. It occurs, in fact, sparingly, sometimes alone, sometimes associated with the transparent tapeworm, but always in the duodenum. The male worm is some 20 mm. in length, the female twice as long; they are extremely thin, and resemble short lengths of very fine white silk.

Like other members of the family Trichotrachelidæ the anterior end of the Grouse whipworm, for about one-fifth of the whole body-length, is narrowed like the lash of a whip. The males are much rarer than the females, and seem to occur, as far as our experience goes, in the proportions of about one to from seven to ten of the females. The eggs, which are very characteristic of the family, do not segment in the body of the female; in fact, no egg of this species has been seen segmenting. Like the eggs of other members of the family they probably do not develop until they get into water or damp earth. They probably pass directly into the bird, without the mediation of any secondary host, and they infect it at a very early date. They have been found in Grouse-chicks only two weeks old.

This worm does not seem to be associated with any grave disease, though where it is present there is a great destruction of the epithelial cells lining the duodenum. Masses of epithelial cells, singly and in clumps, are found in the fluid contents of the intestine, and these can hardly be due to *post-mortem* digestion, as we find them in birds opened immediately after death.

(iv.) Fam. Ascaridæ.

XV.—*Heterakis papillosa* (Bloch).

Stossich mentions this round worm, as occurring in the Grouse. It is a very common parasite in poultry and pheasants. We have not yet met any examples of it in wild Grouse, but it has occurred in hand-reared birds.

(v.) Fam. Filariidæ.

XVI.—*Filaria smithi.*

Dr Sambon has described under the above name, a "microfilaria" or larval form of some species of *Filaria* in the blood of Grouse. The adult forms of such larvæ usually live in the lymphatics and subcutaneous tissues; their larvæ pass into the blood, and are conveyed to new hosts by some blood-sucking insects.

PROTOZOA.

The great group of Protozoa, or unicellular, animals contains many parasitic forms which give rise to the most dangerous diseases. Sleeping sickness and malaria in man, biliary fever in horses, Texas fever in cattle, Coccidiosis in rabbits, Microsposriidois in bees, are evidence of this. Although already some eight Protozoa have been described from the various tissues and organs of the Grouse, so far only one, *Coccidium avium*, has been associated with distinct virulent disease, and this parasite causes the death of many young birds. In dealing with the Protozoa it has proved quite impossible to avoid scientific and technical terms, they are indeed the only words which exist for describing the organisms in question. These terms have been explained in the original Report of the Committee.[1]

ORDER I.—LOBOSA.

XVII.—*Amœba* (*Entamœba*) *lagopodis* (Fantham, 1910).

Specimens of amœbæ have been found in the freshly deposited droppings from Grouse, and presumably the amœbæ came from their alimentary canals. This amœba has also been found in the rectum but rarely. It has never been found in the contents of the small intestine. Certain species of amœba are pathogenic, and give rise to dysentery and other disorders in man. There is no reason to believe that the amœbæ found in Grouse were the cause of disease such as that known as "blackhead" in turkeys, which was formerly thought to be due to an amœba. It is now known that "blackhead" is a form of Coccidiosis—the so-called amœbæ in turkeys being a stage in the life history of a Coccidium.

ORDER II.—SPOROZOA.

SUB-ORDER I.—GREGARINIDA.

XVIII.—*Monocystis* (sp).

Some spores of a Gregarine, almost certainly those of *Monocystis*, and probably of one of the species inhabiting the earthworm, have been observed in Grouse. Grouse do not often eat earthworms; in fact there are, as a rule, few earthworms for them to eat on Grouse moors, though this is not perhaps so true in the lowlands and in England as further north. Where, however, earthworms abound, the soil is full of gregarine spores which might easily be picked up by a Grouse. They are but accidental parasites, and seem to cause no harm. We have found them in the intestines of three birds.

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[1] See also Fantham, *Proc. Zool. Soc. Lond.*, 1910, pp. 672-722.

Sub-Order II.—Hæmosporidia.

XIX.—*Leucocytozoön lovati* (Selig. and Samb.).

This Protozoön, a species of *Leucocytozoön*, one of the Hæmosporidia, was first found in 1907 in the blood of a Grouse. Since then it has been observed[1] alive in two birds, and in stained smears of the blood of two other birds. A new feature in the life of the Leucocytozoa of birds was the discovery by Dr Fantham of the young multiplicative stages of the parasite in the spleen of the Grouse.[2] Few birds are infected, and in the cases observed the degree of infection was slight. The parasite causes a certain amount of destruction of the colourless blood corpuscles; but is not sufficiently common to cause more than a sporadic and slight amount of disease.

XX.—*Hæmoproteus mansoni* (Samb).

This second parasite of the blood corpuscles was first recorded by Dr Sambon, who has seen something which he thinks to be stages in its life history in the body of the Grouse-fly. Some minute parasites seen since by Dr Fantham in the red blood corpuscles of two birds may be young forms of this species.[3]

Sub-Order III.—Coccidiidea.

XXI.—*Eimeria* (*Coccidium*) *avium*.

This is a dangerous parasite, and its presence is associated with much disease and frequent death in the young birds during the first few weeks of their life. The disease is of a very definite character, and is termed Coccidiosis. The parasite occurs especially in the duodenum and in the cæca, and by entering, growing and multiplying in the epithelial cells of these regions of the alimentary canal it destroys the lining membrane. The spores are taken up direct from the ground or on the food, and the action of the pancreatic juice dissolves the spore-cases and sets free the parasites to attack the epithelial cells. It has been found possible to infect young fowls and young pigeons with this parasite of the Grouse, and to set up fatal disease. In all cases the birds suffer from enteritis, accompanied by acute diarrhœa, and the dejecta contain millions of spores which thus are spread all over the ground; the spores pass uninjured through the intestine of the larvae of the dung-fly,[4] and these maggots which live in Grouse droppings may thus help to disseminate the parasite.

For further details of this organism reference is made to chap. ix. on Coccidiosis.

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[1] *See* Fantham, *Proc. Zool. Soc. Lond.*, 1910, p. 693.

[2] *See* Fantham, *Ann. Trop. Med. and Parasitol.*, iv., 1910, p. 255.

[3] See *Proc. Zool. Soc. Lond.*, 1910, p. 697.

[4] *Scatophaga stercoraria.*

ORDER III.—FLAGELLATA.

XXII.—*Trichomonas eberthi.*

A small flagellate has been found in the contents of the cæca and intestine of several apparently healthy birds. This flagellate is either the same as, or is only a variety of, *Trichomonas eberthi*, which has been recorded from the cæca of fowls.

XXIII.—*Monocercomonas* (sp).

Forms of this parasite were also seen in the Grouse. They did not occur in very large numbers.

ORDER IV.—SPIROCHÆTACEA.

This group includes such forms as cause relapsing fever in man and in fowls, and syphilis in man. The Spirochætes are dangerous parasites when occurring in large numbers in the blood. Two species of Spirochætes were found in Grouse, on a few occasions, both species being new.

XXIV.—*Spirochæta lagopodis* (Fantham, 1910).

This parasite was found in small numbers in the blood of two birds. It caused a slight alteration in the relative constituents of the blood, but was not associated with any specific disease.

XXV.—*Spirochæta lovati* (Fantham, 1910).

This species was seen alive and in stained specimens. It occurred in the cæca and intestine of six or seven of the many birds examined, and was not specially associated with disease.

The protozoal parasites of Grouse mentioned above are described by Dr Fantham in greater detail, with illustrations, in the original Report.

CHAPTER VIII

"GROUSE DISEASE"—*CONTINUED*—STRONGYLOSIS [1]

PART I.—EFFECT OF STRONGYLOSIS ON THE GROUSE

THE round worm *Trichostrongylus pergracilis* was first described under the name of *Strongylus pergracilis*, by Cobbold.

T. pergracilis is an extremely fine worm, measuring in the male from $\frac{1}{3}$ to $\frac{3}{8}$ of an inch, and in the female from $\frac{3}{8}$ to $\frac{1}{2}$ inch. They are very narrow and hair-like, and, as a rule, whitish in colour, but sometimes have the tinge of blood when seen in a very thin layer on a slide through the microscope. The extremely fine head and neck, finer than the finest needle, readily penetrates into the tissues of the cæcal walls. The worms are very transparent, clearly revealing their internal structure, and they are so soft that the pressure of a cover-slip almost always ruptures them. The cuticle is very clearly and definitely ringed, and the rings are so constituted that whilst the worm can easily work its way forward through a tissue, it would have difficulty in wriggling backward. The rings give the edge of the body a strongly serrated appearance like a saw. This is most marked a little way behind the head, and extends over about one-third the body length. There is no trace of longitudinal marking on the cuticle. The general appearance of the worm when seen under the microscope is shown on the accompanying figures, and a detailed description of its anatomy is given in the original Report.[2]

[1] The term "Strongylosis" is employed in this chapter to denote the disease caused by *Trichostrongylus pergracilis* (Cobbold); though it would perhaps be more strictly correct to name the disease *Trichostrongylosis.*

[2] Report, vol. i. pp. 209 *et seq.*

FIG. 18. Male *Trichostrongylus pergracilis*, showing *m* mouth, alimentary canal, spicules, and genital bursa. Magnified.

FIG. 19. Female *T. pergracilis*, showing *an.* anus; *c gl.* cephalic glands; *m.* mouth; *oe.* œsophagus; *of.* ovejector; *o.* ovary; *r.* rectum; *ut.* uterus with segmenting eggs; *v.* vagina. Magnified.

FIG. 18.

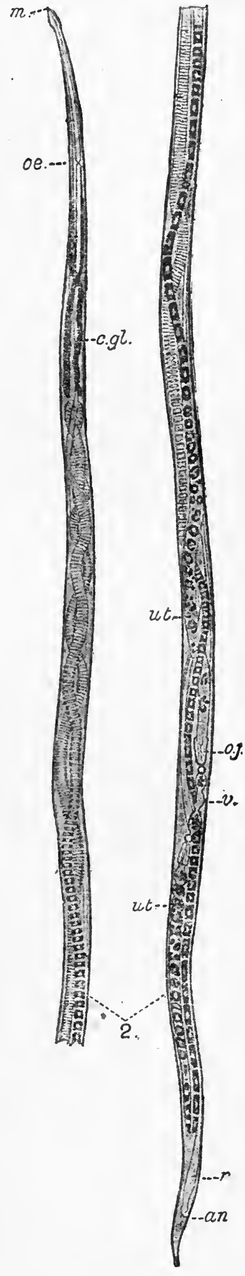

FIG. 19.

Specimens of *T. pergracilis* are found in the cæca of most Grouse. They have been found, with hardly an exception, in every one of the two thousand Grouse examined by the Committee. They are apt to cover themselves with mucus and dirt, and are consequently hard to see, and are often overlooked. But they may be rendered opaque and white, and hence much more apparent, by shaking up the contents of the cæcum in 75 per cent. alcohol, to which a few drops of corrosive sublimate have been added. Their presence is also readily detected by compressing a drop or two of the cæcal contents between two microscope slides and holding them up to the light. The worms, if there be any, then appear as thin, white, transparent lines.

A small pellet of the cæcal contents, such as can be carried away on the point of a needle, when spread out under a coverslip, will, in a well-infected bird, show some twelve to twenty worms and one hundred to two hundred eggs in the field of a two-thirds inch Ross's objective with a No. 2 eyepiece.

For the purpose of ascertaining the exact numbers of this worm in a single specimen a method of isolating and counting them has been devised and found to be practicable. The method is as follows: The cæca are laid out straight on a board and opened throughout their length, their contents are turned out, and all the material liable to contain Strongyli is collected. Small quantities are shaken up with water in a large test-tube, and poured out little by little into a Petri dish containing water. With suitable illumination the Strongyli can be clearly seen and picked out with a mounted needle and counted. As may be seen, by reference to Table I., in all but two birds (Nos. 57 and 67) approximately equal numbers of the worms are present in each of the two cæca.

Strongyli are almost constantly present in the cæca of wild Grouse believed to be perfectly normal, and certainly of fair weight and in good general condition. In a few so-called healthy birds they may be present literally in thousands, but they are more numerous in diseased than in healthy birds.

TABLE I.—Showing the Results of counting the Strongyli in the two Cæca separately.

Grouse No.	Strongyli.		Total.
	One cæcum.	Other cæcum.	
52	0	0	0
81	0	0	0
58	54	59	113
65	89	94	183
59	108	127	235
46	131	128	259
55	201	214	415
63	281	252	533
64	268	303	571
57	331	268	599
62	365	375	730
67	285	548	833
68	420	457	877
66	455	490	945
56	754	1,114	1,868
53	1,103	1,403	2,506
60	3,118	2,877	5,995
61	4,769	4,793	9,562

Table II. shows that the number of Strongyli present in diseased birds, though varying considerably, is greatly in excess of that found in the great majority of normal birds. In a small minority of the presumably healthy birds the numbers were as large as those found in many of the diseased birds. It is, of course, impossible to be certain that these exceptional birds were not really suffering from the early stages of "Grouse Disease." The two (Nos. 60 and 61) with the largest numbers came from a moor on which "Grouse Disease" was prevalent at the time.

The presence in diseased birds of Strongyli in numbers far in excess of those found in normal birds does not, of course, prove that they were the cause of the disease, because it is conceivable that they may have multiplied as a consequence of the disease. Nevertheless, taken in conjunction with the

TABLE II.—SHOWING THE RELATIVE NUMBER OF STRONGYLI IN HEALTHY BIRDS AND IN THOSE BELIEVED TO BE SUFFERING FROM "GROUSE DISEASE"

Birds received alive, apparently in good health, or sent as average specimens of normal Grouse.		Diseased birds picked up dead.	
Grouse No.	Number of Strongyli.	Grouse No.	Number of Strongyli.
81	0	53	2,506
52	0	79	2,556
48	32	74	3,114
43	45	78	3,340
58	113	74 (*a*)	3,406
59	235	80	3,840
46	259	75	4,352
50	290	39	6,230
49	330	71	7,058
47	344	73	7,484
55	415	77	8,800
63	533	72	10,266
51	540	76	18,332
64	571		
57	599		
62	730		
69	730*		
67	833		
44	871		
66	945		
54	1,645		
56	1,868		
70	2,524*		
60	5,995†		
61	9,562†		

* One cæcum only counted and the numbers doubled.
† These birds came from the same moor.

changes hereafter described in the mucous membrane of the cæcum, and the relation of the worms thereto, it is exceedingly probable that the worms are really the cause of the disease.

It is to be noted that the maximum incidence of infection is strictly seasonal, for though in isolated cases or in isolated outbreaks birds may die from Strongylosis, even in late autumn, both sexes die in April and May in very much greater numbers

TABLE III.—SHOWING THE SEASONAL PREVALENCE OF THE PRINCIPAL GROUSE ENTOZOA.

APPARENTLY HEALTHY BIRDS. Hand-reared, shot, or caught by keepers as examples of healthy birds.			
Date.	Hymenolepis.	Davainea.	Strongylus.
Feb. 3, 1909	0	1	1,645
,,	0	7	415
5	0	5	1,868
,,	0	11	599
,,	0	0	113
6	0	0	235
Mar. 17	Few	Numerous	5,995
,,	Numerous	,,	9,562
19	0	0	730
20	Numerous	0	533
,,	,,	Many	571
,,	,,	2	183
,,	,,	1	945
30	,,	Moderate	833
April 22	Few	0	877
27	Numerous	Numerous	730*
,,	,,	,,	2,524*
May 7, 1908	0	0	...
June 3, 1909	0	0	Few
July 10, 1908	Few	1	Few
,,	0	0	0
...	0	0	0
28	0	0	Few
Aug. 5, 1908	0	0	0
10	0	2	Numerous
15	Numerous	Numerous	0
18	0	0	0
,,	0	1	0
26	0	0	Numerous
30	Few	Numerous	Few
...	Numerous	Few	Numerous
30	Moderate	Moderate	Moderate
...	Numerous	Numerous	Few
...	Few	Moderate	,,
Sept. 2, 1908	0	0	0
14	0	0	0
Oct. 23, 1908	0	Numerous	Numerous
28	0	0	Few
Dec. 8, 1908	0	1	45
...	0	0	871
9	0	0	259
...	0	0	344
...	0	0	32
...	0	Several	330
...	0	0	290
...	0	0	540
17, 1909	0	0	0
21, 1908	0	0	0

* The Strongyli in one cæcum counted and number found doubled.

than in any other months of the year. This fact is brought out in Tables III. and IV., from which it will be seen that while twenty birds are reported to have been diseased in April and May only five are shown during the remainder of the year.

TABLE IV. — Showing the Seasonal Prevalence of the Principal Grouse Entozoa.

Diseased Birds. Picked up dead on the moors or caught in a weak condition.			
Date.	Hymenolepis.	Davainea.	Strongylus.
May 10, 1909	Numerous	0	7,058
,,	,,	Numerous	10,266*
5, 1908	,,	...	Numerous
...	,,	Numerous	,,
...	,,	Few	,,
...	,,	Numerous	,,
7, 1908	,,	,,	,,
,, 1909	,,	Fragments	7,484
9, 1908	,,	Numerous	Numerous
,,	,,	,,	,,
,,	,,	0	,,
,,	,,	0	,,
,,	,,	Numerous	,,
19, 1909	0	Moderate	3,114*
,,	Numerous	0	3,406
,,	,,	Numerous	4,352
,,	0	,,	18,332*
,,	Numerous	0	8,800
24, 1909	,,	Few	3,340
June 3, 1909	Few	0	2,556
,,	0	0	3,840
Aug. 26, 1908	0	0	Numerous
30	Numerous	Numerous	Numerous
Oct. 23, 1908	Few	Many	6,230
28	0	Moderate	Numerous
...	0	Moderate	Numerous

* The Strongyli in one cæcum counted and number found doubled.

The serious injuries caused by the presence of *T. pergracilis* in the cæca, the accompanying symptoms and the general pathology may now be referred to.

Appear-ance of unhealthy cæca.

When the cæcum of an infected Grouse is examined it will be found to show certain well-marked appearances.

Instead of an intestine of a brownish or greenish grey colour moderately filled with soft brown pasty material, and showing greyish yellow lines running down its length on the outside indicating the eight or nine long villous ridges within, the cæcum of a diseased bird becomes a distended tube with overfull and congested blood-vessels ramifying over it on the outside, standing out very often in conspicuous contrast with a yellowish fatty-looking gut-wall; or the whole substance of the wall of the cæcum may be congested to a deeper tone, and may look dark, blue-black, and unhealthy. Before opening the gut, the congestion of the mesenteric vessels is the most conspicuous point. This is due to a venous congestion, and it means that the liver and other abdominal viscera and the right side of the heart are overfull. The liver may be very dark. It decomposes rapidly, becoming of a black, tarry, soft and very rotten consistency; but this is not a safe indication of disease. The difference in appearance between a healthy liver during decomposition and a diseased liver is so uncertain that, after a day or two of summer heat, it becomes impossible to judge whether the bird was diseased or not. The right side of the heart is often enormously distended with black blood in a bird that has died of disease. This condition of the heart, however, must not be taken as necessarily present whenever the cæcum is diseased.

When the cæca of a large number of Grouse, all suffering more or less from Strongylosis, are opened up and examined in various stages of freshness, and in some cases after a lapse of many days since death took place, the appearances are very variable.

In some birds the upper portions of the cæca are almost transparent, but this transparency is certainly increased by the *post-mortem* decay of the mucosa. The longitudinal ridges, moreover, gradually diminish in breadth as the blind end is approached. The thickenings so conspicuous in some birds are far more abundant at and towards the open end. The ridges are sometimes very obviously alternately large and small, giving four broad and thick and four narrow and thin.

In bad cases the villi are intensely congested, and in a certain number of cases there is evidence of internal bleeding having taken place here and there. But extensive bleeding does not occur in Strongylosis, or at any rate no indication of it has been seen in any bird dissected. The reasons which lead to the belief that there is always a loss of blood as a chronic symptom in this disease are that the congestion is always present, and is often excessive; that a small amount of bleeding has been seen, and that in some advanced cases there is every appearance of anæmia or bloodlessness. In some birds the pale, bloodless, fatty and degenerated aspect of the tissues of the internal organs was most suggestive of anæmia, and of chronic blood poisoning.

Tricho-strongylus in healthy birds.

It is possible to find quite a number of very healthy looking birds of good weight and yet with a large number of *Trichostrongylus* and a considerable amount of villous reddening. This is not surprising in such a disease as Strongylosis, which is essentially a progressive ailment. Everything depends upon the strength of the bird, and its power of resistance. There is no doubt that some birds will retain their weight and continue for some time in apparently perfect health, with a very great number of *Trichostrongylus* in the cæca, and a considerable amount of congestion. There is also little doubt that an observer may be easily misled by a normal redness of the cæcal lining due to ordinary processes of digestion. This is especially the case if the bird examined happens to have been in the middle of this process at the moment of death, and if death occurs without loss of blood. The digestive organs must all be more full of blood at that time than at others, though in a bird like the Grouse which eats all day long, the difference may be less marked than it would be in ourselves or in birds of prey which feed at intervals.

Signs of Strongy-losis.

The chief signs of a bad case of Strongylosis so far as the cæcum is concerned are:—

(1) An excessive number of the worms, which can be seen stringing across between the lining membrane and the caked contents of the gut, if the contents are fairly dry. If the contents are moist by taking a small quantity of the gut

contents and squeezing this flat between two glass slides, the worms can be easily seen as transparent threads when held up to the light. Innumerable ova of the worm also will be found lying loose in the cæcal contents.

(2) The longitudinal ridges of the cæca, eight or nine in number, are very much thickened, chiefly because the amount of blood held by them is excessive, and the lining becomes inflamed.

(3) The swellings on the ridges which are conspicuous in a healthy bird as greyish nodules, are far more conspicuous in a case of Strongylosis when they become reddened and congested, and seem to suffer to a greater extent and earlier than the remainder of the ridges and the rest of the cæcum. In some cases, however, the time comes when every villus in the whole gut seems to be intensely red and congested from one end to the other.

(4) There may be a very great deal of thickening of the lining membrane from the swelling up of the villi and, after *post-mortem* decay, the cæcal membrane seen in water may have the appearance of a furry rug. The contents of such cæca are sometimes obviously blood-stained, and there seems to be a bleeding form of the disease which results from the sudden access to the gut of a very great number of young worms all in a fully metamorphosed state. Such a case was produced experimentally, and bleeding occurred in the cæca. There is no apparent reason why under certain easily imagined circumstances the same thing might not happen in early spring-time under natural conditions.

(5) There may be appearances of recovery. In a good many birds the cæcal lining is dotted all over with minute black pigment granules, in other words some of the villi show no blood-vessels injected, but are filled with pigment granules instead. These are sometimes so abundant as to colour the gut. They lie in the villi in great numbers.

It is possible that they result from previous chronic congestion, and that there are circumstances under which the bird may rid itself of an excessive number of *Tricho-strongylus.* This supposed recovery from Strongylosis may have resulted from some unknown vermifuge herb or from improved conditions of life. The worms, one must suppose, remain in the gut; but the congestion is overcome, and the bird is not very much the worse for their presence. But, if the congestion is allowed to continue and become chronic, the digestion and absorption of food must go from bad to worse, and with it every other function of the body. Nothing will prevent the bird in this case from losing weight, and eventually its life.

As for the exact cause of the congestion, it may be due to mechanical constriction of the filaments of the villi by the nematode worms. Each time the gut contracts peristaltically the worms have to hold on tightly to the gut lining to avoid being dislodged with the dejecta, and the result is seen in sections where the villi are evidently mixed up inextricably with the coils of *Trichostrongylus.* Or the congestion may be due to the chemical irritation of some poison produced in the gut by the worms, or by the defective digestion of food stuffs, or by bacteria living in the gut in its unwholesome state. Alternatively it may be due to some or all of these conditions together.

On the whole the mechanical view seems the most probable. The peristalsis is acting in a way to dislodge the worm, and the *Trichostrongylus* has no other way of retaining its position in the cæca save by coiling round something, and the peristaltic action of the cæcum must be fairly strong in comparison with the strength of the worm, for the free end of the worm has to be released at every wave of peristalsis from immersion in a thick, pasty material which is being driven outwards at each contraction of the gut. It thus seems evident that the small and delicate processes of the villi may be continually on the stretch, at first looped round tightly by a worm, the coil may then relax, blood may enter the capillaries, only to be compressed anew and so on, conditions which cannot but produce irritation and congestion on a large scale if multiplied a sufficient number of times.

Loss of Weight.

Apart from the appearances in the cæcum there are several other indications of this form of disease. The most reliable, and certainly the most easily recognised, is that of loss of flesh and weight.

It is for this reason that the average weight of the birds on a moor is the best indication of the prospect of health or disease in the near future.

The tradition, for it is probably no more than a tradition, that in some outbreaks of "Grouse Disease" birds have been found dying or dead in plump condition and of normal weight, is discussed elsewhere. No such case has been observed during the course of the recent Inquiry. Grouse do not die of Strongylosis without loss of weight, and the reason is not far to seek when an infected bird is dissected.

Strongylosis does not appear to have a very marked effect upon the temperature. The average body temperature of a Grouse in full health is 106·42° F., but when suffering from Strongylosis this temperature tends to fall. The average temperature of birds infected with Strongylosis was found to be about 105·07° F., but the number of cases observed was not large, and the question requires fuller investigation.

Strongylosi and bacilli.

In view of the opinion expressed by Professor Klein and others that "Grouse Disease" is due to an infection with bacteria, more especially with bacilli of the "coli" group, the Committee made careful observations as to the relation between *Bacillus coli* in the organs and Strongyles in the cæca. At an early stage of the Inquiry it seemed probable that some such relation existed, for in birds reared in captivity, and thus kept entirely free of Strongyles, the organs contained no bacilli of the coli type (one exception). On the other hand, in the organs of Grouse with very large numbers of Strongyles, *Bacillus coli* was constantly present, either in the liver or some other organ. In other Grouse with fewer Strongyles, *Bacillus coli* was present in some and appeared to be absent in others. The results may be given in the form of a table.

TABLE V.—Showing the Relation between the Number of Strongyles in the Cæca and *Bacillus coli* and *Bacillus enteritidis* in the other Organs.

Grouse No.	Number of Strongyles.	Cultures from Organs.			
		Liver.	Lungs.	Spleen.	Kidneys.
52	0	0	0	0	0
81	0	0	0	0	0
48	32	0	0	0	0
43	45	0	0	0	0
58	113	0	0	0	0
59	235	*B. coli*	0	0	0
46	259	*B. coli*	0	0	0
50	290	*B. coli*	*B. coli*	*B. coli*	0
49	330	0	0	0	0
47	344	*B. ent.*	0	*B. ent.*	0
55	415	0	0	0	0
63	533	0	0	0	0
51	540	*B. coli*	*B. ent.*	*B. ent.*	*B. ent.*
64	571	0	0	0	0
57	599	*B. coli*	0	0	0
62	730	*B. coli*	0	0	0
67	833	0	0	0	0
44	871	*B. coli*	0	0	0
66	945	0	0	0	0
54	1,645	*B. coli*	0	*B. coli*	0
56	1,868	*B. coli*	*B. coli*	0	...
60	5,995	*B. coli*	0	0	0
61	9,562	*B. coli*	0	0	0

The points which come out clearly from this table and from other observations are: (1) that when Strongyles are absent from the cæca or are present only in small numbers (less than a hundred), intestinal bacteria, especially *Bacillus coli*, are not present in the liver or other organs of the Grouse (eleven Grouse —one exception); (2) that when a moderate number of Strongyles are present (one hundred to one thousand), *Bacillus coli* may or may not be present in the organs (twenty-one Grouse); and (3) that when great numbers (over one thousand) are present, *Bacillus coli* has invariably been found in the liver or other organs (twenty Grouse.)

Having ascertained that a relation exists between the numbers of Strongyles and the presence of *B. coli* in the organs it became necessary to discover whether a similar relation exists between *B. coli* and the other intestinal parasites commonly found in the Grouse. The tables of results are given in the original Report, but it is only necessary here to state (1) That the presence of the tapeworm *Davainea urogalli* in the intestine is not related to the presence of *Bacillus coli* in the liver and other organs; (2) That the presence of the tapeworm *Hymenolepis microps* in the duodenum is occasionally related to the presence of *Bacillus coli* in the liver and other organs.[1]

It has been shown that *Bacillus coli* is constantly present in the organs of birds whose cæca contain large numbers of Strongyles, and that the latter are present in far larger numbers in diseased than in healthy birds. It may therefore be assumed that *Bacillus coli*, while not invariably absent from the organs of the apparently healthy bird, is constantly present in those of diseased birds. The small number of colonies of *Bacillus coli* cultivated from the tissues of diseased Grouse indicates that these bacteria do not multiply in the tissues. We therefore do not suggest that "Grouse Disease" is essentially an infection with these bacteria.

It is very doubtful whether the bacilli which find their way into the organs do much harm. Some harm no doubt they do, but how much cannot be said. Microscopic examination has not revealed any profound changes in the livers of Grouse. The numbers of these bacteria which penetrate into the organs is difficult to estimate because, doubtless, they soon get killed in the living tissues, so that the numbers of colonies cultivated must bear only a small proportion to the total number of bacteria which have entered the fragment of tissue examined. The number of *living* bacilli in the organs of these Grouse is undoubtedly small from which it is evident that they do not multiply in the organs. "Grouse Disease" is therefore not an *infection* with these bacteria. Is it a form of blood poisoning (*toxæmia*) caused

[1] *Vide*, p. 200.

by the poison liberated from bacteria which have been absorbed from the intestine, and which have almost immediately perished in the tissue? We know that in order to produce serious mischief in animals by a single injection of dead bacteria a considerable quantity must be employed; and it is difficult to believe, when we remember the small number of colonies which grew on the cultures, that relatively to this quantity the numbers of bacteria absorbed could have been very large. On the other hand, there is little information concerning the influence of the constant absorption of small numbers of bacteria, but this is believed by Adami and his school to be a potent source of disease. The fact that *Bacillus coli* has been repeatedly found in the livers of "normal" birds, badly infected with Strongyles, prevents us from ascribing the death of the Grouse directly to these bacilli, though they probably play some part. If these are really numerous, their products will doubtless exert some amount of harmful influence, but how much we are not at present in a position to say. The fact that no important lesions have been found either by macroscopic or microscopic examination in the livers which have yielded cultures justify the view that the bacilli play only a secondary part in the causation of death.

ect of natodes health.

From the foregoing remarks it will be seen that the case against the nematode, or round worm *Trichostrongylus pergracilis*, is fairly clearly established, for though this parasite is seldom entirely absent from healthy birds, its presence in large numbers in the cæcum is usually associated with definite lesions. *Trichostrongylus* probably does little harm if not present in too great numbers. With regard to the presence of the worm in large numbers in some of the birds caught on the moor, and supposed to be healthy birds, it must be remembered that strong wild Grouse are difficult to catch, and that some at least of the methods of capturing Grouse alive seem calculated to catch the weaker birds rather than the stronger ones. On the other hand, on counting the Strongyles in a number of "normal" and diseased birds, there has been found a great difference between the two classes, very large numbers being always found in the diseased birds, much larger indeed than those found in all but the exceptional members of the healthy class, and these, for reasons just stated, may perhaps not be normal at all but suffering from the early stages of "Grouse Disease."

These nematodes, in birds picked up dead or sent for examination as suffering from "Grouse Disease," are almost always associated with grave changes in the lining membrane of the cæcum. Concurrently with these changes intestinal bacteria, particularly those belonging to the *Bacillus coli* group, find their way into the liver, or even into other organs, but no direct injury can be traced to the presence of these intestinal bacteria.

"Grouse Disease," then, does not appear to be a specific bacterial infection. It would seem that all the birds which are more or less severely affected by Strongyles suffer direct injury to the cæca to an extent which is more or less proportional to the severity of the infection. Some exceptionally strong birds may stand a larger infection better than weaker birds will stand a lesser; but, on the whole, the birds with the largest numbers of Strongyles suffer most. Their nutrition is impaired owing to interference with the normal absorption of digested food, and to the abnormal absorption of soluble poisons and intestinal bacteria. Such birds become the weakest; and when food is scarce, as it is at the beginning of spring, especially after bad winters or on overstocked moors, or when other harmful influences prevail, it is the weakest birds which suffer most. They die of Strongylosis acting on a constitution already weakened by the consequences of privation, while their stronger neighbours manage to pick up a living somehow, and so tide over the period of distress.

Part II.—Life History of *Trichostrongylus pergracilis*

In view of conclusive evidence accumulated by the Inquiry regarding the constant presence of the *Trichostrongylus pergracilis* in the cæca of nearly all sick adult Grouse, it became a matter of importance to study in some detail the life-history of this parasite with a view to determining the manner in which it is reproduced and disseminated, the mode of infection of healthy birds and, if possible, to obtain experimentally the symptoms of " Grouse Disease " under artificial conditions. In order also to have some reasonable basis of fact upon which to establish preventive and curative measures, a knowledge of the conditions favourable to and inimical to the growth of the parasite at its various stages of development became necessary.

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The sexually mature females give rise to their progeny as eggs, which undergo a certain degree of development while still within the body of the worm. By the time they are laid the egg content has become subdivided into a large number of cells, forming what is technically known as the *morula* (Fig. 20). As *morulæ* these eggs pass into and mix with the contents of the cæca of the Grouse, all further development thereupon ceasing. This suspension of development appears to depend upon a lack of some necessary stimulant in the cæcal contents, for the eggs may be found alive and at the same stage not only several days, but even so long as a month after the death of the bird. In nature the cæca are evacuated periodically, and the ova thus pass out of the body with the soft portion of the bird's dropping. In one or two cases where a portion of the cæcal contents had passed into the rectum, and had there become diluted somewhat by the fluid from the large intestine, eggs were found to have progressed to the formation of an embryo while within the body of a dead bird; but such a condition is obviously abnormal, and does not invalidate the general conclusion that the eggs of this parasite require to pass out of the body of the bird before they are able to continue their growth, and that, in consequence, the parasites within the body cannot increase in number by sexual multiplication. Each and every parasite

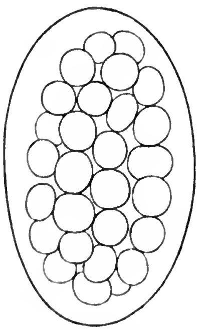

FIG. 20.
Morula stage of egg.

found within the body of the Grouse must therefore have actually entered it from the outside. We shall see later that this explains the apparent anomaly that whereas practically all Grouse are infected with *Trichostrongylus* only some suffer from the disease. The egg, when newly passed, measures 0·075 mm. by 0·046 mm. and contains a *morula*, composed of about sixty-four cells.

Development of the egg outside the body.

If a freshly passed cæcal dropping be isolated and kept uncontaminated no further development will take place in the ova contained in it. A fungus will gradually grow upon it, and owing to this and bacterial contamination the eggs eventually die. If the dropping be exposed to the drying influence of sun and wind, as on the moors during summer, it becomes caked and dry, and the eggs die. If, on the other hand, a cæcal dropping be spread out in such a way as to admit of the whole becoming oxygenated by the atmosphere, and it be also slightly moistened, development will proceed, its rapidity increasing with the temperature.

Cultural methods.

For the experimental study of the extra-corporeal development the following method was found most reliable. Petri dishes, as used in bacteriological research, of a diameter of about 4 inches, were employed in pairs. Into the upper dish was placed a closely fitting piece of thick blotting paper, which was thoroughly moistened with water. The inside of the lower dish was smeared uniformly with a very thin layer of cæcal dropping or cæcal content taken direct from a dead bird. Several drops of water were then added and mixed into the viscid layer by means of a glass microscopical slide so as to produce a glairy mixture that would but slowly slide off the Petri dish when it was held almost upright. The layer of fæces should be sufficiently thin to allow of an examination under the microscope with a two-thirds inch lens. The upper Petri dish was then placed over the lower dish, forming a close chamber, the atmosphere of which quickly became saturated with water vapour. From time to time the Petri dish was opened and a small quantity of fæces removed on a platinum wire for microscopical examination, or the lower part was placed upon the stage of the microscope and directly observed.

A similar method, and one which permitted the study of the various stages of development in a small number of eggs, was the use of hanging drop dishes.

If the former of these two methods has been adopted, in the course of twelve hours the colour of the culture in the Petri dishes should have changed from a greenish yellow to a reddish brown, and a sickly sweetish odour, similar to that found in lactic acid fermentation, should have become distinctly appreciable. Otherwise experience teaches that putrefactive processes will almost certainly set in and lead to the destruction of the eggs and worms in the culture. After the eggs have hatched, and when minute worms are seen wriggling through the culture, it will be found advantageous to leave the Petri dish open for several hours in order to allow of the evaporation of some of the water, so that the culture acquires more consistency.

A larger amount of water appears to be necessary for the growth of the young parasite previous to hatching than afterwards. Indeed we shall see later that a certain amount of consistence in the medium appears to be absolutely necessary for the full growth of the young worm.

Develop-
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changes in
ovum.

In the culture made by the above method the egg mass continues rapidly to segment until the resulting cells are exceedingly small. The mass becomes somewhat flattened, and a slight dimple appears at one border of the oval disc (Fig. 21). This is the first step towards the formation of the cylindrical body of the young embryo. By the gradual deepening of this dimple the egg mass acquires a tadpole-like appearance, the anterior end being, thus early, easily distinguished from the posterior end of the body. The anterior portion soon exhibits a central depression, which indicates the commencing formation of the mouth (Fig. 22). As the lateral dimple continues to deepen the body mass elongates to such an extent as to become folded upon itself two or three times, in order to become accommodated within the shell (Fig. 23). The alimentary canal meanwhile has gradually been developing, so that by the time the embyro attains a cylindrical form the canal is found to extend throughout the body as a distinct cell-walled tube (Figs. 24, 25). During the whole of this period the embryo remains quiescent, but about an hour or so before it leaves the egg-shell it commences to exhibit a certain amount of movement. This movement gradually increases in extent and vigour, until it ultimately overtaxes the resistance of the egg shell, which

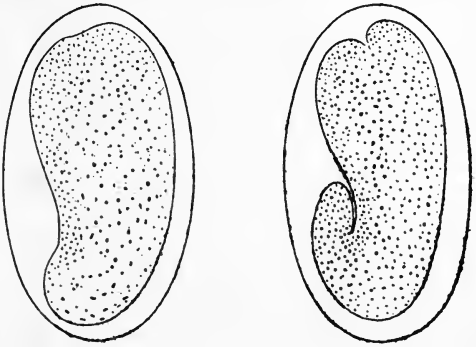


Fig. 21. Fig. 22.
Developing ova of *T. pergracilis.*

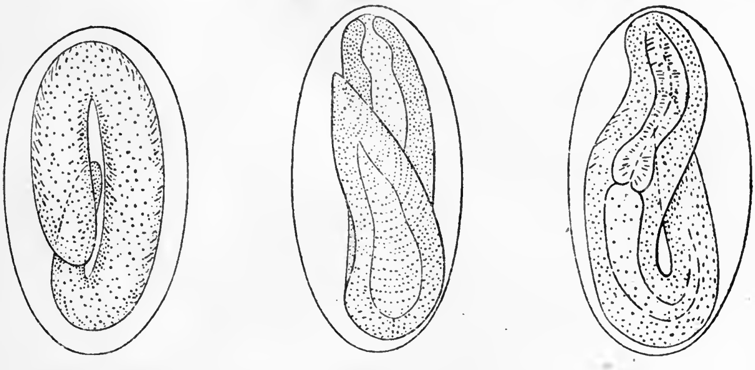


Fig. 23. Fig. 24. Fig. 25.
Formation of the larva of *T. pergracilis.*

suddenly ruptures. The success or failure of these efforts on the part of the young worm appears to depend on the amount of water which is imbibed from the outside, for if only such an amount of water be added to the culture as is absolutely necessary to set the process of development in motion, and the culture be then allowed to dry somewhat, it will be found that the embryo is incapable of rupturing the egg shell. A slight collapse of the egg shell, owing to an insufficiency of water, causes the death of the embryo at any period of its growth. Hatching usually takes place from thirty-six to forty-eight hours after the egg passes out of the bird; but in summer it may be delayed for even as long as a month.

When the embryo is hatched there seems little purpose in its early movements. The cuticle, at first irregularly crinkled, gradually smoothens as the parasite becomes saturated with water. The movements now appear to gain in purpose, and very soon the little worm is actively moving about, obviously in search of food.

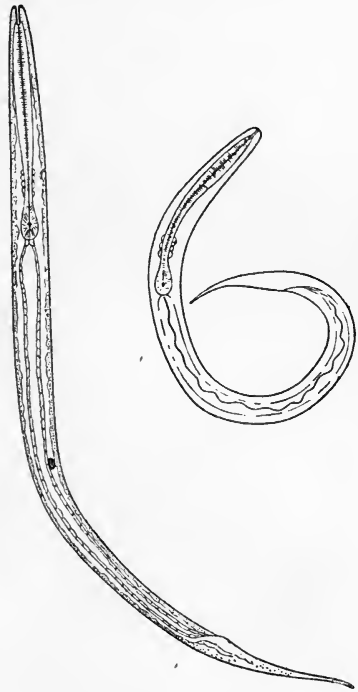
Description of the embryo.

When newly hatched, the embryo measures 0·36 mm. in length, and 0·15 mm. in greatest thickness (Figs. 26, 27). The body is cylindrical, tapering to a slender pointed tail in the last 0·1 of a mm. of its length. Anteriorly it maintains an almost uniform diameter to within 0·05 of the mouth, when it shows a slight and gradual narrowing. The anterior extremity ends bluntly, and has a diameter of 0·0075 mm., presenting at its summit the small rounded opening of the mouth capsule. At 0·06 mm. from the tail the anal pore opens with but little external indication.

Alimentary Canal.—Two faint parallel lines are seen running inwards for a distance of 0·01 mm. from the oral pore. These are the walls of a cylindrical mouth capsule, which later, with the growth of the worm, become much more thickened and obvious.

Upon the success of the embryo in obtaining a plentiful supply of food depends almost wholly its future growth. If a freshly hatched embryo be transferred to plain water it will live for several days, but show no growth or further development. Evidently there is only a sufficiency of reserve substance within the ovum to develop the embryo to the time of hatching. When there is enough food, but the medium is very liquid, the worm requires to exert itself to a much greater extent in order to entrap small solid particles of food into its rigid mouth capsule. If, however, the culture is of such consistency that the embryo is able, by burrowing its way through the fæcal matter, to force this into its mouth capsule, there follows a very rapid growth in size even when there is a marked lack of oxygen. Under these favourable conditions of food supply an embryo increases in size to such an extent that on the fourth or fifth day from the commencement of the culture it is obliged to shed its cuticular covering. At this time thousands of very delicate sheaths may be found floating in the culture for a few hours; but they very rapidly disappear.

The first moult or ecdysis.



Figs. 26 and 27. Newly hatched embryos of *T. pergracilis*, highly magnified.

No important structural alterations accompany this first moult or ecdysis, but during the succeeding three or four days certain changes within the body of the worm gradually become evident.

The cylindrical mouth capsule (Fig. 28) slowly loses its clear cut border and appears to be undergoing absorption, and its lumen decreases (Fig. 29). At the same time the œsophagus lengthens, the bulbous posterior portion becomes pyriform, and later merges into the anterior portion, but so gradually as to be only definable with difficulty. The cuticular lining of the whole œsophagus, and the marked triradiate lining of the

The metamorphosis.

œsophageal bulb (Fig. 29) become resolved into a simple thin cuticular covering (Figs. 30, 31). The walls of the intestine, which have gradually increased in size, become more clearly defined, and now appear as cylindrical turgid cells distended with large globules of highly refractile substance, giving the

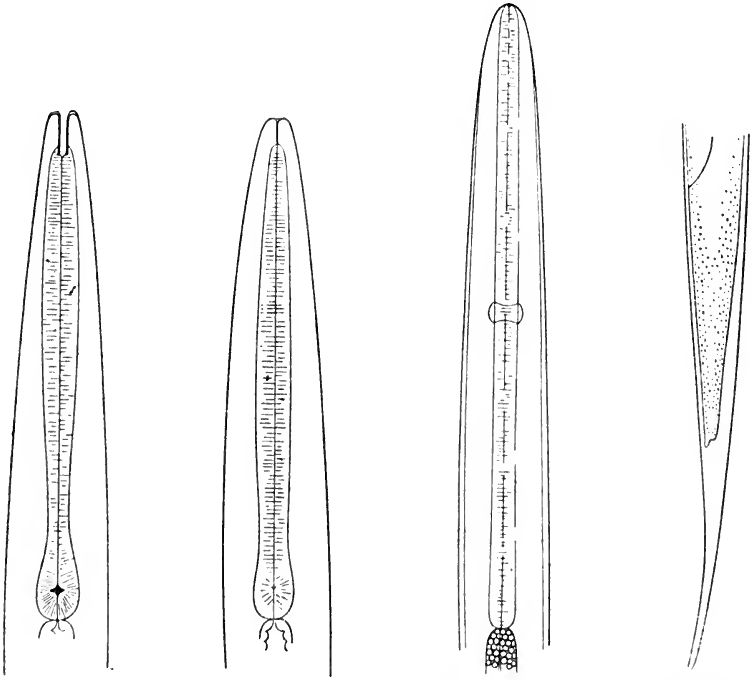


FIG. 28. FIG. 29. FIG. 30. FIG. 31.

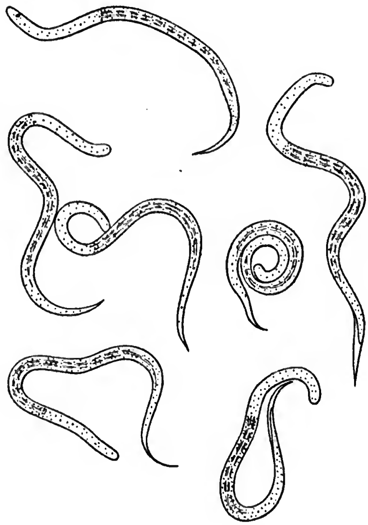
Changes in *T. pergracilis* during ecdysis and encystment.

larva a characteristic appearance by which it can be readily distinguished from free-living nematodes (Fig. 30).

The whole body appears to have slightly narrowed during the process of metamorphosis, by the conclusion of which the larva has become changed into a slender actively moving worm, with a simple elongated œsophagus without mouth capsule (Figs. 30, 31). Accompanying the metamorphosis in structure is a marked change in habits, for instead of burrowing into the denser portions of the food these metamorphosed forms now rush about with great rapidity, and either wriggle into the patches of open water or make their way on to the actual surface of the culture, and may be seen standing out in numbers into the moist atmosphere above, forming a kind of hoar frost on the surface of the fæces apparently in search of oxygen. Those larvæ, which are fortunate enough to be near the edge of the culture, ascend in the condensed water on the sides of the Petri dish and make their way on to the upper part, eventually reaching the blotting paper. Others will crawl out of the thin edge of the culture medium and become stranded on the dry glass. This metamorphosis takes place between the eighth and sixteenth day from the commencement of the culture, the difference in time depending almost entirely on the temperature at which the culture is kept.

The second moult or "encystment."

If the blotting paper be now removed, and the upper part of the Petri dish be put aside, so that the moisture on its inner surface, which contains the actively wriggling metamorphosed larvæ, be allowed to evaporate slowly, it will be noticed that as the water disappears the movements of the larvæ gradually diminish and eventually entirely cease, so that ultimately the larvæ lie, sometimes making irregular figures like notes of interrogation, sometimes coiled up like a watch spring (Fig. 33). If drying proceeds sufficiently slowly, it would be found on examining the dish with a hand lens that when all traces of moisture have disappeared the little coiled larvæ stand out as turgid, glistening streaks. They seem to be capable in this condition of retaining a certain amount of moisture within their thick resistant cuticle for several days, and to make up for any loss of fluid by evaporation by slowly retracting the body from either end and of detaching themselves from their cuticular skin (Figs. 30, 31, 34). This retraction may go on to such an extent that if one suddenly adds water once more to a Petri dish containing such dried forms the little worms are found enclosed in long sheaths that extend much beyond each end, recalling the sheathed embryos of filaria seen occasionally in the blood of man (Fig. 34). This second formation of a sheath, or as it is sometimes called, the " encystment," is the last stage of the development of the larvæ outside the body. It appears



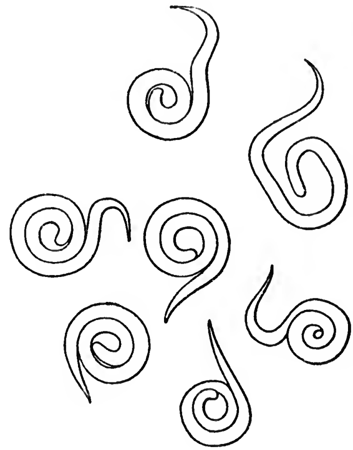


FIG. 32.
As seen in water.

FIG. 33.
As seen stranded on sides of dish.

Larval forms of *T. pergracilis.*

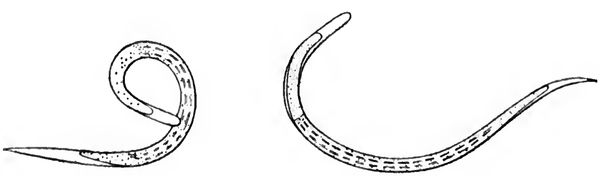


FIG. 34.
Encysted larvæ of *T. pergracilis.*
Appearance on addition of water to forms shown in Fig. 33.

to be a necessary preliminary to the attainment of infectivity, and once this stage is reached the larvæ can remain alive without food or further growth for weeks. The larva does not shed this second sheath until it reaches the alimentary canal of the Grouse. There are thus two moults in the extra-corporeal development. The first is completed prior to metamorphosis while the larva is free-living; the second, subsequent thereto, is not completed until after the larva has entered the bird.

So much then for artificial experiments.

The following details of an experiment made during August 1909 serve to illustrate what actually becomes of the hatched worms under natural conditions upon the moors. A culture made in the manner described above was taken to a small village, on the coast of the Bay of Cardigan, where no Grouse lived or had been known to exist for many years. Two or three small plants of hill heather were detached uninjured from crevices in rocks. These were planted in a Petri dish, and the dish was half filled with water so as to cover the roots. The plants were then set aside. A week later they were found to have survived the transplantation, and to have commenced to grow under the new conditions. As the weather was showery the plants and dishes were left out in the open, and for two or three days in succession the raindrops hanging from the tips of the heather were microscopically examined. They were found to be almost free of life. On one occasion, however, a small free-living nematode was found. Although slightly resembling the larvæ of *Trichostrongylus pergracilis* it was readily distinguished from them by its microscopical characters.

Immediately after one of these periodical examinations, the culture of *Trichostrongylus pergracilis*, in which the majority of the larvæ had just undergone metamorphosis, was poured into the water round the roots of one of the experimental plants. The plant was left out in a typical "Scotch mist" for a couple of hours. At the end of that time raindrops were again taken from the highest tips of the heather, which were about 3½ inches above the surface of the water, and they were found to be literally swarming with the actively wriggling metamorphosed larvæ of *Trichostrongylus pergracilis*. These larvæ had ascended the wet stems and leaves of heather against the current of water that was trickling down towards the roots. Their intense activity was doubtless due to the large amount of oxygen present in the fresh rain. The plant was then taken from the Petri dish and placed in a cardboard box, which was sealed down. A month later the box was opened. The heather was found to be alive still and growing, but very dry. The tips of the shoots from which the raindrops had been taken were cut off and soaked in little watch glasses of fresh water, and in the course of half an hour there wriggled out from the crevices of the leaves of the heather a considerable number of larvæ, showing at either end the long collapsed parts of the sheath which as we have already seen are characteristic of the larvæ that have undergone drying under artificial conditions. The intestine showed the characteristic refractile appearance already noted.

The following synopsis of the life history of this parasite may be of interest as summarising the order and minimal duration of the various stages in the life-cycle.

April 1. Egg in morula stage passes out of Grouse in soft dropping.

,, 3. Larva hatches out and lives in dropping of Grouse or in moist earth.

,, 5. First moult or ecdysis.

,, 8. Metamorphosis, larva now in actively migrating form.

,, 9. (or after). Larva ascends to tips of heather; if there is no mist, rain, or dew the ascent will be postponed.

,, 10. (or after). Encystment or drying; this represents the first stage of the second moult—an indefinite interval may intervene here.

,, 10. Larva swallowed by Grouse, and completes second moult.

,, 11. Reaches cæca of Grouse.

,, 13. Completes the hypothetical third and fourth moults, thereafter become adult and sexually productive.

,, 13. Pairs as soon as adult stage is reached.

April 14. Lays eggs in cæca.
,, 15. Eggs pass out of Grouse.

Thus the exact mode by which the worms attain to the most favourable conditions for infecting the Grouse had been determined, for the young growing tips of heather are those most sought after by the birds. It remained to be seen whether the administration of these metamorphosed encysted larvæ to healthy Grouse would result in the actual production of Strongylosis.

Experimental induction of Strongylosis.

It had been found that the administration of eggs and embryos of the *Trichostrongylus pergracilis* and of centrifugalised washings of heather from the moors to healthy uninfected Grouse had given uniformly negative results. From the observations described above the explanation of these failures becomes evident. The eggs and embryos of the parasite require to undergo certain essential developmental changes for a period of almost a fortnight's duration before they acquire the power of infection when swallowed by Grouse. Even the administration of larvæ was at first inconclusive, for the larvæ obtained from the heather in the earlier experiments were undoubtedly those of non-parasitic nematodes, the young of which bear a general resemblance to the unmetamorphosed embryos of *Trichostrongylus pergracilis*—many of them having a very similar type of mouth capsule. Moreover, the embryos of *Trichostrongylus pergracilis* do not acquire their migratory habit until they have become metamorphosed, and therefore do not ascend the heather until they have entirely lost their oral capsule. Until the above described experiments were successfully concluded the characters of the metamorphosed larvæ were quite unknown, and therefore it was impossible that they should have been recognised in washings of heather.

The administration of the metamorphosed larvæ was carried out at the Committee's experimental station at Frimley in Surrey.

On June 19th, 1909, a culture of larvæ which had just undergone metamorphosis, and which were therefore in the active migrating stage, was administered to an adult male bird one year old. The droppings of this bird were entirely free from *Trichostrongylus* ova when the experiment was begun, and therefore the bird was entirely free from all suspicion of prior infection. An examination of the fæces on the successive days showed that no infection had taken place. By June 26th the culture had undergone further developmental changes, and showed a large number of "encysted" forms. A dose was again administered and some four days later ova of *Trichostrongylus pergracilis* were found in the droppings. The number of ova increased on successive days. On July 3rd a further dose of the same culture, now thirty days old, was administered. The bird died five days later, showing distinct loss in weight, the presence of a large quantity of chalky fluid in the rectum, and the cæcal contents red with blood. From the *post-mortem* examination the conclusion was formed that the bird had been killed by the passage of some of the last culture into the lungs, for there were obvious signs of pneumonia, and quantities of the culture were found in the fine tubules.

This first experiment was therefore not wholly conclusive as regards the actual induction of Strongylosis by the administration of encysted metamorphosed *Trichostrongylus pergracilis* larvæ. It served to establish, however, that these larvæ can reach the cæca of the Grouse, attain their adult condition, and become sexually productive in the very short space of four days. It also demonstrated that the sudden invasion of the cæca by a large number of *Trichostrongylus pergracilis* produced so marked an effect upon the mucous membrane as to fill the cæca with blood.

In the second experiment the culture was much older, and contained encysted forms. The doses were repeated periodically, with the result that in the course of two and a half months the bird fell in weight from 17 ounces to $11\frac{3}{4}$ ounces. The cæcal droppings were as full of *Trichostrongylus pergracilis* ova as those of a bird suffering from Strongylosis, and the bird itself showed a similar condition of progressive weakness and emaciation. The mucous membrane of the cæca was covered with *Trichostrongylus pergracilis*, but no evidence of extravasation of blood into the lumen of the cæca was found on the death of the bird. Apparently that seen in the first case must have been associated in some way with the development of the parasite before reaching maturity.

These two experiments indicate in so far as such a limited number may, that this parasite in very large numbers has a marked pathogenic action upon Grouse, inducing loss of weight, progressive wasting, and in extreme cases, death.

Remedial measures.

If it be accepted that *Trichostrongylus pergracilis* is the primary and essential factor in the production of the common form of "Grouse Disease" remedial measures must be directed either to the destruction of the adult parasite within the bodies of the birds, or of the young forms during their stay outside the body.

The impracticability of the former of these two methods is obvious. The birds are unapproachable, and are spread over a very wide area. Vermifuges or antihelminthics are expensive and more or less poisonous substances, the dosage of which has to be carefully estimated and controlled. The problem therefore resolves itself into that of destroying the eggs and larvæ of the parasites during their existence outside the body of the bird.

The destruction of the eggs or embryos by surface dressing with cheap chemical substances would appear at first sight to be a hopeful line of action, but the occurrence of the cæcal droppings more or less all over the moor, and the enormous area requiring treatment, render the suggestion of any such method futile. Moreover, as we have shown, the larvæ after a brief period of development ascend the heather and can remain hidden in the crevices of the leaves, in a quiescent, invisible, and living state for a prolonged period. The only conditions that could be inimical to these—the infective forms—would be atmospheric conditions of marked severity, possibly a prolonged frost or a prolonged drought, or destruction of the infected heather by fire or cutting. The effect of extreme cold has been tested by subjecting the metamorphosed larvæ to freezing in the cold storage rooms at the Albert Dock for a period of a week. On being thawed out of the solid block of ice they were found quickly to regain their activity. Exposure to slow drying, on the other hand, under experimental conditions, results in the death of the encysted larvæ. Death from lack of moisture must be continually taking place on the moors, although there may often be, even at the hottest parts of the day, an insensible transpiration from the growing plant, sufficient to maintain the life of the larvæ by preventing desiccation. Burning and cutting appear to be the only practical means by which infected heather plants can be properly purged.

To any one unaccustomed to the moors it is a matter of astonishment to notice what might be described as the extraordinary insanitary condition of the Grouse's home. Nearly every square yard of moorland shows traces of fæcal deposits, and this fact when once appreciated forcibly directs attention to the unnatural over-population of the moors.

When one remembers that practically all Grouse are infected with *Trichostrongylus pergracilis*, and that from every dropping thousands of potential parasites normally emerge, it becomes evident that the greater the number of birds upon a given area the greater in turn must be the infecting capacity of the moor. But on most moors only a very small proportion of the heather is suitable for food for Grouse at certain times of the year,[1] and as the Grouse is a very heavy feeder it follows that the parts of the moor from which the food supply is derived are just those likely to be the most heavily contaminated with droppings.

The number of birds on a moor should be correlated, not with the size of the moor but with the extent of the suitable food area thereon. The amount of stock on a large moor may seem low proportionately to the whole area, but when estimated in proportion to the food area it may prove exceptionally high, and this means a high potential capacity for the production of *Strongylosis*, whilst the entrance of a few bacteria or

[1] *Vide* chap. xii. pp. 351 *et seq.*

protozoan parasites into the body may suffice to cause serious diseases owing to the rapid multiplication of the original germs. In helminthic infections, as we have shown, the parasite *does not* multiply inside the bird. Birds with few worms remain healthy. The progress of the disease is correlated with the actual number of parasites entering and surviving in the body. The more heavily infected the food, the more heavily infected does the bird become.

The following facts connected with the growth of the parasite outside the body of the Grouse emerged from the Inquiry, viz. :—(1) that moisture is necessary for the development of the egg; (2) that a minimal temperature of several degrees above freezing point is essential not only for the development of the egg, but also for the metamorphosis of the larva; (3) that the larva ascends the heather only after metamorphosis; (4) that the metamorphosed larvæ are not killed by extreme cold; (5) that they may be killed by extreme drought. These facts afford us some explanation of the disease being a fatal one in the spring months. During the summer months many of the cæcal droppings must be dried by the sun and wind shortly after they are passed, and the eggs thereby killed. The same agencies must also desiccate beyond revival a large number of the encysted larvæ upon the heather. During the winter months, however, this loss does not occur. Owing to the low temperature and continual wet the eggs remain in a living but quiescent condition. Even if an occasional spell of warmer weather occurs, and the eggs develop into embryos, it would be necessary that such period of high temperature should continue for at least a fortnight to enable these embryos to become converted into the active migrating larvæ. The result probably is that there accumulates upon the moors during the whole winter vast numbers of undeveloped eggs and unmetamorphosed embryos. The low temperature merely suspends their growth for the time being. At the spring-time the minimal temperature rises gradually to such a point as to allow the continuous development of the eggs and embryos to and throughout metamorphosis. The result is that at this period the accumulated result of fæcal contamination during the winter months presumably ascends the heather. The frequent rains and mists at this time give the larvæ ample opportunity to reach the topmost tips of the plant.

The rapid death of the eggs of *Trichostrongylus pergracilis* in fæces that have undergone temporary drying indicates that the drier the moor, the more efficacious will wind and sun prove as natural antagonists to "Grouse Disease." Again, as the infective forms of the parasite occur on the "food" heather, it is evident that the greater the amount of "food" heather in proportion to each bird, the less likely it is to become infected. As the periodical burning of heather not only increases eventually the area of food heather, but at the same time destroys in the only effective way known the living parasites upon the area of heather burned, the policy of heather burning, advocated by the Committee upon other grounds, receives additional support.

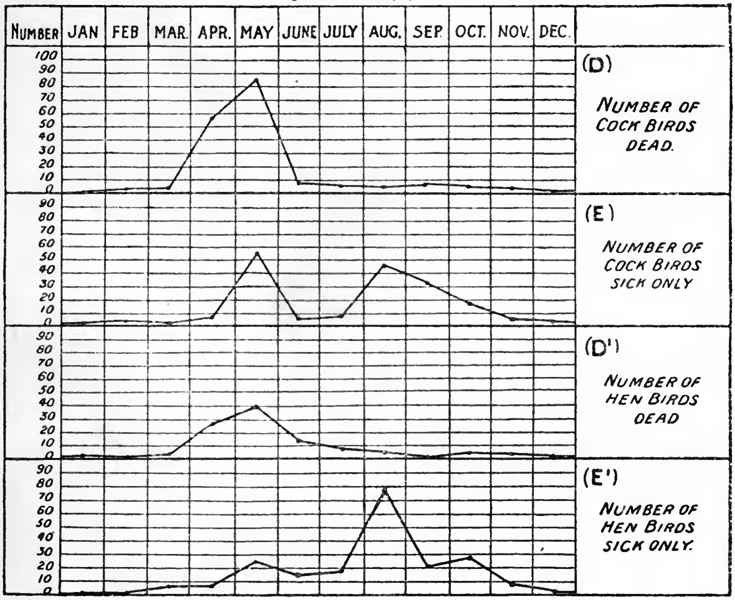
The practicability and value of a periodical cutting of the heather requires further consideration by those acquainted with local conditions; but, if practicable, such a measure should not only be a means of ridding large areas of the moor of infective material, and of bringing about a rapid increase in the "food" heather area, but might also be applicable to those parts of a moor and in those seasons of the year when burning is impossible.

Part III.—Incidence of Infection.

It is necessary to emphasise the fact that Strongylosis is essentially a spring disease, for hitherto the view has been held that this form of Grouse Disease mortality occurs both in the spring and in the autumn with a break between. The mistake arises from incomplete observation of the facts.

Owing to the natural objection to the disturbance of the moor in the breeding season the majority of gamekeepers make a point of never searching the ground for dead or sickly birds between the month of May when the early broods are hatched, and the end of July when the dogs are taken out to make a survey of the shooting prospects. Consequently, no diseased birds are found during that period even though they may be dying in hundreds, and by an optimistic method of reasoning it is assumed that because no disease is observed no disease exists. Conversely from the intimate knowledge of the moor

TABLE VI SHEWING THE FALLACY OF THE AUTUMN OUTBREAK OF DISEASE



after August 12th, undue importance has been attached to this idea of autumn disease owing to a certain number of sickly birds being found in the August and September bags—birds which would otherwise have escaped notice altogether, but which were shot in the day's sport and afterwards picked out as "piners."

The point is brought out in Table VI. which shows the number of dead or pining birds sent to the Committee for examination during a single year. It will be seen from Chart (D) that whereas no dead cocks were found in January, and very few in February and March, the number in April rose suddenly to over fifty, and in May to over eighty. This was followed by a sudden drop in June to less than ten birds, and from that time forward only occasional specimens were received. The fact that there was no increase in the number of victims in August when the moors once more came under observation, proves conclusively that mortality had practically come to an end by that date. It is probable that the sudden drop in the number of specimens shown for the month of June, would not have been quite so marked were it not for the practice, already mentioned, of avoiding all disturbance of the ground at this critical period.

On turning to Chart (E) we find that few, if any, sick and pining birds were found in the first three months of the year, but that in April they begin to be noted, and in May the numbers rise to over fifty ; doubtless the numbers both in April and May might have been larger were it not that at a time when dead birds were to be found correspondents preferred to send them in preference to those which were merely sickly. It must also be remembered that a live bird is more difficult to catch than a dead one, and this fact doubtless accounts for more specimens being procured in May when presumably they had become weak, than in April when they were still strong enough to evade suspicion and to elude capture. We may assume, therefore, that both in April and May the number of sick birds is very much larger than would appear from the specimens actually sent up for examination ; indeed, we may go so far as to say that the numbers of Grouse that die in an ordinary season is trivial compared to those that are sick and do not die. Once this point is established we have an answer to the question so frequently asked : " When once a Grouse is attacked by disease has he a chance of recovery, or is he doomed to succumb sooner or later ? " A further examination of the evidence furnished by the Charts aids us to an answer.

Returning, then, to Chart (E) we find that in June and July practically no sick birds are found; but here, again, we must not be misled, the moor is little visited in these months, and any infected birds there may be are now beginning to recover, and have so far shaken off the evil effects of the spring outbreak as to regain the power of flight. It is not until shooting commences in August that piners again begin to come into evidence; birds that appear to be healthy and strong when on the wing are found when handled to be in poor condition.

Weight as an indication of disease.

It is by no means a rare thing to find hens weighing 14 and 15 ounces still capable of flight. Often such birds are shot and afterwards picked out of the bag as "piners" to be examined and condemned as cases of disease.

The appearances of ill-health are generally abundant. To begin with, the bird is undersized, the bones are found to be unusually small in their measurements and slight in their structure, suggesting that the bird was bred late in the previous year. This gives it a bad beginning, and means that the bird, lacking strength, suffered more than the early bred birds during the previous winter months. If the bird is a hen, it will be evident from the naked skin of the abdomen, from the delayed moult of the feathers of the upper parts, and from the almost featherless condition of the legs and feet, that a long and exhausting period of incubation has been endured, followed by a period of incessant watchfulness while the young brood required protection. Often enough a hen "piner" in this condition appears to have suffered from no more definite disease than over-sitting, demonstrating that this is in itself a sufficient cause of extreme emaciation.

Then, again, it may be found that the bird is overloaded with parasites. These, if the case is a true "piner," will be abundant within and without. The feathers are often alive with *Nirmus* and *Goniodes*, the small flat bird-lice, and the head of the bird may be dotted, especially round the eyes and ears, with ticks (*Ixodes*). The presence of *Ornithomyia*, the Grouse-fly, depends more upon the weather and season than on the condition of the host. Within, the duodenum will be occupied by a mass of

Hymenolepis (tapeworms), or *Trichosoma* (threadworms), or both; the main gut by a far more bulky mass of *Davainea* (tapeworms); and the cæca may be reddened from end to end by villous engorgement due to the irritating presence of thousands of *Trichostrongylus* (threadworms). In this state the bird is flushed and shot, and forwarded for a diagnosis.

And still one more perplexing item, namely, that scattered here and there amidst thousands of *Trichostrongylus* ova, in the contents of the intestine, are encysted spores of coccidia, showing that the bird may have lost weight in the height of the summer by excessive Coccidiosis, and yet have survived.

That these birds are recovering, and not dying, is proved by the fact that no fresh corpses are found, and gradually the piners become fewer as the period of convalescence proceeds, until in November and December there is not a sickly bird to be found on any moor. It follows that the common practice of ruthlessly killing down the stock in a disease year with a view to stamping out the disease is bad policy, for if the birds were allowed to live they would all recover their health before the end of the year.

Turning now to the hens we find from Chart (D′) that April and May are again the months of highest mortality. It is true that the death roll is not so heavy as in the case of the cocks, and this is quite in accordance with the experience of gamekeepers and naturalists by whom it is almost invariably observed that, in the spring, cock Grouse die from disease in a much larger proportion than hens. On the other hand, it is frequently noted that hens continue to die after the cocks have recovered their health, and this is confirmed by the Chart, which shows that the recovery of the hens is slower. The fact is still more clearly shown in Chart (E′), which shows that in August a very considerable proportion of hens are still suffering severely from the after effects of the spring outbreak.

The difference in the liability to sickness of the cock and hen respectively is almost certainly due to the difference in the conditions affecting each sex.

Power of resistance

It may be assumed that both cocks and hens have the same opportunities for obtaining food, and that the quantity and quality of that food is the same for each, consequently each will be equally liable to infection by the Strongyle worm. Why then do the cocks die in larger numbers than the hens? Only one answer is possible, and that is, that whereas at this time the power of resistance of the cock is at its lowest, the power of resistance of the hen is at its highest. The fact is sufficiently proved by the comparison of the weights of the sexes, but if further confirmation be required it would be found in the fact that in June as the cock increases in weight so he becomes less liable to disease, whereas the hen, whose weight is on the downward grade, continues to suffer, and sometimes to die, throughout the summer months.

The fact that the average weight of the cock is slightly on the upward grade during the months of greatest mortality is somewhat misleading, until it be remembered that he is still far below his best condition, and was probably about his worst at the time when he first contracted the infection.

The reason why cocks do not die in September, nor hens in November, when their respective weights are again at their lowest, is obvious—mere loss of condition is not enough to cause death. It is only where this loss of condition is found in conjunction with a heavy infection of parasites that it becomes a source of serious danger.

The reason why the cock bird should be improving in condition in June, while the hen bird should be falling off, has already been discussed,[1] and it is only necessary here to repeat that in March and April the cock is subjected to the strain of breeding and moulting, and is recovering in May and June, whereas the hen does not begin to feel the corresponding strain until June and July. This probably also accounts for the fact that cocks die in larger numbers from "Grouse Disease" than hens, for at the time when the nematode infection is at its height the cock is more vulnerable than the hen.

[1] *Vide* chap. i. pp. 33 *et seq.*

Relation between disease and weight.

Although healthy Grouse are at a much lower ebb, as evidenced by their average weight, during certain months of the year than during others, Strongylosis does not necessarily kill them off at these seasons. It kills off the hens when they ought to be at their flood tide of health and vitality; and the cocks when they ought to be on a good rising average tide.

We have thus a paradox which may be stated in the following terms:—

More hens die of Strongylosis during April and May than in any other month of the year, notwithstanding the fact that the healthy hen is then at her best so far as weight, fat, and plumage go.

More cocks die of Strongylosis during April and May than in any other month of the year, notwithstanding that the healthy cock is then already recovering the weight which he lost during courtship, and is at a fair average and rising weight.

And although one might expect cock birds to die in March and September, when the average weight is at its lowest, this does not occur.

And whereas one might expect hen birds to die in June and July, or in November, when the average weight in health is at its lowest, this also does not occur.

In attempting to explain this paradox, it is necessary to recapitulate shortly the conditions which lead to an over-infection of the Grouse with the larval Strongylus.

Elsewhere it has been pointed out that, owing to the small proportion of heather which produces good food during the months of February, March, and April, all the birds upon a moor are forced to concentrate upon small areas of feeding ground.[1] Consequently there is a tendency for these small areas to become heavily infected with Strongyles even from the droppings of healthy birds. At first there are no evil results, for the eggs take some weeks to go through the necessary stages of metamorphosis without which they cannot become actively dangerous to the health of the bird.[2] Thus, even by

[1] *Vide* chap. iii. p. 90. [2] *Vide* p. 233.

the end of February and beginning of March, there is comparatively little mortality among Grouse.[1] As time goes on, however, the infection becomes more and more intensified, for not only do the larval nematodes assume their most active form, but those which have been eaten by the Grouse at the beginning of the period have had time to produce eggs in the intestine of their host, and these eggs are in turn distributed over the moor to add to the infection. The unhealthy conditions do not result in immediate mortality—it has been shown by experiment that the birds which have been fatally infected may not die for many weeks.[2] In some cases a severe infestment does not result in death.[3] Even in March the mortality has not reached its height,[4] for the majority of birds fatally infected in March will probably not die till April. The infection of the ground goes on with growing intensity, and if the same conditions were prolonged for another month or two it is possible that on the majority of moors hardly a bird would survive. Fortunately the advent of spring brings a blessed relief to the plague-stricken stock, and with the first appearance of new heather growth at the end of April and beginning of May the risk of new infection is past.

Thus it is that in April the infection reaches its climax, but the birds which die in April are probably the result of infection in March, whereas the birds infected in April die in May, even although the conditions have improved.

[1] *Vide* Table VI., p. 239.
[2] *Vide* p. 234.
[3] *Vide*, p. 240.
[4] *Vide* Table VI., p. 239.

CHAPTER IX

"GROUSE DISEASE"—*CONTINUED*—COCCIDIOSIS

REFERENCE has already been made to the circumstance that in certain years there is a mysterious disappearance of the young birds even though the old birds appear to be healthy, and the weather conditions ideal.

At first it appeared probable that this failure of the young stock was due to some climatic cause, such as wet or drought, or to the failure of some essential element in the food supply. As the subject was further investigated, however, it was seen that none of these explanations were satisfactory, and the matter remained in doubt until it was discovered that the mortality in question was the result of a definite disease which more particularly affected the young birds, and which had hitherto been overlooked.

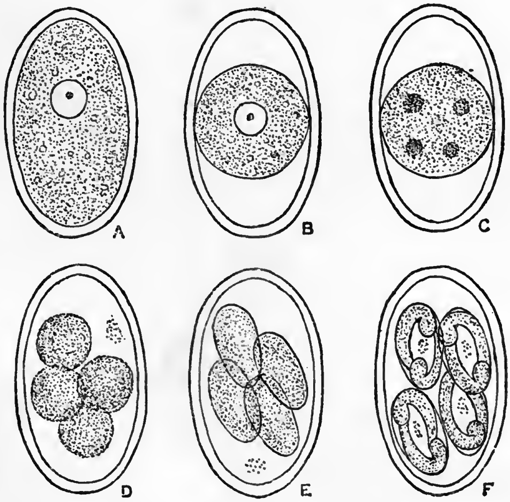
In the course of investigating Strongylosis in Grouse on the moors in May 1909, it was noticed that the cysts of a Coccidium —a minute animal parasite—often occurred in large numbers in the gut of Grouse chicks. These coccidian cysts are oval (*see* Fig. 35), and at first sight might easily be mistaken for eggs of worms, though they are somewhat smaller. The presence of the cysts was often associated with enteritis—in many cases with fatal results. The discovery suggested that Coccidiosis was a factor in "Grouse Disease," especially in young birds. It is true that the occurrence of coccidian cysts had been observed in adult Grouse at various times, but not in large numbers, and there is no evidence that their presence in adult birds is attended with fatal results in any but exceptional cases.

ccidiosis Grouse icks.

With a view to further investigation of this disease, Dr Fantham, in June 1909, spent some time upon a Grouse moor in Scotland, and the results of his researches there, and afterwards in the laboratory and experimental station, form the subject of the present chapter. The experimental results throughout have been carefully compared with those of natural Coccidiosis occurring in wild Grouse-chicks picked up on the moors each subsequent season.

The Coccidium found in the gut of the young Grouse is known

TEXT FIG. 35.



FIGS. A-F.

Stages in the development of the oöcysts of *Eimeria avium*, as seen in fresh preparations.

A. Cyst (more correctly oöcyst) with protoplasm completely filling it.
B. Older oöcyst with contents forming a central sphere. Many such cysts are found in infected cæca and infected fæces of Grouse.
C. Oöcyst with four nuclei, about to form young spores.
D. Oöcyst with four round spore masses.
E. Four ovoid spores (or sporocysts) within oöcyst.
F. Fully mature oöcyst with four spores, each containing two sporozoites.

The Coccidian oöcysts are about one-hundredth the size of a small grain of wheat.

to science as *Eimeria* (*Coccidium*) *avium*, and is a protozoal parasite invisible except under high powers of the microscope.

Coccidiosis has long been known as a disease of rabbits, and is often fatal, but the species of Coccidium which attacks rabbits is different from that which affects Grouse, for Grouse chicks into which the Coccidium of the rabbit has been artificially introduced, remain unharmed, and the cysts are merely passed out of the birds in their droppings. Occasionally Coccidiosis occurs as a disease in man.

The species of Coccidium which infects Grouse is also capable of infecting fowls, pigeons, turkeys, pheasants, sparrows, and canaries; indeed, it is probable that nearly all birds are liable to be attacked by this parasite. Amongst poultry farmers the disease is familiar under the name of "White Diarrhœa," one of the symptoms being the fluid condition of the excreta and the white colour given to them by the presence of millions of cysts—more correctly called oöcysts of the Protozoön. In turkeys the disease is often known as "blackhead."

history he cidium.

The life history of the Coccidium is extremely complicated, even though, unlike some parasites, the organism completes its development within one host. Its life-cycle is fully described and illustrated in the first edition of the Committee's Report, and it will be sufficient here to give a brief summary of the changes through which the parasite passes during the period when it remains within the Grouse. Reference may be made to the text-figure on p. 248, which gives a diagrammatic representation of these changes.

rozoites.

Beginning with the oöcyst, which is swallowed by the Grouse with its food or water, we find that each ripe oöcyst contains four sporocysts (Fig. 36, S) or spores, and each sporocyst contains two germs or sporozoites (Fig. 36, T). These germs are liberated by the action of the digestive juices (Fig. 36, A), and rapidly penetrate the delicate cells which form the lining of the gut (Fig. 36, B). In these cells the sporozoite rounds up (Fig. 36, C), and becomes a passive growing form or trophozoite (Fig. 36, D). After a period of rapid growth, during which time the trophozoite practically destroys the cell harbouring it, the parasite enters upon a multiplicative phase termed schizogony.

tipli- ve es.

The parasite at this stage is known as a schizont. The schizont is at first single (Fig. 36, D), but soon subdivides into a number of curved daughter forms arranged within the host-cell, like the segments of an orange (Fig. 36, E, F, G). These segments or daughter-germs are known as merozoites. The number of merozoites formed from a single schizont seems to vary; eight to fourteen are common numbers, but as many as twenty have been found.

The groups of merozoites now break up, and each free germ seeks out and enters an hitherto uninfected cell in the lining of the gut, and there each daughter-germ undergoes multiplication as before. Several generations of schizonts and merozoites are thus produced, each generation representing an enormous increase in the infection. When it is realised, that after passing through the multiplicative process four or five times, the original germ may be represented by many thousands of similar germs, it will be understood that they must exercise a very destructive effect upon the gut lining of the host, and this engenders the fatal illness in the young chick.

Sooner or later a limit is reached, both to the power of the Grouse chick to provide nourishment for the parasite and to the multiplicative capacity of the parasite itself, and when the circumstances become thus unfavourable to further multiplication, the parasite enters upon a new phase with a view to the perpetuation of its species, and produces forms capable of infecting fresh birds.

The schizonts now cease to develop into groups of merozoites, but instead slowly give rise to male and female organisms. The female organism, containing much food-material, is known as a macro-gametocyte (Fig. 36, I, ♀), and eventually gives rise to a single macrogamete (Fig. 36, J, ♀). The male parent cell, or micro-gametocyte (Fig. 36, I, ♂), multiplies, on the other hand (Fig. 36, J, ♂), and produces a number of small, active, male germs known as microgametes (Fig. 36, K, ♂). Sexual forms.

When the macrogamete or female parasite has attained its maximum development, it invests itself with a cyst wall, and often lies in the lining of the gut near the outer edge of the tissue. The minute but active microgametes or male germs meanwhile have broken away from their parent cells, and have swum out into the gut with rapid lashing movements of their

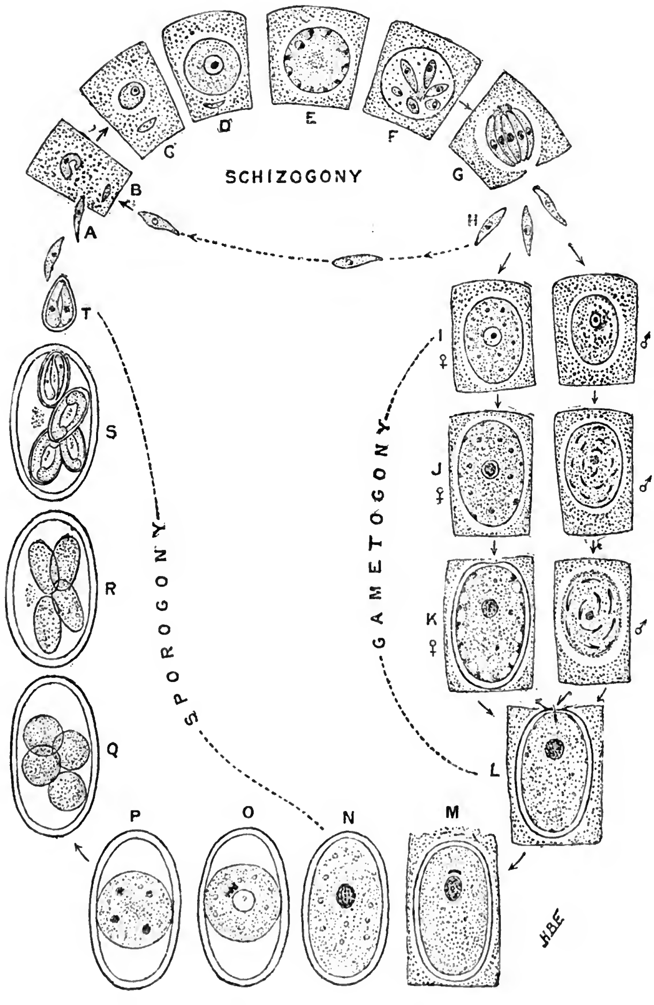


Fig. 36. Diagram of Life-cycle of *Eimeria* (*Coccidium*) *avium*.

D-H represent Schizogony or asexual multiplication. I-L, Gametogony or the formation of sexual forms. N-T, Sporogony or the formation of cysts and spores after fertilisation.

Epithelial cells lining the intestine of the Grouse are diagrammatically outlined.

Explanation of Text-Fig. 36.

A. Sporozoite or primary infecting germ, which penetrates an epithelial cell of the duodenum of the host.

B. Sporozoite curving on itself before becoming rounded within the host-cell.

C. Young, growing and feeding form, the trophozoite.

D. Fully grown trophozoite or uninucleate schizont, which is about to begin to divide.

E. Schizont or dividing form with numerous daughter nuclei arranged at the edge, beginning to form merozoites or daughter forms.

F. Schizont showing further differentiation of merozoites.

G. Merozoites arranged like the segments of an orange ("en barillet"), about to issue from host-cell. At one end of the cluster, residual protoplasm is seen.

H. Free merozoites, each of which can attack a fresh epithelial cell.

I. ♀. Young female mother cell or macro-gametocyte.

♂. Young male-parent cell or micro-gametocyte.

J. ♀. Macrogamete or female form with round nucleus and colourable granules distributed through its body substance.

♂. Micro-gametocyte (male-parent cell) with nucleus divided to form a large number of bent rod-like portions, the future microgametes or males.

K. ♀. Macrogamete or female, showing food granules, the colourable granules being largely used up in forming the wall with which the female has invested itself.

♂. Micro-gametocyte (male-parent cell) with many microgametes (males) about to separate from it.

L. Fertilisation. One microgamete (male) is penetrating the macrogamete (female), while other male cells are near the micropyle or pore but will be excluded.

M. Fertilisation. The male pronucleus which entered through a micropyle is lying above the female pronucleus. Degenerating microgametes (males) are shown outside the oöcyst.

N. Oöcyst (or cyst) with contents filling it completely. Nucleus in centre composed of fused male and female reproductive substance.

O. Oöcyst with contents concentrated, forming a central spherical mass which has a vacuole in the middle and the nucleus to one side. Many such cysts seen in infected cæcal droppings.

P. Oöcyst with four nuclei—beginning of division to form four spores.

Q. Oöcyst with contents segmented to form four rounded sporoblasts or young spores (as seen in fresh preparations).

R. Oöcyst with four sporoblasts (young spores) which have grown oval and are becoming sporocysts or mature spores; the small cystal residuum seen to one side.

S. Oöcyst with four sporocysts (spores) in each of which two sporozoites are differentiated. The oöcyst in this condition ultimately opens, liberating the sporocysts, the upper one of which is seen about to issue from the oöcyst. Slight cystal residuum. Sporal residuum in each sporocyst.

T. Sporocyst or spore which has issued from oöcyst. Two sporozoites or infecting germs are within it, and have assumed the position most suitable for emergence.

flagella. Here they are attracted towards the macrogametes, or female parasites, and commence to swarm round the aperture in the cyst wall of the latter (Fig. 36, L). Before long, one microgamete effects an entry, appears to bore its way into the female, and is finally lost to view. Such is the process of fertilisation as seen in the living organism. Then the aperture in the macrogamete closes up whereby the other microgametes are excluded, and the individuals thus shut out degenerate and die.

After the microgamete has reached the interior of the macrogamete, the male and female organisms become united, and eventually develop into a zygote or oöcyst (Fig. 36, N), which passes into the gut, and is ejected with the excrement of the Grouse. The oöcyst is often called, in short, a cyst.

cysts and res.

The further development of the oöcyst largely depends on climatic conditions. Under the influence of warmth and moisture its contents shrink away from the poles and become a rounded, central mass (Fig. 36, O). This mass rapidly divides into two, then four (Fig. 36, P); a wall is secreted round each, and thus, in time, four sporocysts (Fig. 36, R) are produced within the oöcyst. Inside each sporocyst or spore two sporozoites gradually develop (Fig. 36, S), and when the sporocyst (Fig. 36, T) is ingested by a Grouse, the sporozoites creep out of the sporocyst, which is softened by the digestive juices, and proceed to attack the lining of the gut, producing thereby the primary infection of the bird.

ration of -cycle.

A period of eight to ten days is required for a completion of the life-cycle of the Coccidium from the time it is swallowed by the Grouse till the new generation of cysts is deposited on the moor in the droppings of the Grouse. Eight days old Grouse chicks were the youngest naturally infected chicks that have been observed.

ects of cidiosis.

The effects of Coccidiosis on the Grouse may now be considered. As already stated the chief external evidence of Coccidiosis is the pale colour and great fluidity of the cæcal (soft) droppings of the bird, the pale tint being due to myriads of oöcysts, and the condition being that of diarrhœa. In good health the cæcal droppings are of firm consistency, and olive-green to brown in colour. When Coccidiosis is slight they become softer and brownish yellow, but in acute cases the excrement is almost fluid and the birds void sulphur-yellow fæces with a heavy fœtid odour. As the coccidian parasites cause great destruction of the lining of the intestine, digestive derangements are brought about, and consequent on this, malnutrition occurs, and the bird becomes very thin and anæmic.

The symptoms of Grouse suffering from natural Coccidiosis and those of Grouse, fowl-chicks, and pigeons, in which the disease has been artificially induced, are identical. The symptoms that have been noted in the case of the birds examined may now be stated. Symptoms.

Chicks after ingesting coccidian oöcysts become far less active in their movements as a rule. The first noticeable feature is the drooping of their wings, and a habit of constantly looking downwards. The birds stand about more than normal birds, and their call is more plaintive.

While fowl-chicks and pigeons appear to mope, their appetite is increased, and chicks experimentally infected with Coccidiosis eat far more greedily than the control birds. They also drink considerably more. In spite of the increase in the amount of food consumed, the birds rapidly get thinner, the muscles of the breast and legs showing this to a marked degree. Throughout the progress of the disease the growth of the affected birds is much retarded.

It was necessary to feed infected young pigeons by hand, for even when they reached practically adult life they failed to feed themselves, merely thrusting their heads into the food offered them, without attempting to swallow any of it.

Several breeds of fowl-chicks were used in experimental Coccidiosis, and each lost weight steadily till death occurred. The loss of weight of one pure bred Leghorn chick was very noticeable. It was first fed with coccidian oöcysts when six weeks old. It and its control bird were then of equal weights

(7½ oz.). Two months later the infected chick died, its weight at death being 5 oz., while the weight of its control on the same day was 22 oz.

Sample weights of other experimental birds are given below:—

Bird.	Weight of Infected Bird.	Weight of Control Bird.	Difference in Weights.	Remarks.
Grouse Chick A .	4 oz.	5½ oz.	1½ oz.	Dosed once when 11 days old.
Grouse Chick B .	4¼ oz.	7 oz.	2¾ oz.	Killed *in extremis* when aged 6 weeks.
Grouse Chick C .	6½ oz.	9 oz.	2½ oz.	Died, aged 10 weeks.
Minorca Hen . .	3 lb. 2 oz.	5 lb. 2 oz.	2 lb.	Died, aged 6 months.
Plymouth Rock Cock	4 lb. 8 oz.	6 lb. 5 oz.	1 lb. 13 oz.	Killed, at acute stage of disease.
Cross-bred Leghorn .	4 lb. 10 oz.	5 lb. 4 oz.	10 oz.	Chronic.
Pigeon . . .	9½ oz.	12 oz.	2½ oz.	Died, aged 11 weeks.

Note.—The three fowl chicks were first treated with coccidian oöcysts when aged three weeks. Another fowl chick fed with coccidian oöcysts when aged one day, died when nine days old. The pigeon squab was dosed first when aged nine days.

Another instance of loss of weight resultant on Coccidiosis was seen in the case of a pure bred female Leghorn chick, which was attacked when seven weeks old by Coccidiosis after drinking water fouled with coccidian oöcysts. This bird became a "chronic," and when adult weighed 67 oz., while its sister bird used as a control weighed 84 oz.

Besides loss of weight the infected birds become anæmic. The cere, comb, and wattles become much paler, and the blood-vessels beneath the wing also look pale. The head appendages gradually become more and more pale as the disease progresses, and finally acquire a peculiar bluish tint. This tint is shown also in the eyelids and ears, and the legs are affected, though to a less extent. The feathers on the head tend to fall off so that the fore part of the head and the region round the bill become almost bald, and the bird presents a very peculiar appearance, owing to the bluish coloration. Leg weakness is often present.

The plumage of the infected birds is affected in regions other than the head, and the quills are less rigid than in normal birds. The feathering of the legs is ragged, and the sheen on the neck and tail-coverts is not so well developed, while the replacement of nestling-down by ordinary feathers is much retarded.

During the progress of Coccidiosis the birds sometimes develop much mucus, and a very offensive " breath," a smell of sulphuretted hydrogen being noticeable. Both sticky mucus and smell disappear as a rule in a few days, but may recur.

A day or so before the death of the infected bird the slimy, mucilaginous discharge recommences, oozing from the beak, nares, ears, and eyes. Examination of this liquid by the microscope shows the presence of oval coccidian oöcysts. The ooze from the eyes and beak chiefly contains oöcysts which may be due to regurgitation from the crop just before death. However, it should be noted that while mucous discharge is common, it is not an invariable feature of Coccidiosis. Oöcysts are occasionally present in the crop and gizzard, mixed with crushed food, having probably been taken up with the food.

Death from Coccidiosis appears to be sudden. Some of the experimental fowl chicks were feeding greedily an hour before death, though death was almost expected from the great emaciation and " bluish " appearance of the birds for some days previous to the actual decease.

Detailed examination of the internal organs of diseased birds shows that Coccidiosis is confined chiefly to the main digestive tract, and so is unlike the Coccidiosis of the rabbit where the liver as well as the gut may be affected. Effects on internal organs.

Death of the young Grouse may occur owing to heavy infection in the duodenum, whereby almost the entire lining of this part of the gut may be destroyed by the action of the parasite. In many cases, however, some of the merozoites pass along the intestine and reach the cæca, the tissues of which are similarly invaded and mutilated. The exact shape and size of the oöcyst is determined by the space in the cell available for the development of the macrogamete and by the numbers of the parasite present. Where many parasites are aggregated together in a limited area the macrogametes and oöcysts are small, while in areas of the gut which are but slightly parasitised large oöcysts preponderate. Nutrition of the parasite has obviously a great influence on both its size and its propagative power.

In some cases the gut-wall becomes extremely thin and tender; in other birds this is not so marked. Inflammatory patches may be seen at intervals, particularly in the cæca, and the cæca are usually enlarged.

The main intestine of chicks infected with Coccidiosis sometimes shows inflammatory patches, and blood may be present in the rectal contents. The rectum itself is rarely attacked, though its contents usually contain oöcysts.

The kidneys, spleen, liver, and gall-bladder of the infected birds examined have not been found to contain Coccidia, though the liver and gall-bladder are sometimes enlarged.

Examination of the generative organs has shown no trace of the parasite, though it is possible that eggs may become contaminated during their passage through the cloaca of the mother. The young chicks then might be hatched in contact with infected material, and so acquire Coccidiosis early in life.

Effect on the blood.

A reflex of Coccidiosis is seen in the blood of infected Grouse. Besides becoming anæmic, there is an alteration in the relative numbers of the blood corpuscles, infected birds showing an increase in the number of polymorphonuclear leucocytes.

Coccidia and bacteria.

It has already been shown that many bacteria are naturally present, mixed with the contents of the gut even of healthy Grouse, and it might be thought that these bacteria would have a harmful effect on the bird if they gained access to other parts of its system. It has been proved that these bacteria may be introduced into the tissues of the gut through the agency of the Coccidium, the sporozoites, and merozoites acting, in fact, as inoculating needles. Thus, the injurious bacteria may, by way of the blood and lymph, reach other organs. The agency of parasitic worms and Coccidia, as a means of inoculation of harmful bacteria, is of far-reaching importance, and probably of wide application in the elucidation of certain intestinal diseases.

While observation seems to indicate that intestinal Coccidiosis may so injure the gut that bacteria are allowed to pass into the circulation, it is not suggested that "Grouse Disease" is essentially an infection with these bacteria. The direct effect of the parasite is alone quite sufficient to produce fatal results.

Coccidiosis duodenal and cæcal.

Probably Coccidiosis set up in the duodenal wall is sufficient to kill very young chicks, *e.g.*, chicks eight to ten days old, while older chicks dying at the age of about four to six weeks may have partially recovered from duodenal Coccidiosis, but succumb to Coccidiosis in the cæcum (typhlitic Coccidiosis). In cases of intense duodenal Coccidiosis, merozoites are found free in the intestinal contents, and even in freshly shed fæces.

The onset of sporogony of the Coccidium (*Eimeria avium*) means, as a rule, either the recovery or the death of the infected chick. When the oöcysts pass out from the body of the host, the epithelium of the gut may be able to regenerate itself, and the bird gradually increases in weight, and makes partial or entire recovery. This recovery is sometimes aided by infiltration of connective tissue into the lesions. If, however, the infection has been heavy, the epithelium cannot regenerate itself, and the bird becomes exhausted and dies.

Susceptibility of Grouse of various ages.

Young chicks are far more susceptible to Coccidiosis than adult birds. Very young fowl chicks (up to eight days old) die in a few days after being fed with coccidian oöcysts. Chicks first dosed with cysts when fourteen days old do not succumb so readily; they may live for some weeks, or some may become chronics, when daily examination of their fæces shows periodic small crops of oöcysts.

Older chicks are more likely to recover from Coccidiosis. For example, a Grouse chick aged thirteen weeks was fed on oöcysts, and when killed three weeks later very few Coccidia were observed. A young Grouse was picked up dead on the moors in Inverness-shire and was received on September 15th,

1909. In its cæca numbers of both coccidian oöcysts and *Trichostrongylus pergracilis* were found. The bird had probably survived an attack of Coccidiosis, and in its weakened condition had fallen a victim to Strongylosis. Several other birds in a similar condition were examined in September 1911.

Though Coccidiosis is peculiarly fatal to Grouse chicks during the first few weeks of their lives, adult Grouse also can become infected, for an adult bird has been examined that probably died of Coccidiosis. Old birds in the chronic condition serve as reservoirs of oöcysts, and so may form sources of new infections on the moors.

Coccidiosis outbreaks spread with fair rapidity, but though many birds in one locality may become diseased, adjoining districts may be free. Epizoötics of Coccidiosis also disappear very quickly, the disappearance often coinciding with a change of weather.

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Infection has been shown experimentally to be due to the ingestion of oöcysts (cysts), either by way of the food or drink. Coccidian cysts undoubtedly occur on the heather, and in the tarns and pools from which the Grouse drink.

The soft droppings of infected chicks are heavily loaded with cysts, and not only do they foul the ground, heather and water in their vicinity, but, when dried, the powdery material produced is disseminated by the wind, and thus oöcysts and their contained sporocysts are scattered over comparatively large tracts of country. Such cysts may remain infective from season to season.

Other methods of producing local infections may be due to insects. The agency of insects, both larval and adult, such as dung-flies, has been observed in nature, and demonstrated experimentally.

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oöcysts.

The conditions most favourable to the coccidian cyst, and the duration of its vitality on the open moor, are two points of the greatest practical importance, for without some knowledge on these subjects it is impossible to suggest any preventive measures. Some of these conditions may now be considered:—

(a) *When the Oöcysts are kept in Water or very moist.*

Much moisture is present on many moors, and droppings of infected chicks contain coccidian spores which not only get washed into the soil, but also into the pools, springs, and tarns, at which Grouse drink. It is, therefore, of some importance to determine the time required for the death of the resistant spores of the parasite in water.

Coccidian oöcysts were placed in water, kept at about 20 degrees C., the water being replaced as required, to avoid evaporation effects. Ordinarily, the oöcysts develop sporocysts or spores very rapidly—in two to three days. In the case of cysts kept in water, nine days elapsed before much change was noted. At the end of that period, a few oöcysts showed some development, and still fewer showed four sporocysts. Two days later many more oöcysts contained four sporocysts, and this progressive development continued for some days. Few signs of decay were seen until about the fortieth day, when some showed signs of gas bubbles in their interiors. Others, however, had completed their development, and their four sporocysts, apparently unharmed, were set free into the liquid. By the fiftieth day practically all the oöcysts had either matured or decayed, and the sporocysts had begun to die.

From the above experiment, the conclusion is that the development of oöcysts and sporocysts is delayed by the presence of much moisture, but that the power of infection is retained for a long time.

Very damp air has similar effects.

These observations are borne out by observations in the field; a moist spring is seldom associated with serious loss of young birds unless the rainfall is sufficiently heavy to cause extensive drowning.

(b) *When Fæces are merely kept and allowed to dry on the outside.*

When freshly voided soft droppings of Grouse containing coccidian oöcysts are allowed to dry, the oöcysts in the surface layers rapidly develop sporocysts, the inner ones remaining unaffected.

It has been proved experimentally that soft droppings kept *en masse* in covered dishes for as long as twelve months [1] have retained the power of infecting birds. Such material contains undeveloped oöcysts within, while its outer layers mainly contain oöcysts with four sporocysts.

(c) *Development under Different Conditions of Temperature.*

It was found that when the coccidian cysts were transferred from a chamber, kept at 15 degrees C. to a temperature of 10 degrees C. the effect was to delay all further development for a considerable time. Smaller changes of temperature also arrested the development of sporocysts, though the effect naturally was not so marked.

Changes of temperature and moisture on the moors might result in the occurrence of occasional outbreaks of disease after the first attack had passed off. Moisture and coolness would retard the development of certain oöcysts for a considerable time, during which period the disease would disappear. A return of conditions favourable to the Coccidium then ensues, rapid development of sporocysts occurs, and a fresh outbreak of disease is initiated.[2]

Unfortunately, it is difficult to follow the course of the disease under natural conditions on the moors; the greatest mortality occurs among very small chicks, and the dead bodies are rarely found. It might be possible for nearly every Grouse chick on a moor to die without the owner or his gamekeepers being aware of the fact. In such cases it is only when the stock is inspected in July and early in August that it is discovered that there is a scarcity of young birds. It is significant that one of the causes most commonly given is drought, *i.e.*, that a long period of hot, dry weather in May and June has

[1] Further experiments have shown that some coccidian oöcysts can retain their vitality for two years.

[2] It is possible that the second outbreak of the disease will not be so fatal as the earlier one, owing to the increased age of the birds.

caused the birds to die from want of water. We now know that young Grouse chicks seldom, if ever, die of thirst,[1] whereas we also know that dry heat is not unfavourable to the development of the oöcysts.

Effects of climatic variation the moor

Having ascertained by experiment that moisture and cold had a retarding effect upon the development of the coccidian cysts, and that dry heat appeared to assist it, it became necessary to learn whether the variations of climatic conditions on the moors produced similar results as shown by the mortality observed among the young stock.

In this stage of the investigation it was found that the reports of the Committee's local correspondents for the years 1906, 1907, and 1908 were of the greatest value.[2]

These reports are rather difficult to interpret, owing to the fact that in some cases the stocks suffered heavily from Strongylosis among the adult birds, and drowning among the chicks, thus causing a reduction in numbers which could in no way be connected with Coccidiosis. One or two points, however, are significant. In the first place, in the years 1906 and 1907, though the nesting and hatching seasons were everywhere very wet and cold, and there was a heavy loss of chicks from drowning, there is nothing to indicate that the young stock was affected by disease of any kind, and as a whole they appear to have survived in greater numbers than was then expected. In 1908, on the other hand, when the spring and summer were exceptionally warm and dry, and no young birds were reported as drowned, many observers noted a disappearance of the young Grouse for which they could not account.

After 1908 the annual reports were discontinued, but the year 1911 was marked by such an exceptional drought that an additional report was obtained for that year with a view to the further elucidation of the subject. The answers received from one hundred and forty correspondents, while unexpected in some respects, went far to establish the hypotheses based on experiment. There was no universal outbreak of

[1] *Vide* chap. iii. p. 105. [2] *See* pp. 273 *et seq.*

Coccidiosis, and in the majority of districts the stocks were far above the average both in numbers and health. It is, however, interesting to note that on the moors where mortality did occur, it was much more marked in the case of chicks than in the case of mature birds, and in many districts the mortality occurred among the chicks only—a most exceptional occurrence, and one which indicated the probability of coccidian infection.

An abstract of the whole reports is given in another chapter[1] and it is sufficient to give here the following summary of the reports for the year 1911 :—

Number of cases where there was no mortality either among the old birds or the chicks .	71
Number of cases where there was mortality both among the old and young Grouse . .	14
Note.—In nearly all cases it was reported that a larger proportion of young birds died than of old birds.	
Number of cases where there was mortality among old birds only	10
Number of cases where there was mortality among young birds only	35
Number of cases where observations on this point were unreliable	10
	140

The majority of the correspondents stated emphatically that the young birds had died of drought, obviously an untenable hypothesis, for if drought had been the cause of death the mortality would have been distributed throughout the whole Grouse moors in the country. This was far from being the case, for the majority of the moors, including many badly watered ones, were well stocked with young birds, while mortality was especially severe on some of the best watered ground. One observer drew attention to the fact that whole coveys of chicks were found dead close to the edge of streams and drinking pools.

[1] *See* p. 302.

The principal known sources of coccidian infection are :— Sources of coccidian infection.

(i.) Cysts may remain on the moors from previous outbreaks, and retain their infectivity till the next season.

(ii.) Some birds may largely recover from an early attack of Coccidiosis but become chronics, harbouring oöcysts and thus acting as reservoirs and carriers of infection.

In view of the fact that the commonest cause of outbreaks of Strongylosis is the congestion of a large number of Grouse upon a smaller area of moor than can carry them with safety, it was only natural that the Committee should suspect that overcrowding might similarly be a contributory cause of Coccidiosis. The reports seem to support this view, for of fourteen moors which had high mortality among chicks, no fewer than eleven were reported as having more than an average stock left over from 1910. Of thirty-five moors where the mortality among chicks was slight, twelve were reported as heavily stocked, four as lightly stocked. Of seventy-one moors where no mortality among chicks was observed, twenty-seven were heavily stocked, eleven were lightly stocked, and thirty-three carried an average stock. For comparison the results of the reports may be arranged in tabular form as follows :— Overcrowding.

Table showing Percentage of Mortality among Grouse Chicks during the Summer of 1911, in Relation to Stock left over from 1910.

	Number of moors affected.	Number of moors heavily stocked.	Percentage of heavily stocked moors.	Number of moors with average stock.	Percentage of moors with average stock.	Number of moors lightly stocked.	Percentage of moors with light stock.
Heavy Mortality	14	11	68	3	32	0	0
Slight Mortality	35	12	34·3	19	54·3	4	11·4
No Mortality .	71	27	39	33	45·5	11	15·5
Total for all moors reported on .	120	50	41·6	55	45·8	15	12·5

It is significant that not one moor with a stock below the average had high mortality among chicks, whereas nearly three-fourths of the moors which were understocked were absolutely healthy.

These figures seem to imply that overcrowding is a contributory cause of Coccidiosis; but there must be many other factors which combine to influence the distribution of the disease, for it will be seen from the table that many moors were very heavily stocked and yet remained perfectly healthy.

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Considering Coccidiosis as the chief cause of high mortality among Grouse chicks the evidence of the reports for 1906, 1907, 1908, and 1911, may be briefly summarised as follows :—

1. In wet, cold seasons Coccidiosis probably rarely occurs.
2. In hot, dry seasons Coccidiosis is more frequently observed.
3. Its intensity appears to be but little affected by the water supply on the moor.
4. When the drought is universal, as in 1911, Coccidiosis is not universal.
5. High mortality in chicks then is not caused by heat and drought, but when the coccidian infection is present heat and drought seem to assist the development of the disease.
6. A heavy stock of birds appears to be one of the contributory causes of infection.

Other deductions might be made from the reports which might lead to further elucidation of the subject, and one or two special features reported from individual moors might also throw light upon the nature and effects of the disease.[1] For example, on one moor where the outbreak was particularly severe the young chicks died in large numbers at a few weeks old, the survivors then seemed to make a partial recovery, but about July they again commenced to die, and continued to do so till late into September. On examination, it was found that the

[1] *See* also pp. 302-303.

second series of deaths was due to Strongylosis and not Coccidiosis, though in every case the victims showed traces of an earlier infection of Coccidiosis. The case is remarkable, for it is now established that Strongylosis is essentially a spring disease, and it is very exceptional for birds to contract it after the month of May.[1] It would appear that Coccidiosis had so weakened the birds as to make the survivors particularly vulnerable to the other form of disease.

Certain experiments have been made with a view to finding a means of destroying the coccidian cysts on the moor without killing other forms of life.

Destruction of oöcysts on the moor.

This is not an easy matter, for while it is relatively easy to take preventive measures in the case of Coccidiosis in fowls, it is most difficult to take active measures in the case of Grouse.

By heather-burning.

The remedy of heather-burning is efficacious to some extent, for the coccidian spores which are present in the tract burned are then destroyed, but as the heather most likely to be infected is probably that growing on the best feeding ground the immediate result of burning would be the reduction of the food supply of the moor, not only for the year in which the burning is carried out, but for several years thereafter. Another practical objection to this remedy is the difficulty of knowing which areas of the moor are most seriously infected with the coccidian spores, and lastly, heather-burning is forbidden by the law of Scotland at the time of the year when coccidian infection is most dangerous. As a remedy against an existing outbreak, therefore, heather-burning is of little value, but as a preventive measure a course of systematic burning is to be recommended. Any condition tending to raise the general vitality of the birds makes them much more resistant to disease. An abundant supply of healthy young heather, by raising the general standard of health of the birds, is probably one of the best safeguards against the insidious disease, Coccidiosis.

Another advantage of providing a good supply of young

[1] *Cf.* pp. 180, 238.

heather is that the stock will be better distributed over the moor, and there will be less danger of their crowding into small feeding areas and fouling the ground.

No other method than heather-burning has yet been devised for the destruction of the coccidian cysts as they lie upon the moor, although many strong chemical substances may destroy the oöcysts, their application to Grouse moors is not practicable.

The following is a summary of the effects of certain reagents :—

Action of chemicals on oöcysts.

Salt produces plasmolysis in time; but the process is rather slow, and the salt is too readily dissolved in dew and rain, and so merely soaks into the soil.

Quicklime destroys the oöcysts and sporocysts. It also causes the fæces to cake, thereby preventing scattering of the spores. It is somewhat doubtful whether lime could be applied on a large scale. Where the area of infection is small, as in rearing pens, the application of lime to the soil is of service. Small quantities of lime dressing are not detrimental to heather.

Gas Lime and *Slaked Lime* also are useful, but each is open to the same objection as quicklime. Lime in one form or another certainly seems to have the best and most rapid action on coccidian oöcysts of any reagent that has been tried.

Salicylates.—Salicylic acid and sodium salicylate act rather slowly on coccidian oöcysts. Fæces mixed with them remain fluid for a longer period than they otherwise would. The oöcysts become wrinkled and ultimately destroyed, but the contents take longer to degenerate than when lime is used.

Ferrous Sulphate.—Copperas or green vitriol is useful to some extent in destroying coccidian oöcysts, but like salicylates it is somewhat slow in action. A dusting of ferrous sulphate on the moors would probably be beneficial, for the iron present in combination might be taken up in small quantities by Grouse and, by acting as a general tonic, might better enable the birds to resist Coccidiosis if they became attacked. Ferrous sulphate in the proportion of 10 grains to the gallon of drinking-water has been found of service in the treatment of Coccidiosis in young fowls and young pheasants.

Sodium Nitrate.—Nitrate of soda mixed with fæces destroyed the contents of the oöcysts after some time, but the length of time required for its effective application would militate against its use on a large scale.

In one series of experiments, three portions of infected fæces were mixed with equal quantities of lime, sodium salicylate, and ferrous sulphate respectively, and were kept in open dishes, exposed to the action of the weather. The results obtained may be shortly given.

In the case of *Lime*, the fæces rapidly formed a caked mass. In a fortnight the oöcysts were shrunken and wrinkled, and some showed cracks. At the end of three weeks the cysts were more broken up and the contents largely disintegrating, while after a lapse of two months there was a difficulty in finding spores at all. Bacteria were not found after lime treatment, and there was only a slight fæcal odour noticed.

Sodium Salicylate added to fæces rapidly deliquesced, in fact the mixture was quite liquid in less than three hours. After a fortnight's interval the cysts appeared to be slightly shrunken, while fæcal odour was noticeable. A month later, the oöcysts were more shrunken, and a few free sporocysts were found, while ten weeks after treatment a slight smell was perceptible, and the oöcysts present were shrunken and showed oily contents.

Ferrous Sulphate (copperas) had much the same effect as sodium salicylate, but did not deliquesce. Though its action at first seemed to be rather less effective, it secured the same result ultimately.

Preventive measures.

It may be of interest and importance to give a description of various preventive measures which have come under observation in addition to the measures already mentioned. These preventive measures relate especially to fowls and pheasants, but should the hand-rearing of Grouse ever assume large proportions, then such measures might be applied directly thereto.

Recalling the old saw that " Prevention is better than cure," the following points may be kept in view :—

All corpses of Grouse or Grouse chicks infected with Coccidiosis should be burned, not buried. It may be pointed out that every buried diseased bird is a new source of infection, and the polluted soil is distributed in many and unseen ways by earthworms, the round worms of the soil, carnivorous beetles, moles, etc., so that the infection can be extended over a much wider area than was originally the case.

In regard to pheasantries in which havoc has been wrought by Coccidiosis, it is as well to consider the direction of the prevailing winds, and to place the new rearing pens in such a position that they are not wind-swept from the infected and fouled areas. This is not an easy matter in many instances, but should be observed wherever possible.

In the case of birds kept entirely or partially under domesticated conditions (*e.g.*, fowls, hand-reared Pheasants, Grouse in captivity), great care should be taken to burn all droppings and to prevent fouling of food and drink as far as possible. This can be achieved to a considerable extent by providing movable boards on which food and drink can be placed. These feeding boards should be frequently cleansed and scrubbed. All food débris should be burned. The pens should be so constructed that easy cleansing can be done daily. Lime-washing of all coops, breeding-places, perches, etc., at least once a week is desirable. Wherever possible, healthy birds should be taken off the infected areas, and their coops, etc., placed in new positions, as remote as possible from the former ones. The fouled soil should then be thickly treated with quicklime, which, after an interval of about a week, should be well dug into the soil, the latter being turned to a depth of at least 1½ feet. No birds should be raised on this land for at least a year. Where the infected run is relatively small, the top soil can be taken off to a depth of 3 or 4 inches and then burned. Even after this treatment it is advisable to lime the soil.

It is useless to remove *heavily* infected stock to fresh places, for it is far better to destroy such birds and to place healthy stock on fresh, unpolluted grounds. All other suspected birds should be isolated, and careful examination made of their excrement. In the case of epizoötics among fowl-chicks, an example recently occurred where over fifty birds died in a very short time of undoubted Coccidiosis. Tracing the history of the remainder it was found that they had come from broods reared by handsome hens obtained from an estate where there had been heavy mortality from Coccidiosis during the previous year. The mothers and foster-mothers were all carefully isolated, and examination made of their fæces from day to day. In a very few days two fine hens were discovered whose dejecta showed daily crops of oöcysts of *Eimeria* (*Coccidium*) *avium*; there is little doubt that these two birds had become chronics, and that their excrement had fouled the large grass run, and was the source of the trouble among the young birds. It may be added that washings of the grass and clover in the run also yielded the oöcysts of the parasite when examined microscopically.

The importance of considering the possible infection of foster-mothers in pheasant-rearing is already recognised.

Fowls and turkeys should never be reared on grounds where much mortality from "white diarrhœa" or "blackhead" has been known to occur. If the original occupants of the land were turkeys, the oöcysts of *Eimeria avium* producing "blackhead" are certain to be present in the soil, and when taken up with grit, food, or drink by fowls, produce the Coccidiosis popularly known as "white diarrhœa," especially in young birds. Conversely, fowls can be the source of infection of turkeys. Pigeons feeding in infected fowl-yards themselves become infected, and whole cotes have been wiped out by Coccidiosis thus acquired.

Where valuable poultry are kept in wired runs it is well to provide in addition an overhead wire or net covering. Not only pigeons, but sparrows, visit poultry yards, etc., for food, and there take up coccidian cysts which, voided elsewhere in their droppings, serve as new sources of infection. The damage thus done by sparrows, in their wanderings and flights, as agents in the spread of disease can be easily inferred. The access of such birds to infected spots should be prevented as far as possible.

Should incubators be used for hatching chicks, these should be carefully disinfected a few days previous to their use, care being taken that no fumes are apparent when the eggs are introduced. The eggs themselves, whether for natural or artificial incubation, should be wiped with some disinfectant solution—90 to 95 parts of alcohol (or strong methylated spirit) with 10 or 5 parts of water respectively can be used for this purpose.

Treatment.

As Coccidiosis is nearly always accompanied by anæmia, it has been found that a little *ferrous sulphate* dissolved in the drinking-water given to infected birds is of service, its tonic action helping them to make a better resistance against the disease.[1]

The following method of direct treatment of Coccidiosis has been successful in the case of hand-reared fowls, Grouse, pigeons, hand-reared pheasants, and canaries. At two large poultry farms, where serious outbreaks of Coccidiosis occurred, the owners also tried the treatment detailed below, with uniform success.

When Coccidiosis was discovered by the presence of cysts in the droppings, the infected birds were supplied with drinking water in which crude *catechu* was dissolved — 10 to 15 grains of catechu being dissolved in a gallon of water. The solution so obtained was of a deep sherry or old ale colour. It should be noted that the catechu solution always darkens on keeping; but this does not affect its curative properties to any extent. The fowl chicks, pheasants, etc., were given this strength of solution

[1] *Vide*, p. 266.

for ten to fourteen days, and if the voiding of oöcysts had then entirely ceased for several days the dosing was discontinued. If, on the other hand, passage of oöcysts continued during the ten days of treatment, though steady decrease in their numbers occurred, the birds were then given water containing 5 to 8 grains of catechu per gallon for a further period, until practically no oöcysts were found in their fæces. Usually the first treatment, with the stronger dose, was sufficient. The birds showed no dislike of the catechu-water, but drank it readily.

In very severe cases, treated late, as much as 20 grains of catechu per gallon of water have been administered; but, as a rule, this strength is too great, and causes the birds to become constipated.

Although the objection might be raised that catechu is merely an astringent, yet the great success of the treatment up to the present justifies it being brought to the notice of those interested in the breeding and raising of game-birds and poultry.

In the earliest experiments, ten fowl-chicks, aged fourteen days, infected with Coccidiosis, were all cured, while twelve pullets suffering from a mixed infection of Coccidiosis and worms were also satisfactorily treated. From experience gained with these cases, further experiments were made with the following results:—

At a large farm in Cambridgeshire, where some three hundred head of poultry are kept, an outbreak of Coccidiosis occurred. Catechu was given to all the birds in their drinking water, and after its administration no further deaths occurred, and the majority of the birds were perfectly well in ten days; nor was there a return of Coccidiosis. After treatment the birds were all removed to a fresh run.

At a Sussex general poultry farm where fowls, geese, ducks, turkeys, and pigeons are raised, and about two thousand head of birds are always present, catechu has been used now for some time in treating sudden outbreaks of Coccidiosis—usually after the introduction of new stock for breeding purposes. At the same farm a few pheasants are reared in captivity, and on one occasion a brood of six young pheasants (four weeks old) were in a very bad state owing to Coccidiosis; but all recovered after the administration of 10 grains of catechu per gallon of water for ten days.

Recently in an epizoötic among fowls at Cambridge, in which some seventy fowls were given catechu, all recovered. But a curious reflex occurred, for an outbreak of Coccidiosis occurred among a number of pigeons that used to come to the poultry run for grain. As the pigeons in question were of some value, they, too, were confined in an aviary and treated with a solution of catechu containing 10 grains per gallon. Twenty recovered out of twenty-one treated, one bird being accidentally killed.

A recent case of Coccidiosis is that of two canaries. Five birds out of an aviary of seven had already died, and the others were very sickly. Catechu in a dose of 5 grains per gallon was given them. After a week the two treated birds showed no oöcysts in their fæces, and had recovered their song.

Some ailing Grouse of varying ages, reared in captivity at Frimley, were given catechu in their drinking water. All showed marked improvement in a short space of time.

CHAPTER X

PART I

THE CONNEXION BETWEEN LOCAL CONDITIONS AND THE HEALTH OF GROUSE

FROM a consideration of the immediate and direct causes of mortality in Grouse it is natural that the enquirer should wish to learn what special factors are indirectly connected with "Grouse Disease," in other words, what are the predisposing causes which bring into existence the unhealthy conditions referred to in the preceding chapters.

For the study of this question it is necessary to approach the subject from an entirely new standpoint. Instead of concentrating the attention upon the physical effects of "Grouse Disease" upon the individual victim, and tracing the life-history of the particular worm or other harmful organism to which the damage has been traced, it becomes necessary to collect statistics of all recorded outbreaks of disease, and then endeavour to ascertain whether these outbreaks could be associated with any particular conditions of climate, food, situation, or stock.

Such a study involves a considerable amount of labour for the results are of small value unless they are spread over a large number of cases, and the work of collecting and analysing the reports of field observers must extend over a period of several years.

An endeavour was made by the Grouse Disease Committee to accomplish the task, and with the assistance of a large body of local correspondents they were enabled to publish certain evidence which, while inconclusive in some respects, is not without interest.

During each of the years 1906, 1907, 1908 the Committee obtained exhaustive Reports on the conditions affecting the numbers and health of the Grouse stocks in different districts of England, Scotland, and Wales.

The main points dealt with in these Reports were :—

(1) Health and numbers of stocks at beginning of year.
(2) Weather in breeding season.
(3) Success or failure of breeding season.
(4) Food supply throughout the year.
(5) Results of season as evidenced by bags.
(6) Health and numbers of stocks at end of year.

It was hoped that, by making a careful collation of facts extending over a considerable period, some light might be thrown upon such problems as the following :—

(1) What are the conditions of weather and food supply during the winter which tend to ensure a healthy and vigorous stock at the commencement of the breeding season ?
(2) Are the reproductive powers of the stock most noticeably affected by the health of the birds themselves, or by the character of the weather which they experience in the breeding season ? In other words, will a healthy stock breed successfully in spite of adverse weather conditions, or would a better result be obtained from a less robust stock, provided the weather in the pairing, sitting, and hatching season is ideal ?
(3) What are the ideal weather conditions required to ensure a successful breeding season ?
(4) What are the ideal weather conditions required to ensure a good food supply ?
(5) What are the ideal weather conditions required to ensure that the chicks when hatched will live to maturity ?
(6) What are the weather conditions usually associated with mortality from Strongylosis ?
(7) What are the weather conditions usually associated with mortality from Coccidiosis ?

(8) What connection, if any, can be established between the food supply of one year and the health of the stock in the following year?

The Reports obtained on these and other matters were full of detail, and reflected the greatest credit on the powers of observation of the correspondents who drew them up, but the work of abstracting and analysing the material proved long and laborious, and it is to be feared that in some respects the results may not appear conclusive. Perhaps more definite results might have been obtained had the Reports been spread over a longer period, but it is more reasonable to suppose that as a matter of fact the direct effect of any one natural agency is incapable of exact definition owing to the impossibility of eliminating the various other natural agencies which form factors in the case. Thus it might conceivably happen that a fine dry breeding season, which is favourable to the hatching and growth of the young chicks, might also be favourable to the development of one or other of the parasites which cause their destruction. The frost, snow, and rain which brings privation to the nesting hen and hardship to the growing brood may also serve to purify the ground of many a harmful taint. Recorded effects of different natural conditions are often unexpected, and still more often quite inconclusive as a guide to the conditions which make for the welfare of the Grouse. In such cases we must be satisfied with negative evidence, and in face of some of the beliefs which have been universally accepted in the past, even negative evidence and inconclusive results are not without their value. Hitherto, it has quite naturally been assumed that bad weather in the breeding season is universally destructive to the young stock, and must necessarily mean a bad shooting season, yet from the detailed reports now received it is surprising to find the extent to which this hardy bird may rise superior to mere climatic discomfort. Conversely an apparently perfect breeding season is sometimes followed by an unexpected shortage of young birds in August. The reason for these unexpected results must remain a subject for speculation in each case, for in each case the combination of natural conditions is different, but at least the study will be useful if it checks the tendency to indulge in generalisations founded upon speculation rather than observation.

It became evident at the early stages of the Inquiry that no Reports could be of value for the purpose of striking an average for the year unless they dealt with a similar set of conditions ; it was therefore decided to divide the whole Grouse-producing area into a series of districts, each having common characteristics in respect of latitude, rainfall, altitude, etc., and then, by tracing the history of the Grouse stock in each district from one year to another, to endeavour to find a solution to some of the problems which are enumerated at the beginning of this chapter.

The Districts adopted for the purpose were those used by the British Meteorological Committee, and embraced the following geographical areas :—

Meteorological District 0. Scotland, North — Caithness, Sutherland, Ross, Cromarty, Inverness.

Meteorological District 1. Scotland, East (Northern Half) —Moray, Banff, Aberdeen, Kincardine, Forfar, Perth and Fyfe.

Meteorological District 1. Scotland, East (Southern Half) —The Lothians, Berwick, Peebles, Selkirk, and Roxburgh.

Meteorological District 6. Scotland, West—Argyll, Bute and Arran, Stirling, Dumbarton, Renfrew, Lanark, Ayr, Wigtown, Kirkcudbright and Dumfries.

Meteorological District 2A. England, North-East—Northumberland, Durham and Yorkshire (North Riding).

Meteorological Districts 7A and 7B. England, North-West, and North Wales—Cumberland, Westmoreland, Lancashire, Cheshire, Denbigh, Montgomery.

Meteorological District 4. England, Midland Counties—Yorkshire (West Riding), Derbyshire.

Even by making use of the foregoing subdivisions it was found that many districts contained a very varied assortment of climates, altitudes, etc. Nevertheless, the main climatic tendencies in each were approximately uniform, and enabled certain broad generalisations to be made.

Before examining the records of the separate districts it may be pointed out that this department of the Inquiry commenced under favourable auspices in respect that the year 1905 had been singularly free from "Grouse Disease." In spite of the Committee's endeavours to hear of an outbreak, mortality was only reported from one district in Scotland, and then only in a mild form.[1] In fact 1905 may be regarded as one of the most disease-free years within the memory of the present generation. The stock throughout Scotland, therefore, must have commenced the period under review in a condition of perfect health, and any mortality that occurred in 1906 and the subsequent two years must have been due to the conditions which prevailed during that period, and could not have been the result of sickness lingering from the previous year.

Let us now consider what these conditions were. Commencing with the North of Scotland we find :—

District 0. Scotland, North.

1906—22 Reports.

Weather.—In the early months average winter weather inclining to wet and snow ; a fair spring and early summer with a sharp snowstorm in the middle of May ; a dry shooting season ; an open winter with a heavy snowstorm at Christmas.

Heather.—The young heather grew well, there was little damage by frost, the bloom was good but rather late, except in Easter Ross where the reports were not so favourable.

Stock.—At the beginning of the year the stock was above the average in numbers and healthy ; the breeding season was unequal ; in the north and south reports were good, but in East Ross and Mid Ross there was destruction of eggs and young by frost, snow, and floods. A few isolated cases of mortality were reported (eleven birds from four Report centres, of which seven birds came from Easter Ross),[2] but nothing amounting to an outbreak. On August 12th the stock

[1] *See* map, 1906. [2] *Ibid.*

was universally above the average and very healthy; the bags were excellent, especially in the north, and the stock at the end of the year was well above the average in numbers and quite healthy.

Remarks.—A first-class season all round, large stocks, large bags, no disease. The snowfall in May apparently did no harm, though birds were sitting at the time. The unfavourable reports from Easter Ross appear to have been exaggerated; but the poor heather growth in this district may be found to have affected the health of the stock in 1907.

1907—26 Reports.

Weather.—An uneventful season. In the early spring the weather was open except in the Highlands of Inverness-shire, where there was a good deal of snow in the late spring (breeding season), normal in the north, wetter in the south; August wet, September fine; mild open winter.

Heather.—In the north reports of heather growth were good, but damage by spring frosts was reported. In some places autumn burning gave better results than spring burning. Further south the heather growth was not so good; in Badenoch the heather was blighted where the drifts lay long; the bloom was late and poor, and the heather seed did not ripen very well.

Stock.—At the beginning of the year the stock was above the average in numbers and healthy; but the breeding season was extremely bad, both nesting and hatching, owing to cold and wet. There was much destruction of chicks by floods, a good many second broods and many late broods; from Ross-shire two nests were reported as having hatched after August 12th. There was little mortality from disease (sixteen birds sent for examination from seven Report centres).[1] The stock on August 12th was a good average and very healthy; the bags were above the average, in some places abnormally good, especially in Strathnairn and Badenoch. The stock at the end of the season was a good average and healthy. In Badenoch an overstock was left.

Remarks.—A bad breeding season followed by a bumper shooting season, this year furnishes an example of how a healthy stock may survive unfavourable weather conditions, probably, however, the big stock left from 1906 helped to equalise the losses in the breeding season. The mortality from disease was

[1] *Vide* map, 1907.

not appreciably greater in Easter Ross than in other districts in spite of bad heather growth reported in 1906. The poor heather growth in this year will probably be found to affect the health of the stock in 1908, especially when combined with an overstock in Badenoch and Strathnairn.

1908—24 Reports.

Weather.—In the first three months of the year average winter weather in the north, more snow in the south ; April and May were cold, June and July fine. The shooting season was very fine, dry, and warm. The winter was fine and open with a severe snowstorm in the north at Christmas.

Heather.—Unanimous reports of exceptionally good heather season ; growth good owing to fine summer, little damage by frost, bloom exceptionally luxuriant and early, seed ripened extremely well and early all over.

Stock.—At the beginning of the year the stock was rather over the average and apparently healthy ; but as the spring advanced mortality was reported from forty-eight centres, and of the birds examined a large proportion came from Badenoch and Strathnairn, though Caithness, Sutherland and, to a less extent, Ross were also severely affected.[1] The breeding season was exceptionally good in Caithness ; further south and west it was not so good, there was a shortage of young birds which some reporters attributed to the effects of frost on the eggs, but this explanation is not quite satisfactory ;[2] in Inverness the reports were better. On August 12th there was a fair average as regards numbers, but there still remained some signs of disease. The bags were up to the average with one notable bag of five thousand and ten brace on a high-lying moor in Inverness-shire.[3] The stock at the end of the year was about an average in numbers and quite healthy.

Remarks.—An interesting season—a fairly good breeding season was interrupted by a sharp attack of disease ; this was probably due to the poor heather year of 1907 which kept the birds short of food during the winter of 1907-1908. The outbreak was most severe where the largest stocks had been left.

[1] *Vide* map, 1908. [2] *Vide* p. 11.

[3] This bag is of special interest owing to the fact that this moor was under snow during the whole winter, and had not a single bird on it till the month of May, when a breeding stock appeared simultaneously with the disappearance of the snow. This stock was particularly healthy and prolific, probably owing to the heather having remained uncontaminated for so long; a much larger bag might have been killed. *Vide* Table (Moor No. 7) p. 418.

The mortality might have assumed much larger proportions but for the timely advent of fine weather and a luxuriant growth of heather, consequently the stock was not seriously affected, and had quite regained its health by the end of the year.

The series of Reports comes to an end with the year 1908, but we may be permitted to glance at the map for 1909[1] to see whether the fine heather growth of 1908 has had the beneficial effect upon the following season that might have been expected. The result comes up to our expectations, for we find that, throughout the whole district which in 1908 had been filled with piners and sickly birds, there has not been a single case of disease except in those districts lying between Badenoch and Loch Ness where we anticipated some mortality on account of the large overstock left from 1908.

District 1. Scotland East (Northern Half).

1906—25 Reports.

Weather.—For the early parts of the year the Reports vary. Near the coast the weather was rather open, inland it was much colder with snow in Perthshire. In May there was a very severe snowstorm in the north-east, particularly in the high ground of Aberdeenshire. In Perthshire May was wet, cold, and frosty. The weather in the shooting season was good, though in some places August was wet. After that the weather was normal till Christmas, when there was a severe snowstorm.

Heather.—Young heather grew fairly well; but in this district it grows very slowly after burning. Several reporters express favourable views on the effect of autumn burning; the bloom was late but good, and the seed ripened well throughout the district.

Stock.—At the beginning of the season the stock was above the average and healthy. The breeding season was reported to be very bad with good nesting but bad hatching weather; much damage reported from snow and frost in May. Owners were in despair at the bad breeding season, and in some cases, especially in Aberdeenshire, even cancelled their arrangements for shooting their ground. Yet on the 12th the stock was universally good and fairly healthy, and the

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[1] *Vide* map, 1909.

bags throughout the district were far above the average. Only one case of disease was reported,[1] and at the end of the season the stock was above the average and very healthy.

Remarks.—A first-rate season all round, large stocks, large bags, no sickness, in spite of conditions which were at the time believed to be disastrous. The prospects for 1907 are fairly good; but there is a danger owing to the large stock left.

1907—54 Reports.

Weather.—In the early part of the year the weather was normal, with stormy weather on the hills, snow on the east coast and in Perthshire, and some frost. The breeding season was generally wet and cold, August was wet, September fine; the winter was variable and rather open.

Heather.—Over the whole district the heather growth was poor, both young and old; many reports received of damage by frost, bloom universally late and poor. Seed ripened very badly, and there was little of it; a very bad heather year.

Stock.—At the beginning of the year the stock was above the average and healthy; but some weak spots developed later, especially in Perthshire. Over eighty birds were received from thirty-five centres, eight from Moray and Banff, fifteen from the Borders of Aberdeen and Kincardine, five from Forfarshire, and forty-two from Perthshire.[2] The breeding season was universally bad owing to wet and cold, especially in Kincardine and Perthshire, where many young were destroyed; not many second broods except in Perthshire. On the 12th the stock in Moray and Banff was far above the average in numbers, Aberdeen above the average, Kincardine and Forfar not so good, Perth poor, being very patchy with few young birds. The shooting season showed corresponding results, very large bags in Moray and Banff, good bags in Aberdeen and Kincardine, not so good in Perth. The stock at the end of the year was healthy throughout, and the numbers left were above the average in the north and normal in the south.

Remarks.—A very bad breeding season and a very bad heather year; the former might have been expected to affect the stock of young birds equally throughout the district. In actual fact this did not occur, for the birds in the north were not affected by the bad breeding season, whereas in certain districts in the south the shortage of young birds was very

[1] *Vide* map, 1906. [2] *Vide* map, 1907.

serious. The reason for the shortage was obviously bad health rather than bad weather, for in those parts of Perthshire where the stock was healthy, the bags were good in spite of the bad breeding season. There does not appear to be any reason why the stocks should have been more healthy in the north than in the south. The prospects for 1908 are not good; 1907 having been a bad heather year, the danger will be greatest in the north owing to the large stocks left.

1908—47 Reports.

Weather.—A fine open January and February, March cold and stormy with wet and frost in places, April very wintry with hard frosts at the end of the month and in the beginning of May (17°, 16°, and 18° F.), May, June, and July universally fine, dry and warm, August dry, September wet, followed by fine weather with a snow storm in December.

Heather.—The growth was excellent; on one moor in Perthshire birds were reported to be feeding on ground burned this spring. The growth was checked temporarily by the frosts in April and May; but the bloom was exceptionally good and early, and the seed ripened well all over the district; a first-rate heather year.

Stock.—At the beginning of the year the stock was above the average in numbers, but in one or two places it was reported not very healthy. The breeding season was disappointing considering the favourable hatching weather, the nests were very badly filled, and a mysterious disappearance of chicks was reported from many districts. A good deal of disease was reported, especially from Moray, Banff, and Aberdeen,[1] where the large stock had been left from 1907. On the other hand, from one district which had been swept by disease in 1907 the reports were excellent—well-filled nests, plenty of young birds, no disease. On August 12th the stocks were reported unequal, but the majority were below the average in numbers, and in many cases birds were reported still sickly; afterwards the stock recovered, and at the end of the year was reported to be a fair average in numbers and very healthy.

Remarks.—This season offers an opportunity for considerable speculation; very cold weather in the mating season, frost in the nesting season, magnificent weather in the hatching season, and a fine warm summer. Why were the results so bad? Many

[1] *Vide* map, 1908.

reporters consider that the shortage was due to the loss of eggs by frost; but there is little evidence to support this view. What eggs there were seemed to have hatched out unusually well, and it must be borne in mind that the shortage was noted before the frost came for there were few eggs in the nests. Possibly the wintry weather in the mating season may have caused the birds to postpone their pairing, and so delayed and disorganised their usual breeding habits; this view is supported by the fact that many barren birds were seen, the inference being that these birds might have mated and bred had the weather conditions been more favourable. Against this theory we have the experience of 1906 and 1907, where it was conclusively shown that a healthy stock of birds can breed prolifically even under the most unfavourable weather conditions. Hence we are forced to adopt the view that the solution of the problem had more to do with the condition of the parent stock rather than with the weather. We know that the stock has wintered badly, we know that many birds are pining and sickly, and we also know from anatomical investigation that a bird when attacked by Strongylosis often becomes incapable of breeding owing to the non-development of the reproductive organs.[1] One point of exceptional interest is the mysterious disappearance of chicks in a season which appeared to be ideal for the growth and development of young birds. This circumstance seems to have puzzled many of the reporters. Some ascribe the loss of chicks to drought, others blame migration, but for the reasons given in another part of this book neither of these solutions appears to be the correct one.[2] The view already expressed that the mortality may be due to Coccidiosis[3] is suggested as a more probable explanation, and is supported by the fact that warm dry weather, appears to be favourable to the development of this parasite.[4] Until further evidence is obtained on the subject, however, the question cannot be regarded as settled.

[1] *Vide* chap. vi. p. 179.

[2] *Vide* chap. i. pp. 16 *et seq.*

[3] *Ibid.* p. 18.

[4] *Vide* chap. ix. pp. 260 *et seq.*

If we again refer to the map for 1909, we find that the fine heather year in 1908 has had the effect of entirely restoring the health of the birds. Only two isolated cases of mortality were reported throughout the whole of this extensive district.[1]

District 1. Scotland East (Southern Half).

1906—6 Reports.

Weather.—A normal year, except for much snow in May; a very wet August and October, and more snow in December.

Heather.—Young heather grew well, especially after autumn-burning; some damage by frost in the Lammermoors and Peebles. The bloom was variable, but the seed ripened well.

Stock.—The year began with a healthy stock, above the average in numbers. The breeding season was bad, many eggs and young birds being destroyed by snow, frost, and rain. Mortality was reported in the spring from several districts, more especially Peebles and Selkirk.[2] The stock on August 12th was below the average, but quite healthy. The bags were below the average, and the stock left was about an average and quite healthy.

Remarks.—Here for the first time we find the stock seriously affected by the bad weather in the breeding season, for the "disease" does not seem to have been sufficiently severe to account for the great shortage of young birds, though it may have contributed. The nesting season is described as the worst for years, nearly all the early broods were destroyed in some places, and everywhere there were many second broods. These second broods and late hatchings will probably affect the health of the stock in 1907, for late birds have not the same stamina as early ones, and the heather crop is only moderate.

1907—10 Reports.

Weather.—Variable in the early months. The breeding season was rather cold and wet. A wet August was followed by a dry September, and the winter was open.

Heather.—The spring growth was poor, but grew best after autumn-burning; the bloom was late and poor, and the seed ripened badly—a bad heather year.

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[1] *Vide* map, 1909.

[2] *Vide* map, 1906.

Stock.—A good healthy stock at the beginning of the year. The breeding season was unfavourable owing to cold and wet; but the losses do not appear to have been serious. There was a good deal of sickness throughout the district[1] with a remarkable three weeks' outbreak on the Lammermoors in April, which swept off 10 per cent. of the birds, nearly all cocks. The attack passed away as suddenly as it had come, and the stock on August 12th was much over the average in numbers and very healthy. Elsewhere the stocks on the 12th were irregular, and the bags variable; the stock left was about an average in numbers and quite healthy.

Remarks.—As was to be expected there were a good many scattered cases of mortality, though the outbreaks were nowhere very severe except on the Lammermoors, where an excellent example was furnished of a quick recovery before any harm had been done. The cause of the recovery was probably a sudden burst of young growth on the heather which enabled the birds to obtain food on uncontaminated ground. As is usually the case when an outbreak occurs in April, it was chiefly cocks that died;[2] had the attack extended into May and June hens also would have been affected, and the effect on the young stock would have been serious. The prospects for **1908** are not difficult to forecast. The bad heather year in **1907** will make the wintering poor, and there is sure to be some mortality in the spring; but it will probably not be very serious for the birds of this year were hatched early and are consequently vigorous; they are in excellent condition and no overstocks are reported.

1908—10 Reports.

Weather.—A normal winter with a cold, wet March, followed by a very severe frost in April and snow in places May and June; rather cold July; August and September fine, hot, and dry. A fine open winter.

Heather.—As in other districts this was an exceptionally good heather year. Some damage was caused by the frost in April; but the bloom was excellent, and the seed ripened well.

Stock.—At the beginning of the season there was an average stock, all healthy except on one moor in Midlothian. The nesting season

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[1] *Vide* map, 1907.

[2] *Vide* Table VI. p. 239.

was favourable except for losses from frost in April, and on the Pentlands from snow which covered the nests for ten days.[1] Everywhere there were a number of unhatched eggs left in the nests, and broods were small. A certain number of isolated cases of "disease" were reported, but it was nowhere serious except on the Midlothian moor referred to where early mortality was reported.[2] On August 12th there was a fair stock of healthy birds, the bags were a little below the average, and an average healthy stock was left.

Remarks.—The only unusual event was on the Midlothian moor when mortality was reported at a much earlier date than is usually the case. The fact that many eggs were left unhatched in the nests may have been due to damage by frost, or because their fertility was impaired owing to the parent birds being in indifferent health and condition after bad wintering.

The good heather year in 1908 resulted as before in an improvement in the health of the stock in 1909, though this improvement was not so marked as in some of the other districts.[3]

District 6. Scotland, West.

1906—32 Reports.

Weather.—The reports vary considerably in different parts of the country; the early part of the year appears to have been rather wet; the breeding season was good in Argyllshire, but, further south, May was wet. August was hot, September fine. The end of the year was wet and stormy, with snow at Christmas.

Heather.—The reports were contradictory; on the whole a normal year for growth, bloom, and seed. The reports as to the effect of frost vary greatly.

Stock.—The year began with a good average stock of healthy birds. The breeding season in Argyllshire was good, with some flooding in May. Elsewhere it was a bad breeding season, eggs were frosted, birds drowned, and there were a good many second broods. A few cases of mortality were reported, but there were no serious outbreaks.[4] The stock on August 12th was a good average, counting second broods, and quite healthy; in some places the stocks were exceptionally good. The bags ranged from a good average to exceptionally good, and the stocks left were above the average and healthy.

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[1] *Vide* chap. i. p. 10.
[2] *Vide* map, 1908.
[3] *Vide* map, 1909.
[4] *Vide* map, 1906.

Remarks.—It is difficult to deduce information from the reports owing to the variety of conditions in the district. The mild climate of West Argyllshire is so different from that of Lanark and Dumfries that wet weather in the first-named county may be represented by hard frost in the last two. The season as a whole was good all over, and justifies the view that a good healthy stock will breed a good healthy stock in spite of bad weather in the breeding season.

1907—40 Reports.

Weather.—The season as a whole was cold, wet, and cheerless, with frost and snow in the early part of the year. April normal, May and June very wet and cold, July fine. The shooting season was wet, and the end of the year wet and cold.

Heather.—A poor heather year; growth was moderate, but the bloom was late and poor, and the seed ripened badly.

Stock.—At the beginning of the year the stock was rather above the average and healthy. The nesting season was bad, and the hatching season very bad. Many losses of nests and much drowning of chicks was reported, and in some districts there were many second broods.

Mortality from "disease" was reported in April and May from many places throughout the district,[1] but though general it nowhere assumed the importance of a serious outbreak, and by August 12th the birds had practically recovered their health. The stocks on the 12th were mostly below the average, and bags were poor with one or two striking exceptions, especially in Lanarkshire where stocks were good. The stocks at the end of the season rather below the average and quite healthy.

Remarks.—A cold, wet season, a bad heather year, much mortality in nesting season resulting in small bags, some losses from disease. Here, again, we find losses in the nesting season owing to exceptionally bad weather; but the results were not so bad as might have been expected, and in some cases the bags were good in spite of adverse circumstances. As a rule, it was found that the nesting results were worst on those moors where birds were unhealthy. The reason for the birds being unhealthy cannot be stated with certainty, but was probably connected with delay of the young growth owing to the back-

[1] *Vide* map, 1907.

ward spring. It is to be expected that the bad heather year will have a bad effect on the stock in 1908, but the fact that the stocks are moderate may go far to save them from serious disaster.

1908—26 Reports.

Weather.—The first three months were good with some wet weather in Kintyre; the nesting season was dry and favourable, but a severe frost was reported universally in the third week of April, ranging from 10° to 22° F. according to the district; a fine summer except September, which was wet; snow at the end of the year.

Heather.—A good year for growth, but much frosting of heather was reported from Argyllshire; the bloom was universally excellent, and the seed ripened well throughout.

Stock.—At the beginning of the year the stock was moderate in numbers and healthy. The nesting and hatching seasons were unequal, good in Argyllshire, not so good in Ayr and Lanark, where it was reported that eggs were destroyed by frost; in some places many young birds disappeared mysteriously in the dry weather, and most of the reporters ascribe this to drought. A good deal of mortality from disease was reported from North Ayrshire, especially on those moors where a large stock had been left.[1] On August 12th the birds were almost universally healthy, but below the average in numbers, and the bags were small. The stocks left at the end of the year were rather below the average and quite healthy.

Remarks.—The general health of the stock was only moderate, but was better than might have been expected considering the poor heather year in 1907. This was probably due to small stocks being left. The reports of heather being frosted in Argyll were probably incorrect, for there was less frost in that county than in any other, and it passed away long before the young growth of heather had made an appearance. The cause of damage was far more likely to have been the heather beetle (*Lochmæa suturalis*),[2] which did a good deal of harm in this year. With regard to the disappearance of young birds in the dry weather see the remarks on this subject on pp. 299 *et seq.*

The good heather year in 1908, combined with the light stocks left at the end of the year, resulted as before in a marked

[1] *Vide* map, 1908.

[2] *Vide* chap. xiii. pp. 370 *et seq.*

improvement in the health of the birds in 1909; only one isolated case of "disease" being reported for that year.[1]

District 2a. England, North-East.

1906—11 Reports.

Weather.—A normal year with an unfavourable nesting and hatching season, and a snowstorm in December.

Heather.—No outstanding facts were reported. Autumn-burnt ground made the quickest growth, and the heather grew best where the ground was wet at the time of burning. The bloom and seed were not very good.

Stock.—The year commenced with a good average of healthy birds. The breeding and hatching seasons were disastrous, eggs were destroyed by snow, frost, and floods, and young birds by cold and floods. There were many second broods, yet in some cases eggs bleached quite white with rain hatched out. Only five diseased birds representing two moors were sent to the Committee for examination. The stock in the shooting season was rather below the average, as also were the bags; but at the end of the year the stock was up to the average and healthy.

Remarks.—An abnormally bad nesting and hatching season, yet the stock was surprisingly good, doubtless owing to the excellent health of the birds.

1907—15 Reports.

Weather.—At first normal with a fine March, cold and wet in April and May, better in June and July, August wet, September fine, thereafter inclined to wet.

Heather.—The growth was universally bad, much damage being caused by frost, especially to old heather. The bloom was late and poor, and the seed ripened very badly.

Stock.—The reports vary, but on the whole the stocks at the beginning seem to have been rather over the average, and healthy except in the North Tyne district. The nesting season was bad, and the hatching season very bad, owing to frost, hail, wet, and cold; there were a good many second broods. "Disease" was reported from nine districts, and twenty-two specimens were sent up for examination; but the outbreak was only severe in the North Tyne area, and the district as a whole was healthy. The stock on August 12th was exactly

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[1] *Vide* map, 1909.

an average and quite healthy. Except in the North Tyne district, the bags were up to the average, and at the end of the year the stock was a good average and universally healthy.

Remarks.—Rather a cold, wet season and a very bad heather year; the breeding season was unusually bad, yet once more the young birds did well, except where the parent birds were unhealthy. 1908 will probably be a bad year.

1908—12 Reports.

Weather.—Average winter weather for the first three months with snow and frost in April, a normal summer and a fine mild winter.

Heather.—A very good year for growth; damage by frost reported in one case only. The bloom was good and early except in Wensleydale, and the seed ripened well except on the high ground.

Stock.—At the beginning of the year the stock was rather above the average and healthy; except in the North Tyne district where "disease" reappeared early in the year. The breeding season was unfavourable, snow and frost destroyed many eggs but not many chicks; there were many second (or late) broods. On the whole the birds were fairly healthy, though on some moors they were reported to be in poor condition, and a few were found dead. The reports of the stock on August 12th were very variable, as also were the bags, and neither of these can be summarised. At the end of the year there was a good average stock, and the birds were quite healthy.

Remarks.—The year was unexpectedly healthy considering the unfavourable wintering conditions.

As might be expected after the good heather year in 1908, the stock in 1909 was exceptionally healthy.

District 7a and 7b. England, North-West and North

1906—6 Reports.

Weather.—No special features, some snow and rain in May, otherwise a fair average season.

Heather.—Growth of young heather was fair, spring-burnt being the best; the bloom was poor and late, and the seed ripened badly.

Stock.—At the beginning of the year there was a good healthy stock. The breeding season was very unfavourable, both eggs and young being destroyed, yet only in a few places was the stock on August 12th below the average on the bags affected; there was no "disease." At the end of the season the stock was up to a fair average and healthy.

Remarks.—An uneventful year. The bad growth of heather may have a detrimental effect upon the health of the stock in 1907.

1907—11 Reports.

Weather.—Normal at first, then wet and cold, especially in May and June; but July was warm and dry, August wet, September fine, and the autumn wet.

Heather.—On the whole the growth was bad—best after autumn-burning. The bloom was universally late and poor, and the seed ripened badly except in Wales.

Stock.—At the beginning of the year the stocks were a good average and healthy, except on one moor in Cumberland. The breeding season was universally bad. Eggs were destroyed by frost and floods, young birds lost in large numbers by drowning. A good deal of disease was reported. The stock on August 12th was below the average, so were the bags. At the end of the year a fair average stock was left.

Remarks.—Nothing calls for special attention. The bad heather year in 1906 does not seem to have affected the stock seriously; but the birds were not in really good condition.

1908—11 Reports.

Weather.—A wet and snowy winter was followed by frost and snow in April (6°, 7°, and 17°), then finer; but heavy rain in June. A fine August and wet September were followed by a fine, mild, open winter with some snow in December.

Heather.—A good year for growth; the bloom was good and early, and the seed ripened well.

Stock.—At the commencement of the year there was a fair average stock and quite healthy, except in one moor in Lancashire, where the stock was small and the birds were dying in large numbers. In the breeding season there was an outbreak of mortality in one or two places; it was chiefly cocks that died, and when this occurred the eggs were unfertile. Frost and snow destroyed many nests, and there were many second broods. The reports on August 12th were conflicting. At the end of the year there was a fair stock and quite healthy.

Remarks.—Two bad heather years have had their effect upon the health of the birds, but there has been no general outbreak of " disease."

District 4. England, Midland Counties.

1906—10 Reports.

Weather.—A mild season till May, when the weather turned wet and cold with snow in parts. August was wet, September fine, and the end of the year was very wet with snow in December.

Heather.—Young heather grew well, especially when burnt in spring. There was some damage by frost in May ; the bloom was fairly good but late, and the seed ripened fairly well.

Stock.—At the beginning of the season the stock was above the average and healthy. The breeding season was most unfavourable, eggs were destroyed by frost, and chicks by floods and cold. There were many second broods, but these did well owing to first broods being early. The stock on August 12th was fair on the low ground and bad on the high ground, the bags were rather below the average, and at the end of the year there was a fair average of healthy birds. There was no " disease."

1907—9 Reports.

Weather.—The early part of the year was normal, but rather wet and cold. The breeding season was very wet and cold, especially in the hatching season. August was wet, September fine, and the end of the year was wet and cold.

Heather.—A bad heather year ; young growth poor and much damaged by frost. Bloom universally bad and late ; seed ripened badly except in a few places where it ripened fairly well in spite of late bloom.

Stock.—At the commencement of the year there was a fair average of healthy birds. The nesting and hatching seasons were fairly good, though some eggs were lost ; but there was a great mortality among the young birds owing to extreme wet and cold in May and June. There were not many second broods. A few cases of " disease " were reported. The stocks in the shooting season were all below the average, and the bags were poor. A fair average stock was left, and very healthy.

1908—7 Reports.

Weather.—Wintry weather in the beginning of the year. April very cold with snow and frost, thereafter fine and normal.

Heather.—Young heather grew well; the bloom was good, and the seed ripened well.

Stock.—The year began with a good average stock and healthy. The snow in April did much damage to eggs. There were a good many second broods. On August 12th the stock was up to the average and healthy, the bags were below the average, and the stocks left were below the average but healthy.

Remarks.—The health of the stock in 1909 was excellent only one isolated case of "disease" being reported.

Summary of Results Obtained.

From the foregoing abstract of Reports, it will be seen that the weather conditions varied considerably in different parts of the country. In the majority of cases the combinations of natural causes produced results which might have been expected —this is especially well marked in Scotland. In other cases the results came as a surprise, but were sufficiently conclusive to justify us in amending some of the theories which have hitherto been regarded as established. The Reports are capable of various constructions, but the following may be regarded as a reasonable interpretation of some of the facts observed.

1. *Good Heather Growth, i.e.*, good growth of leaf, flower, and seed, is followed by a healthy stock in the following year. We have a striking example of this in 1908-1909, when a first-rate heather crop was succeeded by a disease-free year. It follows that when the heather growth is good a large stock may be left.

2. *Bad Heather Growth* is usually followed by some mortality, and where stocks are large this mortality may assume serious proportions. It follows that when the heather growth is good stocks should be killed down.

3. *The Direct Effect of Weather Conditions on Grouse.*— The direct effect of weather upon Grouse seems to be slight, though the indirect effect as affecting their food supply is enormous. Adult Grouse seem to be unaffected by cold, snow,

wet, or frost, and even in the breeding season the destruction of eggs and young caused by climatic conditions does not seem to be disastrous except in a few extreme cases. It is true that many reporters speak to the fact of eggs being destroyed by frost, snow, and rain, and chicks being killed by wet and cold; but as the statement is often followed by a favourable report upon the young stock on August 12th it is obvious that the damage cannot have been so serious as was supposed, or that what damage there was had been repaired. We have too much faith in the accuracy of the Reports to suppose that no such losses have occurred; but we believe that where the stock is healthy the nests contain a larger proportion of eggs, and that a larger proportion of these are fertile, consequently a loss of even 25 per cent. of eggs and chicks might still leave a very satisfactory stock of young birds. Then, again, there is always a possibility that these losses may be repaired by means of second broods, and where the parent stock is healthy there is more chance of these second broods being successful. The case is different where the stock is unhealthy, for then the nests contain fewer eggs, the eggs are less fertile, and the parent birds have not sufficient stamina to produce successful second broods. This seems to be a reasonable explanation of the rather puzzling fact that it is only where the parent birds are unhealthy that the young stock seems to be seriously reduced by bad weather in the breeding season. Another possible explanation is that the weather does not affect the case at all, and that the only reason for the failure of the young stock is that the parent birds are unhealthy, and therefore not prolific. But this explanation would entail the discarding of the unanimous evidence of the reporters on the subject, and we think that the evidence goes far to establish the following points.

(*a*) Eggs may be destroyed by (1) snow; (2) frost; (3) wet; their liability to destruction depends upon the stage of development they have reached. If they have not yet been sat on probably none of these agencies will destroy them, provided the hen does not desert or lose the nest. Cases have been reported of eggs being buried in snow for many days,[1] or covered to a depth of several inches with water without suffering any harm. On one occasion (May 14th, 1911), a sitting hen was driven off her nest by flooding; the eggs were covered with water and their colour washed off, nevertheless the hen returned, and on May 25th the whole clutch hatched out. Frost, unless very severe, is probably less destructive than rain or even snow, for while the hen is sitting the eggs are safe, and before she has begun to sit it is doubtful if they are damaged unless the frost is hard enough to split them.[2]

(*b*) Young chicks may be destroyed by drowning, but are seldom killed by frost, snow, or extreme cold.

(*c*) Very hot, dry weather after hatching has sometimes been associated with loss of chicks; a possible solution is suggested on p. 8.

4. *Relation of Weather Conditions to Health of Stock.*—If the stock is healthy bad weather in the breeding season does little harm; if the stock is unhealthy bad weather at nesting and hatching time will result in a failure of young birds.

The effects of a good breeding season upon a healthy and unhealthy stock respectively cannot be stated with certainty, for during the three years under review there was no really good breeding season. The nearest approach to favourable conditions occurred in the east of Scotland in 1908, and then the results seemed to indicate that even where the weather conditions are favourable an unhealthy stock will not be prolific.[3]

In the light of the foregoing remarks we may now with some confidence attempt to answer the list of queries with which this chapter opened.

(1) The weather during the winter appears to be immaterial, provided the food supply is good. The winter food

[1] *Vide* p. 10. [2] *Vide* pp. 11, 12. [3] *Vide* p. 281.

supply depends on (*a*) good spring growth; (*b*) good summer bloom; (*c*) good autumn seed in the preceding year. The first-named item is probably the most essential, and the second is probably only a result of the first, but as it is more easily noticed it forms the best guide to the prospects of the following year. A good year for corn crops is usually a good year for heather.

(2) The health of the parent birds is of far greater importance than the weather in the breeding season.

(3) It is believed that the best weather conditions in the breeding season are an early spring and an absence of all climatic extremes. Mere cold probably does little harm, and rain or snow in moderation may be disregarded. The important matter is that the stock should pair early and proceed with their nesting without interruption. The value of early hatchings is referred to elsewhere.[1]

(4) From the reports it would appear that fine, dry, warm weather from May to July is associated with the best growth of leaf and bloom, and early bloom is followed by well-ripened seed, unless the autumn is unusually wet. Occasionally late bloom may result in a well-ripened crop of seed if the autumn is fine and warm. It would appear from the Reports for 1908 that a hard frost in April is not injurious to growth, but probably frost in May would retard it seriously.

(5) Once the chicks are hatched they will survive all ordinary weather conditions; but excessive wet soon after hatching means great danger from drowning. A very hot, dry summer has frequently been associated with a disappearance of the young stock, probably caused by Coccidiosis. The rapid growth and development of chicks probably depends entirely on a good food supply, *i.e.*, a good spring growth of heather.

[1] *Vide* pp. 434 *et seq.*

(6) Strongylosis is probably caused by insufficient or inferior food during the months of February to April rather than by any particular weather conditions at the date of the attack. Insufficient food causes the winter feeding areas to be restricted, and so the ground becomes heavily contaminated with the Strongyle worm. Weather conditions may indirectly affect the case, but to what extent cannot be stated with certainty. Heavy snow would doubtless be beneficial by covering certain feeding areas and keeping them uncontaminated until the snow has melted ; on the other hand, it would tend to further restrict the feeding areas so long as it lay on the ground. It has been thought that heavy rain might be beneficial as a means of purifying the ground, but experiments have proved that the larvæ of this worm seem to flourish best in damp surroundings. Frost and dry cold may do something to suspend the vitality of the larvæ for a time, but drought is the only climatic condition which appears to do it any permanent harm.

(7) Coccidiosis as a disease in Grouse chicks has only recently come under investigation, and the study of the subject is attended with much difficulty. From experiments in the laboratory it has been found that the Coccidium develops most rapidly under conditions of warmth and drought, and it is certain that in the hot, dry summers of 1908 and 1911 there was a marked loss of Grouse chicks. In the former year the cause of such loss was apparently undetermined, or at least only suspected, but in 1911 Grouse chicks, picked up dead on the moors, were found to be heavily infected with coccidian cysts.

(8) The foregoing Reports have established a clear connexion between a good heather year and a healthy stock the following spring.

It may be thought that the foregoing observations are of little practical value to moor-owners and sportsmen, since they only go to prove that the welfare of the Grouse is in the hands of Providence, and that there is nothing that man can do to improve the spring growth of heather or moderate the rainfall of May; but apart altogether from the general necessity of knowing the natural conditions which affect the bird, it is believed that the ascertainment of the foregoing facts may be of some real practical value to game preservers.

It has already been pointed out that the condition of the heather may be a useful guide as to the manner in which the stock should be regulated in accordance with the probable food supply available for wintering; but it is also hoped that by proving the supreme importance of good winter food on the health of the bird, owners and their servants may be encouraged to give more attention to the question of heather culture. It is true that in a poor heather year the heather on a well-burned moor will suffer equally in proportion with that on a badly-burned moor, but the total area of winter feeding on the former is so much greater than in the latter, that the well-burned moor can better stand the strain of a lean harvest, and its stock of Grouse will manage to struggle through the winter without serious loss; while on less well managed ground the mortality may be very heavy. Heather culture is better understood and more extensively practised in England than it is in Scotland, and to this is probably due the fact that the health of the Grouse in that country does not appear to have been so seriously affected by the bad heather crop of 1907 as it was in Scotland whenever the heather crop failed. On those moors in Scotland where heather burning has been carried out on proper lines it is found that the stock is not so hard hit, and always makes a more rapid recovery after a bad heather year, than on moors where the heather has been neglected.

NOTE

Since the foregoing chapter was written an opportunity has occurred of studying the effects of prolonged drought upon the health of Grouse. The spring and summer of 1911 was one of the driest ever recorded. From May till September the drought was almost unbroken all over the country except for a few days' rain in June in certain parts of Scotland. All surface water disappeared, and all but the deepest springs were dried up.

The opportunity was a good one for putting to the test the results of previous observations. This was specially desirable so far as related to young Grouse, for as we have stated there were grounds for believing that heat and drought were favourable to the development of the intestinal parasite *Eimerium* (*Coccidium*) *avium*, which had been identified as a cause of mortality among chicks. But although this suspicion was supported by the circumstance that in very dry summers there was often a mysterious disappearance of young Grouse, and further by laboratory experiments which proved that this parasite developed most quickly under the influence of dry warmth, yet there was still a hiatus in the chain of evidence, for it had never been clearly proved that the young Grouse which had disappeared in previous dry seasons had actually died of Coccidiosis.[1]

In studying the effect of the abnormal drought of 1911 the following points were kept in view :—

(1) If a shortage of young Grouse was reported in the shooting season, was this shortage due to mortality among the chicks or to failure of the hatching season owing to the eggs being few in number or unfertile?

(2) If it could be shown that such shortage was due to mortality among the chicks, was there any cause other

[1] For fuller details regarding Coccidiosis *see* chap. ix. pp. 246 *et seq.*

than Coccidiosis which could be responsible for such mortality?

(3) If no other cause of mortality could be found was there any direct evidence that the mortality was due to Coccidiosis?

(4) What effect, if any, had the numbers and health of the parent birds upon the numbers and health of the chicks?

(5) Whether the best-watered ground carried a better stock than the less well watered ground?

It was quite evident that no accurate observations on mortality among chicks could be based upon the number of chicks found dead, for thousands might die undiscovered, it was therefore decided to base the investigation upon the average number of eggs successfully hatched, and the average number of young birds counted in the coveys at the beginning of the shooting season. This method was found to be extremely satisfactory, and threw light upon many points in the life history of the Grouse which had not hitherto come under observation.

For the purpose of collecting evidence, a table of queries was drawn up and sent to 300 correspondents. Of the reports received from these correspondents, one hundred and forty of the most explicit were selected, and the contents were tabulated.

The evidence obtained was somewhat unexpected. The drought did not appear to have caused universal mortality among the young stock, on the contrary, the yield of Grouse in the majority of districts was abnormally large, and the stock of birds throughout the country was probably greater than it had been since the magnificent Grouse years of the early seventies. Record bags were reported from a number of moors. In Perthshire, and the Border Districts, and in certain parts of Yorkshire and Lancashire records were the rule rather than the exception, and in some cases the bags were two or three times as large as they had ever been before. From this it would appear that severe drought is not in itself an unfavourable condition to the health of Grouse, and this is quite in accordance with previous observations.

On the other hand, in certain clearly defined areas there was an abnormally large mortality among the young stock, far larger than had ever been observed before. From the difficulty of obtaining specimens for examination it cannot be stated with absolute certainty that in every case the cause of this mortality was Coccidiosis, but the suspicion that this disease was responsible was so strongly confirmed that it now almost amounts to a certainty. Every specimen examined was severely infected with the Coccidium, and no other cause of mortality could be discovered which applied to the affected districts and not to the healthy districts. From this it may be deduced that where the Coccidium infection exists dry warmth is favourable to its development. This also is quite in accordance with previous observations, and especially with the results of laboratory experiments.

The reports contained such interesting information that it may be permitted to give in tabular form a brief summary of the principal facts brought out. No apology is needed for mentioning the names of the districts affected, for they are already only too well known, and the fact that mortality has occurred in a particular district in one year does not denote that it will be subject to disease in future years; indeed, the reverse is usually found to be the case.

The following table is the more interesting in view of the fact that the stock of Grouse left at the end of 1910 was, without exception, healthy and vigorous. Thus every district commenced the nesting season of 1911 on equal terms.

[TABLE

TABLE Showing Summary of Results of Observations in Stock in 1911.

Number of Reports received.	Name of district.	Numbers of stock left at end of 1910.	Average number of eggs hatched from each nest.	Average number of young birds in each covey on 12th August.	Percentage of mortality among young stock.	Adult birds found dead after nesting season commenced.	Young birds found dead after hatching.	Remarks.
2	Caithness . .	above average	8	7½	6	none	none	Bags much about the average
14	Sutherland . .	above average	7	4	43	few	many	Very small bags but some exceptions
8	Ross and Cromarty	average	7½	5	30	very few	few	Bags below the average
10	Inverness . .	average	7	5	30	none	few	Bags below the average
11	Moray and Banff .	much above average	6	3½	42	very few	many	Bags much below the average
7	Aberdeen . .	above average	6½	5	20	very few	some	Bags below the average
6	Kincardine and Forfar . .	above average	7½	5½	30	none	few	Bags below the average
16	Perth . . .	above average	7½	6½	13	none	very few	Bags exceptionally good in central Perthshire
9	Lothians and Berwick, Peebles, Selkirk, Roxburgh .	above average	7½	7	7	none	very few	Bags abnormally good
12	Argyll and Dumbarton, Stirling, Renfrew, Lanark	above average	7	6	14	none	none	Bags above the average
2	Arran . . .	average	8	7½	6	none	few	Bags much above the average
5	Ayr . . .	above average	7½	6½	13	few	few	Bags above the average
6	Wigtown, Kirkcudbright and Dumfries . . .	average	8	6	25	none	few	Bags above the average
7	Northumberland and Durham .	above average	7½	5½	13	very few	very few	Bags above the average
12	Yorkshire . .	average	8	7	12	none	very few	Bags above the average but unequal
6	Westmorland and Cumberland .	above average	8	7	12	none	very few	Bags much above the average
7	Lancashire and Wales . . .	above average	7	6½	7	none	none	Bags exceptionally good
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The foregoing table gives only a general idea of the result, and the reports from individual moors were in many cases more striking, for example, on many shootings the percentage of mortality among young birds was much higher than the average for the county, in some cases amounting to 60 per cent. or 80 per cent. On the other hand, in some cases the mortality among the young birds was *nil*, and when this occurred the bags in the shooting season were abnormally large.

No accurate information was obtained as to the age at which young Grouse were most susceptible to coccidiosis, few chicks were picked up dead, but of the specimens obtained some were reported as living a few days old, some a few weeks old, and some half-grown. From observations upon birds received in captivity it would seem that the younger the Grouse the more vulnerable it is.

The figures throw a sidelight upon the normal mortality which may be expected among young Grouse, even in a good season. They indicate that provided there is no serious mortality among the adult birds the deaths among chicks may amount to as much as 25 per cent. without unduly reducing the bags. On the other hand, if the mortality among the chicks amounts to more than 30 per cent. the bags tend to fall below the average. This observation is confirmed in practice, for experience has shown that the average yield of a moor is about two birds for every bird left as breeding stock ; in other words, if a pair of birds produces a brood of seven chicks it is found that of the total number (nine) only about four come to the gun, two are left as breeding stock, and the balance of three goes to make up the wastage caused by disease or misadventure. Little wonder that few survive to die of old age.

The foregoing table does not bring out any marked connexion between overstocking and mortality among the chicks, for although the districts where mortality occurred were in the majority of cases very heavily stocked, the same condition existed in many districts where there was little or no mortality. On the other hand, it is significant that a more detailed examination of the separate reports showed that in no case where there was less than an average stock was there any serious mortality.

Perhaps the most striking fact brought out by the reports was that even where the mortality among chicks was highest, the results were by no means disastrous. It is true that in such cases the yield was below the average, but the loss was never anything like as serious as it would have been in the case of even a moderately severe attack of Strongylosis among the adult birds. In the cases where individual bags were noticeably reduced it was usually found that the mortality among chicks had been accompanied by a certain amount of mortality among old birds. From this it would appear that Strongylosis is more to be dreaded than Coccidiosis.

It only remains to say a word as to the different results obtained from well-watered and badly-watered ground. On the whole, it was not found that there was much connexion between the supply of water and the health of the stock. The well-watered moors were quite as severely affected as the drier ones; in one case it was recorded that a whole covey of chicks were found dead within a few yards of a drinking place. It is true that in the autumn birds were found in greater numbers on the wetter parts of the moors, but correspondents were almost unanimously of the opinion that such birds were the result of successful nesting on the drier parts and subsequent migration.

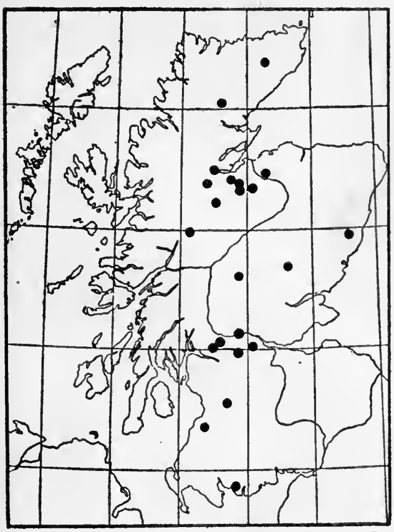
At the time of writing it is difficult to foretell what results the drought of 1911 will have upon the Grouse stock of 1912. The heather in 1911 had the appearance of being shrivelled and parched by the heat, and the bloom was brief and not luxuriant; but we do not at present know enough to say whether this would affect its food value through the winter. On the analogy that a district with a low rainfall produces the best heather for Grouse, there are grounds for the hope that the recent dry season will have a similarly favourable effect. The test will be a severe one, for the Grouse stocks left from 1911 were abnormally large, and only the most favourable conditions will enable them to safely survive the critical period of early spring.

PART II.

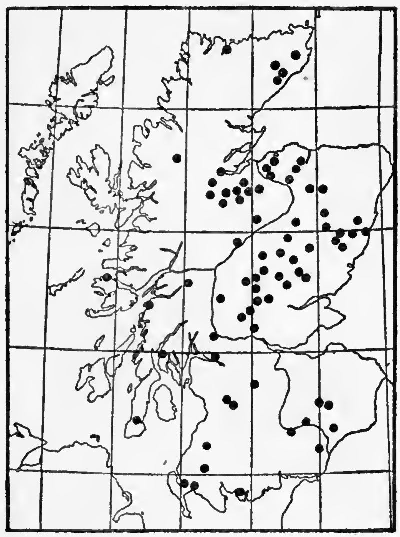
SERIES OF MAPS SHOWING THE INCIDENCE OF "GROUSE DISEASE" IN FORMER YEARS.

The following series of maps has been prepared to show the localities in which "Grouse Disease" has occurred during the last thirty-nine years, and the local distribution of the various outbreaks.

1872



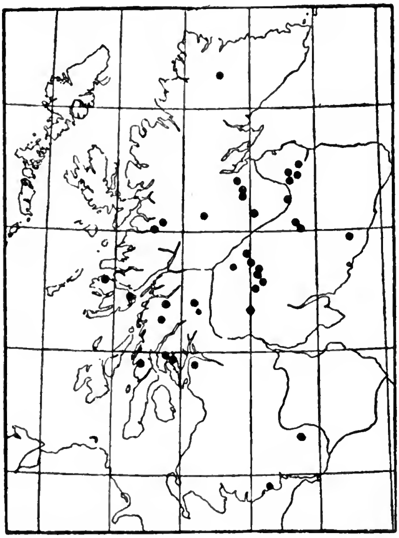
1873



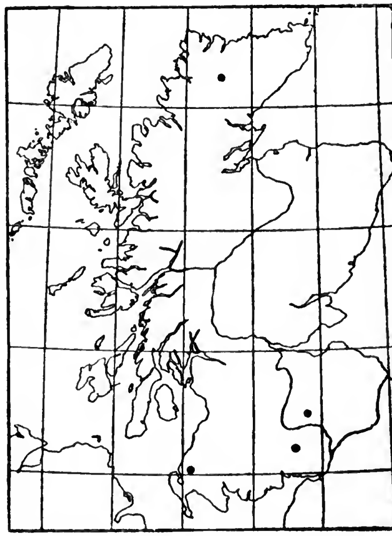
Scotland alone has been dealt with, for the information obtained from that country on the subject of "Grouse Disease" has always been fuller and more accurate than from England.

The series of maps commences with the year 1872, which, with 1873, will always be notorious as the date of one of the most severe and widespread epidemics of "Grouse Disease" ever known. An endeavour was made to go back to 1867, the year

1874

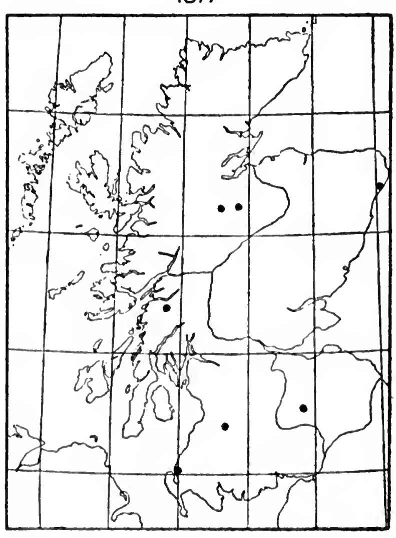


1875



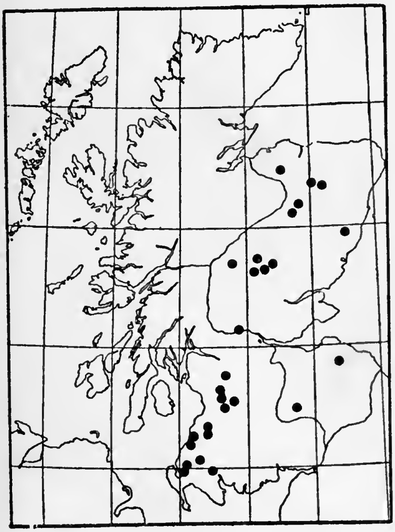
1876

1877



of another serious outbreak which, especially in the Border districts, seems to have rivalled 1873 in severity; but at this early date the interest in the subject does not appear to have found expression in the form of recorded observations, and the evidence is scanty and inconclusive.[1]

1878

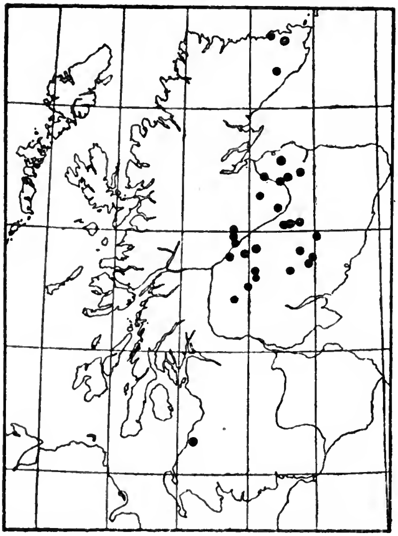


1879

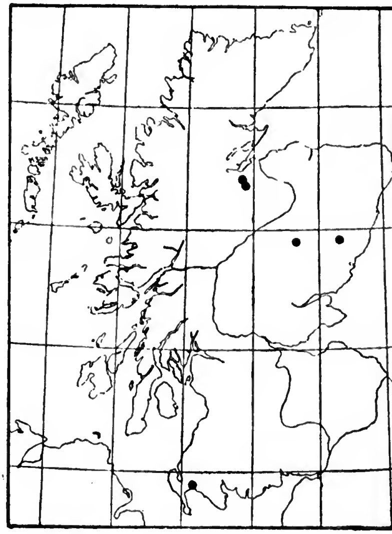
The records have been obtained by a systematic search of private memoirs and gamebooks and published material, and of the latter the annual reports contained in the *Field* newspaper have been of the utmost value. Most of the material was collected at a time when the more serious attacks were alone thought worthy of mention, and the earlier maps in consequence contain a smaller number of recorded outbreaks than would have been the case had a note been made of every moor on which dead birds had been picked up. As the knowledge on the subject increased it became evident that the milder outbreaks of mortality were only different in degree, and not in kind, from

[1] But *vide* chap. xv. p. 443.

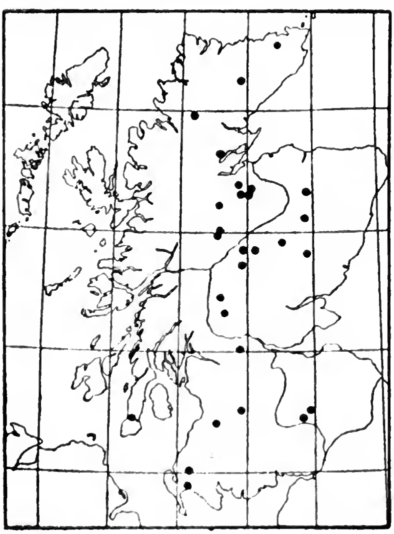
1880



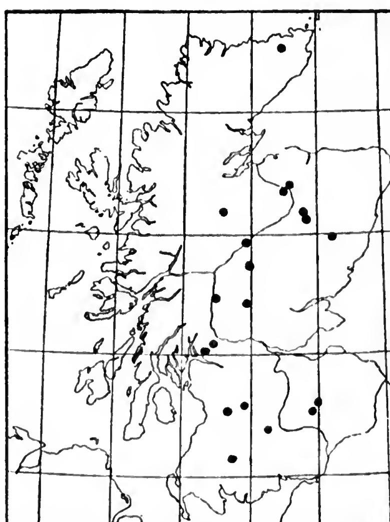
1881



1882



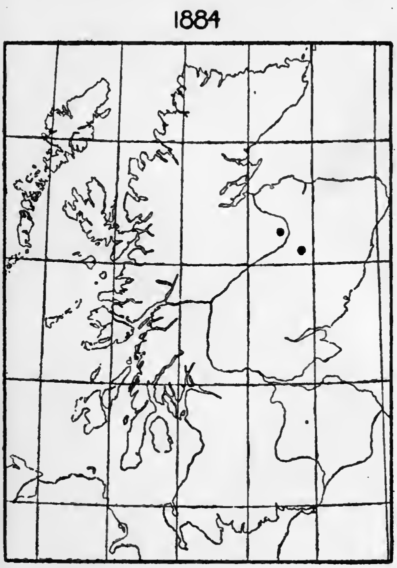
1883



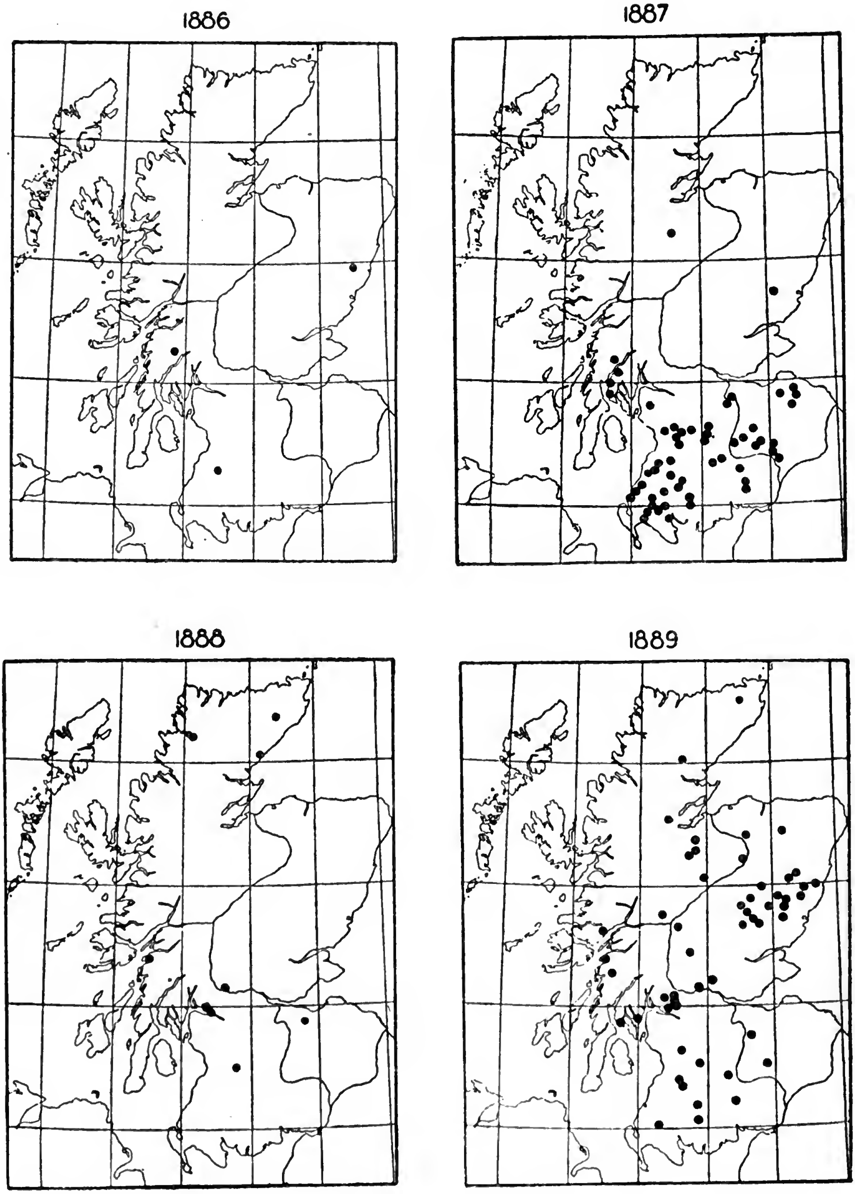
the more serious ones, and in the later maps every place is marked from which even a single case of Strongylosis had been reported.

In the original maps each place from which "Disease" was reported was marked by name, but for the present purpose it is thought undesirable to do more than indicate by a dot the district in which the outbreak occurred.

Beginning with the year **1872** it will be seen that "Grouse Disease" was general throughout the greater part of Scotland, and when it is remembered that only the most severe epidemics were noted it may be imagined that the country as a whole was very severely affected. The really disastrous year, however,

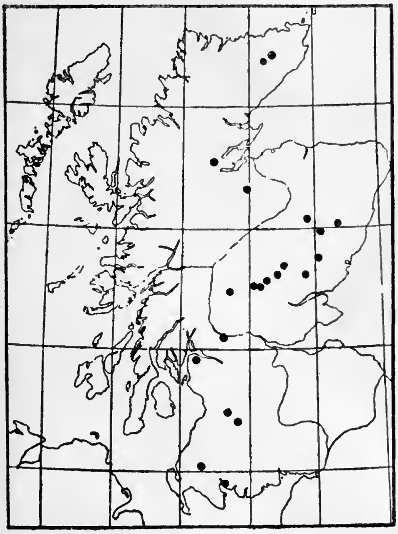


was **1873**, when the mortality was so widespread that the stock was reduced to a condition from which it took years to recover. What moors were not cleared of Grouse in **1873** were swept by the scourge in **1874**, and then there commenced a series of lean years during which there were few Grouse and little disease.

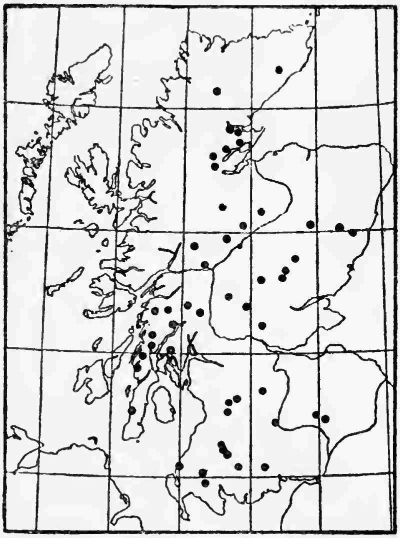

1886
1887
1888
1889

The first appearance of another outbreak was in 1878 when a certain amount of mortality was reported, more especially in the south of Scotland. This district may have been more liable to attack owing to its having been less severely affected in 1873. The northern moors also had not long to wait before they were visited by another outbreak; in 1880 a sharp attack was reported from Moray, Banff, Perth, and Forfar. There

1890

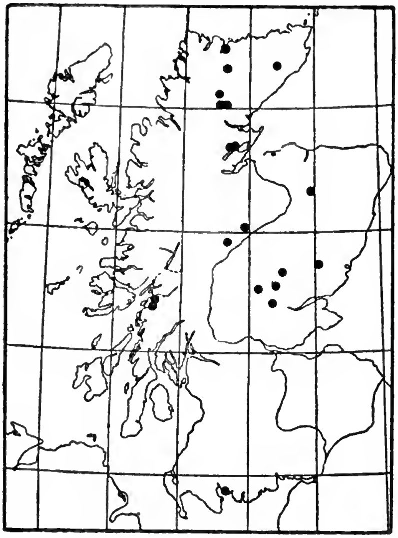


1891

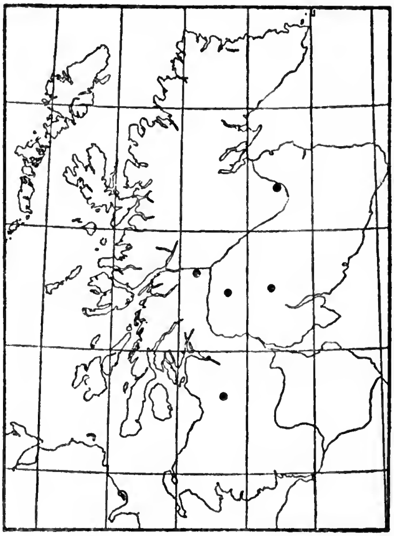


was a recovery in 1881, but 1882 and 1883 were bad years, and after that there followed a succession of healthy seasons up to the record years of 1886 and 1887, when a very severe outbreak occurred in the south of Scotland. In 1889 there was a widespread epidemic throughout the whole of Scotland, the disease being noticeably severe in Forfar and Kincardine; the sickness lingered through 1890, and broke out afresh in 1891. From 1892 to 1898 the country was never quite free from disease, though the principal centres of attack changed each year. Then followed two comparatively healthy years only to be succeeded by further scattered outbreaks.

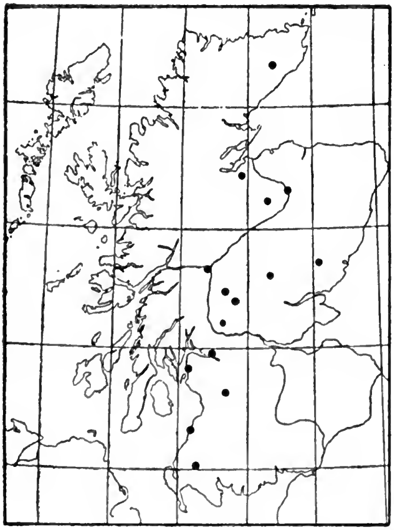
1892



1893

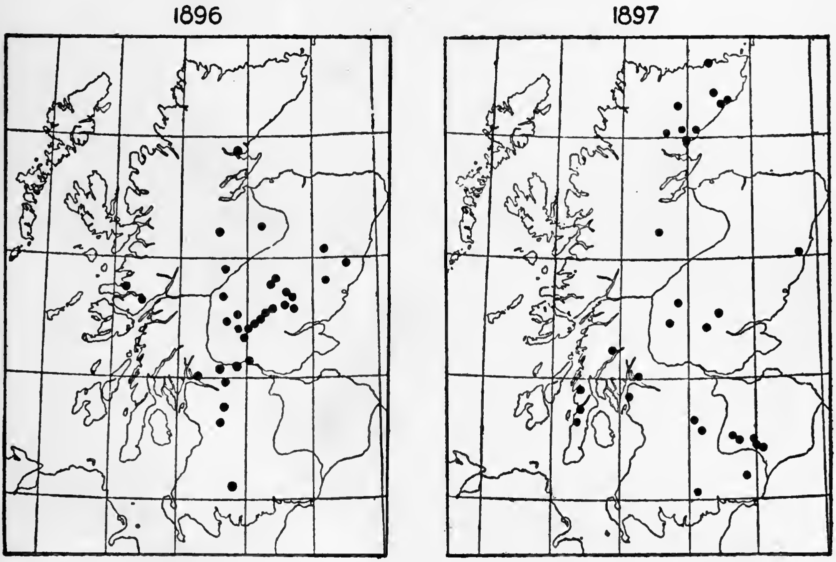


1894



1895

In 1905, the year of the Committee's appointment, there was less disease than there had been for many years, a fact which at the time caused some disappointment, but which in reality was of the greatest assistance to the Committee, since



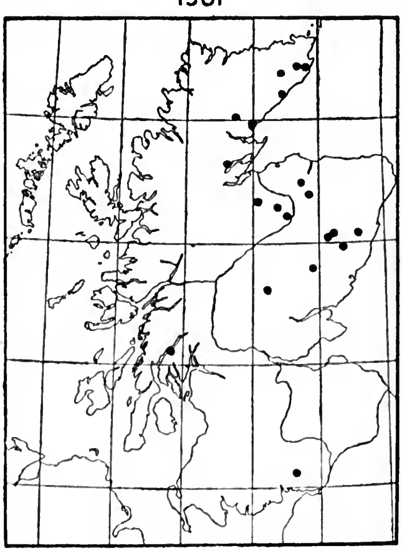
it enabled them to study the natural history of the normal Grouse under the most favourable conditions. From that year onwards to the close of the Inquiry the history of each outbreak has been closely followed, and an endeavour has been made to ascertain the predisposing causes of the epidemic. No very serious outbreaks have occurred within the period of the Inquiry, and the fact that the maps for 1907 and 1908 show a very large number of disease centres is due rather to the more complete system of collecting information than to the severity of the attacks. Had the same facilities existed in 1872, 1873, 1874, 1880, 1887, 1889, 1891 the probability is that each of these years would have shown a very much larger number of cases. Indeed, it is believed that since the principles

1898

1899

1900

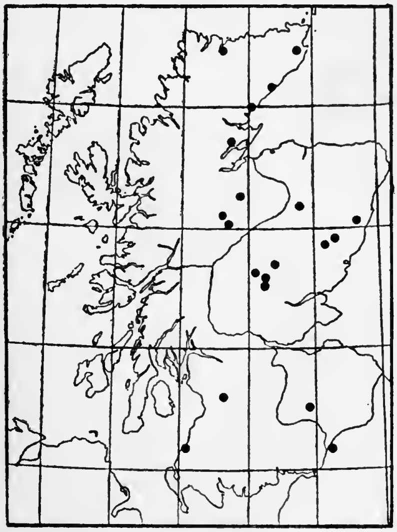
1901



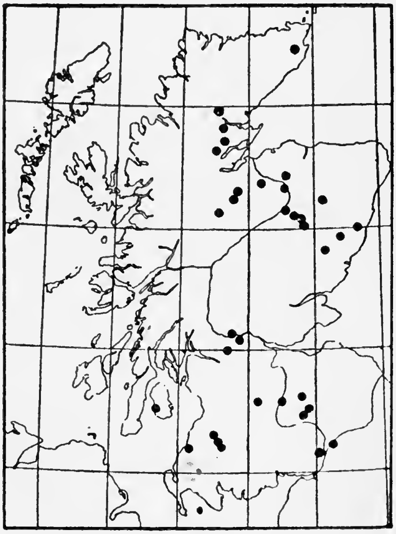
of stock regulation and moor management have come to be more generally recognised and practised, the conditions which gave rise to the disastrous outbreaks of "disease" in 1867 and 1873 no longer exist to the same extent as before.

The deduction to be drawn from the study of the series of maps is that there is no Grouse-producing district which can claim to be entirely immune from attack. Occasionally an individual moor may show a clear record for a long period; but even this is probably due to strict control of stock and freedom from immigration rather than because that particular piece of ground possesses characteristics which protect the Grouse from disease. The only true test of freedom from disease is the

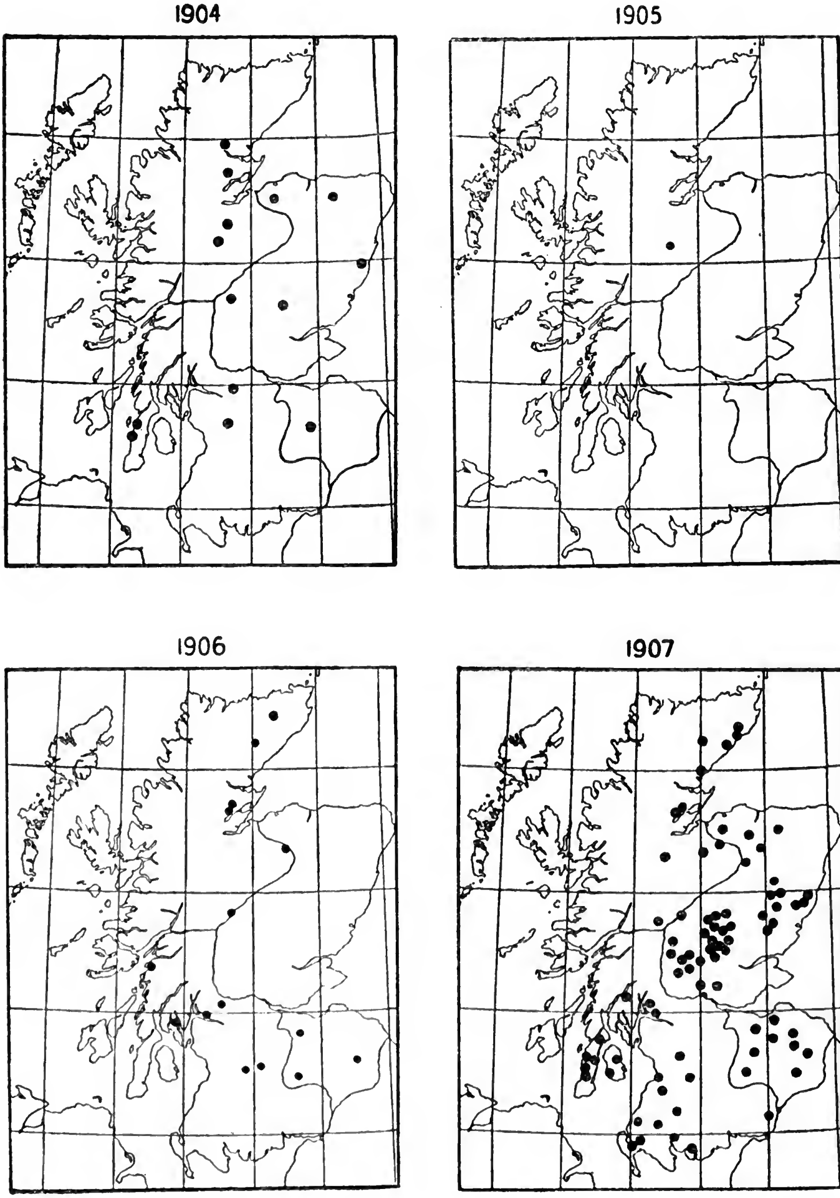
1902



1903



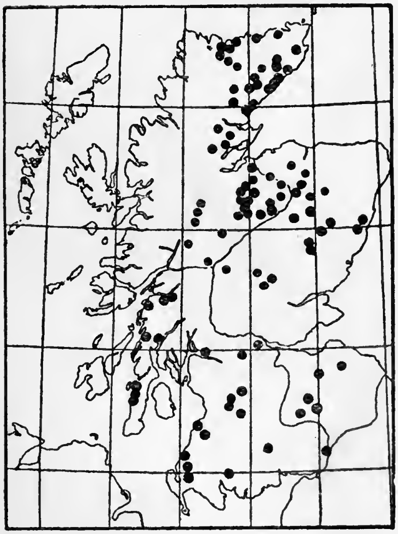
dissection of the birds themselves. If it can be shown by dissection that the birds from any particular moor are at all times free from the Strongyle worm it may fairly be claimed that that moor is disease-free. But up to now only one moor


1904
1905
1906
1907

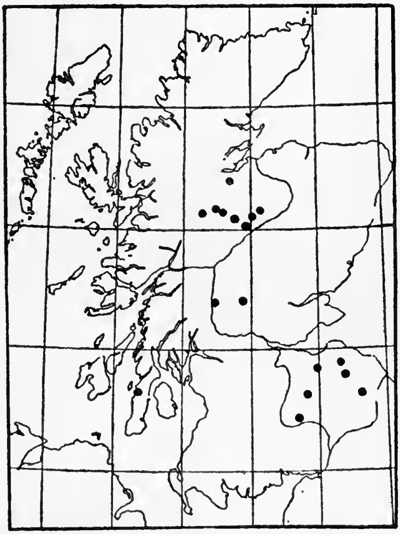
has been formed which reaches this exceptional standard, and that moor is affected by abnormal circumstances.[1]

The fact that no district in Scotland is immune from "Grouse

1908



1909

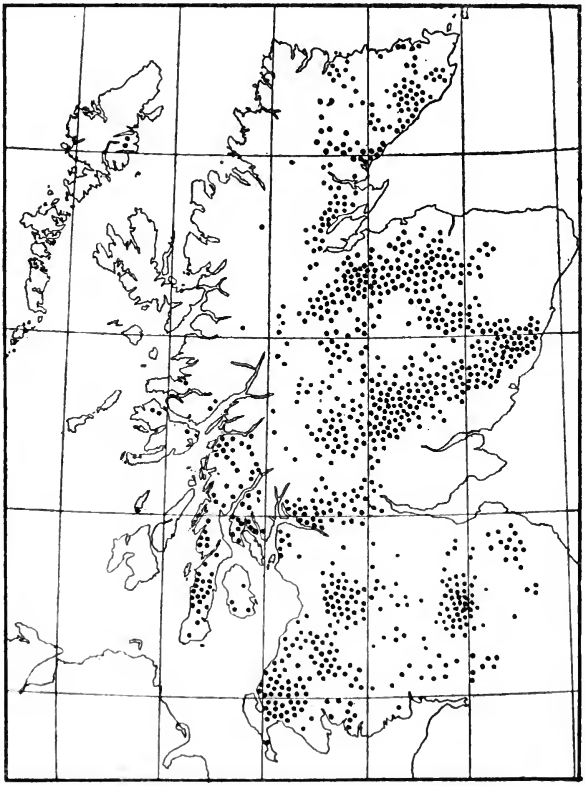


Disease" is proved by the map reproduced at the end of the series. This map shows approximately the districts from which authentic Reports of "Grouse Disease" have been received

[1] The moor in question is on Tentsmuir in the county of Fife,—a stretch of sandy soil of about 1,000 acres lying on the edge of the North Sea, and only a few feet above high water mark. It has a good but somewhat irregular growth of heather. Until 1872 there were no Grouse on the moor, but in that year a few wild birds were turned down, and speedily became established. The moor now yields an annual bag of from forty to sixty brace. This moor is entirely free from any appearance of Strongylosis, and the Grouse obtained from it are the only Grouse examined by the Committee which, on dissection, show no trace of the Strongyle worm. The absence of this parasite may be due to the fact that the moor is isolated from other Grouse ground; but this can hardly be the correct explanation, seeing that the original wild birds by which the moor was stocked must presumably have been infected with the normal quota of this nematode. A more probable explanation is that the salt from the sea spray has so impregnated the ground as to make it impossible for the worm to exist, for it has been proved by experiment that even a mild solution of salt is fatal to the Strongyle in the larval stage. On the other hand, hand-reared Grouse are often entirely free of the Strongyle worm, and it is for this reason that they are the only birds which can be usefully employed for experimental purposes.

during the past thirty-nine years. Where reports were received from the same centre in more than one year additional dots were marked as close as possible to the correct spot upon the map, and thus, though the maps are useful as showing the general distribution of mortality, they must not be regarded

MAP SHEWING THE PRINCIPAL CENTRES OF OUTBREAKS OF GROUSE DISEASE IN SCOTLAND DURING THE PERIOD FROM 1872 TO 1909 INCLUSIVE.



as a reliable guide to the exact position of the moors on which the outbreaks occurred.

In spite of the fact that the reporting in some centres was better organised than in others, it will be seen that during the period under review the mortality has been impartially distributed amongst the Grouse-producing districts of Scotland,

and moreover that it bears an exact proportion to the importance of each district from a sporting point of view. Thus it will be seen that on the finest Grouse ground of Caithness, Ross, Inverness, Banff, Aberdeen, Forfar, Perth, Argyll, and the Border counties disease has occurred more frequently than in the lightly stocked areas of the same countries, while from the extreme west coast and the deer forests of the Central Highlands little or no mortality has been reported. The map of Northern England shows the same results, though not quite so conclusively since the reports from that country are less complete than from Scotland.

"Grouse Disease," then, is not confined to any particular geographical area, but seems to bear a relation to the number of Grouse in each moorland district, and the maps accordingly form an interesting record of the districts in which the largest numbers of Grouse are to be found.

An attempt has been made to trace a connexion between the numbers of Grouse, and their liability to "disease" in a particular district, and the geological formation or meteorological conditions in that district. So far as geological formations are concerned there does not appear to be any close connexion. The best Grouse-producing district in Caithness has a mineral sub-soil of old red sandstone on the east and granite on the west; Sutherland, in addition to the above-named rocks, has oolites and gneiss, Easter Ross consists principally of old red sandstone. The famous Grouse moors of Strathnairn, Strathdearn, and Badenoch lie principally on a bed of gneiss or gneissose rocks; the equally productive moors of Upper Banffshire on quartzite, mica-schist, and graphitic mica-schist with smaller areas of old red sandstone and granite. The upper districts of Strathdon and Strathdee contain an assortment of nearly all the above-named formations with a few others in parts. The Forfarshire and Central Perthshire moors lie principally on quartzite and mica-schist. Ayr, Strathclyde, and the Lothians contain a large assortment of different carboniferous rocks, while in the southern Highlands from Wigtown on the west to Berwick on the east the most representative formations are graptolite shale, Llandovery, old red sandstone, Ludlow, and Wenlock.

With regard to meteorological conditions the case is different, as may be seen at a glance from the Rainfall Map of Scotland published by Messrs Bartholomew for the *Journal of the Scottish Meteorological Society* for the years 1866 to 1890, and here reproduced by the kind permission of Messrs Bartholomew and of the Society. It will be seen that the principal Grouse-producing areas coincide almost exactly with the districts of low and moderate rainfall, the only exceptions being in the western districts of Sutherland and Ross and the islands of the Outer Hebrides. Whether the heavy rainfall has a directly detrimental effect upon the Grouse, or merely affects it indirectly by preventing the best development of the heather on which it feeds, may be a matter of conjecture, though the latter seems the more probable explanation. The fact remains that where the rainfall is heavy Grouse are few, and it is feared that this fact will always prevent the Grouse moors in certain rainy districts from being brought to the same standard of productiveness as in more favoured region.

The points brought out by the series of maps may be summarised as follows :—

(1) " Grouse Disease " is one of the natural risks to which Grouse are subject, and is to be found wherever Grouse are numerous.

(2) Except in specially favourable seasons there is always a certain amount of " Grouse Disease " in one district or another.

(3) " Grouse Disease " does not usually persist in the same locality for more than one or two years. This is probably due to the fact that by the reduction of the stock the risk of further infection is lessened.

(4) There is no connexion between "Grouse Disease" and the geological formation of the district in which it occurs.

(5) Where the rainfall is heavy there are few Grouse—and Where the rainfall is heavy there is little " Grouse Disease."

RAINFALL OF SCOTLAND FOR 25 YEARS, 1866-90

MEAN ANNUAL

A. Buchan, delt.

Bartholomew, Edin.

Scale of Rainfall in Inches

UNDER 30	30 - 40	40 - 60	60 - 80	ABOVE 80

PART III.—MANAGEMENT OF GROUSE MOORS

CHAPTER XI

MOOR MANAGEMENT

Before going into the question of moor management and the various suggestions that have been brought forward from time to time with the object of maintaining the health of Grouse, it seems advisable to give a brief *résumé* of some of the more important hygienic and economic facts established in the preceding chapters.

New data, intelligently apprehended, must of necessity entail a regrouping of ideas, and it is therefore expedient, in the light of a heightened standard of knowledge, to re-examine old assumptions, sift the good methods from the bad, and look into the why and the wherefore of recognised specifics, before embarking on suggestions as to the lines on which further developments should best proceed.

It is not only in the advancement of abstract knowledge and the co-ordination of existing practice with scientifically established fact that progress is to be made. The results on the practical side should be no less important. In the first place, the keeper is by profession a trained observer, and, as far as the consideration of natural phenomena is concerned, an educated man. Nothing is more likely to act as a stimulus to personal exertion, and therefore to increased attention to the moor, than a clear understanding on his part, not only as to what should be done—of which he has already a pretty thorough grasp—but also as to the reason why a given action is taken about which he has but too often the most vague ideas. Again, if any advance is to be made in methods of moor management, it is obvious that the details must be worked out by the practical man on the spot; this can only be done if the keeper realises the nature of the difficulties to be met, and the reasons for which the suggested remedies are put forward.

In recapitulating certain findings of the Committee it will not be necessary to go into questions of purely scientific interest, still less to set out again at any length the facts established in former chapters. As far as possible, scientific nomenclature will be avoided, and only such matters dealt with as bear directly on the health of moors.

Cause of "Grouse Disease."

Briefly stated, the "Grouse Disease" Committee claim to have defined the main—in their opinion the only—primary causes of what is commonly known as "Grouse Disease."

During the six years of their investigation they have examined outbreaks of disease in every Grouse-producing county of England, Scotland, and Wales.

They have dissected birds, not only in the laboratory, but freshly killed in the vicinity of the moor; they have had the advantage of all the conveniences of modern and recently devised scientific appliances; they have been kept accurately informed of the outbreaks of disease, and by means of a network of correspondents extending to every part of the Grouse-producing area, have been able to observe the epidemic in every phase of its progress.

Apart from these advantages, not enjoyed by any former body of inquirers, the Committee were assisted by field observers of experience, who reported and classified variations in local conditions. In the main divisions of research—entomological, pathological, helminthological, parasitical, botanical—into which the Inquiry resolved itself, it had the whole-hearted co-operation of a large and experienced staff of investigators, and the help and advice of many leading men of science to whom the subject has directly or indirectly appealed.

After examining nearly two thousand cases of death from

Strongyle worms the cause of adult "Grouse Disease."

other than natural causes, and the facts and surrounding circumstances of over two hundred separate outbreaks of disease, the Committee arrived at the conclusion that the Strongyle worm, and the Strongyle worm alone, is the immediate *causa causans* of *adult* "Grouse Disease."[1]

The Inquiry did not confine its energies merely to restating the theory advanced by Dr Cobbold in 1873. It put the question to the test by proving not only that Grouse under certain specified conditions die by an over-infection of the Strongyle worm, but also that healthy birds can be artificially infected with overdoses of the worm in its larval form, and that, provided the doses are sufficiently often repeated, the bird so treated will die with all the recognised symptoms of true "Grouse Disease."

In addition to the examination of the cæca or blind guts of diseased birds, the Committee paid very close attention to the intestines of healthy birds, with the result that over 95 per cent. of the birds examined have proved to be infected with the Strongyle worm; that is to say, that almost every bird on a moor contains in its body under normal conditions the immediate cause of "Grouse Disease," and is to a greater or less extent an agent for the dissemination of that scourge.

If we admit the truth of these statements, and close perusal of the preceding chapters will make it difficult not to do so, we see at once that we have in the Grouse, not a bird free from all the ills that flesh is heir to, struck down in thousands at no infrequent intervals when the gods are unkind, but rather an unfortunate moor-fowl, carrying in its body an inherent liability to disease which only requires certain specified conditions to develop and turn the hardiest of all game birds into a badly-feathered, rusty piner, scarcely able to fly, and ripe for death.

What the conditions are that make this latent and endemic evil assume an epidemic or partly epidemic form is a subject which is all-important to moor-owners, and on the correct

[1] *N.B.*—Coccidiosis (chap. ix.), the most common cause of mortality in Grouse chicks can rarely be described as the direct cause of the death of adult birds.

definition and recognition of these conditions the health of the moor directly depends.

Briefly put, we have two factors common to all epidemic diseases, the always present, occasionally harmful intruder, and the host; that is to say the Grouse, at times successfully resistant, at times pathologically affected by the nematode worm. In examining the action of these two variant factors from the point of view of the moor-manager, all that is necessary to ascertain is (1) with regard to the Strongyle—what are the predisposing causes which affect its occurrence in the Grouse's cæca, in greater or less numbers with more or less harmful consequences? And (2) with regard to the Grouse—what are the predisposing conditions that tend to raise or lower the bird's power of resistance to the ever present evil?

If we can get a clear conception of these two sets of contributory causes we can proceed with some confidence to investigate measures put forward for the improvement of the health of moors.

Life history of the Strongyle worm.

Before considering the conditions affecting the degree of infection of birds by the Strongyle worm, it is necessary to refer to the life history of the parasite itself.

As will be seen in chapter viii., this portion of the investigation has afforded the Committee no little difficulty; the small size of the worm, and the fact that a great part of its existence is passed outside its host, have made it difficult to follow this parasite through all its changes of form. The proverbial hunt for a needle in a bundle of hay is simplicity itself compared to the labour of detecting the larval nematode (so small as to be visible only under a high-power microscope) in an acre of heather. In addition to the difficulties arising from the small size of the worm, the search was made more complicated by the presence of other free-living nematodes, very easily mistaken for *Trichostrongylus pergracilis*. Some of these complete the whole cycle of their life in the soil, and are never parasitic at all.

With very few exceptions every Grouse has in its body a varying number of Strongyle worms, of which the females are each capable of producing many eggs; these eggs pass from the body with the cæcal deposit, and after three days' incubation on the moor, reach the larval stage. The cæcal deposit is well known to all field observers, and is readily distinguished from the hard cartouche-shaped dropping of the main intestines by its light chocolate brown appearance and moist consistency.

The number of the larvæ in a Grouse-dropping varies enormously, and depends directly on the degree of infestment of the bird from which it comes; in the case of heavily infected birds they may be reckoned in tens of thousands.

The larvæ during the earlier stages of their existence appear to have the power of lying dormant for an indefinite period, they are not affected by the frost; a rise of temperature will at any period raise them out of their torpid condition; excessive drought and perhaps the salt spray of the sea are the only conditions known to be injurious to their health.

After passing through the casting of skins common to most nematode worms, and after a period generally to be reckoned in weeks, but probably never less than ten days, the larvæ assume a resistant sheath and become active young nematodes; they climb the shoots of the damp heather, and, like the East Coast fever-tick on the South African spear-grass, lie in wait for an opportunity to complete their life history by returning to their natural host the Grouse.

Once the Strongyles have returned to their host the further stages of their life history follow in rapid succession. Absorbed with the heather shoot into the crop, protected in the gizzard by the sheath-like covering from the action of any but the sharpest grits, the encysted Strongyles pass once more into the cæcum, and on the third day reach the adult stage; the females become fertile, and three days later the myriad offspring set forth once more to infect the moor.

It is only when the adult Strongyle is found in the cæcum in large numbers that the health of the Grouse is appreciably affected. If we consider that birds may be packed on one portion of the feeding area, for perhaps weeks at a time, herded together by stress of weather or shortage of food, that the number of Strongyles will increase by geometrical progression as the birds get more heavily infected and therefore increasingly able to foul the moor, it is not difficult to realise, despite the countless thousands of larvæ destroyed by drought, mishap, heather-burning, etc., how the moor may become more and more tainted, until at last every shoot of heather bears the seeds of "Grouse Disease."

Power of resistance of Grouse.

Equal in importance to the presence or absence of the Strongyle is the second factor, the power of resistance of the individual Grouse. The fact that the normal Grouse, in the proportion of ninety-five to five, has its cæca charged with Strongyle worms shows that, under a certain set of natural conditions, the worms are not necessarily hurtful to their host. Upset the natural balance, and this at once ceases to be the case.

This varying power of resistance of the host to parasitic or bacterial infection has long been a recognised commonplace of science.

Recent scientific investigation seems to indicate that the power of resistance varies directly with the health of the subject, and as far as the Committee's investigation goes, the Grouse appears to be no exception to the rule. A bird in full health, weight, and plumage can carry his quota of Strongyles like an alderman his wine; but once allow the vitality or weight to go below a certain recognised figure, then immediately the Strongyle worm appears to operate harmfully on the vitality of the bird. The cæca become inflamed, the digestive process is no longer effective, the moult is delayed so that the bird loses the fresh colour of its plumage, it declines in weight, and, after a more or less protracted resistance, eventually succumbs.

Without going into the whole argument in support of these statements it is only necessary to say that the weight of the bird is the most easily recognised indication of its power of resistance to disease. That nine-tenths, if not all, of the outbreaks of "Grouse Disease" have their origin in the spring, when the food-supply is at its shortest, and when the bird is in its lowest condition; that in early spring the cock-birds, wearied out with fighting for their nests and mates, lightened in condition and without time to feed, die in the proportion of seven or ten to one hen; whereas in late spring and early summer, when the hens are weakened after their moult, and light in weight through shortage of food during the sitting period, the relative proportions in the death-rate are reversed.[1]

From the consideration of the two factors set out above, the immediate objective of the moor-owner stands out clearly —to keep the Strongyle infection at its lowest, to keep the power of resistance of the stock at its highest, and at the same time to maintain the greatest number of birds that the moor is capable of supplying with suitable food.

Definition of moor management

Successful moor management may therefore be defined as the maintenance of a margin in the power of resistance of the weakest individual Grouse, sufficient to enable it to overcome the greatest nematode infection to which the surrounding circumstances may render it liable. To put it briefly and in practical language: *Moor management is the science of distributing the stock of birds over the moor, so that at no period of the year can any area be so infected by the Strongyle worm as to make it a source of danger to the least well-nourished bird* (*that is, to the bird of the lightest weight*) *on that area.*

In considering this definition it is important to realise not only the main factors connected with "Grouse Disease," but also the contributory causes which produce them, (*a*) the power of resistance of the Grouse, which varies directly with diet, moult and seasonal conditions, (*b*) the liability to infection, which varies with the number of larval nematodes on any given feeding-ground. These contributory causes in turn depend on the number of birds on the given area, the number of nematode eggs deposited in each cæcal dropping, and the length of time

[1] *N.B.*—Investigation in the Frimley area has shown that light birds and birds not in good plumage die more easily from artificial infections of nematode worms, and measurements go to show that light and weakly birds of one year, without sufficient strength to feed themselves at the time of stress in winter and autumn, are the piners and diseased birds of the year following. *Vide* Report, chap. xxi. pp. 469-470.

that the stock has been congested on any portion of the ground.

It must be clearly understood that "Grouse Disease" is not dependent on any fixed number of Strongyles in the cæcal intestines, or that any fixed standard of power of resistance guarantees immunity from the disease, but rather that the epidemic depends on the relation between the amount of infection and the power of combating the same. That is to say, that the nematode infection which would be fatal to the weak bird might conceivably be the normal burden of the strong Grouse; and that the same bird might carry with ease in autumn—when well nourished and fully feathered—the number of Strongyle worms to which he would succumb in spring when light in weight and short of food. If we realise this theory in its entirety we shall find ourselves on vantage ground from which the many and apparently contending aspects of "Grouse Disease," and the numerous hypotheses based thereon, can be readily explained.

Theories of "Grouse Disease."

CERTAIN THEORIES OF DISEASE HELD BY SPORTSMEN AND FIELD OBSERVERS.

(1) Frosted heather.

First Theory.—A very common theory, especially on the west coast of England and Scotland, is that frost is the cause of "Grouse Disease." This theory is usually stated in the form —that "the frost of early spring browns the heather, birds eat the heather and die of indigestion." This is a very good example of an incorrect deduction drawn from properly observed natural phenomena, and of the ease with which secondary causes are confused with primary ones. It is quite incorrect to say that frost in spring is the immediate cause of "Grouse Disease," for the very excellent reason that of nearly two thousand crops examined by the Committee not one single crop has been found to contain a shoot of brown or frost-dried heather. It is, however, correct to say that when frost comes in late spring, or when the cold east winds scorch the young shoots, the area of ground on which the birds can feed is reduced, and there may be therefore both a lowering of the Grouse vitality through a shortage of the food supply, and an increased danger of infection by the Strongyle worm through the congestion of the birds upon a small area of feeding-ground. The old stick heather, ragged and sparse, is the first to suffer from frost, and is therefore of little use for food during the winter and spring. It is only in the thick six- to fifteen-year-old heather that green shoots can be found under the browned tops.[1] On a badly-burned moor this may mean a very great curtailment of the food yield of the moor; greater perhaps than the health of the weaker birds will stand.

(2) Period outbreaks unavoidable.

Second Theory.—It is stated that disease comes every seven years: that it is a recognised order of creation, and that no effective steps can be taken to alter the periodicity of its recurrence. This theory, like the preceding frost theory, is quite beside the point. In the first place, "Grouse Disease" does not occur on any moor in the regular order of once in seven years. The examination of some hundreds of Grouse records show that the disease occurs, on those moors which are liable to the epidemic, at irregular intervals of three to eight years.

The ordinary sequence of events is, one year of disease, one or two years of recovery, two or three average seasons, one or occasionally two bumper years, followed by disease in the following spring. Disease after a record year is due partly to a heavy Strongyle infection in the winter months, resulting from an overstock at a time when the birds are packed together on the lower portions of the moor, partly also to the Grouse's decreased power of resistance arising from a heavier stock without a corresponding increase of the food-supply As has been already pointed out this food shortage is most marked in spring, and the outbreak of the disease accordingly occurs at that time.

[1] *See* chap. iii. p. 83.

) Two rms of sease.

Third Theory: Klein's Disease.—The third theory, associated with what is commonly called Klein's disease, is that the mortality can assume two forms, the first or epidemic form (pneumo-enteritis), which sweeps the moor, and in which the birds are said to die in plump condition, fully feathered; the other a lingering disease in which birds waste away and die only after loss of plumage and weight. The Committee have paid very close attention to Klein's disease, and the remarks on p. 153 should be read. It may be noted that in all the outbreaks investigated not one single case was found of birds dying in good condition, *i.e.*, at normal weight. On seventeen different occasions during the course of the Committee's investigations keepers have reported birds dying plump and fully feathered; in every case the spring balance has indicated that the birds referred to were below the normal weight, and visceral examination has shown that the cæca were charged with Strongyle worms.

) Midges gnats.

Fourth Theory.—The fourth theory put forward is that when birds die of disease on lightly-stocked moors it is impossible that they should die of shortage of food or by parasitic infection, and that therefore midges or gnats must be the cause of death. This theory is not supported by any ascertainable facts or data, and, as far as examination of the blood goes, there is strangely little evidence in its favour.

It cannot be admitted that a shortage of stock on a moor is necessarily a guarantee of immunity from infection by the Strongyle worm, although it may lessen the risk of such infection. It will be shown later that moors in Yorkshire, which one hundred years ago were unable to carry three hundred brace to ten thousand acres without a certainty of disease, have by careful burning been made to carry ten times that stock without risk.

Infection of a light stock can be brought about in various ways:—

(1) If, in a hard winter, the birds are driven by snow off their own ground and congested on a small feeding-area for a

long enough time for the larval nematode to go through its changes and infect the heather, the birds may become so charged with Strongyle that they die as soon as they return to their own ground, however lightly stocked that ground may be. There are very few owners of high-lying moors who have not heard the remark: "The birds were quite healthy before the last winter storm; as soon as they returned to the high ground they began to die."

(2) "Grouse Disease" occasionally appears the second and third year after a severe epidemic, especially on wet, badly-drained moors, and this notwithstanding the small stock that may have survived the first outbreak. As has been shown in chapter viii.,[1] the Strongyle worm flourishes best in damp surroundings, and it is possible that on a wet moor a smaller quantity of ova may be sufficient to cause fatal infection.

(3) On the west coast of Scotland a very light stock sometimes contracts disease. West coast heather is, as a rule, of ranker growth and more open habit than what is found on the east coast; it is therefore more liable to be scorched by the frost and cold winds of early spring. The food-supply in consequence is apt to become so short that the normal quota of Strongyle worms are enabled to become actively pathogenic without the aid of further and outside infection.

Fifth Theory.—Another theory put forward is that a hard winter affects the health of a moor. This theory takes two forms. First, that a hard winter makes for healthy stock, and secondly, that a hard winter causes disease in the following spring. (5) Hard winters.

These theories are mutually destructive, but, paradoxical as it may appear, both are conceived on a certain basis of truth. A hard winter tends to kill off sickly birds, to shift the stock and to mix the breed; snow lying on the heather till far into the spring protects it from larval infection during the critical months of February and March, and so ensures a fresh, untainted

[1] Chap. viii. p. 237.

food-supply in April and early May ; lastly, heavy snow followed by floods tends to wash the moor clear of Strongyle larvæ ; all these are factors which benefit the moor.

On the other hand, a hard winter may do incalculable harm if the birds are driven off the hill ground and massed for several weeks on a small area of feeding-ground. The winter storms, especially in the Highlands, drive birds off great tracts of heather land, with the result that when the food is at its shortest the local feeding-area is reduced sometimes to a half, sometimes to a tenth, of its normal size. The migration of Grouse is a question that has only recently been systematically studied, and some remarkable facts have been brought out as to the length of time for which birds may desert the high ground.[1]

)) Feeding n corn.

Sixth Theory: Corn Theory.—This theory suggests that by eating corn in the stook birds are seriously affected in health, and die of disease in the year following.

This is another example of faulty deduction from correctly observed natural phenomena. The fact that birds go off the moor in October to eat corn on the low ground usually means that there is not a sufficient natural food-supply on the moor.

If the birds are short of food in autumn and early winter it is quite certain that they will be still shorter of food in the spring when the carrying capacity of the moor is at its lowest, and it is easy to see how they will in consequence become liable to the hurtful influences of the Strongyle worm.

It is not necessary to go into any of the other theories of "Grouse Disease" examined by the Committee. The majority appear to be based on a misinterpretation of natural phenomena, and in most cases confusion has resulted from mistaking the predisposing conditions for the immediate causes. All the theories on the subject fall into line with the solution put forward by the Committee, that the immediate cause of "Grouse Disease" among adult Grouse is the Strongyle worm.

[1] *Vide* chap. i. pp. 28 *et seq.*

The next question that has to be considered is whether there is any proof that the liability to "Disease" can be artificially controlled. Can it be shown that more birds can be carried on a moor if they are well distributed, and if their vitality and weight are raised by an increased supply of food at all times of the year? The answer to this is undoubtedly Yes! and the four following examples are put forward to show what results have been obtained on well-managed moors. Remedial measures.

Bolton Abbey Moors, Yorkshire.

These are high well-burned moors with good grit; they are well watered and considerable attention has been paid to draining; the patches burned on the moors every year are very large; they have probably not always been so well burned as they are to-day, and the older heather takes three or more years to spring from seed after burning. The average annual rainfall is about 38 inches. The record given below is a very remarkable one, extending as it does over a century. The following points should be noted:—

(1) That the yield of Grouse has increased from a minimum of two hundred to a maximum of over three thousand brace.

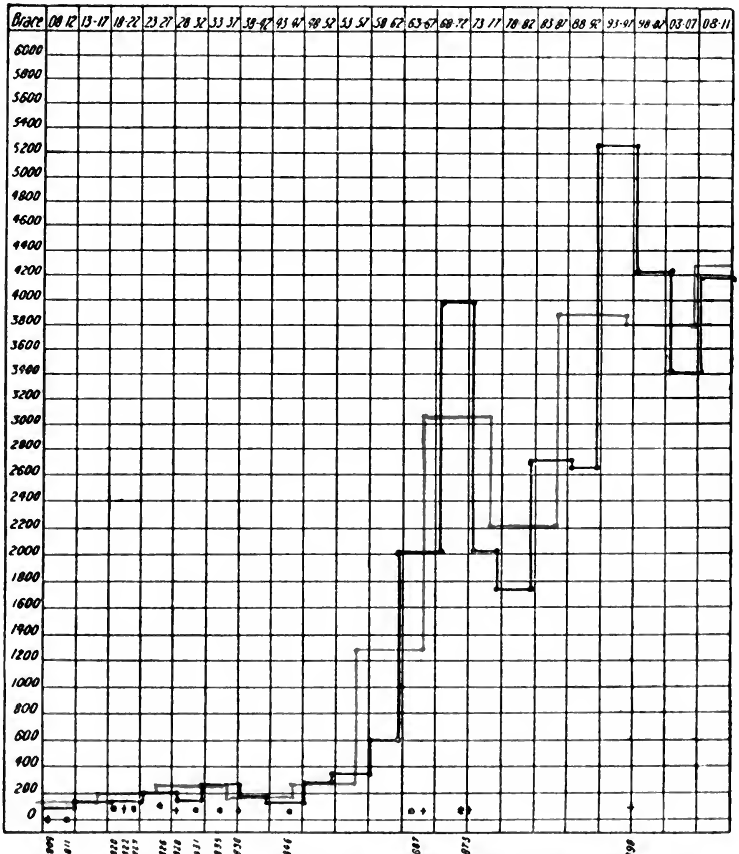
(2) That for the first twenty years any year in which over three hundred brace was killed was invariably followed by disease, that is to say, that the same ground which now yields three thousand brace with safety, could not then give a bag of more than two hundred brace without risk from disease.

(3) The difference in the time required for the moors to recover from the epidemic under the new and old conditions is very marked. When the moors were badly burned it used to take three to four years to get over an outbreak of disease; in the last two outbreaks the season following the attack has shown an average yield.

BOLTON ABBEY MOORS NEAR SKIPTON IN YORKSHIRE

14,000 ACRES

ANALYSIS OF BAGS



—— 10 YEARLY AVERAGE OF BAGS

—— 5 YEARLY AVERAGE OF BAGS

●··· NO SHOOTING † DISEASE

NOTE In addition to the numbers stated the Gamekeepers have killed annually during the last 29 years an average of 500 cock birds during the latter part of the Season

These moors are still improving from the effect of years of regular and heavy burning and draining. There is every reason to suppose the rate of heather growth will increase, thus affording an extended area of ground bearing a full crop of food.

An analysis of results is given in chart form on p. 334.

Broomhead Moor, Yorkshire.

This is a very remarkable moor. It has been well cared for for over forty years; it is now probably one of the best, if not the best burned moor in England or Scotland, with the result that it has not only the thickest but also the quickest growing heather that the Committee have seen anywhere.

There are not twenty square yards of old stick heather on any portion of the ground; there is a *larger* proportion of six- to twelve-year-old heather than on any moor the Committee have investigated, a bigger stock of birds is carried to the acre, and disease has not occurred for over thirty years.

On examining the Game Records the following points are brought out:—

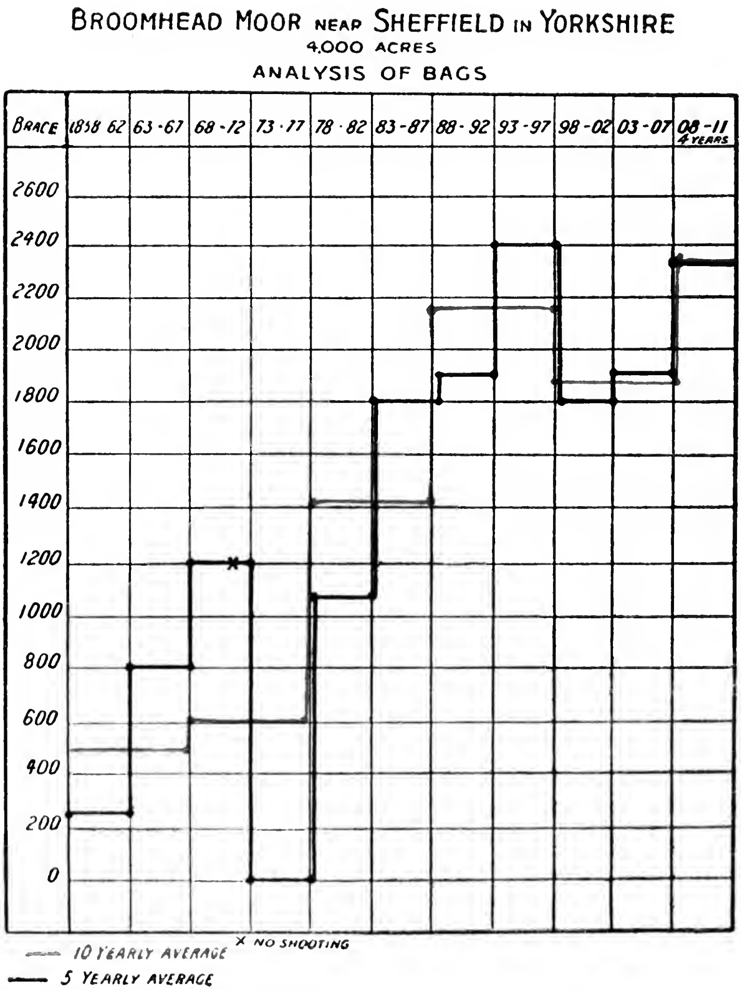
(1) The steady growth of bags from two hundred brace before 1870 with disease recurrent every few years, up to two thousand seven hundred brace per annum with no danger from disease.

(2) In the last decade there appears to be a slight set-back, but this is more apparent than real, and unsuitable weather in the shooting season is largely responsible.

(3) There is now a larger stock on the ground than ever, and the owner with forty and the keeper with fifty-one years' experience of the moor are agreed that the maximum yield has not yet been reached.

The points about this moor that are especially noteworthy to moor-managers are that:—

(1) Though there is no long heather the birds are kept on the moor all the winter.


BROOMHEAD MOOR NEAR SHEFFIELD IN YORKSHIRE
4.000 ACRES
ANALYSIS OF BAGS
BRACE
1858 62
63-67
68-72
73-77
78-82
83-87
88-92
93-97
98-02
03-07
08-11
4 YEARS
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
× NO SHOOTING
10 YEARLY AVERAGE
5 YEARLY AVERAGE

(2) Although the moor is relatively a small one, and is burnt in large patches, yet the total acreage burnt is only with difficulty maintained at one-twelfth of the moor per annum.
(3) The management of the stock and methods of driving[1] have undoubtedly much to do with the health of the birds on the moor.
(4) The moor is all above the 1,000 feet line.
(5) The climate is dry, the average annual rainfall being about 30 inches.
(6) Beautiful white quartz grit is found all over the moor.
(7) There are about a dozen good springs, and a deep burn runs through the centre of the moor.

A chart is given on p. 336 showing the gradual improvement in results which has followed improved methods of management. It should be mentioned that the steady increase in the stock commenced about 1872, and that it was just before that date that close and constant heather-burning was first introduced.

Carron Moor, Morayshire.

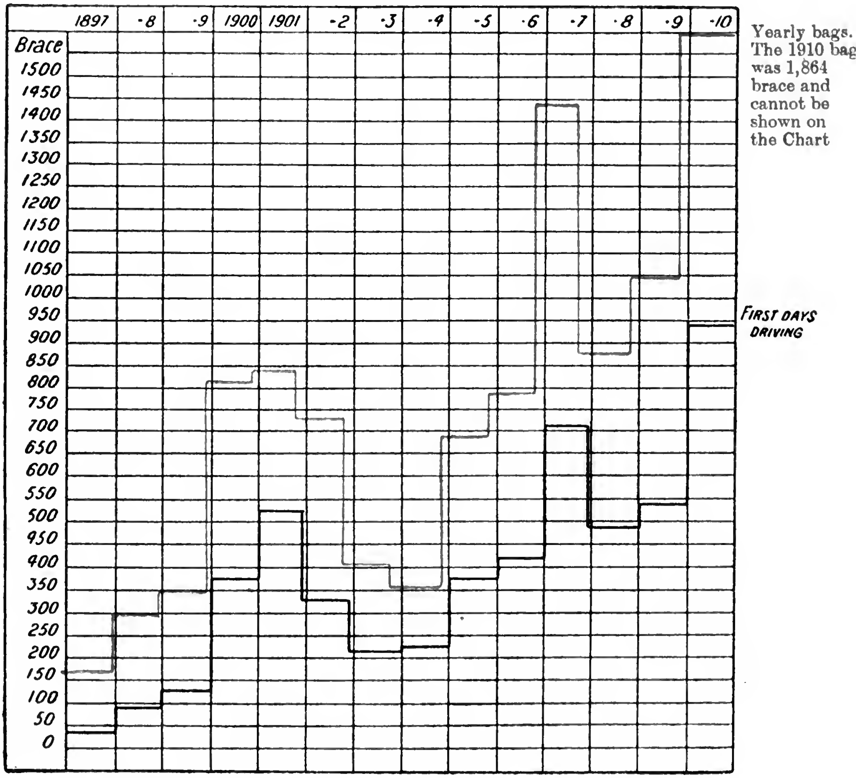
A moor of about 3,000 acres, of which about 1,000 are flow ground, and the rest heather. The altitude ranges from 700 to 1,300 feet. Previous to 1897 the heather-burning had been neglected, in many parts the heather had grown to a height of 3 feet or more; since that year the burning has been most carefully and thoroughly done, when possible. The heather all over the moor should continue to improve, for it has only been regularly burnt for the last fourteen years, and during some of that time, owing to bad weather, little or no heather could be burnt. A considerable quantity of old heather still remains to be burnt, and much that has been burnt has not yet reached the most valuable stage. Good grit is abundant, and great attention has been paid to drainage. A moderate stock of sheep is carried on the ground.

[1] *Vide* pp. 415 *et seq.* and p. 446.

CARRON MOOR MORAYSHIRE

3,000 ACRES

ANALYSIS OF BAGS



	1st days driving		Yearly Bags	
1897	94	BRACE	158	BRACE
1898	93	"	223	"
1899	128	"	341½	"
1900	373½	"	809	"
1901	420	"	850	"
1902	326	"	745	"
1903	211½	"	903½	"
1904	215	BRACE	350½	BRACE
1905	378	"	686½	"
1906	414	"	778	"
1907	715	"	1439½	"
1908	470½	"	861	"
1909	548	"	1043½	"
1910	946	"	1864	"

In 1910 the experiment was tried of introducing an artificial water-supply to the drier parts of the ground by means of dew pans. The results appear to have fully justified expectations; in one case it was observed that five coveys were hatched in the immediate vicinity of a dew pan, where there were no young birds before. The results are conclusive so far as they go, but the experiment has not been continued long enough to admit of absolute certainty.

The years 1907-1908-1909 yielded an average bag of 1,114 brace, as compared with an average bag of the years 1897-1898-1899, of only 241 brace, showing an increase of 873 brace. In 1910 the bag was upwards of 1864 brace. No disease has occurred since this improvement began.

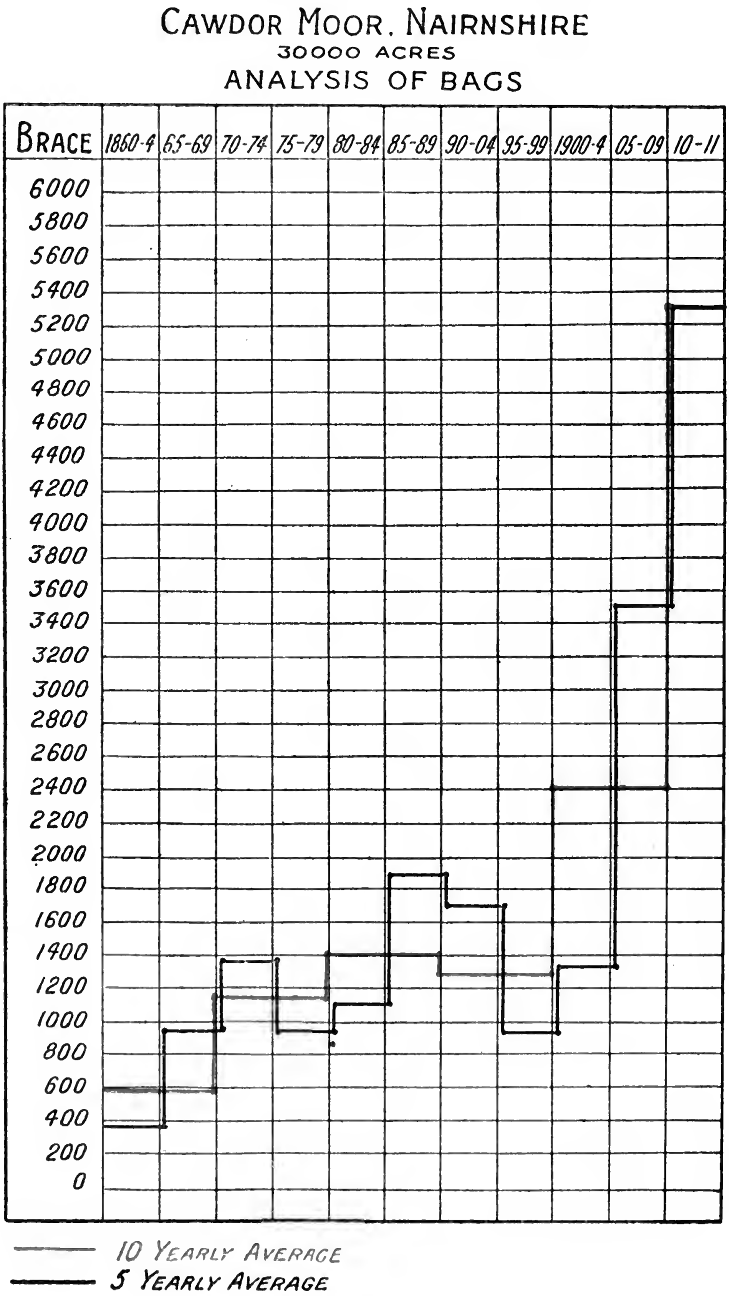
From the evidence available it would appear that the whole of the birds are bred on the moor, and the suggestion that so large a bag can only be obtained by the immigration of birds from neighbouring moors is not supported by the facts. The progress of the stock is carefully watched from the date of hatching to the commencement of the shooting season, and it is always found that the total bag corresponds to the prospects at the nesting season; there are no berries on the ground to attract neighbouring birds, and the first day's driving always takes place before any of the surrounding moors are driven.

Towards the end of the year there is often an immigration of birds from other moors; but these visitors arrive after shooting has ceased for the season, with the exception of the gamekeeper's annual crusade against old cocks.

The whole stock has been known to leave the moor in time of heavy snow, and to remain away till the snow has disappeared; but such migrations have not been found to affect the number of birds on the ground at the next nesting season.

The owner of the moor has drawn the following deductions from the foregoing facts:—

(1) That it is possible, by improving the heather, to raise the permanent stock of Grouse that a moor can carry


CAWDOR MOOR, NAIRNSHIRE
30000 ACRES
ANALYSIS OF BAGS
BRACE
1860-4
65-69
70-74
75-79
80-84
85-89
90-04
95-99
1900-4
05-09
10-11
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
10 YEARLY AVERAGE
5 YEARLY AVERAGE

without fear of disease developing locally, *i.e.*, among the home stock of Grouse.

(2) That drainage is very beneficial.

(3) That an abundant supply of good grit is essential.

(4) That Grouse driving is largely responsible for the increase.

(5) That the limit has not necessarily been reached.

(6) That the introduction of an artificial supply of water may be beneficial in a dry season or on the drier parts of the moor.

Cawdor Moor.

A very fine moor not yet fully developed or arrived at its full carrying power, with good young heather. The following points in the record should be noted :—

(1) The improvement in each decade.

(2) A slight set-back in 1890 to 1900, probably due to the moor being less well cared for during that period.

(3) The period 1900 to 1910 shows a marked advance, owing to regular driving and improved methods of management.

(4) The time required for the moor to recover from the effect of the 1907 epidemic was one year; on all previous occasions it took upwards of four years to get back to the average yield.

This moor is in the centre of a Grouse-bearing district, and will probably always be liable to disease from overcrowding by birds from higher and less well-burnt moors in late winter and early spring. This danger will remain until some system is adopted for the proprietors taking joint action to regulate the stock in good Grouse years.

The bag in 1910 was 7,180½ brace and in 1911 (a bad season in the district) it was 3,443½ brace. The moor is probably now capable of yielding an average yearly bag of 5,000 brace as compared to 600 brace in 1860 to 1870.

From the examples that have been given four deductions can be made :—

(1) That it is possible by careful management to raise the permanent stock of Grouse on a moor, and do so without increasing the danger of infection beyond the power of resistance of the individual bird.

(2) That during the various stages or periods of development of the carrying capacity of the moor there is a corresponding limit of stock which it is dangerous to come up to, and fatal to exceed.

(3) That as far as yet ascertained the limit has not been arrived at on any moor beyond which a permanent increase of healthy stock is not possible by improved moor management.

(4) That, though many moors by their proximity to less well-managed moors, and owing to the difficulty of getting the stock killed in a good year, immigration, abnormal seasonal conditions, etc., cannot entirely escape the ravages of disease, yet there is every reason to believe that the disease is both rarer, less hurtful in its incidence, and quicker to pass away on the well-managed than on the badly-burnt moors.

CHAPTER XII

HEATHER-BURNING

THE student of the heather-burning question will be struck, from the very outset of his inquiry, by the curious fact that while all parties are agreed that there is the closest possible relation between the state of the heather on any given moor and the health of the birds on that moor, there is the greatest divergence of opinion, not only as to what are the best methods of burning, but even as to what are the special characteristics of a really well-burned moor.

The vexed question of the relative values of autumn- and spring-burning, the percentage of a moor that it is advisable to burn in any given year, the effect on the heather of the presence or absence of sheep, the limit of sheep stock desirable, the proportion of long heather to be left for spring feeding or cover, the management of the steep slopes for winter feeding, the methods of burning—patches, blocks or strips—and the treatment of the various descriptions of moorland, all give rise to a much greater variety of opinion than the difference of local conditions appears to justify.

In the previous chapter, the findings of the Committee have been discussed in relation to the various theories which have been put forward as to the causes of "Grouse Disease"; in the present chapter it is proposed to discuss the practical steps that must be taken to prevent its occurrence by:—

(*a*) Raising the power of resistance of the Grouse;

(*b*) Lessening the risk of nematode and coccidian infection.

With these objects it is intended, in the first place, to trace briefly the history of moor management in the last century, to show how blind but intelligent experiment has slowly been working its way towards comparative hygienic success; to see where methods have failed through incorrect deductions from observations of natural phenomena; to indicate broad precepts of moor management in accordance with our present standard of knowledge; and lastly to lay down lines on which further experiments can be made with reasonable prospects of success.

History of heather-burning.

In the early days of Grouse shooting, when shooting rents were low or non-existent, and the Grouse was an appanage of the sheep farm, not the main rent producer of a hill property, the moorland in the majority of cases was burned by the farmer and his shepherds. The methods used were rough and ready, but effective. The object, as set out in the tack or lease, was to burn one-tenth of the moor; the driest and most windy days were chosen, and, provided the hirsels were burned approximately in the authorised proportions, the matter of a few acres more or less in a single burning was not considered of much importance.

Judging from occasional bags recorded it is probable that during this period the actual stock of Grouse throughout the country was often very considerable, but they were seldom fully shot so that the recorded bags are so scanty that an exact comparison with the results of the present day is impossible.

In the middle of the last century in England, and in Scotland a few years later, railway facilities, improvement in guns, increase of wealth, and, more than anything else, fashion, made the sporting value of the Grouse moor gradually approach the grazing value of the farm.

The Grouse, up to then the occasional victim of the landlord and his friends, or of the poacher for the pot, became all at once a saleable article, for which there was, and has been since, an ever-increasing demand. The moor-owner was quick to realise the enhanced possibilities of his property, keepers were appointed to even the smallest areas of moorland, and the rights of burning the moor were transferred from the shepherd to the keeper, under the mistaken idea that the policy of burning to benefit

Grouse, not sheep, would at once increase the yield of birds.

It is a curious fact that, while the average man can predict with some degree of certainty the immediate result of any change in the existing order of things, the correct calculation of even secondary consequences requires the attention of brains of a very different calibre. When the landlords in their wisdom appointed the keeper to the rôle of moor-burner they achieved their immediate aim—better cover for shooting over dogs; but they gained also a second and not less noteworthy result, a drop both in the average bag of Grouse and in the grazing value of the hill-ground, a thing neither foreseen nor in any way desired.

Founded on latter-day experience the reason for this is not far to seek. In the dogging days long heather was the ideal. "Keepers' delight," when applied to 3-foot heather, is still a recognised and but too often well justified term. The keeper, acting up to his lights and wishing to show the best sport on the Twelfth, not only stopped the shepherd from burning big stretches of heather, but stopped him from burning the heather at all. In books of sport in the year 1863 places are mentioned—as splendid Grouse ground—"fifteen hundred acres of heather without a single break!" This method of heather culture was admirable for approaching wild birds; in these jungles a covey once settled could be massacred at ease with "snap-hance" or breech-loader. Unfortunately, the change of methods was not equally satisfactory with regard to the health of the moor, and a very rude awakening was not far distant.

A few lucky seasons, with a heavy crop of heather seed for food in winter and early ripening shoots in spring, gave in certain favoured districts an increase of bags by improving the conditions for approaching the birds; then a cold summer followed by a winter with late spring frosts, and a seasonal shortage of food intensified by an overplus of old stick heather, led to the inevitable result—a general outbreak of disease.

As early as 1857 there were reports of heather on certain moors " man high "—by the sixties the whole effect of the shepherds' burning had passed away, and in many districts where the non-burning practice was at its height, not only were there few birds and disease frequently recurrent, but the graziers' complaint became more and more common—that there was not enough young heather and grass to feed the sheep-stock. At this period the relations between sporting tenants and sheep-farmers became so strained that big sheep-farmers, then a well-to-do class, used in many districts to rent the shooting as well as the grazing of their holdings, and so get the control of heather-burning into their own hands.

In 1871 and 1873 the Game Laws Commission investigated the relations of the sporting and farming interests, and some very interesting facts were elicited. Not the least important of these facts was the similarity of heather conditions required for sheep and for Grouse. This was brought out by the evidence of farmers who had leased the sporting rights of their farms, and who spoke of doubling and trebling the bag of Grouse by burning tracts of ground in order to get the land back into the proper rotation for sheep, viz., one-tenth of the moor burned per annum.

The reports of these and other successes obtained by heavy burning were not long in being spread abroad. Partly from increase of knowledge, and partly to satisfy the sheep interest, more intelligent methods were pursued. On many estates the principle was adopted—" The shepherds light the fire, the keepers put it out." As a principle rather than as a practical usage this is not far from the ideal. The shepherd wants the acreage burned for food, the keeper wishes the patch or strip method maintained for the segregation of birds.

Matters in the early seventies were thus proceeding through the usual course of friction and inquiry towards mutual understanding and settlement, when in 1872 and 1873 the great disease year occurred.

Just as 1881, by the introduction of the Ground Game Act, may be described as the Jena of the rabbit, so for a very different reason 1872 and 1873 may be said to be the Austerlitz of the Grouse. From end to end of the Grouse area the epidemic created unparalleled destruction; authorities realised that old methods must give place to new ones, and from that date the intelligent management of moors may be said to have commenced.

Broadly speaking, we may divide the history of heather-burning into three periods, not always synchronous, but through which the majority of moors have passed at one time or another.

1800 to 1850, when the heather was burned by the shepherds in wide tracts, and one-tenth of the moor was fired every year without any attempt at scientific burning. During this period shooting rents were low. Large blocks of land were hired in Scotland for as many sovereigns as they now fetch hundreds of pounds. The frequently quoted example of the sporting rights of the Island of Lewis, hired by Lord Malmesbury for a period of years for £25 per annum, is a case in point. At this time few moors were rented in England, and although Grouse driving had just begun in Yorkshire the results generally were not great, and the flint-lock, contemporary writers tell us, still had its devotees in the firing line! Mr Snowie of Inverness was the only shooting agent for Scotland, and the names of moors for hire could be contained on a single sheet of foolscap.

1850 to 1873 marks the transition period of heather-burning. Moors generally were taken into the hands of owners and shooting tenants, the patch method of burning came into fashion, and the proportion burned, as far as records show, dropped from one-tenth to one-hundredth part of the moor burned per annum.

In this period great strides were made towards fitting out shootings with lodges, approach roads, and other conveniences. Large sums were paid out in the wilder and poorer districts, and a great deal of employment was given.

Moors were let for sheep and Grouse at about the same figure. It is instructive to note that to-day on many of the same moors sporting rents represent five, in cases ten times the value of the grazing rents.

The third period begins with the years of disaster 1872 and 1873, which were followed by four years of recovery and very restricted bags. These lean years were the immediate cause of the study of Grouse pathology. The investigation has continued more or less ever since, and after passing through the vicissitudes customary to research in a new field, has culminated in the comparatively extensive knowledge of the present day.

Notwithstanding the fact that Cobbold had indicated in 1873 that the cause of the great outbreak was the Strongyle worm, the first move towards an improved system of management was not in the right direction. The moors had been indifferently burned so long, that in order to catch up the rotation recourse should have been had to big fires rather than to the patch or strip system of burning. This, however, was not realised.

Many land-owners, seeing that "patch-burned" moors were less affected by the disease than moors on which no heather had been burned, jumped to the conclusion that it was the smallness of size of the individual patch, and not the total area of the burning that was all-important. This belief is prevalent in many localities to-day, and it is no exaggeration to say that to this error, more than to any other cause, is due the persistent recurrence of disease.

Conclusions.

From the foregoing history of past failures, and the knowledge scientific investigation has given us, we can proceed to lay down with some approach to certainty the following rules of heather-burning, and the reasons on which they are based :—

(1) That, in order to maintain the vitality and therefore the power of resistance of the Grouse, the moor must be so burned as to keep the food-supply at its highest.

(2) That the early spring food-supply is the index of the carrying capacity of a moor, and that therefore heather-burning must be so ordered as to insure the maximum yield of food in February, March, April, and May.

(3) That the patch or strip method of burning must as far as possible be pursued in order to segregate the birds, and thereby lessen the risk of infection by the Strongyle worm and the Coccidium.

In discussing the question of burning for food two difficulties at once arise :—

(1) That of persuading the average moor-owner that by burning small patches with a small staff he cannot possibly get over his moor.

(2) That of persuading him that at any time of the year the birds can be short of food, or that there is any real difference in the heather supply on well and on badly burned moors.

To convince him of these facts it is necessary to go into figures, and those set out below may be taken as a reasonably accurate statement of conditions that obtain on many average if not model moors.

Estimate of area burned on average moor.

On the ordinary 5,000 to 6,000 acre moor in England, and the corresponding 10,000 acre moor in Scotland, on which one thousand to fifteen hundred brace are killed in a good average year, and on which two keepers and one or more watchers are maintained, the landlord thinks he is doing all that can be expected of him, if in addition to the keepers, six to eight extra hands are employed in spring to burn the moor.

Speaking generally, after a careful investigation of east and west coast conditions, of high and low moors, a good spring-burning season will give an average of ten whole days or twenty half days on which the hill can be fired. Taking into consideration dry and windy weather when the fire goes well but requires great control, and wetter conditions or less wind when the fire does not " run " so fast and may be managed by a couple of men, it may be calculated that on an average each keeper, dividing his gang to the best advantage (each gang consisting of not less than two parties), will not burn more than thirty, or at the very outside forty patches or strips in a full working day. That is to say, if the small patch or narrow strip method of burning is followed (*i.e.*, burning in areas of from one-eighth to half an acre), the two keepers and their parties will burn 20 acres a day, or a total of 200 acres of the moor in a year.

Those who have not had a practical experience of heather-burning are apt to hold exaggerated ideas as to the amount of work that can be done in a single day's burning. It is only when facts and figures are subjected to a careful scrutiny, and the amount both of the day's work and the season's results are thoroughly gone into, that the smallness of the area burned becomes apparent. If we admit this contention to be correct, a little simple arithmetic will show that 200 acres on 6,000 acres of moorland is one-thirtieth of the total area, that is to say that, if the heather is regularly fired in rotation it will be thirty years, or in the case of the 10,000 acre moor fifty years old before it comes to its turn for burning.

If we consider that every year is not a good burning year, and that on many moors on the west coast a good burning year occurs only once in three years, that some districts suffer from fogs, "haars," and mist; that others get so dried up after a continuance of east wind that it is dangerous to burn at all; that in Scotland the high ground in a late spring is covered with snow until the end of March; that there are the additional difficulties of suddenly rising winds, late dews, and of getting men away from their holdings, etc., it will be easily seen that a moor may go for a series of years with only one-sixtieth or one-hundredth part of its total area burned, and that instead of catching up the heather rotation in force when the sheep-farmer was responsible for maintaining it, many moors are steadily going back in their yield of young heather, and therefore in their power of maintaining a healthy stock of Grouse.

The second difficulty, viz., of persuading the moor-owner that his birds may be short of food, is not less great. Many proprietors only see their moors in August—every head of heather in bloom and green shoots on every stem. He sees sheep grazing at the rate of one to the acre. It is very difficult to persuade him that at certain seasons there may not be enough food for at least an equal number of Grouse.

Let it be at once admitted that through the summer and autumn, even on the worst moors, there is abundance of food; but then at that time, except for a previous infection, Grouse do not die. Let the doubter visit the moor in March, when the heather seed has fallen from the pod, when the young heather up to four and six years old is frosted a clarety red or brown colour, when the old stick heather sparsely distributed and bare of side shoots does not carry a "canopy" with which to keep out the withering effect of the cold winds and frost, and he will find a very different state of affairs. Careful examination will show that the close-growing six- to fifteen-year-old heather with a thick matted covering affords the only feeding at this time of year, and that even here the shoots are green, not at the top, but half-way down the stem, where they are protected from the weather.

It is at this time that the real test of moor management is seen, and a little careful study will prove to demonstration certain facts not found in the philosophy of the "small patch" enthusiast. Granted the premises set out above, it follows that, if the moor is being worked on a hundred years' rotation, the total amount of spring-feeding heather, that is to say, the amount that lies between six and fifteen years of age, is roughly 9 per cent. of the total area of the moor. If the moor is burned on a fifty years' rotation, which is the rotation of the majority of moors to-day, the amount is 18 per cent. of the total area. If, however, the heather is burned on a fifteen years' rotation, the rotation the Committee advise, the amount of edible heather represents nine years out of a total of fifteen, *i.e.*, 60 per cent. of the total acreage of the moor. That is to say, if we admit the early spring months to be the critical time in the life history of the Grouse—no great admission seeing that it is in spring that disease invariably appears—we shall realise that a well-burned moor can carry seven and a half times the stock of the moor burned on a hundred years' rotation, and nearly four

Rotation.

times as much as that of the average moderately burned moor.

These figures may possibly be challenged; but with regard to the area burned the proof is perfectly simple. Employ a surveyor to measure up the patches of a strip or patch-burned moor, burned in 1910—a very good burning year—compare the acreage with the total area; the result will astonish many landlords who habitually boast that they burn one-tenth of their moor every year.

It will perhaps be argued that the six- to fifteen-year heather is not the only spring feed, that even the stout stick heather will present occasional green shoots, and therefore afford some small measure of sustenance to the Grouse in the spring-time. This is true, and it is a fact that, *faute de mieux*, Grouse are able to exist on an unburned moor. It must, however, be remembered that they require probably twice or three times as much of the sapless, partly dried-up heather of April as they do of the more succulent shoots of summer and autumn. The weights of crop contents show that late winter and early spring up to two hundred and fifty grains of heather are found in the average afternoon crop as against fifty grains at any other time of the year. It is therefore reasonable to say that as the Grouse have to increase the amount of their food they will naturally go to those places where edible *Calluna* is most readily obtained, and thus by congestion of the stock on a small area will not only over-crop the food there, but also, as will be shown later, will be exposed to an increase of infection by the nematode worm and by the Coccidium.

Before leaving the question of the comparison of feeding areas of well and badly burned moors, one further point should be mentioned. On a well-managed moor the heather burned is all under twenty years old, and when it is burned the young heather springs from the root the same year. On a badly-burned moor, where old stick heather forms the main crop, the heather springs from seed,[1] and in many cases only affords

[1] *Vide* Plate xx., fig. 2.

food for Grouse after the area burned has passed through successive stages of grass and cross-leaved heather varying in point of time from six to twenty years. If the soil has a tendency to grow bracken the heather may be lost for ever. That is to say, in a fifty years' rotation moor, probably 20 per cent. of the moor is either black ground, bracken, grass, or cross-leaved heather, and is not yielding its proportionate quota of food. When we consider this loss of food area as well as the generally recognised fact that on a frequently burned moor the heather grows thicker and more luxuriantly than on one that is badly burned, it is no exaggeration to say that the food-bearing capacity of a moor at its best and worst is as ten to one.

This change in the flora of a moor after burning is specially noticeable in the case of accidental fires, such as occurred on a large scale in Yorkshire in 1887 and 1893. Accidental fires are commonest in very dry weather, and thus there is a danger of the peat and soil being burned to a depth of several feet, thus destroying the roots of the heather.

The second reason for burning is to keep the birds at all seasons split up over the ground. Grouse frequently get together into big packs for purposes of safety after frequent disturbance, or for shelter on the approach of storms, or in search of food, or to avoid snow or drought, or to prepare for migration, but, once the immediate cause of packing is removed, their instinct is to get away from their brethren and take up their family life apart. To help the birds to develop this instinct, the patch or strip method has been advocated in the past, and, provided always the strips and patches in their totality suffice to maintain the food yield of the moor at its highest, no better system could be adopted.

The minor point of whether narrow strips or square patches are advisable is not worth discussing ; keepers have their fancies, self-appointed authorities will air their views ; it is probable that both methods can be used with effect, each to suit the special circumstances of individual moors.

The object to be aimed at is clear, that every bird should have its tufts to nest in at the edges of the burned ground, its bare ground to sun itself in and on to which to take out its chicks; its older heather for concealment, its breast-high 6-inch heather for feed, its well-matured heather for seed and shelter in winter, and, finally and of most importance, its six- to fifteen-year-old heather to keep it in health and vigour in early spring.

In cases where it is impossible through the wetness of the season, shortness of labour supply, etc., to get the moor thoroughly burned in strips or patches, it may be asked whether it is not better to abandon the small patch system and burn a large acreage of moor? The answer can be given with no uncertain voice—patches are only a secondary consideration, the first essential is to get the proper proportion of the total acreage of the moor burned each year. Apart from the destruction of Strongyle larvæ by fire it must never be forgotten that it is the sufficiency of the food supply that enables birds to stand a heavier infection of this parasite. On Broomhead and Moy moors, which carry regularly the highest stock per acre, and are among the best burned moors in England and Scotland respectively, the patches burned are large and disease is practically unknown; but so also is old stick heather!

Methods of burning.

Having laid down the reasons which make heather-burning necessary, the next thing to consider is the various qualities of soil and heather into which a moor is divided, the treatment of each, and the limitations, some natural and some artificial, which stand in the way of a complete realisation of the object in view.

Old heather should be burned in strips, for when old stick heather is burned the fire is so hot that the roots are charred and killed; in this case regeneration can only proceed from seed, and if the burned areas are narrow, self-seeding is materially helped by wind-blown seed while only a small proportion of the total area is rendered destitute of cover.

While it is necessary to burn off blocks of old heather in strips, it is advisable at the same time to get a considerable total area burned on each beat of the moor.

PLATE XX.

FIG. 1. *Calluna vulgaris* (Common Heather or Ling).
Showing form of plant when growing from the root—first year's growth.

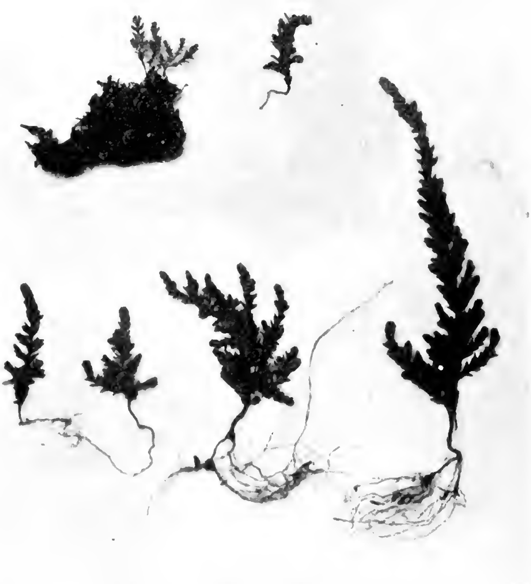


FIG. 2. *Calluna vulgaris* (Common Heather or Ling).
Showing form of plant when growing from seed.

Opposite p. 355.]

Sheep always rush to the newly burned ground for the sweeter grasses that grow there, and unless there are good stretches of burned ground for them to feed on, they will concentrate on the small isolated patches and pull up all the young heather plants as they spring from seed. Every one who is acquainted with a moor in autumn must have observed the hundreds of little brown shrivelled-up heather seedlings pulled up by the sheep's teeth on every patch of newly burned ground.[1] To obviate this wholesale destruction it is sometimes considered advisable, where the sheep stock is heavy and the moor has a tendency to go back to grass, to fence off areas of old stick heather for two or three years after burning. This gives the young heather a chance of coming away, and once rooted it can defy the efforts of the stoutest-toothed "black-face." Sheep.

Old heather should, whenever it is possible, be burned "against the grain," that is to say, against the lie of the heather sticks. "Back-firing" or burning against the wind gives a very clean burn, the fire travels slowly, and destroys not only a larger percentage of the stalks of the heather, but also burns into the "fog" or moss which surrounds the roots of old stick heather. Owing to the shortness of the time available for burning in an average year, dampness of the soil, etc., "back-firing" is not always possible. In the case where an overcrop of partly charred sticks have been left it is advisable to run a fire through the burned ground a second time if possible in the second or third year following the first burn. This second firing has the effect of clearing the ground of the charred heather sticks and burning off the moss which, having been exposed to the air, is drier than at the first time of kindling. This affords a good clear seed-bed on which the wind-borne heather-seeds rapidly establish themselves. Second burning.

The very greatest care must be taken of steep banks, especially those facing south, as these are the places that in time of snow give shelter and food to the Grouse. It must be understood that careful treatment does not mean allowing Steep faces.

[1] *Vide* Pl. xx., Fig. 2.

such places to run into old stick heather. Many keepers are so frightened of touching these winter feeding-places that on many moors the heather in these places has become rank, and is rapidly losing its value as winter food. Burning on steep banks should be carefully done so as never to reduce the total yield below the minimum which is necessary for food in time of snow.

"Flow" ground.

In the interest of both sheep and Grouse wet "flow"[1] ground should be burned in big stretches outside the ordinary rotation—if possible once in every six years. Flow ground usually overlies deep, damp peat, and is therefore protected from the full effects of the fire; the grass and the stunted heather in consequence come away quickly from the root. It is often difficult to burn flow ground owing to the heather being broken up into tussocks, and the driest weather should be chosen for the task.

Knolls.

Knolls and hillocks are the favourite haunts of the Grouse, and however small they are, never more than one-third should be burned at one time; the keeper's aim should be to provide in this way both food and cover for the birds frequenting them.

North slopes of hills.

The keeper should invariably get at the northern slopes of his ground as soon as the opportunity occurs. On high moors late snows make this possible only once in half a dozen years.

Grey heather killed by snow or frost should be burned wherever it appears; it is absolutely useless for food, and serves no purpose beyond cumbering the ground. Probably also heather which has been damaged by beetle should always be burned, as it is very doubtful whether it ever recovers from the attack of this pest.

[1] By "flow" ground is meant the flat stretches of peaty land where, owing to the retentive nature of the soil, the surface water lies in pools and channels between tufts or tussocks of heather; it is to be distinguished from marshy or boggy land where the water lies in suspension below the surface. Flow ground cannot as a rule be drained owing to the absence of a natural "fall," and even when drains are cut the nature of the soil is not sufficiently porous to make them effective. Flow ground grows a poor quality of stunted heather usually mixed with sour-looking grass, yet Grouse are often found to frequent it during the day time, especially when it lies on a high plateau or immediately under the crest of a ridge.

Peat hags.

Peat hags should be burned when the ground is not too dry. Grouse are particularly fond of broken peat ground, and the food supply of short gnarled heather that grows there should be maintained at its highest. The peat itself occasionally gets on fire, and has been known on occasion to burn right down to the bed rock. In one or two cases that have come to notice excellent heather has grown on the mineral soil thus exposed. As the new growth in such cases may take twenty or thirty years to come up, such burning is outside the rotation that even the most progressive of moor-owners would care to adopt.

Burns and streams.

The sides of burns and streams are most important features on a moor; they are the favourite nesting places of Grouse, they afford shelter during storms, and are places where food can be obtained in times of snow. They should be carefully burned in very small patches, special care being taken to clear up the immediate burn-side and prevent its being used as a shelter for vermin, particularly for stoats, who otherwise use it as a convenient covered way to reach their prey.

Burning for sport.

It is hardly necessary to point out that in burning a moor the keeper must consider the method in which the shooting is carried out. In the case of the driving moor broad belts should be burned immediately in the rear and patches immediately in front of the butts to facilitate the "picking up" of Grouse; settling ground with good cover should be left in the direction towards which it is intended to drive the birds. In the case of "dogging" moors, favourite banks should have a special allowance of long heather into which the birds can be worked at the end of the day. In deer forests "the beds" on which deer lie in the sheltered corries should be lightly burned.

Limitation of heather-burning.

Heather can be burned at all times of the year in England. In Scotland, by statute, heather-burning is confined to the period from November 1st to April 10th. On high wet moors an extension of the period to April 25th can be obtained. In Wales, by custom, burning is usually carried on during the spring months.

Autumn-burning.

As soon as it was established that the health of the Grouse depended not only on the distribution of edible heather, but also on the total extent of the supply, it became a matter of primary interest to the Committee to decide whether in their opinion the burning season should be extended, and how the results of autumn- and spring-burning were to be compared.

The investigation was begun by sending an inquiry paper to correspondents, asking for their experiences of autumn-burning; the time taken for heather to grow again when springing from the root and from seed respectively; the opinion of sheep farmers as to the merits of the two methods and the character of soil least and most suitable for autumn-burning, based on a comparison of results obtained. In neighbourhoods where heather had never been regularly burned in autumn, correspondents were asked to burn patches in spring and autumn side by side and to compare the results.

The idea was intelligently taken up and thoroughly worked out, from the south of Wales to the north of the Highlands.

The results of the observations taken have brought out the following conclusions:—

(1) That in the interests of sheep and Grouse autumn-burning is advisable on all moors.

(2) That it is necessary on large moors.

(3) That it is the only possible method of getting high ground with a northern exposure into a proper rotation of heather crop.

The Committee are further of opinion:—

(*a*) That in the North of England the evidence goes to show that, whether springing from the root or from the seed, the growth of heather following autumn- and spring-burning is identical.

(*b*) That on the more northern moors the heather is probably slightly slower in reaching maturity after autumn-burning, especially on shallow peat or hard ground.

(*c*) That, while there is a certain prejudice, especially amongst older keepers, against autumn-burning, this prejudice did not appear to be founded on substantial grounds; as far as the Committee were able to learn, the majority of those who expressed themselves opposed to autumn-burning were found on examination not to have themselves tried it, and to have based their opinion either on general reasons or second-hand information.

(*d*) That on 95 per cent. of the moors in England on which autumn-burning had been tried the practice had been continued with the full sanction and approval of the sheep farmers interested.

(*e*) That at least 75 per cent. of the larger moors examined are insufficiently burned, and that in many cases an extension of the burning period would enable a larger stock of both sheep and Grouse to be maintained.

(*f*) That autumn-burning is necessary in the interests of the health of the Grouse and sheep, and that legislation in Scotland making it permissible to burn after October 1st should be introduced into Parliament without delay.

Opinion of sheep-farmers.

With a view to further ascertaining the opinions of sheep-farmers on the subject of heather-burning, a meeting was arranged between representatives of the Committee and a number of sheep-farmers from different districts. The views expressed clearly indicated that in the opinion of sheep-farmers there is not enough heather burned for either Grouse or sheep on the majority of moors in England and Scotland, and that there is a general wish on the part of sheep-farmers on heather ground that more heather should be burned. The farmers further stated that they would be glad to try autumn-burning in co-operation with owners, and that they could probably give more assistance in the autumn than in the spring, because in the spring they are usually busy with sheep that have returned from wintering, and with the superintendence of their stock during the lambing season. They considered that it matters little whether autumn-burned heather grows as well as spring-burned heather, the great object being to get rid of the large tracts of old useless heather which are of no value either for Grouse or sheep. They confirmed the view of the Committee that high ground with a northern exposure can only be burned in the spring in very exceptional years.

The sheep-farmers further drew attention to the following points :—

(1) That where heather is allowed to grow too old, there is a danger of its place being taken by bracken after burning, whereas if the heather is burned young the fresh growth has more vitality and usually defeats the bracken.

(2) That old heather is undesirable because after burning many " burrens " or bare sticks are left which tear the wool off the sheep's bellies.

(3) That sheep-farmers prefer the heather to be burned in large patches, because otherwise a large enough area is not burned each year; but that they have no objection to burning in small patches and strips provided the total area burned reaches the full proportion proper to the moor. This proportion was estimated at from one-ninth to one-twelfth of the total acreage.

[M]ethods of [p]rocedure.

On the actual methods of carrying out the burning there is not much to be said. The gear is simple; a birch broom and a paraffin firing lamp.[1] The necessary party of six or eight men under a keeper can work in pairs on a calm day with a fairly dry moor, the keeper starting the fire, the couples guiding its course, extinguishing and controlling it as occasion demands. In windy weather, or when the heather gets dry, the whole party have to act together, and in consequence, though the individual burning may be done at a quicker rate, a smaller total area will be got through in a day. As a health-giving exercise heather-burning has much to commend it; it is particularly hard work and trying to clothes, temper, and especially to the eyes.

[1] Special lamps are sold for the purpose.

Having laid down the object of heather-burning, the methods of treatment of different types of ground and certain laws applicable to all moors, it only remains to discuss the practical steps the owner of a badly burned moor must take to get his heather-land into "good heart" with the least possible delay. We will presume that the moor under consideration is one of those many moors in England or Scotland which has possibilities, but which has been neglected; a moor which has its high ground difficult to burn, its boggy undrained land, and its stretches of stick heather with a tendency to revert to grass; that, moreover, it is a moor which has disease at irregular intervals as well as average and bumper years; and that, like all moors that form part of a tract of Grouse ground, it is liable to be over-stocked at the critical period of late winter and early spring. Practical steps.

The first thing that the owner of a moor of this sort must do is to decide what rotation of heather crop is to be aimed at, *i.e.*, what is the total area of moorland available, and how many acres of it are to be burned every year. Choice of rotation.

The period of rotation requires very careful consideration, and depends on the average age of the heather, the sporting results the moor-owner wishes to obtain during the period of transition from bad conditions to good, and the local difficulties —labour, climate, etc. From what has been stated on the results of burning stick heather, it is evident that if really old heather bulks largely in the total area it is impracticable to jump at once into a fifteen years' rotation and maintain any stock of Grouse. A little calculation will show that in the extreme case of a moor on which all the heather has reached the "keeper's delight" stage, and therefore requires six to twenty years to come again, to burn the whole moor in fifteen years would leave not only no spring feed, but scarcely any edible heather at all.

In treating a really badly burned moor, therefore, unless it is determined to sacrifice several years of sport by setting all the old heather ablaze, less heroic methods should be adopted, and the ground should be got gradually into a shortened period of rotation. To fix how long this intermediate period should be, it is necessary to go carefully over the burned ground of the last decade in order to see how long the general average of burned heather takes to come to maturity. This will vary, not only with the age of the heather, but with the elevation of the moor, the climate and exposure, the depth of peat, the amount of flow and hard ground, and the stock of sheep. By carefully noting the results and comparing them with similar results on well-burned moors, it will be possible to arrive at sufficient data to give the number of years for the first rotation.

It is probably generally true to say that on a moor on which heather grows readily, and on which all the heather is burned before it has passed its best, heather springs from the root the year it is burned, and comes into flower sometimes in the first and generally in the second or third year. That on a badly burned moor situated 600 to 1,200 feet above sea-level the ground covered by partly withered heather of an average height of 2 feet will remain black for two years after burning, that for the next three to five years it will be covered by grass and cross-leaved heather, and that six further years will be necessary before there is a full yield of edible *Calluna* heather. This will mean a handicap of nine years, and on a moor of this sort a rotation of twenty to twenty-five years should, in the first case, be attempted. It must not be thought that for the whole of these nine years the ground is useless. During that period it is useful for old birds as a basking-ground, and for young chicks as a feeding-ground; and the early grasses and seeds and even ferns that grow there are not without value. It will afford, however, little or no spring food.

Size of patches.

Having fixed the rotation and the acreage to be burned, the next thing is to decide on the allocation and size of the individual patches or strips. We will suppose that the badly burned moor is one of 4,000 acres, that there is a sufficient labour supply, and that the rotation attempted is to be one of twenty years (*i.e.*, one-twentieth of the heather ground burned per annum). The amount to be burned every year would be 200 acres; but to make up for bad burning seasons 300 acres should be attempted whenever seasonal conditions permit.

To burn this area in patches of one-eighth or one-fourth of an acre is obviously impracticable; even allowing for an area of 50 to 100 acres being burned in big blocks (flow ground or high ground with a northern exposure), it would be impossible to burn the remaining twelve hundred odd strips necessary to make up the total acreage prescribed. It is therefore necessary to decide on certain general lines of moor-burning which will give the necessary total area burned, and still maintain the patch system as far as possible. This will be obtained by treating each type of heather on its own merits.

Example of scheme.

1*st.* To burn old heather in strips 50 yards wide, and let the strip run as far as the fire will take it.

2*nd.* To burn average foot and a half heather in strips and patches of one fourth to one half of an acre.

3*rd.* To burn patches and strips on the steep faces of the wintering ground in small blocks of not more than one-fourth to one-tenth of an acre each.

4*th.* To burn the burn-sides, knolls and nesting grounds of Grouse, in even smaller plots.

5*th.* To burn the wet flow ground in big patches of 1 to 10 acres.

(*N.B.*—This should be done so as to cover the flow ground every six to nine years.)

6*th.* To burn the high ground with a northern exposure in large 3-acre blocks.

7*th.* To burn good broad strips round each of the boundaries.

8*th.* To treat specially those portions of the moor which have a tendency to revert to grass.

By adopting these methods with, say, three keepers (watchers to count as keepers), each in charge of two parties of two or three men each—a total of from fifteen to twenty-one burners—it may be possible to get the work done. The burners will have to fire twenty patches of 1 to 5 acres, say a total area of 50 acres, 300 patches of from one-fourth of an acre to one acre, making, say, 150 acres, two hundred patches of from one-fourth to one-tenth of an acre, say 50 acres, *i.e.*, about 500 burns with a total of between 250 and 300 acres.

Taking the average as four parties burning a day, for it must be borne in mind that on very dry or windy days the keepers will often have to use the whole of their posse as one burning party, it will require about ten days or twenty half days to get through the work, calculating that each party burns an average of fourteen patches a day.

This is a fair statement of what ought to be done on a 4,000-acre moor; it probably exceeds by a very considerable amount what is done on many moors of double that size.

If the number of men for the burning parties cannot be got the area of the fires must be bigger; but the ratio of heather burned to total area of the moor must be maintained at all costs.

Arguments against extensive burning.

In considering the general question of heather burning, undue weight must not be attached to arguments such as the following:—

(1) *That the expense is too great.*

Apart from the question of sport, this argument can be proved to be erroneous in mere pounds, shillings, and pence, for, as has been shown already, some moors can be raised from a yield of under three hundred brace per annum to over three thousand, or, expressed in terms of existing values, from £300 a year to not less than £3,000. Even on moors where such great advances cannot be made, the avoidance of a single year of disease would alone save more than three times the expenditure incurred in a decade through the employment of a few extra men for burning.

(2) *The argument that the old keeper frequently puts forward that "to strip the moor is sufficient."*

It is not necessary to deal with this point again; it is sufficient here to point out that keepers have not the least idea of what acreage they burn in a year, and will often say and believe that they burn one-tenth part of the moor when one-hundredth is nearer the mark.

(3) *The argument that the existing method of burning has produced good results in the past.*

This may be admitted, but with the reservation that good results in the past have almost invariably been followed by disease in the following year. It is to avoid disease and heighten the average yield of the moor that the progressive landlord will see that it is worth while to limit the food crop for a few years in the attempt to get the moor into good "heart."

(4) *The old-heather argument that it is dangerous to burn the old heather as birds will have no food in winter.*

Three things should be remembered in this connection.

1*st.* That on some of the most heavily stocked moors no old heather exists, yet there is enough winter food.

2*nd.* That in time of snow the medium-sized heather can be raked with little labour and thus afford abundant winter food should the moor be buried in snow, especially if the longer heather is destroyed by frost.

3*rd.* That long heather is valuable only as long as it gives food—*Grouse eat heather shoots, not wood.* Much of the heather in England and Scotland that has been left for winter food has been steadily going back for twenty years, and it now produces barely one-tenth of its proper food yield.

(5) In a good burning year keepers often wish to knock off "work" under the plea that enough burning has been done for a single season. It is very doubtful if too much burning can ever be done in any season *provided*

the areas of the fires are reduced in size as the patching and stripping of the moor progresses. By large fires a moor can be easily burned out, but no area of heather is so small that a smaller patch cannot be taken out of it and the moor be thereby improved.

Treatment of green ground.

Certain moors or portions of moors have a tendency to go back to grass, and therefore require special treatment. The most common reasons for this reversion from heather to grass is lack of attention during the period from 1850 to 1900, over-stocking by sheep (especially of the black-faced variety), and big fires after the heather has got old. In practice it is found that these causes often work in combination.

The attention of gamekeepers should be directed to the burning of "white grass" as well as heather. By doing so they provide directly for the sheep and indirectly also for the Grouse; for, so long as they are plentifully supplied with grass, sheep will not draw heavily on the heather. "White grass" can be burned in large stretches and consequently more rapidly than heather, and advantage should always be taken of any specially dry season to burn the low, damp hollows where this grass chiefly abounds; in four seasons out of five such places are too damp to burn.

To bring green ground back to heather is always a slow and often a costly business.

Control of the sheep stock to prevent an over-cropping of the heather seedlings, fencing of the newly-burned patches, sowing of heather seed in specially prepared ground are all methods that may be found useful.

The *laisser faire* argument—that the change from heather to grass or bracken depends on the seasons, and that nothing should be done—is one that the Committee view with suspicion. Putting off burning where old heather exists only means putting off the evil day, and it is probably correct to say that for every year that the old heather is left unburned after maturity, at least one year is added to the time required for the young heather to replace the grass after burning.

There can, unfortunately, be no doubt that bracken is spreading considerably on very many moors in the south and west of Scotland, and that not much effort is being made to combat this pest. Thick bracken will rapidly destroy both grass and heather, but of the two it is probable that the heather will be the more easily destroyed, and if bracken has once taken possession of ground for a period of years it will be found, on clearing the ground by regular cutting, that grass will probably come where heather formerly flourished. It is a common experience, when burning fairly old heather, to find that the few bracken stems which existed among the heather give rise to a much thicker crop on the bare ground, and may entirely choke the fresh growth of young heather. **Bracken.**

Despite much careful investigation by the Highland and Agricultural Society and other interested bodies, no specific has yet been discovered to cure the bracken trouble.[1]

It has been noticed that bracken very seldom grows on crofter "soumings" where there are many ponies. While there is not enough evidence on the subject to establish this as a solution, the fact may be worth further inquiry and experiment.

In considering the general question of heather-burning, blaeberry ground has been dealt with as heather ground, and its further treatment need not be gone into in any detail. It is unfortunate that sheep are specially fond of the blaeberry in its younger stages, and on moors carrying a heavy stock of sheep this valuable plant is often grazed down to the root. Grouse eat blaeberries (buds, leaves, and berries) with avidity; even the caterpillars that infest the plant in early summer are a source of food supply for young birds. It may be noted from an examination of the tables of crop-contents that the consumption of blaeberry by the Grouse is irregular, and the percentage seems to depend more on the general supply of food **Blaeberry.**

[1] Colonel G. J. Fergusson-Buchanan of Auchentorlie has recently printed a pamphlet setting forth the success which has attended his efforts to get rid of bracken on heather and grass land.

than on any tendency of the birds to eat the plant more in one month than another.

From statistics collected, blaeberries appear to form 30 per cent. of all the foods taken by the Grouse in Derbyshire; 22 per cent. in Yorkshire; and 11 per cent. in some of the counties of Scotland. Undoubtedly a good deal could be done to increase the food-yield of the moor by encouraging the growth of this hardy plant, either by fencing off areas where it is eaten down by sheep or by planting it in suitable places.

Draining.

Close observers of "Grouse Disease" have always held the idea that the mortality has been in some way connected with the wet, undrained portions of the moor. Scientific investigation shows that there is probably a good deal of truth in this view. The Strongyle larvæ have been shown to pass the free-living portions of their lives in damp surroundings. Even in frozen water they appear to live for an indefinite period, whereas complete drought may kill them in a very short time.[1]

Without putting drainage forward as an absolute specific against disease, it can be urged with confidence that a well-drained moor is less liable to dangerous infection of nematode worms than a moor with stagnant pools and great stretches of flow ground.

Draining should be done on a well considered plan. Nothing is more common than to see the water carefully drained from the top of a hill-face descending only to flood a much larger acreage below, owing to there being insufficient drainage arrangements for carrying off the surface water thus collected.

It will generally be found advisable to employ a professional sheep-drainer, and allow him to work by contract at a fixed price per chain. The specifications must ensure that the drain is clear cut, at least the breadth of a spade at the bottom, that the sides are at a slope of not more than one in two, and

[1] *Vide* chap. viii. pp. 234, 235.

that the turf dug out is thrown away not less than 6 feet from the drain. Shallow drains made in this way reduce the danger to the young Grouse, and are also less liable to choke and flood the moor. Drains should be made on the herring-bone pattern, and begin with wide arms high up the hill face to catch the surface water. Special care must be taken that the central drains are sufficiently large to allow the water collected to run off easily into a main burn. The ground that it is desirable to drain is not the flat sodden bog or sour flow land, but the ground on which the fog or moss has only recently begun to choke the heather.

Draining, when undertaken, should be thorough. It is better to confine the area of work and watch results, with an occasional clearing of the drains, than to spread the work over a great extent of country where little immediate result is seen, no attention is paid to upkeep, and the lie of the drains is soon lost. On most moors money would be well expended in draining, for not only would the risk of infection be thereby lessened, but the total yield of heather would be increased. The supply of grit which drain-making often exposes is not a trifling consideration to the general health of a moor, as will be seen in chapter iii.[1]

[1] *Vide*, p. 107.

CHAPTER XIII

THE HEATHER BEETLE

Part I.—On " Frosted " Heather and its Connexion with the Heather Beetle, Lochmæa suturalis.

For a long time the attention of many proprietors of Grouse moors and their keepers has been directed to the fact that large patches of heather, varying in size from a few yards square to hundreds, or even thousands, of acres, have turned a rusty red or withered grey colour, and have become useless as food for Grouse. In the districts which suffered most from this condition large numbers of the Grouse have left the affected area and migrated to neighbouring moors where the heather was in a healthy state.

Not only does the shooting value of such a moor become thus seriously impaired, but the health of the birds themselves is affected. Although there does not as yet appear to be any direct connexion between the diseased state of the heather and " Grouse Disease," inasmuch as the birds have been proved not to eat the withered shoots, yet the deficiency of food on an affected moor undoubtedly results in a weak state of health, rendering the Grouse less fit to resist the attacks of tapeworms and other parasites, or to combat disease of any kind whatsoever.

It is, therefore, of the utmost importance to ascertain, if possible, the exact cause of this blighted condition of the heather, and to devise some practical remedy.

During the progress of this Inquiry many letters have been received by the Committee which serve to show the great extent of heather affected in various parts of the country. Diseased heather has been reported from moors in the counties of Nairn, Perth, Inverness, Argyll, Ayr, Lanark, Kirkcudbright, Dumfries, Selkirk, Roxburgh, Fife, Cumberland, Yorkshire, and Montgomery. From this list it will be noted that the blight has been met with principally in the western districts; but this may be due to lack of information from the east, and it is hardly safe at present to lay much stress upon the distribution of "frosted" heather as indicated by this correspondence alone.

Now this peculiar and serious condition of heather was, up to a comparatively recent period, universally attributed to the action of frost, whence the popular name of "frosted heather," and even at the present time this opinion is firmly maintained in some quarters. After a careful investigation of the subject we are now in a position to assert with some degree of confidence that the damage is more often the work of an insect. Attention was first drawn to the question in August 1897, when a correspondent in Ayrshire sent to Mr P. H. Grimshaw, of the Royal Scottish Museum, a patch of heather, the shoots of which were brown and withered, while among the roots were a number of small grubs and pupæ. This correspondent thought that the damage was caused by these insects, and he suggested that the diseased condition of heather which was so widely known as "frosted" was identical with that of his specimens, and due to the attack of the same species of insect. Acting upon this suggestion, Mr Grimshaw examined the soil about the roots of this sample, and of two other samples sent by the same gentleman a few days afterwards, and found therein numerous examples of the insect in all stages between that of fully-grown larva and mature insect. He identified the insect as a phytophagous beetle known as *Lochmæa suturalis* (Thomson), published and a short account of it, with figures.[1]

Little more was thought of the matter until it was again brought to notice in connection with the investigations of the

[1] "Annals of Scottish Natural History," January 1898, pp. 27-29.

recent Committee. In order to obtain more evidence, either for or against the theory that the beetle was alone responsible for the damage, a circular was issued in January 1909 asking for reports from correspondents regarding the extent to which their moors had suffered from diseased heather, and requesting samples to be sent for examination. Typical examples of "frosted" heather were received from many sources, and it is important to note that *in every case where the shoots had changed colour* the leaves had undoubtedly been nibbled by some insect, this being easily shown by examination with a hand lens. Not only were the bases and edges of the leaves eaten, but in many cases all the leaf had disappeared except the mid-rib, which remained as a kind of bristle on the shoot. The specimens furnished absolute proof that the rusty red withered appearance is associated with, if not entirely due to, the attack of some insect, presumably the beetle referred to above, and which we now call the heather beetle.

Method of finding.

In order to ascertain if the beetle was actually present in the samples of heather sent—not by any means an easy matter—the following plan was devised by which the little creature could be made to show itself. As all the samples were sent between the months of October and February it appeared probable that the insects, if present at all, would be in the mature stage. In all likelihood, too, they would be in a hibernating condition somewhere about the roots or surface of the soil. As it was impossible to find them without tearing to fine pieces every cubic inch of soil—a most laborious task—each block of soil, with heather attached, was soaked for several hours in water, gradually increasing the depth of the water until the actual shoots of the heather were submerged. The result was very interesting. In every case a beetle appeared a few minutes after the sod had been placed in water to be followed every few seconds by another, and so on till they had all been driven out. In this way sixteen samples of diseased heather were examined, and only two of them failed to yield specimens of the beetle; these failures may probably be attributed to the small size of the samples, for they measured only 12½ and 30 square inches respectively.

The following table indicates the number of beetles obtained from the samples by the above method.

No. of Sample.	Date.	County.	Size in sq. inches.	No. of Beetles obtained.	Remarks.
1	Oct. 13, 1908	Lanark	288	47	
2	Oct. 22, 1908	Argyll	288	70	
3	Jan. 26, 1909	Selkirk	144	18	
4	Jan. 30, 1909	Argyll	144	23	
5	Feb. 4, 1909	Ayr	60	52	
6	Feb. 5, 1909	Argyll	90	48	
7	Feb. 5, 1909	Ayr	64	36	
8	Feb. 6, 1909	Argyll	152	3	
9	Feb. 6, 1909	Cumberland	16	2	Very little soil sent.
10	Feb. 14, 1909	Argyll	112½	21	Badly diseased.
11	Feb. 14, 1909	Argyll	72	7	A few twigs diseased.
12	Feb. 14, 1909	Argyll	148	11	Very little diseased.
13	Feb. 15, 1909	Argyll	35	6	
14	Feb. 22, 1909	Argyll	12½	0	Very small sample.
15	Feb. 22, 1909	Argyll	30	0	Very small sample.
16	Feb. 22, 1909	Argyll	72	52	Badly diseased.

Number to acre.

If these figures are worked out they show an average of 1,437,480, or nearly a million and a half beetles per acre. Thus *Lochmœa suturalis*, if the cause of the diseased condition, is an important pest, and cannot be ignored.

It may be of interest to give some further extracts from the correspondence on the subject, to show that the greater part of the evidence either actually supports, or at least is not in conflict with the idea that the heather beetle and not frost is the agent responsible for the destruction of so many acres of heather.

(*a*) "The enclosed . . . larvæ I found yesterday on the ground amongst the grass and moss, where the heather is all dead and diseased. I thought it might be the larva of the heather beetle, so thought I would forward them to you for examination." [Contents of box were nine larvæ and twelve pupæ of *Lochmœa*.]

(*b*) "Here we had very little signs of the insect last year, but this year it is over-running the moor and doing great damage. The insect made its appearance in beetle form in May, and its grubs about three weeks or a month ago, and is now to be found in hundreds on every bit of 'rusty' and 'so-called frosted' heather. The grub appears to appreciate [? prefer] young to old heather."

(*c*) "From what I saw . . . about six weeks ago, I have no doubt you are correct as to 'frosted' heather. There are great areas and many patches of this brown, withered heather on the moor, and there was a whole colony of the larvæ at the roots of every such patch we looked at."

(*d*) "My keeper has had two days on the moor, searching for the larvæ or pupæ of the heather beetle, and he can find none. . . . I am sorry the search was not successful; but the information that the larvæ disappears between September 5th and November 5th amounts to something."

(*e*) "On the . . . moors there were, in places, many patches of the so-called frosted heather—heather which had grown well up to a certain point, perhaps four to six years, and then without apparent rhyme or reason lost its sap and turned brown and withered before the flowering season. It looked very much like what heather might be expected to appear after a severe and late frost in May, but it was quite evident that atmospheric conditions (wind or temperature) had nothing to do with the result, as the 'frosted' patch ended quite suddenly and was abruptly framed in perfectly sound healthy heather, which must have been exposed to exactly the same external conditions as the 'frosted' heather. The keeper and I had many discussions over the cause of the spoilt heather, and we only agreed on one point, namely, that frost had nothing to do with the disease. I suggested a vegetable parasite, and he had views on improper burning, and there we left the matter (both of us being wide of the mark as it turned out). On . . . at the time I am speaking of, there was a very considerable quantity of the 'frosted' heather; I couldn't, even very roughly, give the acreage, but over the whole ground it must have mounted up to a big total, probably not much less than 750-1,000 acres. The 'frosted' heather is entirely useless for food, neither cattle, nor sheep, nor game will touch it so far as I know; therefore in this particular year the wretched and insignificant little beetle destroyed the agricultural and sporting value of (?) 1,000 acres on one moderate-sized estate alone. How far the pest is spread over the whole of Scotland I don't know, but the total acreage of spoilt heather must be something very big indeed, and both the farmer and the game preserver have a very troublesome enemy to cope with in *Lochmœa suturalis.*"

(*f*) "It may interest you to know what we have been doing about the heather beetle—practically they have damaged the whole moor, and we notice what I think was mentioned in your pamphlet, that they steadily work *eastwards.* We have been burning the affected heather as much as possible. At the time we were burning there was a very hard frost, and as regards the ground we turned up to examine we found the beetles not deep down as we expected, but clustered just round the root of the heather practically on the surface, and they didn't seem to be at all affected by the frost."

(*g*) "I am sorry to say the heather beetle is very bad with us this year. It was seen on the wing first on April 5th in very large quantities. Now [August] the grub can be seen in the roots of the heather. The heather which was badly affected last year seems to be quite dead, and has turned white. We found in burning this spring that where the heather was burned in narrow strips the portions of heather left between were specially badly attacked, which looked as if the fire had not killed the grub, but had driven them to the heather close by. In cases where we burned one side of a knoll, we find the side left has not suffered. This may be simply a coincidence, but would appear to show that the grub can move short distances to find fresh heather to attack, but cannot move more than a few yards. With regard to stock of Grouse, we have never had such a poor show although some of the moors in this district have a fair average stock. I think we shall have to face burning a very large amount of the dead heather next spring."

(*h*) "All the gamekeepers in this district obstinately maintain that the mischief is due to frost, but none of them can account for the fact of its only appearing in patches, and not by any means in the most exposed places."

(*i*) "I send you a portion of damaged heather with peat. . . . My keepers here scout at the idea of beetles, and say the damage came too quickly and over too great a radius, and they consider it caused by sudden thaw on frosted heather and bleak east winds following."

(*j*) "There was a good deal of frosted heather all over this country. In my opinion the heather beetle was not responsible for the damage, at least on my own estate. The burned patches of heather were plainly noticeable within two days of the severe frost which occurred on April 23rd, 24th, and 25th last. The heather was uninjured on dry slopes, most of the damage occurring in wet, cold, and waterlogged ground, and the patches have not extended since they were first seen. On a neighbouring estate I understand that the patches have been gradually extending; but I have not verified this. I could understand the frost affecting places where the heather had already been damaged by the beetle; but one would expect the injured portions to increase afterwards, and the heather to be affected on dry as well as on wet ground."

(*k*) Same correspondent as (*j*). "It is very difficult for me to believe that the injury to the heather is due to the beetle, though I can well believe the beetle is a contributory cause. It is easy to find any number of beetles about the roots of the injured heather. The injured heather was all apparent immediately after the frost, and has not increased during the summer. It is also in places facing the morning sun as far as we can judge. . . . In looking at the heather all over the hill there seems no place where it is quite perfect, that is to say, there always seem to be a few injured or dead shoots when one looks closely at it."

(*l*) "You will be interested to hear there is very little to be seen of the heather beetle this year, and this bears out our local experience of the pest, that after a wet winter the numbers and damage by them is very considerably checked, and that after dry winters they get bad again. This year we have had a very wet January and February, while these months in 1908 and 1909 were comparatively dry. I am sending two samples of heather for your inspection. I am sending one of young heather, which has turned quite white and withered-looking, and is growing on the side of a hill facing the south-east. The other sample is off a large stretch of level, wet, mossy land. It seems to grow till a certain height, and then to die away."

(*m*) "My keeper says it [*i.e.*, diseased heather] was confined to the young heather, and the old was not frosted at all. Also the west end of the moor, about 2,000 acres, was bad with it; and there was none on the remainder of the moor."

(*n*) "The damage done on my own estate was not very serious, but in neighbouring places it was much worse. . . . With regard to the permanency of the damage, I do not think there is much fear. I examined some of the ground as recently as yesterday, and find that even where it has the withered grey look, the twigs are green under the bark; only in a few cases is the previous season's growth dead, and in no case is the two-year-old growth destroyed. . . . I should have stated above that the damage has only occurred where the ground was very cold, wet, and waterlogged—the sort of ground on which, even when drained, it is useless to plant forest trees."

(*o*) "We think the damage is chiefly, if not entirely, confined to places where the sun strikes during the day, and especially in the morning. . . . My ground faces chiefly north-west and west."

(*p*) "With regard to your inquiries on the subject of rusty red heather, we have noticed several small patches of this all over the moor, and the majority of them are to be seen on the south-west and south faces of the hill, and a fair amount was to be seen on the low ground at . . . This burned appearance first showed itself during the hot weather in the month of July, and that is the time that it is noticed each year, according to keepers and shepherds. It is, of course, useless for Grouse-feeding purposes."

On referring to the foregoing extracts the reader will gather that the damage is usually noticed between the months of April and August. As will be seen later, when the life history of the beetle is dealt with, these months are exactly those in which the beetle may be presumed to be in the egg and larval stages; fully fed larvæ are to be obtained in September, while the mature beetle hibernates during the winter, and has been noted on the wing in April and May (*see* extracts *b* and *g*). They would presumably pair and lay eggs in one or other of these two spring months, the egg state would only occupy a few days at most, and the larva would feed during the whole of the summer months. In most cases where the diseased heather has been examined *in situ* the beetles or their larvæ (according to the time of year) have been noted as numerous, and these observations form an interesting supplement to the figures actually obtained by experiment.

Relation to climate.

The districts from which damage from heather beetle is most commonly reported are those situated on the west coast of Scotland lying to the south of Oban. In Argyll, Ayr, Lanark, and Cumberland the pest is well known, whereas on the extensive moors in the northern and central Highlands of Scotland it is practically never heard of. It would appear, therefore, that the insect flourishes best in a mild climate with a high average rainfall; but it is curious to note that after a very wet winter the beetles are not so numerous as after a dry one.

With regard to the position of the ground affected there does not appear to be any rule, for the extracts show the damage to be done on slopes which face all points of the compass from north-west through west to south-east. Again, the age of the heather liable to attack appears to vary, for while some correspondents report that *young* heather is chiefly affected, others note the damage as done to plants of from four to six years old and upwards. Most of the damaged heather occurs in patches, and there is a certain amount of evidence that low-lying wet, mossy ground is most subject to attack. This may indeed well be the case, for the beetle requires a good deal of moisture during the period of its metamorphosis from larva to mature insect, and during the course of experiments in artificial breeding of the beetle, it was found that pupæ which were allowed to become dry failed to develop properly.

Taking the whole of the evidence into consideration it would appear that the condition known as "frosted" heather is entirely due to the attacks of the heather beetle. The subject has been further tested by experiment. A patch of heather kept during the winter of 1908-1909 in a warm room was eaten by a number of mature beetles kept in confinement. The condition of the shoots, after being nibbled, was undistinguishable in appearance from some of the samples sent in by correspondents for examination, and in this case frost was, of course, entirely out of the question. This experience is additionally interesting as proving that the mature beetle, as well as the grub, feeds upon the leaves.

The question of remedy alone remains for consideration; but this is a matter which presents some difficulty. It is obviously impossible to use any of the ordinary insecticides, as almost any chemical substance sufficiently poisonous to kill the grub or beetle would be dangerous to the Grouse, to say nothing of sheep. The great extent of the area to be dealt with in most cases of attack is also a serious deterrent to the use of spraying mixtures. **Remedy fo**

Extensive draining of damp, mossy flats might be indirectly beneficial as a preventative of beetles, and would be directly beneficial to the moor in other respects. But draining is an expensive business, and except in districts where the ground can carry a heavy stock of Grouse, or is valuable for pasture, it may be better policy to allow the low-lying flats to remain in a water-logged condition.

Another remedy that suggests itself as, at any rate, worth trying, is the introduction of some creature which would feed upon the beetle or its grub, and so keep its numbers in check. Unfortunately the Red Grouse itself does not appear to devour the insect at all, but a close relative, namely, the Black Grouse (*Tetrao tetrix*) has been proved to have a partiality for *Lochmæa suturalis*. In December, 1908, the Keeper of the Natural History Department in the Royal Scottish Museum, received for identification a small box filled with beetles. In the accompanying letter it was stated that the beetles formed part of the contents of the crop of a Blackcock. The beetles, of which there were a great many, proved to be our old friend, or rather enemy, *Lochmæa suturalis*. Again, in 1907, Professor E. B. Poulton of Oxford, communicated to the Entomological Society of London an interesting account of the food of Blackgame, based upon observations made by Dr F. Menteith Ogilvie, of Oxford. In this communication Dr Ogilvie's notes on the contents of the crops of five Blackgame are reproduced, and in four cases out of five the heather beetle had been consumed in large quantities. These notes are of so much interest in the present connexion that we cannot forbear quoting those portions which refer to the beetle. The summarised contents of the crops, numbered 1, 2, 4, and 5, include the following :—

(1) " An immense number of small dark brown beetles, *Lochmæa* (*Adimonia*) *suturalis* of Thomson."

(2) " Many dark brown beetles, as in ♀ of October 17th, 1907 [No. 1], but less numerous."

(4) " Three hundred or more dark brown beetles (*Lochmæa suturalis*)."

(5) " Immense number of the usual small dark brown beetle."

" The two outstanding features are the spangle galls and the small beetle. Almost all the birds were crowded with these, and, judging by my specimens, the Blackgame must have been destroying enormous numbers of both. I don't think, as regards the beetles, it is any exaggeration to allow three hundred beetles per day per bird. Ours is not a very good Blackgame ground now, and perhaps we have three hundred head in all; that would equal ninety thousand beetles per day. I was surprised to find, too, how little heather was eaten in most cases, despite the fact that the birds were in almost every case found on the moor and not in the woods." It is interesting to note that this was written and printed before any one realised the importance of the heather beetle as a destructive insect!

Probably the only practicable method of dealing with the pest is that of burning the affected heather, not at the usual season for so doing, but at the time when the grub is on the shoots feeding. As the beetle hibernates between the months of September or October, and April or May, it would probably be of little use burning within this period, for the beetles would then be lying in a torpid condition below the surface of the soil, with cool and moist surroundings, and the flames would pass over them without doing them serious harm. The burning should, therefore, be done between May and August, when the grubs are above ground feeding on the shoots. There are two principal objections to this plan, namely the legal restrictions on heather burning in Scotland, and the practical difficulty of getting the heather to burn when in a green and sappy condition. A special dispensation might be obtained in order to try the effect of burning the diseased areas during the summer months. The difficulty regarding the green condition of the heather might be got over by spraying the portion to be burned with some inflammable fluid such as paraffin or petrol, in small areas at a time, and well before any light is applied. It would not be necessary for the heather itself to be so thoroughly burned as for the purpose of promoting young growth for feeding, the fire obtained from the inflammable agent itself might be sufficient to kill the grubs, even if the shoots did not burn so freely as at other seasons.

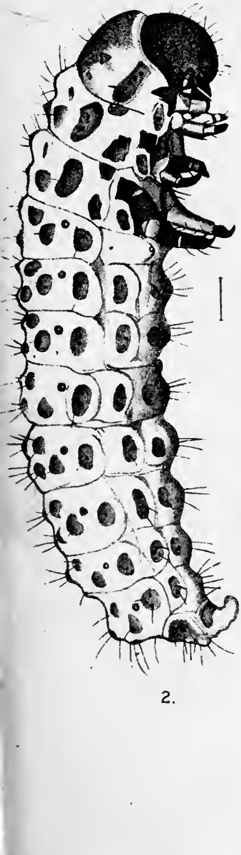
Part II.—The Life History of the Heather Beetle
(Lochmæa suturalis).

The heather beetle (*Lochmæa suturalis*), whose ravages form the subject of Part I. of this chapter, is a small creature a little less than a quarter of an inch ($5\frac{1}{2}$ mm.) in length, of an oval shape, and usually of an olive brown colour. It belongs to the family Chrysomelidæ, and was first described as a distinct species in the year 1866, by the Swedish entomologist, C. G. Thomson, in his great work on the beetles of Scandinavia.[1] It is very closely allied to *Lochmæa capreæ*, Linnæus, a species which, as its name implies, feeds on sallow (*Salix caprea*). From this it differs in having the forehead more shining, the little black tubercles immediately behind the bases of the feelers more distinct and polished, while the whole of the thorax is more shining. Since both species have been thoroughly described in the various works, British and Continental, which deal with Coleoptera, it is quite unnecessary to do more than refer the reader to the figure given on Pl. XXII. It is interesting to note that Thomson, in his original description, says the beetle is "not rare on *Salix repens* and other species of willow," while Julius Weise, in his account of the Chrysomelidæ in the "Naturgeschichte der Insecten Deutschlands," says it occurs "on marsh plants, also on birches and willows in marshes." Canon Fowler, on the other hand, in his "Coleoptera of the British Islands," states correctly that it is found "on heather, by no means uncommon, and very widely distributed"; but also adds: "it also occurs on birches and willows."

Our knowledge of the life history of this beetle is yet incomplete. No larvæ have been seen earlier in the season than the end of August, and by this date they are practically full-grown. From this stage, however, several specimens of the mature beetle have been reared.

The full-grown larva is represented in Figs. 2 and 3 of

[1] "Skandinaviens Coleoptera," vol. viii. p. 151.



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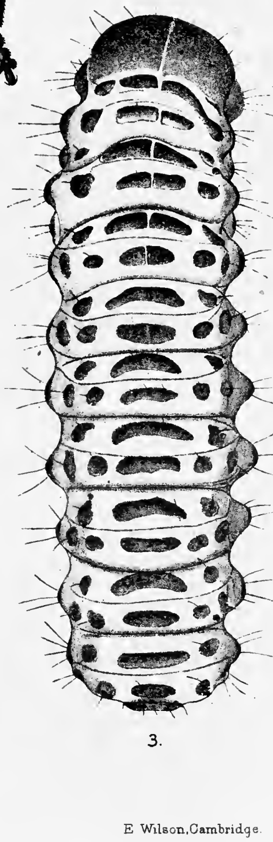

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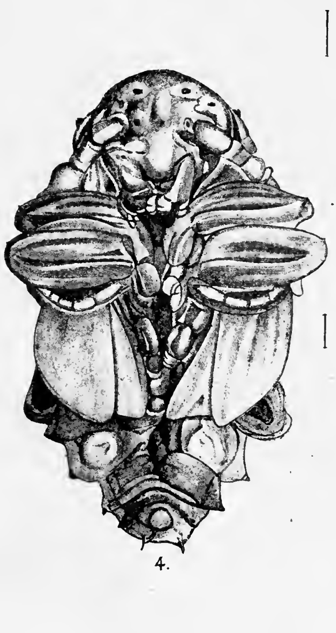

4.

E Wilson, Cambridge.

Pl. XXII. It measures, when straightened out, about a quarter of an inch (6 mm.) in length, but it is usually more or less curved, and if disturbed rolls itself up close. It is of a dirty white colour, studded all over with dark markings and tubercles, which have a definite arrangement on each segment. The segments themselves are transversely wrinkled, while each tubercle is tipped with a fine bristle of a pale brown colour. The dark markings are arranged as follows :—Almost the whole upper surface of the segment immediately behind the head (that bearing the first pair of legs) is covered by a dark patch, which extends down each side to a level with the spiracles or breathing openings, and is divided down the middle by a fine line of the pale ground colour. Between this patch and the legs on either side is a small oblong dark patch two or three times as long as broad. On each of the two succeeding segments are two linear transverse dark marks, one anterior and the other posterior, and each divided in the middle like the patch on the first thoracic segment. On each side, opposite the extremities of each of these linear dorsal markings, is a more or less circular, but small, patch, the anterior one in each segment being smaller than the posterior; below these, on each side, is a large dark patch of a kidney shape with the concave side uppermost, and below this again two small marks on each segment. On the dorsal surface of each of the succeeding segments are two transverse linear markings, one longer at the anterior edge and the other shorter and placed at the posterior edge. Between these and the spiracles are three dark spots on each segment, one of which is anterior and in line with the longer of the linear markings, and the other two posterior and opposite the shorter. Below the spiracles a series of large more or less circular spots runs along the side of the body. The head is black and shining, and hemispherical in profile; the legs black, with the basal joints marked with white. Larvæ.

When the larva is about to pupate it crawls down to the ground and lies amongst the moss and stems of the heather, at the same time curling itself up into a sort of horse-shoe shape. Pupal stage.

The anterior half of the body becomes gradually stouter, and the larva adopts the peculiar and interesting habit of suddenly straightening itself and then reassuming the horse-shoe form. In course of time, by this means, the skin of the dorsal surface of the three segments behind the head splits, and the emergence of the pupa is gradually effected by wriggling. This process, as observed by Mr Grimshaw in favourable circumstances, may be accomplished in twenty minutes, but may also take an hour or even more.

The pupa, when newly emerged, is of a creamy white colour throughout, with the exception of the tiny bristles about to be mentioned, which are blackish. The characteristic form of a Chrysomelid beetle is now distinctly traceable, while the legs, wing-cases, antennæ, and even mouth-parts can be recognised. Seen from above, the hemispherical thorax (prothorax of the mature beetle) occupies the most anterior portion of the body, and carries about a dozen tiny bristles, four of which form a curved row near the posterior margin, and the rest a row near the anterior margin. In a dorsal view the head is quite invisible. The meso- and meta-thoracic segments, and those of the abdomen, are each provided with a row of four bristles, which are about equidistant from each other. Laterally, below the level of the spiracles, the abdominal segments are each tipped with a tiny bristle. Seen from beneath (*see* Pl. xxii., Fig. 4) the pupa shows distinctly the legs folded up close under the body, and the antennæ beautifully curled under the two anterior pairs of legs and brought out again so as to show the tip of each close to the four anterior tarsi. Most of the joints of the legs may be distinctly seen, the posterior pair being folded beneath the wing-cases, which are bent round from the dorsal surface of the pupa and do not nearly reach the end of its body.

The first change to be noticed in the pupa is that on the fifth day after emergence the eyes begin to change colour, assuming a pale brown tint, while a couple of days later they are of a more distinct brown, and the separate facets may be distinguished. On this day also (the seventh) the extreme tips of the mandibles become darkened. Six days later the eyes have become very dark brown, almost black, while the mandibles are of a rich brown tint. When two more days have elapsed, *i.e.*, on the fifteenth day of pupal life, the tips of the mandibles are quite black, while the maxillæ have commenced to darken at the tip. On the seventeenth day the wing-cases, legs, and antennæ darken in colour, and the markings on the forehead, etc., characteristic of the mature beetle, are plainly seen, while on the eighteenth day the changes are fully accomplished, and the beetle emerges to enjoy a free and active existence. The pupal stage thus lasts, in a typical case, about three weeks.

The emergence of the beetle from the pupal skin commences with the liberation of the legs from the body, and occupies, judging from an example which was carefully watched, about four hours; but the elytra (wing-cases) are even at the end of that time quite pale, and only darken and harden quite gradually, assuming their permanent condition several hours later. The anterior legs and the antennæ are the first appendages to become capable of free movement, while the whole of the six legs are practically free in the space of an hour. As the struggling movements proceed, it is easy to notice the extreme thinness of the enclosing pupal membrane. It is apparently of considerable toughness, but is ultimately ruptured by the vigorous movements of the limbs.

After observing the above details in the transformation of several examples, all the newly emerged beetles, together with a large number of others received from correspondents, were placed in a breeding-cage on a sod of healthy heather. In a very short time they had all disappeared, and in order to ascertain their whereabouts a small piece of the sod (about 4 inches square), was detached and torn carefully bit by bit into small fragments. It was found that in this small piece five beetles were lying in a torpid condition in little hollows immediately below the surface of the soil. When the moss, etc., was gently torn off, the beetles were betrayed by their shining elytra, as they lay back *upwards*. They began to move when disturbed, and three of them got away and were recaptured. This observation tends to prove that the beetles assume the hibernating condition immediately after completing their development, which in most cases is effected by the third or fourth week of October. This date, of course, may vary slightly according to local conditions.

It is a matter for regret that the life history has not been traced any further. Considerably over two hundred specimens were kept alive in cages throughout the winter of 1908, and early in the spring of 1909 (March 2nd and succeeding days), under the influence of the sunshine streaming into the room, they emerged from the soil in numbers, and became very active and excited, a few specimens indulging in short flights. Several were soon pairing; but even with the most careful searching no eggs were discovered. Further investigation is therefore necessary before the biography of this interesting little beetle can be fully written.

CHAPTER XIV

KEEPERS AND KEEPERING, WITH SUB-DIVISIONS DEALING WITH POACHERS AND VERMIN

It is a very common belief amongst moor-owners—tacitly accepted rather than openly confessed—that provided the proprietor is interested in moor management, his keenness in the shooting season, and his intermittent interference at other times of the year, will make up for any shortcomings on the part of his paid keeper.

This is, unfortunately, very far from being the case.

Great help may undoubtedly be given by advice and criticism, and the interest of the employer cannot fail to stimulate the keenness of the subordinate. Still the fact remains that however accurate may be the theoretical knowledge of management of the landlord, and however complete his personal attention to the general principles of moor hygiene, the gamekeeper will always remain the executive officer responsible for the thousand and one details on which the health of the moor ultimately depends.

In undertaking the management of shooting, it is, therefore, of primary importance not only that a good keeper should be chosen, but also that the terms of his engagement, the nature of his duties, and the extent of the assistance, both permanent and casual, to be given to him should be of such a kind as to give him the widest scope for efficient service.

It is not intended in this chapter to go at length into a description of the methods of selection of a keeper, or the technical details of the duties that he should carry out after appointment. It is only proposed to suggest a few general principles founded on observations made during the course of the recent Inquiry, and shown by experience to be established on a strong and certain base.

Keepers should be the owner's servants.

In the first place it may be stated as a universal rule, and from this there should be no departure, that the keeper should be the *owner's* and not the tenant's servant. The reasons for this are many, and it would be hardly necessary to go into any of them were it not that this somewhat obvious precept is as often honoured in the breach as in the observance.

A tenant, from the very definition of the term, is an individual possessing but a temporary interest in the moor he rents. The tenant's keeper also, whose arrival and departure synchronise with the period of his master's lease, naturally looks to his immediate superior's interest rather than to the future welfare of the estate, or of those permanently connected with it.

In cases of Grouse moors where the heather is well burned, where there are no troubles connected with rabbits, sheep stock, or rights-of-way, and where, broadly speaking, the interest of both contracting parties are identical, difficulties may not occur; but this satisfactory state of affairs does not always exist.

On a badly burned moor, with large tracts of rank, overgrown heather, it is difficult to see how the immediate interests of a progressive landlord and those of a shooting tenant on a short lease can ever be made to coincide. If the landlord knows his own interests, his first object must be to burn big stretches of stick heather in order to get the moor into a proper rotation of burning. The tenant, on the other hand, should he be equally well informed, knows that though such heavy burning may be beneficial to the moor in future years, the resulting crop of edible heather will not be increased during his occupancy.

The keeper, therefore, who burns in the tenant's interest will burn in the smallest patches, not in order to increase the food yield so much as to provide basking ground for the old birds, and drying ground for the young chicks. He will leave severely alone the big blocks of old or dying heather, for on these he depends for cover for the stock of birds which happen to be on the ground, their prospective food value not being his concern. This method of heather management, though suicidal, is by no means uncommon, and instances could be given in Scotland and England of magnificent moors on which no long heather is being burned, and which at the end of the current leases will show a decrease of 50 per cent. in value for many years to come.

Another reason why the tenant should not directly employ the keeper is that the former is, as a rule, but an autumn visitor. Though his trust in himself be great, and his experience of shooting not small, his knowledge is but too often confined to the months when the heather is in bloom, and the climatic conditions are at their best. He may never have visited the ground during the winter and early spring months, when the food is short, and when the results of moor management are put to the test.

The tenant's knowledge of keepers and their duties is also apt to be perfunctory. A little keenness at shooting time, and a few excuses on the plea of a wet nesting season or bad weather for heather-burning, are quite enough to satisfy the average tenant that every effort has been made to get the best possible results from the moor. In this way the inefficients escape dismissal, and the specious are awarded undeserved praise.

When the keeper is the landlord's servant a very different state of things exists. In the first place, the supervision is continuous and not intermittent. In a year with a short burning season, the foresters' staff, the shepherds and the labourers employed on the estate can be turned on for a few days' burning; draining can be done under an expert sheep-drainer, and the estate *personnel* and organisation utilised without incurring additional expense. Again, in dealing with grazing tenants, the landlord's keeper gets more effective support from the agent, and has the minor difficulties arising from sheep gatherings, dippings, etc., more satisfactorily settled than if the arrangement has to be made through a third party or by a stranger.

This question of the relations between the gamekeeper on the one hand, and the agricultural tenants and their employés on the other, is one to which it is impossible to attach too much importance. The efforts of the most efficient gamekeeper may be nullified by the spite of a hostile farmer or shepherd, while, should a good understanding exist, it will be found that the interests of the moor are studied by all, and that every shepherd is a self-appointed watcher, and not infrequently the best informed man about the moor.

Without dwelling further on this aspect of the question, it may be said that whether from the point of view of management, supervision, or outside help, grave risk is incurred, and no advantage gained, by the transfer of the keeper from the landlord's to the tenant's service.

'erms of ervice.

As to the exact terms of service, no general rules can be laid down. Wages differ in different parts of the country according to local customs, cost of living, etc. It may, however, be stated that it is a good policy to pay keepers a fair living wage, not only with a view to securing good men, but also to let them realise that their services are appreciated, and that they have a billet which it is worth their while to keep.

Zeal may be further encouraged by periodically increasing the wages of a keeper who by his personal efforts has improved the value of the shooting under his charge. When this policy is adopted the criterion should be the net improvement over a term of years, and not the chance bag of one lucky season.

'ayment n kind iot recom- nended.

Though the rate of wages may vary with local custom and individual largesse, there can be no doubt on one point, viz., that the emolument should be in " coin of the realm " and not in " kind."

The keeper should be a keeper " first and last and all the time." In England a garden or the grazing of a couple of cows may be a desirable addition to wages ; in the Highlands a small croft may be a necessity ; but in either case agricultural enterprise should be kept down to the margin of personal comfort, and not regarded as a substitute for wages, nor should it be allowed to afford a separate means of livelihood. The keeper's place is on his beat, and not at the market-place watching the sale of stock. Above all things a keeper should have no interest in the sheep grazing on his beat. A man cannot serve two masters, nor should a keeper practise his retriever in herding a ewe stock, or keep his nesting ground quiet by pushing up the lately returned winter " hogs " to the high ground.

Many employers prefer their keepers to be married men, and there is much to be said for the preference. A married man is less dependent upon his neighbours for society than a bachelor, and so can go about his business without attracting attention; for the same reason it is often better for a gamekeeper's house to be situated some distance away from other habitations.

There is no objection to the head-keeper being a man of mature judgment and of riper years. The very fact that he has reached a time of life when he realises that he is unable to do all the work himself, will make him delegate his command, and by increased attention to his subordinates see that the work of all is efficiently carried out. For the under-keeper who has neither the grit nor the brains to climb to the top of his profession a change to some low-ground beat or to the gate-keeper's lodge will often quickly repay the cost of transfer.

Number of keepers necessary.

There is some difference of opinion as to the number of under-keepers required for a given area of Grouse ground. Speaking generally, many English moors, and most Scottish moors, are under-keepered. This finding may not be readily accepted by the parsimonious, but a little study of the financial aspect may bring conviction. There are many moors of 6,000 to 10,000 acres in extent with one keeper in sole charge. An area of this size cannot possibly be trapped, burned, and watched by a single man. On many such moors even one section of 1,000 acres, properly administered, may easily yield a permanent increase of one hundred brace, which, if translated into money value, would represent considerably more than the yearly wage of an under-keeper.

Dangers of insufficient keepering.

The loss arising from bad or insufficient keepering is often not fully appreciated. A very small number of stoats or hooded crows do an amount of damage which would exceed the annual cost of an extra hand. If we realise that cases can be quoted where a single pair of "hoodies" have been responsible for the destruction of a hundred eggs, or where individual foxes and peregrines have killed a score of paired birds (equivalent to the loss of fifty brace in the shooting season), it is no exaggeration to say that on good Grouse ground adequate supervision *must* be obtained at any cost. It is difficult to lay down exactly the extent of ground for which an under-keeper can be responsible. This varies with the shape of the beat, the character of the ground, the stock of birds, the quantity of vermin, the amount of night watching required, and the outside duties under the keeper's charge such as rabbit-trapping, low-ground watching, fishing, etc. It may, however, be said that on a hill moor with no low ground one keeper should be able to trap, and with proper assistance to burn, from 2,000 to 4,000 acres.

Selection of keepers.

As to the selection of keepers some owners have a preference for dalesmen, some prefer south country Scots; some, very rightly, have a prejudice against men who have come from a rich man's employ; others will only take men off a moor on which a big staff of keepers is kept. It is difficult to generalise. Good men, like good horses, run in all shapes and from all countries, but it will probably be found advisable, where possible, to take a man who has been "through the mill," who has acted as a kennel-boy under a head-keeper, who is himself a good trapper and an honest man.

Whatever fancies may influence the selection of the keeper the essential qualifications can readily be defined. A keeper must be a good trapper, an observer of natural conditions, and a man with the interests of the moor at heart; above all things, he must be a worker, *not a gentleman who goes to the hill with a gun.*

It is hardly necessary to point out that when the good man has been secured, he must be kept up to his work by periodical inspection. A check should be kept on the amount of heather burned, the vermin list should be frequently looked over, the number of traps actually *at work* should be ascertained from time to time, if necessary by surprise visits.

To those acquainted with the best type of gamekeeper, it is not difficult to separate the sheep from the goats. The series of disasters which has made all heather burning impossible, the combination of chances which has prevented the traps being set on the day of the inspection, the number of vermin skins that appeared on examination to have weathered more than one winter's storms, the chance which has made the area visited the only badly burned portion of the moor, all afford reasons to show why Napoleon in his wisdom elected to employ excuse-free generals born under a fortunate star. To sum up, a sufficient number of keen young keepers, adequately paid, able to trap, willing to burn, properly supervised by a head-keeper who knows every detail of moor management, should give the required result.

On small moors where only one keeper is employed, that keeper must combine the qualities of head-keeper and under-keeper; he must have the knowledge and sense of responsibility of the former, with the capacity for hard work so important in both. Many men of this stamp are to be found, and even if at first a young keeper may be lacking in experience he will soon acquire the necessary knowledge if he is willing to learn, and if his employer is competent to instruct.

Every effort should be made to foster the sense of responsibility in a gamekeeper. The importance of this will be admitted when it is considered that during many months of the year the keeper on a Grouse moor is out of immediate touch with his employer, and, if he chose to do so, might leave his beat to look after itself and to become a happy hunting ground for vermin and poachers. Detection of shortcomings is extremely difficult, for no master cares to spy upon his servants, and the sporting department of an estate is seldom if ever efficiently controlled from the Estate Office. Keenness is undoubtedly the basis of the sense of responsibility. If a keeper's whole mind is concentrated upon how best to improve his beat very little training is required to turn him into a conscientious and responsible servant. A young keeper should be encouraged to read the best books on moor management ; he should be made to give frequent reports upon details affecting his beat, both for the employer's information and to help him to realise the many points which require attention. A keeper quickly realises that his opinions are listened to, and is thereby stimulated to experiment in new methods, and attempt to prove their value by definite results.

The ideal keeper.

It is a matter of surprise to those acquainted with sport, many of whom lead an over-busy life in our cities for the greater part of the year, what a number of capable men, intelligent, articulate, shrewd observers, not only of natural history but also of men and matters, are included in the keepers' ranks. There are few owners of moors who have not had the good fortune at one time or another to have men of this stamp in their employment ; men who are friends rather than subordinates, with a frank contempt for, or rather a complete ignorance of, the ordinary conventions which restrict the intercourse between class and class. Men of few words in company but with a power of expansion when the audience is congenial, men who are eager to learn and to accept both new views and new facts on every point connected with their profession. It is a real pleasure for any one interested in animal life to take the hill in company with a man of this sort. The habits of the dwellers of the moor, the history of the locality, old-world traditions, the beauty of the surroundings, the customs, habits and idiosyncrasies of the visitors, are commented upon with shrewd observation not unmixed with humour, the whole presented from the detached point of view of the man who is a lover of his profession, who is outside the scramble for preferment, who is satisfied with his position, and does not mean to leave it.

His personal qualities.

To the really efficient head-keeper the "big shoot" comes only as the crowning circumstance of a busy year. All details have been so carefully prepared beforehand that on the day itself every part of the complicated organisation falls into its proper place at the proper time.[1]

His power of organisation.

To the master of the art the wind is always in the "airt" from which the birds can be most easily manœuvred. Flankers appear by magic in the gully down which, for the first time in the memory of man, the birds have begun to break away. There is an order and bustle about events which acts like magic on the most dilettante breakfast-eater, which pushes on the most grasping of the guns from the "pick up" to the next row of butts, and which even stimulates the gentleman's gentleman to take that extra bag of ammunition which is to help to create the record day.

While the work is proceeding there is no bellowing of forgotten instructions, no downward drives in which startled coveys and volleys of objurgations hurtle past alternately on a full autumn gale. Drive succeeds drive in orderly sequence. The flickering of a parti-coloured flag, quickly seen and answered by the flankers, is all that betokens the master mind. The birds rise, swing round to the downwind flankers, a sudden display of colour, and in a moment they are over the centre of the line. Little escapes the observation of such a man; even the expert in excuses modifies his usual explanations, the most hardened cartridge burier ceases for a while from his miry operations below his butt.

It is not necessary to dwell on the companion picture. The head-keeper who on the day of the shoot prepares to visit the moor for the first time, the shouting and noise which is supposed to make up for the laziness of eleven long months, the beating of dogs, the coursing of hares, the loud echoes which perplex the under-men and frighten the game, all proclaim inefficiency and generally promise bad, certainly unenjoyable, sport. So

[1] While making due allowance for the high standard of intelligence required for the successful driving of Grouse it is remarkable how many gamekeepers are not naturally gifted with this particular form of genius. In nearly every case where a gamekeeper is a master of Grouse-driving his efficiency may be traced to the careful training he has received at the hands of an employer who has himself thoroughly studied the subject.

much depends on the keeper, not only with regard to the bag to be obtained, but also with regard to the satisfaction of successful management, the pleasure and interest of well-organised shooting, that no effort should be spared to secure the suitable man.

The keeper's duties in regard to vermin, poaching, control of old heather, and stock regulation are dealt with in other parts of this book.[1] Certain general rules of conduct are however worth noting.

Principal duties of game-keepers.

The first rule to be laid down is that a good gamekeeper should never be idle. It is a fair criticism to make that laziness is the commonest fault in gamekeepers. Also that this laziness in the majority of cases arises from ignorance and not from *malice prepense.*

Many zealous young gamekeepers have been brought up to believe that their whole duties are to burn the heather in the spring, to attend upon the guns in the shooting season, and during the remainder of the year to keep their eyes open, but on no account to disturb their ground. This belief is convenient for the idle, and had its origin no doubt from small shootings, where one man has charge of both Grouse moor and low ground. The sequence of duties on such shootings goes on without a break from heather-burning to Pheasant-rearing, and from Grouse shooting to covert shooting; a sufficient round of activity to occupy the keeper's time throughout the year. The arrangement was probably considered satisfactory from the point of view of estate economy, even if it did not give a maximum yield of Grouse.

Where a keeper has charge of Grouse ground and Grouse ground only, a higher standard should be aimed at. He must discard the old belief in an "off season," for the "off season" should be his busy time. He must overcome his dread of disturbing his ground even at the breeding season, for it is then that there is most to be learned as to the nesting capacity of his beat, and the means by which this nesting capacity

[1] *Vide* pp. 405 *et seq.*, 411 *et seq.*, 343 *et seq.*, 415 *et seq.*

might be improved. He will not find that the hen bird will desert merely because he happens to have located her nest, whereas if he remains at home one pair of hoodie crows may do as much harm as if he had spent a day walking over the moor and putting his foot on every clutch.[1]

While it may be admitted that all needless disturbance is bad it must be remembered that Nature has provided certain safeguards for the protection of the stock at the most critical period of their lives. It is almost impossible to flush Grouse at this season, and one may walk all day over a well-stocked moor without seeing any indication of the presence of birds except by their droppings. Any birds that may be flushed are usually cocks or barren pairs, and the sitting hens remain undisturbed though the intruder may pass within a few yards of them.

Certain precautions must, of course, be observed, the keeper must avoid all noise, and must not return again to the spot when he has marked a sitting bird. He must creep about the moor rather than walk openly, and above all he must not be accompanied by a dog.

There is a growing feeling among moor-owners that closer supervision during the nesting season is desirable, and is not necessarily followed by disastrous results. In another department of game preserving the nesting arrangements of wild birds are assisted by such plans as the so-called "Euston" or "Stetchworth" systems, whereby the period of incubation is shortened

[1] Many game preservers will challenge the foregoing remarks as contrary to all accepted theories ; but against theory can be put actual experience. One example only need be given :—

On a moor which has come under the Committee's observation, where the annual bag has been known to reach the remarkable total of eighteen hundred brace off 2,000 acres of heather, the gamekeeper in charge, by close and constant attention to his duties, is able to inform his employer whether it is to be an early or late nesting year, whether the stock is large or small, whether the clutches are above or below the average, and how each beat will turn out. This information is obtained by marking any nests that may be found by chance (nests are not deliberately looked for), and by carefully observing the droppings of the "clocking" hens and the young birds. As a rule this gamekeeper and his master form a fairly accurate idea of how the season will turn out even before the dogs are run in July ; after this final test it is possible to prophesy the bag with some confidence.

by removing the eggs from Partridges' nests and substituting for them other eggs that have been almost hatched under a barndoor hen. The results in many places have been most successful in spite of the disturbance caused by searching for the nests and transferring the eggs.[1]

When the keeper has been trained in accordance with conventional doctrines his knowledge of the moor during the nesting season is often very incomplete. He conscientiously marks down some half dozen nests on the edge of the moor, and from these he judges the prospects of the whole ground. If the nests under his observation are flooded out by heavy rain, or destroyed by frost, he reports that the season will be a poor one, whereas if they hatch out successfully his hopes run high, for in his ignorance he does not take into account the distant beat which has been harried by vermin, or the waterless waste in the centre of the moor, where no wise Grouse will select its breeding ground.

Improvement of nesting ground.

It must not be thought that the sole object of watching the stock during the nesting season is to form an estimate of the shooting prospects, though, as will be shown later, an early knowledge on this point is of primary importance in regulating the stock. The foregoing remarks are intended merely to emphasise how closely a keeper may keep in touch with his duties without unduly disturbing his ground. In the performance of these duties many practical benefits result. The observant keeper will first of all note which areas are most favoured by nesting birds, and will try to discover what are the particular conditions which may be profitably introduced in the less favoured areas. Some of the favourable conditions may arise from the configuration of the country, a sunny exposure, good natural drainage, shelter from the coldest winds, etc.; but many may be reproduced by artificial means. Natural drainage may be to some extent replaced by carefully constructed artificial drains, the patent dew-pan may be substituted

[1] For a discussion of the "Stetchworth" and other methods of Partridge preserving *see* Teasdale-Buckell, "The Complete Shot," pp. 246-256.

for the burn which has run dry, or a drain and conduits may be constructed to bring a copious supply of running water through the driest parts of the moor. Bad feeding may be improved by intelligent heather culture, gravel may be exposed, or heaps of broken quartz deposited, in the soft, peaty parts of the ground where there is a deficiency of grit; and thus the nesting capacity of the moor may be extended. It may be argued that the Grouse will always prefer to nest in the places which possess the best natural conditions, and this is no doubt true; still a season will come when a specially heavy stock has been left, and the possession of a reserve of nesting ground may mean the salvation of a moor which otherwise would become overcrowded.

Improvement of drains and springs.

On his visits of inspection during the nesting season the keeper's hands should never be empty, and his eyes should never be closed to the work to be done, the drainer's spade will be found more useful than the gun, ten minutes' work will convert a choked up spring into a clear drinking pool, the dangerous banks of steep-sided drains may be sloped away at suitable intervals, so as to make safe landing stages for any chicks that may be caught unawares by a thunder shower. The fan-shaped morass which spreads down hill from every spouting spring will be tapped at its source, and thus acres of green moss and rushes will be reclaimed again to heather. These will not be the only advantages gained; every stroke of the spade will turn up the grit so often described as "the life of the moor."

Destruction of vermin.

There is no room for vermin and an active gamekeeper on the same beat. His constant presence drives away what he cannot destroy, or at least disturbs the raiders in the prosecution of their designs. The methods of trapping or otherwise destroying vermin are dealt with in another part of this chapter, and here it is only necessary to say that whenever the keeper sees a fox or a stoat or a hooded crow upon his ground he should never rest until he has made an end of it. Every addled Grouse's egg should be given a chance of retrieving its failure by becoming the death-meal of some mountain robber. A keeper should be judged by the paucity of vermin to be found upon his beat, not by the total number he can kill each year.

Building butts: bushing wire.

During the hatching season, and until the young birds begin to fly, the gamekeeper may continue to watch his growing stock. About this time also he may employ himself upon the building up of Grouse butts and the bushing of wire fences with bunches of heather. In June and early July much can be done to increase the heather area by the destruction of bracken, which on many moors has monopolised the sheltered glens, and is rapidly encroaching on the hill ground. Bracken can always be weakened, and sometimes even exterminated, if cut over twice a year in the early summer when the tender young fronds are beginning to appear above the ground, and many cases are recorded where Grouse ground has been reclaimed from this noxious weed by the energy of a determined keeper aided by a temporary staff of assistants.

Destruction of bracken.

When the young birds begin to fly it becomes necessary for the keeper to use greater caution in his visits to the moor. He should still keep an eye upon his vermin traps, but he should not leave the roads and moorland paths more than is necessary, and he should avoid flushing the young coveys.

Observation of stock.

By the end of July he may take stock of his birds with the assistance of his dogs. To ascertain what mortality has occurred since hatching he should count the young birds in every covey, and compare their average number with the average number of eggs which were successfully hatched out. If there appears to be a marked reduction he must try and discover the reason for the loss, whether vermin, climatic conditions, or disease, and if the trouble is avoidable, take measures to prevent a recurrence of the cause in the following season.

Duties in the shooting season.

With the shooting season the nature of the gamekeeper's duties become twofold. His first duty is to assist in the destruction of the stock which he has fostered with such tender care, and at the same time he must keep an ever-watchful eye upon his birds with a view to the continuation of the race into future seasons. With the sporting side of the question we are not concerned, and the practice of stock regulation is dealt with elsewhere.[1] But from the game-preserving point of view it is important that a note should be made of the proportion of old birds to young, of hen birds to cocks, of barren birds to the parents of broods. By a careful comparison of statistics thus collected the gamekeeper may be able to study such important problems of moor management as the following:—The amount of winter stock his ground will carry; to what extent varying conditions of weather and food affect the proportion of young birds to old; to what extent the destruction of old cocks and barren pairs influences the number of breeding pairs on his ground. In his investigations into the condition of the birds brought to bag the gamekeeper should remember that the weight of a bird is the best test of health, and he should not scorn the assistance of the spring balance. Everything possible should be done to ensure that all wounded birds are collected and put in the bag; a pricked "piner" becomes a ready victim to disease, and consequently a danger to the moor.

Destruction of old cocks.

After the regular shooting is over for the season the keeper should, with the permission of the owner, do a little private shooting on his own account, killing down the old cocks whenever he can, either by shooting them down in the green burns or low ground, or by stalking them round the rocky knolls. If too big a stock is left he must get the birds killed in any way that his master will allow.

Autumn burning.

In September and October in England (and in November in Scotland) he will get his first chance of heather-burning, and thus discount the possibility of an unfavourable burning season in the spring. Doubtless during the shooting season he has marked down sundry patches of old heather which urgently require to be broken up, and he should not feel that the year has been a success unless he has at least endeavoured to reduce these patches to smaller dimensions.

Duties in winter.

During the winter the keeper's work is less arduous: the stock by this time is packed and strong on the wing; it requires

[1] *Vide* chap. xv. pp. 415 *et seq.*

little or no protection—but everything possible must be done to keep it on the ground, and if snow should cover the heather for long periods at a time, the keeper must spare no pains with rake and harrow to tide the hungry birds over the time of privation, and, if necessary, provide them with artificial food and grit. But perhaps the most important duty in the winter is that of vermin inspection. Whenever there is a fresh fall of snow the gamekeeper should be early on his beat to search for the tracks of weasels, stoats, and foxes, and thus he will gain the preliminary information necessary for the destruction of these dangerous pests.

Heather-burning.

The months of February, March, and April put the game-keeper's efficiency to the test, for it is principally during those months that it is his duty to provide his stock with food for future years. The good game-keeper must be a far-seeing man, who, like the forester, lives not merely for the morrow but for the day after, and he must burn his moor with a view to improved results many years ahead.[1]

It will be said that the various duties enumerated above represent a far greater volume of work than any man can be expected to perform. It may be admitted that the average gamekeeper is not expected to do so much, but this is rather the fault of the system than of the man, for there is nothing in the foregoing list which may not be overtaken in the course of a year of three hundred and sixty-five days, for even Sundays count where game-preserving is concerned. It is true that for heather-burning, bracken-cutting, and moor-draining the keeper will require temporary assistance; but this assistance should be given ungrudgingly, for the results will yield a handsome return upon the outlay incurred.

The game-keeper as a type.

Before leaving the subject it is only fair to say that game-keepers as a class represent one of the finest types of the community; the healthy, open-air life they have to live seems to develop in them the primitive virtues of honesty, loyalty, and content, while the responsibility of their position leads them to

[1] *Vide* chap. xii. pp. 343 *et seq.*

exercise their intellectual faculties for the furtherance of the interests committed to their charge. If they have a fault, it is an old-fashioned conservatism, tinged with professional pride, which makes them slow to adopt new ideas ; but once they have tested new methods, and found them good, all prejudice is cast to the winds, and they become ardent followers of the cause of reform.

Vermin and Vermin-killing.

The balance of nature.

By a misuse of the term " balance of nature " an argument is upheld in favour of the preservation of birds and beasts that prey upon the Red Grouse.

To speak of a restoration of the "balance of nature" as desirable for the improvement of Grouse moors is beside the point so long as the whole object of every proprietor is to upset that balance in favour of one species only.

How far the destruction of all animals and birds of prey as " vermin " is reasonable, and which of them is most detrimental to a Grouse moor, are questions which should have been settled long ago, yet the discussion as to the use and abuse of vermin-killing has now continued for more than half a century, and still affords ample opportunity to gentlemen of leisure to air their views in the local press.

Arguments in favour of preserving vermin.

The controversialists may be divided into two parties. The one, the more earnest and generally the more articulate, argue that to kill vermin is to interfere with the order of creation and to upset the balance of animal life on the moor. They assert that the mortality due to " Grouse Disease " is of man's own making, because by the introduction of protective measures the weak are preserved as well as the strong, and thus the breed is allowed to deteriorate. They contend that if eagles and foxes were allowed to multiply, all the sickly Grouse would be destroyed by them, and only the fittest would survive.

In the other camp may be reckoned those who believe in action rather than in argument, the moor-owner, the sportsman, and the gamekeeper, and it is to these that the present chapter is more specially addressed. There is no doubt that among game preservers, and more particularly amongst gamekeepers, there is a tendency to destroy indiscriminately. The Committee has known a gamekeeper kill cuckoos, and receive so much a head for them from his master because they had barred feathers "like a hawk." Such a master was worthy of such a servant!

Without entering into the polemics of this well-worn controversy a few points not always put prominently forward may be mentioned. In the first place, it may be suggested that owing to the artificial conditions which have for years prevailed on Grouse moors the natural laws have little direct bearing on the point at issue. It is clear that if moor management has accomplished anything, we have long ago passed beyond the limit of stock that the moor would maintain if left entirely to natural conditions. It is reasonable, therefore, to argue, that if we have established and wish to preserve an unnatural stock of Grouse, we must not return to the natural state of things. The practical moor manager is not concerned with the laws of natural selection and of the survival of the fittest, but rather with the adaptation of these laws to his own special requirements.

Evidence of history.

The evidence of history affords a second and equally conclusive argument against the theory that the presence of vermin is conducive to the health of the stock. Written records go to show that even in the eighteenth century, long before game preserving was introduced, Grouse were no less subject to disease than they are at the present day, in spite of the fact that their natural enemies were left undisturbed to keep the "undesirables" in check. As a matter of fact the whole argument is founded on an error. There is no evidence whatever that Nature's so-called scavengers confine themselves to the destruction of the weaklings—their tendency appears to be exactly the reverse. Observation in the field goes to show that the peregrine striking at birds on the wing more often than not picks out the centre bird of the covey, and that the robber of the hen-roost does not take the undersized piner, but the fattest bird he can find.

It must, however, be admitted that the keeper who thinks his only concern is to kill all vermin indiscriminately goes equally far towards the opposite extreme. Birds and beasts of prey are not wholly good or wholly bad; in the destruction of mice, rats, and voles they often play a useful part, and the extermination of the greater vermin entails the duty of keeping in check the lesser pests, which tend to become too numerous owing to the destruction of their natural enemies. Vermin sometimes beneficial.

With these facts in view we may proceed to examine the credit and debit account of the various animals that decorate the keepers' "dule" tree to see which should be sacrificed in the interests of sport and which should be spared.

Vermin.

The leading offender amongst four-footed vermin is undoubtedly the fox—difficult of approach, suspicious of the lure, a ranger of miles of country, one day picking a Grouse from the nest, the next day visiting the farmer's poultry yard, taking his meals sometimes off rabbits, poultry, and Grouse, sometimes off rats, voles, or even frogs, his diet must always be described as promiscuous, his morals noteworthy only by their absence. Even in his methods of destruction the fox is guided by no known law; he will snap off the heads of a dozen fowls without carrying off a bird; at other times he will carefully bury his victims, and as often as not fail to return to their fragrant and probably well-"trapped" remains. Stories are told of the relics of a dozen Grouse killed in the nesting season, and found in varying stages of decomposition in or near a fox's "earth."[1] Fox.

It is easy to see that every effort should be made to rid the

[1] In a single day's walk the Committee's field observer found three nests in which the hen Grouse had been snapped up by a fox, leaving the eggs scattered and broken, and a line of hen bird's feathers to tell the mournful tale.

moor of an offender with such an established reputation for evil. The methods advocated for his destruction are many, including some of doubtful legitimacy in which strychnine plays a not unimportant part. Of the methods more generally recognised, "trapping" a recent kill, spooring in the snow, watching the den at cubbing time, may be enumerated. In Scotland the "fox-hunter," a gentleman clad not in scarlet but in fustian, is sometimes requisitioned with his mixed pack of lurchers, beagles, and terriers, to aid in the pursuit of his quarry; sometimes he runs the fox to earth, more often he drives him to where a confederate lies in wait to slay him with a shot gun.

Foxes usually travel to a new hunting ground along certain well-defined routes, which from instinct they know to be their appointed path. Keepers are not slow to take advantage of these "trade routes." The mixed pack is laid on to the stale line of a travelling fox at dawn, and the hunters take their posts in well-known coigns of vantage, often with deadly results.

Tom Speedy,[1] writing in "The Keeper's Book," makes many interesting remarks upon the destructiveness of foxes, and the best methods of reducing their numbers; amongst other devices he quotes that of placing a bait on an island in a pool of water. A road or causeway is formed between the island and the mainland, and on this road a trap is carefully concealed; he specially recommends for bait the carcass of a fox or cat. Speedy, with other authorities, draws attention to the importance of never going near the trap after it has been set lest the fox should scent the presence of man.

Stoat.

The stoat, next to the fox, is the most determined destroyer of game. Living in old stone dykes, disused quarries or cairns, he steals on the unsuspecting Grouse at jugging time—a short worry ensues, and a possible covey is abolished off the face of the moor. It is the habit of stoats to hunt in small packs, and when acting together, and in search of food, they are quite fearless, and will let men approach close to them before abandon-

[1] P. J. Mackie, "The Keeper's Book," 7th ed., 1910: T. N. Foulis: London and Edinburgh, pp. 107-109.

ing the chase. On one occasion the Committee's field observer saw a family of seven or eight stoats systematically hunting out a brood of young Grouse while the mother bird hovered about in a state of great anxiety, running round just out of reach, and trying to draw the marauders away from her brood.

The stoat is a great traveller, and on occasions has been tracked for miles in the snow. Like foxes, stoats seem to follow well-defined lines of migration, and cases are known where keepers have by chance struck upon these lines of march, and have been able to trap many more stoats than were ever bred on their own ground.

The stoat is not, as a rule, difficult to trap. The edge of a dyke, or an opening in a wall, a narrow gully or path between rocks usually give the best results. His curiosity is often his undoing, and he is, so to speak, his own best bait. When placed in an open run the trap should be covered by a flat stone overlying two uprights. The habit of the animal makes him wish to investigate all objects of interest without attracting attention, and often merely the satisfaction of exploring a partly concealed passage between two stones is a sufficient draw; when the corpse of a dead brother is placed on the flat stone above, the probability of a kill is greatly increased.

Stoats are rarely killed down in sufficient numbers. Like every other kind of vermin they seem to congregate wherever the stock of game has begun to increase; hardly any moor is without them, and a good keeper will kill his thirty to sixty stoats a year, and keep on doing so year in year out without apparently making any impression on the source of supply. The lazy man has one of two standard excuses which many moor-owners will recognise: on the rabbit-ridden moor—that the stoats confine their attention to ground game; on the moor where there are no rabbits—that there are no stoats. No credence should be given to either statement. Every keeper should have several dozen of the best steel traps (it is useless to employ any other kind) always set and left out on the stoat runs as long as they will spring.

Weasel. The weasel is very similar in his habits to the stoat. He also hunts in packs, but he is not quite so destructive to game, and feeds more readily on mice, moles, voles, etc.

Amongst other four-footed vermin the wild cat, pole cat, hedgehog, may be mentioned; the two first named are particularly destructive, but are now so rare that they may be disregarded by the moor-owner. The hedgehog is by no means uncommon on many moors, and is without doubt an occasional egg-stealer. The domestic cat run wild is, of course, a danger, but he is not met so frequently on the open moor as in the hedgerows and coverts near the habitations of man.

Peregrine. The peregrine must be bracketted equal to the fox and the hooded crow in the list of noxious vermin. He is the shyest of all the hawks, and builds in the most inaccessible places; the quickest to kill as well as the readiest to escape with his prey. No British bird has an easier power of flight or more enjoyment in his strength; he seems to revel in his accuracy of eye, and will strike off the head of a Grouse, pass over it, swoop again, and catch the carcass before it has reached the ground. The peregrine often kills for sport or for revenge, and will strike down an unoffending crow or jackdaw that has built too near his nest, and not even descend to see where his victim has fallen; at other times he will hunt his terrified victim round and round a glade or corrie, striking over and under until the amusement palls. The peregrine is difficult to trap, no bait will attract him, for he scorns to touch any dead bird or beast which he has not killed himself.

It cannot be argued on strictly utilitarian grounds that the peregrine has much to go down on the credit side; when feeding his young he probably averages his brace of nesting Grouse a day, as the heaps of neatly plucked feathers left on the moor plainly testify. It is hoped, however, that owners of Grouse moors will always leave a few of these beautiful slate-coloured pillagers on some of the wilder and less accessible spots.

Hooded crow. For the hooded crow no plea can be made. He is not only the worst but the most widely distributed of vermin. Annually he comes up in his hundreds from his recruiting ground by the sea, and if not watched and destroyed will do incalculable harm both to young birds and eggs. His reputation dates from pre-sporting days. The Celtic name of the bird is "flannag," which means "kill" or "slay." A Morayshire proverb says: "The Guile, the Gordon and the hooded crow are the three worst things Moray ever saw." This is a high testimonial of rascality from a place known to old-time raiders as "The laich of Moray, where all men have their prey."

To see the hooded crow with small beady eye hunt a hillside, drop down beside a pair of Grouse whom he suspects of having a nest, to watch his casual walk round as if merely on a tour of inspection, the fierceness with which he darts at and drives away the pair from their eggs or young, returning again and again until the last of these has been taken, leaves no thought of pity even in the most tender heart. The hooded crow usually nests in the birch woods or plantations at the edge of a moor. It is fortunately easy to kill the pair in the nesting season, and they can be trapped with bait at all times of the year. In the nesting season there is no bait like an egg, and even if the "hoodie" does not fall a victim to this bait, it may prove the death of a stoat, a rook, or some other equally objectionable scourge.

Rooks are nearly as destructive as hoodies or carrion crows on some moors, for the supply is inexhaustible, and the nests being at a distance from the moor cannot as a rule be destroyed. Rooks.

Jackdaws are often a serious pest upon a moor, and should be kept in check with a firm hand. Their numbers can best be reduced by harrying them in the breeding season. If the old birds are kept off their nests in frosty weather the eggs will become addled. Jackdaws.

An interesting example of the damage caused by jackdaws is furnished by a correspondent of the Committee who rents a moor in Scotland. Before he took the moor the average bag was about sixty brace, and the ground was overrun with vermin, more especially with jackdaws, which nested in the rabbit holes on the hillside. The tenant at once commenced to wage war against the jackdaws, and offered a sum of one half-penny an egg to any boys who robbed the nests; in each of the last three seasons he has taken over one thousand jackdaw's eggs—one boy alone collecting upwards of five hundred; at the end of the third season the bag had increased to over two hundred brace of Grouse, while a large breeding stock was left. The jackdaw's eggs were found very useful for feeding young pheasants.

Ravens. Ravens are already so persecuted by the shepherds that they hardly count, though there are still a fair number to be found in the remote fastnesses of the Scottish deer forests.

Golden eagle. The golden eagle is too noble a bird to rank in the list of vermin. He occasionally kills his Grouse on the wing, but feeds for choice on hares, with an occasional deer-calf or lamb for a change of diet. In former days, when eagles existed in large numbers in the Highlands, their depredations were so serious as materially to interfere with sheep farming. The eagle cannot be said to be a desirable recruit to the ranks of the flankers in a Grouse drive; although he not seldom takes on himself this duty, to the rage of the keeper and bewilderment of the birds.

Hawks. Of the hawk tribe all are occasionally destructive; but it must not for a moment be supposed that all should therefore be destroyed.

The kestrel or wind-hover probably does more good by killing mice and rats than he does harm by the destruction of a few young Grouse. The buzzard confines himself almost entirely to small birds, carrion, and ground game.

Gulls. The greater blackback gull is destructive both to eggs and young birds, and should not be allowed to infest any moor on which it is intended to preserve a stock of Grouse.

The black-headed and common gulls are destructive to eggs in certain localities; this, however, must be regarded as the exception rather than as the rule, for Grouse frequently nest and hatch out their broods unmolested in the centre of breeding colonies of these birds.

Poachers.

It has always been customary to divide poachers into two classes, the professional poacher, who makes poaching a means of livelihood, and the occasional poacher, who only takes game for his own consumption, or to satisfy what is called his sporting instinct—for the property of others. Two kinds of poacher

The professional poacher is a dangerous and undesirable member of the community, and should receive no mercy. He is generally devoid of all the finer feelings, and his sole object is to enrich himself by appropriating, in the largest possible quantities, goods that are not his. He usually belongs to the submerged class which is recruited from the ranks of those who have gone under on account of their own shortcomings—dishonesty, drink, or congenital laziness. The professional poacher.

In certain country towns and villages, especially those occupied by a mining or manufacturing population, poaching is not looked upon as a crime, but as a perfectly respectable and often remunerative means of occupying leisure time. Where this spirit exists the task of game preserving is a serious matter, and the preventative measures employed resemble the *levée en masse* rather than what might be called the keeper's "level of every day's most quiet need."

Fortunately for the owners of Grouse moors it is the exception to find the professional class of poacher a very serious menace owing to the remoteness of moors from the centres of population. Nevertheless, the armed gangs do occasionally turn their attention to Grouse, as may be proved by the supply of freshly killed birds that appear in the windows of the poulterers' shops on the morning of August 12th, earlier than could have been possible had they been killed in the ordinary course of sport.

Systematic poaching of Grouse for the market is less common now than it was in former years. The increase in value of Grouse moors has led to more careful watching and to more severe prosecution, the proprietors in the principal game-preserving counties have in many cases combined together to form associations for the protection of their sporting rights, and the duty of bringing the wrongdoers to justice has been entrusted to competent men. The habits of the Grouse, too, have changed in recent years; whether owing to the introduction of driving or because of the destruction of birds of prey, Grouse are much wilder at the beginning of the season than was formerly the case, and on many moors will not sit to dogs at all.

Twenty years ago it was not uncommon for the poacher's gang to spend the nights of August 10th and 11th hunting the moors with a steady close-ranging pointer. Sometimes it is related that a lantern was suspended from the neck of the dog in order that his movements might be followed in the dark. On obtaining a point the poachers would make a detour, and would gently draw a net down wind towards the dog and drop it over the covey. These nets were sometimes captured, and may still be seen hanging as trophies on the walls of some of the shooting lodges in the North: they are beautiful pieces of workmanship, usually made of silk, very light and very strong.

Snaring on the stooks.

The only time when Grouse still can be poached with ease is towards the end of the season, when they pack and flock to the low ground to feed on the corn stooks. On these occasions they may be snared by horsehair nooses, and there is no doubt that in certain districts this form of poaching is carried on. As the majority of "corn-feeders" are young birds, this form of poaching is specially harmful to a moor. There is no excuse for the gamekeeper who permits it. The cornfields to which the Grouse resort, and the hours at which they feed, are perfectly well known, and it is the duty of the gamekeeper to be constantly on the spot.

The subject of poaching cannot be considered complete without some reference to the pastime of "Grouse-becking" as practised in the north of England. Becking has already been mentioned in another part of the Report,[1] and the manner in which this habit of the bird has been utilised by poachers

[1] Chap. i. p. 24.

is graphically described by the Rev. H. A. Macpherson in the Fur and Feather Series.[1]

Occasionally the professional poacher goes alone and boldly carries a gun. This method is common in the extreme north of Scotland, where the daylight is of such long duration that it is almost impossible for the gamekeepers to be always on the watch. It is a well-known fact that in flat, featureless country it is very difficult to detect a man upon the moor, or to hear the sound of a shot.

Facilities for sale of poached Grouse.

All professional poaching might be prevented if the sale of game by unauthorised persons were discouraged. Game-dealing licences are granted far too often to small country tradesmen, who are prepared to act as the receivers of stolen goods. This might be avoided by granting only a limited number of licences in every town, and only granting them to responsible persons. The licensed game-dealer is supposed to ascertain that the vendor had come by his game honestly, but the law in this respect is seldom enforced.

The occasional poacher.

The occasional poacher is a nuisance, and requires careful watching, but it is doubtful if his depredations ever materially affect the stock upon a moor—one pair of hoodies, or the mildest attack of disease, will do more to damage the season's prospects than a score of crofters who take an odd Grouse to give a flavour to the broth.

Though the occasional poacher may not do much harm he must not be encouraged—he disturbs the ground, and wounds more than he kills; too often he is tempted by success to join the ranks of his professional brethren.

No one can deny some measure of sympathy for the small tenant trying to earn a scanty living on a poor hill farm or croft who finds his stooks of corn in October or November black with Grouse. The crop indeed may be well-nigh worthless, but that makes the temptation all the greater to try and get some benefit out of a disastrous harvest. The landlord should deal with such cases in a broad-minded spirit, his gamekeeper

[1] Fur and Feather Series, "The Grouse," pp. 65-72.

should be instructed to assist in keeping the birds off the corn, and any old cocks that he may shoot should be given to the tenant as a *solatium* for damage done.

Netting live Grouse and egg-stealing.

One form of poaching remains to be mentioned, namely, the catching of live birds and the stealing of eggs with a view to selling them for the restocking of other ground. Catching Grouse alive is perfectly legitimate where a man nets only the birds bred upon his own moor, or on a moor which he has rented for the purpose, but in some districts in the north of England, notably in Cumberland, the practice has developed into an abuse. It is a well-known fact that certain small freeholders on the edge of the hill land who have no Grouse of their own take a heavy toll of the birds which visit their ground from neighbouring moors.[1] An example of the damage done is furnished by one of the Committee's correspondents, who writes as follows :—" Owing to the present system of netting on small holdings, Grouse preserving in Cumberland is a snare and a delusion. To give an instance—my moor in the neighbourhood of ——, of about 3,000 acres, used to give a yearly bag of about eight or nine hundred brace, and was worth about £500 a year to let, now two or three hundred brace, all shot in the first fortnight to save them from being caught in nets, with a rent of about £100 a year, represents the present return." The only method of checking this evil would be for purchasers to agree to boycott all sources of supply that are open to suspicion.

Egg-stealing is not a very common form of poaching; Grouse eggs travel badly, and the advantage of introducing fresh blood by the importation of eggs has yet to be proved.[2] The practical difficulties also are considerable.

[1] The following passage is worth quoting: " The cause of offence may be only a tiny strip of sour pasture, heatherless, Grouseless, perhaps not worth sixpence an acre for any purpose but one. Its want of food and shelter may be so evident that birds seldom light on it, but they have to fly over it, and nets judiciously arranged and managed will, in the course of a season, capture a very large number of them, and do very great harm to the adjoining beats." G. W. Hartley, in "Victoria History of the Counties of England, Cumberland," edited by James Wilson, M.A., vol. ii. p. 439. London: Archibald Constable & Co., Ltd., 1905. *Vide* also Fur and Feather Series, "The Grouse," pp. 76-77.

[2] *Vide* chap. xv. p. 445.

CHAPTER XV

STOCK

THE subject of Grouse stock management is a difficult one on which to generalise, owing to the varying conditions which affect the Grouse in different parts of the country. The question is, however, of so much importance that it is necessary to attempt to lay down certain rules that are generally applicable, and at the same time to note the exceptional cases to which these rules do not apply.

The management of stock.

The first question which naturally presents itself is, What is the ideal stock which good Grouse ground should be capable of carrying ?—in other words, how many birds can be supported upon a given area of good heather ? Simple though this problem appears, a little consideration will show that no solution can be put forward applicable to all moors. It must be remembered that the number of birds varies with the locality, the heather, the climatic conditions, and migration. Also, that even on any given moor the number is not constant, but alternates in succession with the autumn, winter, and spring seasons.

The ideal stock.

Before entering into the conditions which govern and limit the number of birds, and before describing the measures which are recommended to keep the stock on a moor inside the margin of safety, it will be necessary to define the position more accurately by stating—

(1) Exactly what we mean by the word "stock."

(2) Certain statistics, from which broad general laws can be deduced, applicable to specific areas of moorland.

(3) Certain facts and figures gleaned from the records of individual moors.

Meaning of term "stock."

The term "stock" is used indiscriminately to mean both the number of birds on a moor in summer when the coveys are unbroken, and the number of breeding birds which eke out a precarious living in the winter and early spring months.

For the purposes of this chapter the term "stock" will be used in the latter sense only.

It has been shown in previous chapters that it is in the early spring that disease invariably appears, it is therefore at that period, and the period immediately preceding it, that the question of numbers is of real significance.

Food conditions.

The reason for this is not far to seek. During the months of May, June, and July the fresh young shoots of heather are probably more nourishing than at any other time of the year—even the oldest and most useless heather is not without some food value. In July, August, and September berries are added to the Grouse's diet, and in the late autumn and early winter the seed or fruit of the heather is largely eaten. In fact, it may be said that from the beginning of May to the middle of the following January the food supply, even on the worst moors, is almost inexhaustible, and during this period the ground is capable of supporting a stock far larger than it could possibly carry during the subsequent three months. If, therefore, a limit of stock is fixed for March and April, it is sufficiently plain that that limit can be carried with safety all through the year.

Stock to acreage.

While it is impossible to give any exact number of pairs of birds that 1,000 acres will carry in any specified district, it will probably be interesting to many of our readers to learn that, broadly speaking, the number of birds to the acre is curiously constant over wide tracts of similarly situated ground. In Yorkshire and Lancashire there are exceptional moors which carry a pair of Grouse to 2 acres; but in the north of England, generally, one pair to 4 or 6 acres is considered a safe winter stock on *fully-developed moors.* In Scotland the proportion is about one pair to 8 or 10 acres, except on the west coast, where the normal winter stock is often only one pair to 20, 30, or 40 acres. This generalisation can only be regarded as true of the aggregate, and not of individual moors, and it must be borne in mind that the bags obtained will show a much higher ratio. In a normal season the bag will usually be about double the numbers of the winter stock, and in a very good year it may be possible to kill as many as five birds for every nesting pair.

The similarity of results obtained by a comparison of bags on great stretches of moorland enables several important deductions to be made.

(1st) That there are certain natural limitations, directly connected with the growth and density of the heather crop, which local conditions of climate, soil, etc., enforce in each district.

(2nd) That while close attention may modify these natural limitations, even the greatest care cannot wholly eliminate them.

(3rd) That given efficient keepering and supervision, and the control both of sheep stock and shooting, the majority of what are considered third-rate moors might in time be raised to the average of the best of the *similarly situated moors* in the same district.

(4th) That in any locality, owing to the slow rate at which old rank heather can be converted into good feeding, the progress of a moor from bad to good is necessarily slow.

Individual moors.

From the consideration of these generalisations we may now turn to the study of the following records of bags from individual moors which have been selected as typical of each main tract or district.

[TABLE

	No. 1 Moor.	No. 2 Moor.	No. 3 Moor.	No. 4 Moor.	No. 5*a* Moor.	No. 5*b* Moor.	No. 6 Moor.	No. 7 Moor.	No. 8 Moor.	No. 9 Moor.
Brace	370	576	350	414	1,701	1,319	1,205	250	2,781½	316
”	425	423	472	420	½	758½	67	784	606½	444
”	636	183	560	430	2	716	474	801	913½	683
”	91	315	1,348	611	7½	1,011	1,158½	1,306	1,829½	1,578
”	320	447	80	1,238	265	704½	1,315	692	2,481½	1,674
”	660	704	259	126	810½	465	2,350½	71	4,922½	1,428
”	880	892	411	480	1,774	382	...	72	4,365	885
”	1,214	420	728	1,247	44½	973½	255	250		696
”	...	450	1,643	480	45½	1,261½	886½	1,063		1,361
”	205	780	455	1,267	232	6	476½	2,487		1,540
”	248	1,155	60	160	600	175½	38	5,010		
”	408	1,737		175	572		154			
”	789	529			157		1,268½			
”	1,625	305			236		1,330			
”	80	180			476½		1,010½			
”		370			410		1,184			
”		617			232		395			
”		1,309			303		315½			
”		1,567			146		158½			
”		422			416		429½			
”					785½		528½			

No figures relating to the breeding stocks on these moors are available, but judging from the bags the following deductions may be made :—

No. 1 *Moor.*—Three hundred to four hundred pair of birds appears to be the limit of stock the ground would carry in March. It will be noted that every time the bag exceeds one thousand brace disaster follows.

No. 2 *Moor.*—An improving moor apparently able to carry three hundred to five hundred pairs of March stock in a normal year.

No. 3 *Moor.*—A very typical dogging moor with four hundred pairs of breeding stock a safe limit.

No. 4 *Moor.*—A small well-burned moor—note the rapid recovery from disease ; also that it is dangerous to approach five hundred pairs of breeding stock.

No. 5*a and* 5*b Moors.*—The records begin with the year 1866, and the disastrous character of the outbreaks in 1867 and 1873 are reflected in the bags.[1] The figures in column 5*a*

[1] *Vide* also p. 443.

fluctuate so greatly from year to year that it is difficult to estimate a safe limit for the winter stock—probably about four hundred pairs.

Column *5b* represents the bags on the same moor from 1894; in this year driving was adopted as the only method of shooting the ground. The results of better stock regulation under the new conditions are shown by the figures. While there are no individual bags as large as in 1866 and 1872, the average bag has increased from four hundred and fifty-eight brace to seven hundred and six brace, in spite of two very bad seasons.

No. 6 *Moor.*—A breeding stock of about six hundred brace would probably be a safe limit.

No. 7 *Moor.*—This is a large moor extending to about 25,000 acres, and probably capable of carrying a larger stock than might be supposed from the bags; probably one thousand five hundred pairs would not be too large a winter stock.

No. 8 *Moor.*—Another large moor, or, strictly speaking, a collection of moors on one estate extending altogether to 34,000 acres; about one thousand five hundred to one thousand seven hundred pairs would probably be a sufficient breeding stock, according to the condition of the heather in the early spring months.

No. 9 *Moor.*—About five hundred to six hundred pairs.

We find that on each moor so examined there is a very clearly defined limit of winter stock which it is dangerous to approach, and almost certain disaster to exceed, and that while in occasional years, owing to unusually favourable conditions, an exceptional stock of birds may be reared, there is a constant tendency for the stock to revert to the normal ratio for the district. The whole art of moor management depends upon a proper appreciation of this tendency, for if the stock be not reduced to the safety limit by artificial means, nature will inevitably intervene, and will regulate the superabundance with such severity that it may be years before the moor recovers.

With these considerations in view we may proceed to lay down the one great law of stock management, viz., *determine the number of birds that the moor will carry safely in March, and irrespective of all other consideration kill the birds down to that limit.*

It is a very curious thing that while all are agreed that stock must be "hammered" in a good year, no real precautions are taken either to find out when a good year is coming, or when a good year has arrived. Nothing is more common than the case of the moor-owner who, after various rumours and counter rumours, at last makes a casual inquiry about Ascot week from his agent or factor as to whether there will be any birds that shooting season. By early July he has settled his Grouse-driving parties, and has selected his shots from his regular autumn visitors, with the sole change of perhaps adding a couple of specially good shots if the report is favourable, or eliminating the names of certain guests in the case of the report not being satisfactory. Towards early August he finds his way on to the moor, and the keeper, who has probably often been found fault with for undue optimism, hints vaguely that there is a "grand appearance," or perhaps, if cautious, "more than the usual stock on the ground." It is not till the first week of shooting that the host at last realises that he has got an abnormal stock of birds. His visitors rejoice, but he himself knows that his prospects of sport for future years are seriously threatened. If he realises the full significance of the position he may attempt to fit in one or two additional shooting weeks late in the season; those who have tried to get together an October Grouse-drive will readily appreciate the difficulties of the task. Added to this he may not be favoured by fortune. The earlier shoots may be spoilt by wind or weather, the later shoots may be rendered abortive by the high gales of the equinoctial period, and by the indifferent marksmanship of a hastily collected team of guns. The result is a foregone conclusion. The moor remains insufficiently shot, and by the end of the shooting season no stroke of fortune can avert the risk of disease.

In the case of the let moor in a big year the situation is even more serious. In the first place, the lessee has less favourable opportunities than the owner for obtaining information as to the prospects of the season; in the second place, he has even less chance of killing down his stock if they are too numerous. He himself is often a fine shot; but the same cannot always be said of his friends. The close-sitting bird of August 12th, or the reluctant "up-winder" in an evening drive, may be killed even by the novice; but once the birds get strong on the wing, or fly with any degree of rapidity, twisting towards the spaces between the guns, rather than following an owl-like course over the centre of the butt, a very different standard of marksmanship is called for. Such birds appear to be immune from all pellets except those in the very centre of the charge. If the lessee does not succeed in thoroughly reducing his stock by early September there is little hope of much being done in the later weeks of the season; he has probably no great acquaintance amongst the "hardy locals," and he will fail to decoy his club friends from London to drive Grouse once the Partridge season has set in.

Early information necessary.

To avoid this state of things, of frequent, one might almost say regular, occurrence on many moors, it is necessary to adopt certain practical expedients. The keeper should be instructed to get about the moor in the earlier part of the nesting season, to ascertain what stock of birds is actually on the ground, and whether they are healthy; he should mark down nests on each of the beats, and report by the middle of June how many of these nests have hatched off, and with what results. The Grouse is a particularly hardy bird, and provided that the stock is on the ground, and the eggs have hatched out, it is possible to estimate with some certainty the probable stock which will be available for sport in the shooting season.

Modern methods of Partridge management require that the keeper should know not only the number of pairs on each beat, but even the number of eggs laid in every nest. Such accuracy is not necessary for the Grouse-keeper. He should have a rough knowledge of the number of breeding pairs on his ground, and from these, by observation of the average yield of marked nests, he should be able to give a shrewd guess as to the number of birds that should come to the gun.

The result from hatchings varies much less than most people suppose. It takes a very bad year to reduce the average yield of a pair of birds below 3·5 of young brought to the gun, and only in very exceptional years does the average covey exceed 5·2 of young birds.[1]

Many keepers will not readily undertake the responsible duty of estimating the probable stock; but it is not really necessary that they should do so, for, provided they can supply the facts, the proprietor may make his own deductions, and in any case it is advisable that the keeper's estimates should be checked by his master before they are acted on.

While on English driving moors there is some excuse for lack of knowledge of shooting prospects, such ignorance is unpardonable in Scotland, where the keeper can run his dogs over the moor in July.

When it is certain that a good season is at hand it is probable that not only one moor will be good, but that all the neighbouring shootings will share in the prosperity. It is therefore advisable to pay no attention to the wise men who contend that frequent shooting will tend to drive the birds off the ground, but rather to let shooting party succeed shooting party until the stock of birds has been killed down to *less than the number which is generally left on the moor.*

How this is to be done so as to give the best sport, and at the same time the most satisfactory results, now falls to be considered.

Methods of shooting Grouse.

To enter fully into the respective merits of shooting over dogs and driving from the point of view of sport, is outside the province of this work.

[1] *See* Table, p. 302.

Dogging.

There will always be those to whom the working of dogs, the study of nature, the finer arts of venery, and the quiet beauties of the moor will provide two-thirds of a day's enjoyment. It is impossible to deny the satisfaction gained from a pair of wide-ranging dogs perfectly trained under a keeper who is thoroughly conversant with his moor, and able to take advantage of every chance of wind or change of circumstance that the day may bring forth. Although the shooting may not be difficult, the surroundings, the assistance which each sportsman is able to give in manœuvring the Grouse, the chance shots which fall only to the alert, the feeling of satisfaction afforded by each old cock that has been outwitted, the short rests, the cool springs, and the cunning cuts from one point to another, all help to make the day's sport difficult to equal, and impossible to beat.

Driving.

To those who are in the first flight of shots, who love organisation for its own sake, and have the latter-day mania for big bags and pleasures condensed into the shortest possible space of time, driving, on the other hand, will always claim the first place.

It will be readily admitted that there are few more exhilarating moments than the beginning of the down-wind drive, the first half-dozen birds neatly killed, the nearest of them lying stone dead 50 yards behind the butts, the conscious feeling of being able to deal with the situation, and the excitement of watching the big pack neatly turned by the flankers and sailing in serried mass towards the very centre of the line.

While opinions differ as to the pleasure to be derived from either method of shooting, the benefits conferred by each are not hard to detail.

The great advantage of shooting over dogs is that the worst shot should be able to kill without wounding. Dogging where it is possible is an excellent method of regulating the stock in a bad year. It gives an opportunity to kill all the old birds and spare the young. It is possible also to "dog" carefully the outskirts of a Grouse moor without doing any harm to the central beats, and thus provide a means of killing the birds on those parts of a moor which are least effectively driven.

In a good year, dogging is but a very imperfect method for getting on terms with the stock. The mere fact that the coveys are large means that May, June, and July have been dry and fine, that all the birds are from first hatchings, and therefore strong on the wing, and proportionately wild. By the end of the third week of the shooting season, if the weather is fine, or earlier if August has been wet and stormy, the Grouse are nearly unapproachable, and long shots and wounded birds are the chief results of a day's outing.

A further disadvantage of shooting over dogs is that single old cocks almost invariably escape. The walking powers of the parent birds of a covey are limited by the pedestrian ability of their brood, whereas the solitary old bird is subject to no such limitations.

Without going into details as to how the dogging moor should be worked, certain points may be mentioned which do not always receive enough attention.

In the first place it may be laid down as a rule—probably an unpalatable one—that in a bad year, when it is desirable to shoot old birds, one gun, and one gun only, should go out with each dogging party. If two guns go together the object of each shooter will be to kill outside birds so as not to interfere with his companion's sport; if the shooter goes out alone his object is to kill the first bird on the wing, in nine cases out of ten the father of the brood.

Where dogging is the usual method of shooting, the owner should work round the lower fringes of the moors towards the end of the season in order to secure as many as possible of the pricked or badly-feathered birds which have worked their way down to the grassier and wetter ground. In settled weather the high tops should also be well hunted or even stalked for the old cocks which have resorted to these supposed sanctuaries.

The main advantages of driving are: (1) That it affords a means by which the stock can be killed down to a proper limit; (2) That it tends to mix the coveys, and so prevents inbreeding;[1] (3) That as the old birds are the stronger fliers, and usually lead the packs, it is certain that in the early drives a large proportion of these elderly undesirables will be killed; (4) That provided the host has selected his guns well the death is assured of all solitary old cocks who risk their fortune over the centre of the line.

Disadvantages of driving.

While these advantages are to be credited to driving, certain items have to be put down on the debit side. Unless the butts are occasionally changed, or the configuration of the ground makes it possible to get all the birds forward to the guns, it is certain that the birds rising nearest to the butts will be more severely shot down than those on the more distant parts of the beat.

All experienced sportsmen have observed that in certain long drives, unless the wind is favourable, a large percentage of the birds first flushed escape to one flank or another, and that only a few come over the guns, while in other drives the birds are flushed from high ground, and, even if they do come forward, are secure from harm, owing to the height at which they fly. The circumstances repeat themselves each time the ground is driven, and become intensified year after year as the birds profit by experience, with the result that on every beat there are certain tracts of ground which form a sanctuary, while other tracts are overshot. It may be said that the over-shooting of certain tracts is, relatively speaking, not important, for if one portion is overshot it will quickly be restocked from the other more heavily stocked areas. It is, however, very important that no portion of a moor should be allowed to become a sanctuary, for this will lead to the survival of a race of old and useless birds, and thus reduce the annual yield of the moor.

While driving is advantageous in a good year, it is a very

[1] *Vide* note by Mr Rimington Wilson, pp. 446 *et seq.*

difficult method by which to treat the stock in the years of recovery from disease. In a bad year the host and a few friends may shoot over dogs and agree only to kill old cocks; they will be satisfied with a third of the usual bag if thereby they can bring the moor more rapidly into good order. To ask a party of guns, however, to drive Grouse, and either to refrain from shooting at the coveys, or only to pick out the old birds, is obviously impracticable.

Effect of driving on total yield.

A great deal has been written, even by those in authority, to the effect that driving *per se* does not add to the yield of a moor. The results of observation do not support this view, and in this connexion it would not be out of place to trace the history of Grouse driving, and to study the results which have attended its introduction in different parts of the country.

History of Grouse driving.

Grouse driving was first introduced in Yorkshire, where, owing to the wildness of the Grouse in that country, it was found difficult to obtain a satisfactory bag by any other means. Naturally the innovation resulted at first in an increased yield, and this gave rise to an exaggerated belief in the merits of driving Grouse as a means for increasing the productiveness of all moors. As a result driving was introduced on many moors where similar conditions did not exist; in other words, when the birds were not so wild as to necessitate this method of killing them. On these moors it was found that driving did not have the same satisfactory results as in Yorkshire, and that in some districts the bags obtained by driving were actually smaller than they had been in the old dogging days.

Hence there arose a school of sportsmen who condemned driving as an undesirable institution, and never ceased to lament the fact that moors which were once good dogging moors had been converted into inferior driving moors, for it is well known that once a moor has been systematically driven its value for dogging is greatly impaired.

The solution of the problem is perfectly simple. On all the moors, both in England and Scotland, when Grouse were naturally wild, the introduction of driving was followed by an increase both in the bags and in the stock, for the bags were increased owing to the increased facilities for bringing the birds to the gun, and the stock was improved owing to the possibility of killing off the old and undesirable birds, and leaving the younger and more vigorous to form a breeding stock.

But once the system of Grouse driving had been fully established the improvement came to an end. Moors whose annual yield had been improved by several hundred per cent. ceased to improve when they reached the higher level, for the beneficial results of driving had been exhausted. The question is very fully discussed by Mr Teasdale-Buckell in "The Complete Shot." This writer draws attention to a condition which he describes as one of "stagnation," which followed the establishment of Grouse driving. The stocks on many moors had been very much increased, it is true, but were no longer increasing. He quotes the figures from various moors in England in support of his argument, and gives examples of moors in Scotland which have not been improved by the introduction of driving.[1]

Mr Teasdale-Buckell seems inclined to think that on the whole the records do not point to any great increase of stock as a result of Grouse driving. He probably does not give sufficient weight to the cases where it was followed by a very marked improvement, for these cases occurred chiefly in England as long ago as 1872 and 1873. He also does not notice that while the introduction of driving in Scotland in more recent years has not had such a marked effect, it has proved an effective method of regulating the stock in "big" years, and has tended to equalise, and, in the main, to raise the average yield on those moors on which it has been given a fair trial.

There can be no doubt that driving has greatly increased the stock of Grouse on practically every moor in England, as may be seen by comparison of the records before and after its introduction. On many moors in Yorkshire, where before

[1] "The Complete Shot," pp. 232-233.

the days of driving Grouse had become almost extinct, they are now numerous.

The beneficial effects of driving at Broomhead are fully discussed in a note by Mr Rimington Wilson, which will be found at the end of this chapter.[1]

Driving to be satisfactory must be efficiently carried out. It is a *sine quâ non* that good shots must be chosen. Owing to the improvement in guns, and the amount of practice that can be obtained, few sportsmen are so inefficient as actually to miss their bird; but there is a vast difference between the first-class shot who steadily kills four birds out of six and the indifferent performer who only wounds a similar proportion. Difficult drives—that is to say, drives in which the birds either come at a great height or dip or curve over the line of butts, should be avoided unless masters of the craft are to form the firing line. Butts should not be too far apart—40 yards is a good average distance, and if this be taken as the maximum it will obviate the necessity of firing long shots, and at the same time allow a good performer to finish off the "tailored" birds of his next-door neighbour. The butts should also, where possible, be sunk so that the birds do not see the guns, and in consequence do not alter the pace and direction of their flight. The expediency of short sky-lines, the disadvantage of having settling ground immediately in front of the butts, the proper use of "hill heads" for cornering the birds, and the general precepts for drivers, flankers, markers, pickers-up, etc., are all important, but do not fall within the immediate scope of this chapter.

Though moors should be disturbed as little as possible, it is a question whether the number of driving days on some of the fashionable moors are not being unduly reduced. The rage for big shoots, and the fact that it is difficult to get good shots unless big bags can be offered, probably prevents the full development of the minor driving days whose main object is the improvement of the moor. On most moors great advantages

[1] *Vide* p. 446.

would be gained by increasing the number of these minor driving days, and this might be done without disturbing the centre of the ground, for the off days might be devoted to the driving of outlying beats and high ground which at other times are never touched.

If then it be admitted that, by means of driving, Grouse may be killed down to the required limit, the question arises as to the exact stock which should be left on each moor.

Stock mu depend o winter feeding.

There are certain general axioms which may be laid down with absolute confidence. The first and most important is that on a badly-burned moor, where the supply of good winter feeding is small, the stock to be left on the ground for the winter must be a light one. By good winter feeding is, of course, meant the close grown six-to-ten years old heather which has already been described in an earlier chapter.[1] Conversely on a moor where the heather has, by dint of severe burning, been brought into such a rotation as gives the largest possible proportion of winter feeding a much heavier breeding stock may be safely left.

Proporti of winter stock to summer stock.

On Broomhead Moor, which may be taken as a typical example of a moor where the heather has been systematically burned for many years past, the ground is now capable of carrying a large winter stock without risk. On this moor of 4,000 acres from one thousand to one thousand five hundred brace is regarded as a fair breeding stock from which to obtain a bag of three thousand brace in the following season.

In estimating the number of Grouse that should be shot, the bags of previous years should be disregarded; a moor which in the past has yielded an average bag of five hundred brace may in a big year produce one thousand five hundred brace and still be dangerously overstocked. It is *the number left alive*, not the number killed, that should be considered.

Difficulti due to migratio

It will be urged by many moor-owners that it is impossible to regulate the Grouse stocks with any precision, owing to the migratory habits of the birds. The objection is a pertinent

[1] *Vide* chap. iii. pp. 83 *et seq.*

one, and it is this migratory habit of the Grouse which has so often defeated individual efforts at stock management.

It has been pointed out in another part of the work that in many districts Grouse annually move about in large packs, often leaving the high ground for weeks, or even months, at a time, and congregating on the lower moors.[1] When this occurs it is obviously impossible for a moor-owner to gauge the numbers of birds belonging to his ground which still survive the shooting season, for he may either find that every bird has left the moor, or alternatively that his own home stock is largely augmented by foreign visitors. In the former case it will be impossible to reduce his stock, for the birds are no longer there to be shot; in the latter case the packs are usually so large that any shooting that may be possible can make but little impression on the stock. The difficulty is further increased by the fact that it is usually late in the autumn before the seasonal migrations of Grouse occur, often after the close of the shooting season, when no legitimate means are available for the destruction of the birds.

Owners have always been ready to admit the principle that there is danger in leaving too large a stock, and some even go so far as to put the principle into practice by instructing their gamekeepers to kill down the Grouse by systematic driving or "stooking" after the regular shooting has come to an end. This practice may result in the reduction of the stocks by a few hundred birds; but is of little practical value unless it be carried out on a large scale throughout a wide district. Other moor-owners adopt a neutral attitude. An owner of a high-lying moor will contend that he has nothing to fear from leaving a large stock upon his ground since the birds will migrate in the autumn to lower ground, when their numbers will be reduced either by shooting or by disease, and thus the stock will be brought to reasonable dimensions before they return to breed in the spring. The answer to this argument is that if they are to be reduced by shooting it would be more

[1] *Vide* chap. i. pp. 29 *et seq.*

profitable that they should be shot by himself than that they should go to swell the bag of his neighbour; whereas if they are destined to become the victims of disease they may never come back at all, or if they do they may return as a decimated pest-ridden stock, quite unfit for the task of reproducing their species. In the same way the owner of a low-ground moor, where the Grouse have come to winter in their thousands, sometimes argues that it matters little what number of birds may be upon his ground in the winter, since they will return to their own higher moors for the nesting season, and will leave behind them a moderate breeding stock. These owners seem to overlook the fact that the presence of an excessive stock during the winter will most probably result in wholesale mortality amongst those that are left behind, however reduced this remnant may be.

Temptatio[n] to leave a large bree[d]ing stock.

The true explanation of the apathy of many moor-owners is that they have not the courage of their opinions. While admitting that in theory it is a dangerous thing to leave a big stock, they know that a big stock may, under favourable conditions, result in a record bag the following year, so they take their chance, unmindful of the risk they run, with the result that a good season, which might be followed by another just as good, often becomes the starting-point of a series of disastrous years.

It may be laid down as a general rule that it is better policy to aim at a high average of bags than to attempt to beat all previous records by leaving a large breeding stock.

Stock regulation.

Stock regulation in a poor season is a comparatively simple matter, and requires but little judgment; no great risk is incurred by leaving the stock untouched, and there is not much temptation to overshoot owing to the indifferent sport to be obtained upon an understocked moor. Sometimes, it is true, a moor may be overshot by an undesirable class of yearly tenant who is more intent upon getting value for his money than upon shooting the ground in a sportsmanlike way; but this danger can be guarded against by a strictly-worded clause in the agreement. It is only in a "bumper" year that the question of stock management becomes an urgent one.

In places where the migration of Grouse is the rule, efficient regulation is impossible without co-operation among proprietors. It matters little that one moor-owner should kill down his birds to the limit of safety if there are too many Grouse in the district, for other birds will crowd into his ground from adjoining moors, or his own stock may migrate for the winter to some other district where there is already an overstock. If, however, moor-owners would combine to reduce the stocks upon their individual moors the whole district would benefit.

Main object to be aimed at.

Each owner should make it his object to kill down his Grouse until only an average winter stock remains. The task will not be an easy one, for in an exceptionally good season it is almost impossible to make any real impression on the stock. There is little risk of over-shooting, for even if a proprietor succeeds in killing every Grouse upon his ground, it is quite certain that his neighbours will not be equally successful, and by the nesting season his moor will be more than sufficiently stocked by birds which had been crowded out from elsewhere.

Co-operation.

The Committee suggest that where a series of moors adjoin, and where the birds by migration are common in a sense to the whole range, the proprietors, with those of the shooting tenants who grasp the stock problem, should come to an understanding as to the best procedure for their common interests.

It is suggested—

Firstly. That all should agree to get full information as to the prospects of the season at the earliest possible date, either on the lines already suggested in this chapter, or by any other means that may seem best to the individual proprietors or tenants.

Secondly. That at some date early in July the interested parties should meet and agree whether the year is one in which the birds should be (i.) shot in the ordinary way; (ii.) shot heavily; or (iii.) really "harried."

Thirdly. That arrangements should be made not only to kill down the birds on those moors where they are most plentiful, but to make a point of shooting hard on the boundaries of moors which from slackness or bad shooting are likely to be lightly shot.

Fourthly. That the local circumstances and knowledge gained from past experiences should be made known between moor and moor; that arrangements should be made for shooting all high ground specially hard; that "cheepers" should be universally exterminated; and that the birds should be killed in October and November when they are massed on the low ground.

While it is improbable that lessees could be got to combine together to shoot lightly in bad seasons, there seems no reason why they should not agree to kill the birds hard in a really good year. The majority would welcome the opportunity for making a record bag, while an increase in the number of birds killed would improve the value of the moor to the landlord.

Maintenance of health of stock.

In addition to regulating the numbers of his stock the moor-owner must also consider how the birds may be maintained in health. The practice of shooting down the stock severely whenever the birds show signs of disease has long been regarded as an established rule of moor management; but it may be doubted whether the practice is justified. As a rule when birds are weak and thin at the beginning of the shooting season this is a sign that there has been an outbreak of disease in the spring; but the birds that have survived the epidemic have reached the convalescent stage by August, and should be spared rather than destroyed, for they will probably be completely restored to health by November, and will be valuable as a breeding stock. This subject is fully discussed in other chapters.[1]

Diseased birds.

[1] *Vide* chap. viii. p. 240.

"Cheepers" and late birds.

The case is different when the bird is weak and undersized as a result of being hatched late. The common custom of sparing "cheepers" in order to give them time to develop as the season advances is one which cannot be too strongly condemned, for it is now believed that late hatched birds are a serious menace to the health of the moor.

This real menace has never been sufficiently considered, but would appear to be one of the worst consequences of the loss of first broods, the full result of which is felt far more seriously in the succeeding year than in the season when it occurs. "Cheepers" of August are seriously handicapped for the remainder of their lives. They often apparently come on quickly during the shooting season, but are lacking in bodily vigour and hardness, and compared with the birds that were hatched in May and early June they feel the pinch of winter badly. The hens, exhausted by the double moult and the trials of nesting, succumb in the succeeding spring with untold loss to the moor; the cocks, undersized and badly nourished by the end of winter, die in still larger numbers owing to the exhaustion consequent upon their efforts to procure and to protect their mates.

Late broods eventually become the most fertile soil for Strongylosis, which is always potentially dangerous even in healthy birds. This being so, it would obviously be desirable to encourage early nesting, and to save early clutches of eggs from destruction.

There is, unfortunately, no possibility of encouraging birds to nest early unless by artificial feeding on a considerable scale; but at least it is possible to avoid the loss of early nests, which is so often the result of burning too late into April. Gamekeepers sometimes speak as though no harm is done if a few early nests are burned over, and as though the second clutches of eggs were every bit as good for the moor as the first hatchings. They may be so far as the shooting of that same season is concerned—with good luck as many birds may be brought to the bag; but for the succeeding season it is likely to be the worst thing that could happen, since it breeds weakly birds that will perhaps manage to survive an open winter, only to disseminate disease in the following year, if they do not actually succumb to it themselves.

Second broods.

There are, moreover, reasons based on actual experience why second clutches must always produce a smaller proportion of fertile eggs than first clutches. The following account comes directly from a well-known moor proprietor as to the result of hatching three clutches of eggs, each clutch consisting of the first eggs laid by three different hen Grouse. All were consecutively "fertilised" by one and the same Grouse cock. The eggs had thus every possible chance, on the mother's side, of producing the full number of healthy chicks in every sitting.

The first hen having paired off with this healthy two-year-old cock Grouse, sat and hatched ten chickens out of ten eggs. A second hen then paired off with the same cock; not immediately, but some time after the first hen had begun to sit.

This second hen laid eight eggs, but only four were fertile, and four chicks only appeared. The same cock again, after a similar interval, paired off with a third hen, which then laid eight eggs, but not one of them was fertile. Could there be stronger evidence for the superior value of a first clutch of eggs? Under natural conditions the first clutch receives the full value of the cock bird with the best the hen can produce when in her best condition. Suppose that this nest is burned, or still worse, suppose that the hen has been sitting for some weeks, and is then forced to desert by stress of weather or disturbance by vermin. We have now, instead of a half-spent cock with a hen at her best, a half-spent cock with a hen already exhausted and short of her stock of subcutaneous nesting fat to the extent of several ounces. She has produced seven or eight eggs weighing an ounce apiece, and she now produces half a dozen more. Not only are these six eggs fewer in number than the first clutch, but they are almost certain to be not all fertile. And what is even worse, there is the male element to be considered, and if, with the best possible materials in an unspent hen, his second effort at fertilisation is 60 per cent. less efficient than his first, what will it be when he has to deal with the resources of a hen already half exhausted?

The most certain way to avoid disease is to encourage the production of strong, early, robust, well-grown, and well-fed birds that can meet and survive the privations of a hard winter, that can, if necessary, fly far afield for food, fight successfully, breed early, moult quickly, and put on new feathers without a check and without exhaustion. Such birds, if they are cocks, should weigh from 26 to 30 ounces, should have large red combs, full voices, and thick white-stockinged feet and legs; if they are hens they should weigh up to 27 ounces, should moult rapidly and efficiently almost in mid-winter, and after hatching out their broods should be fit to moult again without still showing bare legs and weathered plumage in the shooting season.

"Cheepers."

And the other side of the question: "cheepers" too small to rise twice on August 12th, hardly three parts grown when the winter is upon them, barelegged, and with a scanty growth of feathers replacing the chicken down, permanently undersized by the following spring, forced to mate with equally undersized fellows on the lower and less healthy beats where the food is soft and the water laden with the unwholesome washings of the hills around; beaten and often killed in their fights for the more desirable mates, they are forced later on to be content with the undesirable. One can imagine such a pair losing its first nest of eggs, and attempting a second. The hen is already a confirmed "piner" exhausted by the production of half a dozen eggs. If she attempts a second brood she is likely to succumb to the intestinal parasites that infest her. At the best she appears in the August bag as a dull-feathered, shabby, undersized bird weighing 12 or 15 ounces instead of 22 or 24, or she is picked up dead with hundreds of others in April and May as a "piner" which has never bred.

This is no exaggerated picture of the life of more than half the birds that are sent up for examination as "found dead" or "dying" in the spring, or as having been picked out of the bag in the autumn as unfit for food, or suspected of disease. They are all alike—undersized, poorly feathered, desperately thin, bare-legged, and badly infested with every form of parasite within and without, and they are in consequence a very fruitful source of parasitic infection to the healthier birds around them, and a fertile soil for the cultivation and dissemination of disease.

The birds referred to are definitely undersized, their bones are small and thin, their measurements are permanently below the average, they have ceased to grow as chickens when their autumn diet became a winter one, and by the end of October, instead of having enjoyed the full and varied supply of the five fattest food months of the year, they have had that of but three or four.

Early hatched birds, on the other hand, are barely distinguishable from their parents by October, or even by September, and when winter comes they are prepared to meet it. They may grow temporarily thinner with starvation, but they can never be undersized.

Another question of importance in the interests of the stock is that of dealing with the old birds.

The following remarks show how poor is the general opinion held concerning the value both of old cocks and of old hens.

Stuart-Wortley in Fur and Feather Series writes: "It is my firm belief that the presence of these useless, and it is no exaggeration to say destructive, birds (*i.e.*, old cocks) has a great deal to do with the scarcity of broods, and the low average of stock to be found on elevated Scotch shootings.

The uselessness of old birds.

"The older birds interfere with the matrimonial arrangements of the younger to the prejudice of the offspring.

"The old barren hens are bad enough, but the old cocks are the worst, and both must by some means or other be destroyed. . . . I would rather poison them than have them on my own ground.

"In the pairing season the old warriors come down from the heights, fight with and vanquish the younger ones, and absorb the young hens; the latter lay nests full of eggs, but they are sterile, while the more youthful and capable cock bird, who would become the parent of a healthy brood, is either driven off the ground altogether or obliged to remain in a state of combative celibacy.

"The old hen also, who is beyond the age of laying, attacks any young hen who may nest near her, driving her off her nest, thus causing the eggs to get cold, and the incubation to be abortive.

"It is well known that in deer forests, where the great object is to get rid of Grouse, the best means to arrive at this end is to leave them alone altogether. The result is that in a great measure they die out; or at any rate their numbers dwindle to the lowest possible point."[1]

"Another trouble results from the presence of these useless old cocks, namely, over-sitting. Probably if one chicken hatches the mother leaves the rest of the eggs, and so though the brood is lost it cannot often end in the bird's death. But when a whole nestful of unfertile eggs has been laid the hen may continue to sit long after the time when a brood of chickens should have appeared, and may even be found on her eggs dead from exhaustion and disease."

All the views expressed above are fully endorsed by the Committee. There is no doubt that old birds are a danger to a moor, and tend to the degeneration of the stock, for not only are they more pugnacious than the younger birds, but they do not produce such large coveys nor such robust offspring.

All moor-owners who take an interest in the improvement of their stock make it a rule to ascertain as nearly as possible the proportion of young birds to old upon their ground, and whenever they succeed in reducing the proportion of old birds the stock is found to improve.

One of the Committee's correspondents has made a series

[1] Fur and Feather Series, "The Grouse," p. 148.

of observations upon a moor in Inverness-shire extending over a period of thirteen years. His analysis of the Grouse stocks and relative bags is so interesting that the Committee have obtained his permission to publish it in this work as an example of how stock may be recorded for purposes of comparison. The analysis will be found on p. 440, and in the letter which accompanied it the following passages occur:—

"I now enclose table showing nearly all the information I have as to old and young birds for a series of thirteen years.

"As nearly as possible the moor has been shot in much the same way, and the same keeper has been in charge the whole time.

"An effort has always been made to bag as many old birds as possible, both by selection and by driving all the high ground, even above the heather line. Taking the last six years, it is curious to note that whereas the state of the moor as shown by dogs prior to August 12th showed on the average 4·68 young birds in each covey, or a ratio of old to young of 100 to 234; the actual recorded bag during the same years showed 100 to 148. The very high proportion of old birds in the bag is, I believe, due to the following causes:—

"(1) That every effort is made to select old birds in shooting.

"(2) That the inspection by dogs prior to August 12th does not include *all* the barren pairs.

"(3) That before the driving takes place the young birds particularly *pack*, and so escape destruction. I have often proved that many packs consist of young hens."

The analysis is interesting as showing that on the moor in question a larger percentage of old birds is killed by driving than by shooting over dogs; but as the proportion of young birds throughout the season is invariably much smaller than would be expected from the observations prior to August 12th, it is possible that the cause of this circumstance is that there has been a general migration of the young birds to lower

Analysis of Grouse Bag for Old and Young Birds for Thirteen Consecutive Years

Year.	How Killed.	Birds Bagged.	Old Birds.	Young Birds.	Ratio of Old to Young.	General Ratio.	Total Bag.	Remarks.	Dogging Results Prior to August 12th.		
									Coveys.	Young Birds.	Ratio
1897	Over dogs Driving	1166 696	458 341	708 355	100 : 154 100 : 105	100 : 133	1862		No	results	kept
1898	Over dogs Driving	1098 764	364 310	734 454	100 : 202 100 : 147	100 : 175	1862		No	results	kept
1899	Over dogs Driving	966 805	417 325	549 480	100 : 132 100 : 148	100 : 140	1771		No	results	kept
1900	Over dogs Driving	782 763	311 413	471 350	100 : 151 100 : 85	100 : 114	1545		No	results	kept
1901	Over dogs Driving	870 807	358 377	512 420	100 : 143 100 : 112	100 : 127	1677		128	499	2 old t 3·9 young
1902	Over dogs Driving	798 412	378 275	420 137	100 : 111 100 : 50	100 : 86	1210		No	results	kept
1903	Over dogs Driving	244 ...	158 ...	86 ...	100 : 55 ...	100 : 55	244	Moor covered with ice from June 16th-19th.	Nearly	all barre	n pairs
1904	Over dogs Driving	651 311	272 143	379 168	100 : 139 100 : 117	100 : 132	962		108	455	2 old t 4·21 young
1905	Over dogs Driving	758 573	277 216	481 357	100 : 174 100 : 165	100 : 170	1331		145	793	2 old t 5·47 young
1906	Over dogs Driving	1067 896	389 319	678 477	100 : 174 100 : 150	100 : 163	1963		244	1163	2 old t 4·77 young
1907	Over dogs Driving	1387 967	479 412	908 555	100 : 190 100 : 135	100 : 164	2354	Very wet spring and summer.	299	1362	2 old t 4·55 young
1908	Over dogs Driving	1368 967	538 412	830 474	100 : 154 100 : 115	100 : 137	2054	Snow lay in masses up till May.	235	1050	2 old t 4·47 young
1909	Over dogs Driving	810 560	307 296	503 264	100 : 164 100 : 90	100 : 127	1370	Snow very late on high ground.	142	661	2 old t 4·65 young

Remarks.

Since 1904 inclusive, an attempt has been made to run the dogs over every part of the moor prior to August 12th, and the results are registered in the last three columns of above table.

The exact number of barren pairs is not recorded in the figures, but *all* coveys are included.

The whole of the moor is above 1,100 feet over sea level, and the best heather is about 1,200-1,500 feet.

The aspect of the moor is about half south-west and half north-east.

ground before driving has been commenced. It would be interesting to compare the results of this high-lying moor with similar observations made upon a lower moor in the same district, and thus endeavour to solve the mystery of the disappearance of so large a proportion of the young birds seen at the beginning of the season. On a different type of moor the results would probably be entirely reversed, thus pointing to the need of adapting the principles of stock regulation to meet the special requirements of the ground.

Artificial means of improving stock.

Many artificial expedients have been adopted for the improvement of Grouse stocks, either by raising their standard of health or increasing their numbers.

Of these the most generally adopted is that of introducing fresh blood by importing eggs or live birds from other moors. It is believed by many moor-owners that by this means inbreeding and the consequent deterioration of the stock may be avoided.

This view raises an interesting point in the natural history of the Grouse.

Migration.

There is no doubt that on some moors Grouse show a tendency to remain upon the ground on which they are bred, and do not develop the migratory habits referred to in other parts of this work. The reason is usually pretty obvious, for it is found that in the districts where the Grouse do not wander in the winter it is because there are no other moors in the vicinity where the conditions will be more favourable than on their own ground. On the west coast of Scotland, for example, owing to the mildness of the climate, the Grouse are seldom driven off the high ground by snow; and on the moors of Yorkshire, though the general elevation may be considerable, there are not the same marked extremes as in the Scottish Highlands. This distinction is well shown by Mr Stuart-Wortley in the Fur and Feather Series, where he gives two sketches to illustrate the difference of conditions in England and Scotland, and in his chapter on Grouse driving he states: "On a Yorkshire moor you are driving *on the tops* all the time. If there is a high point on the moor, rocky and precipitous, it is in extent probably a mere fraction compared with the acreage of good moorland around it. On a Scotch moor you have usually a large acreage above the line of your highest driving ground."[1] It follows that in Scotland the Grouse is forced to leave the high ground in time of snow to seek his food at a lower elevation, and the same motive will cause him to return again in the spring to the fresh young heather on the "tops," whereas in Yorkshire, where the climatic conditions are much the same on every moor, he would gain little by such migration.

Whether migration actually results in a crossing of blood has been often debated. Some naturalists contend that the migrating packs do not interbreed to any extent with the birds upon the moor where they have sojourned for the winter, but that they return to their own ground with their ranks unbroken. The evidence available does not altogether support this view, and indeed it is doubtful whether it is always the same birds which departed in the winter that reappear again in the spring. It is difficult to obtain conclusive proof on the subject, but one or two facts are suggestive. In the first place it often happens that on ground where there has been a light stock in the autumn, there is sometimes found to be a heavy stock in the following spring, thus pointing to immigration. This circumstance is usually associated with a moor on which the feeding is good. Conversely a heavy stock may migrate wholesale in the autumn, and only a few birds may return in the spring. The reduction of their numbers may, it is true, be due to disease, but is equally likely that the absentees have become naturalised elsewhere.

But the most striking evidence on the subject is furnished by the manner in which a moor, which has been entirely denuded of birds, will recover its proper stock in such a remarkably short time that the only possible solution is the immigration of birds from elsewhere. A good example is furnished by

[1] Fur and Feather Series, "The Grouse," pp. 152-153.

the figures in column *5a* on p. 418. On the moor in question the bag in 1866 was three thousand four hundred and two Grouse; in 1867 it was one Grouse. The gamekeeper in charge of the ground gave the following evidence on the subject: "In 1867 there were only about four Grouse left on this moor of 10,000 acres; in 1868 there were only two broods. The four birds appeared to be pined and very weak. I could not make out whether these bred, or whether the two pairs had come from some other place. I would rather say that these birds were so badly affected that it was not possible that they could recover."

Even assuming that the four birds that were left on the ground had been the parents of the two broods referred to, it would have been quite impossible for them to have been the sole progenitors of the large stock which rapidly reappeared and yielded bags of 530 Grouse in 1870, 1,621 in 1871, and 3,548 in 1872. There can be no doubt that the restocking of this moor was due to immigration of birds from elsewhere, and this restocking would have been even more rapid had it not been that 1867 was a fatal year throughout the length and breadth of the borders, and there were few Grouse surviving in the district. In a "disease" year a moor in the Highlands of Scotland sometimes appears to be cleared of every bird, yet, if the feeding is good, it is fully stocked again within two years.

The conclusion is irresistible that, where Grouse are migratory, it is quite unnecessary to use artificial expedients for the purpose of changing the blood. One heavy snowstorm will do more to shuffle the pack than the introduction of hundreds of purchased birds. Moreover, it often happens that imported Grouse do not remain on the ground where they are turned down. Gamekeepers, it is true, will always profess to recognise the foreign strain for many generations by some real or imaginary peculiarity of plumage; it is difficult to verify their statements except by marking the birds, and wherever marking has been resorted to it is found that the imported birds have wandered far afield.

[I]solated [m]oors.

In districts where Grouse are not migratory, it is possible that the introduction of foreign birds may be beneficial, and this remark applies in particular to moors which are cut off from other Grouse ground by arable land or by wide stretches of water. Examples of such moors are the Lomond Hills in Fife, the islands and peninsulas on the west coast of Scotland, the Solway Moss in Dumfriesshire, and Cannock Chase in Staffordshire. But the number of isolated moors is comparatively small.

The success which has attended the introduction of new blood to the Island of Rum is related in Messrs Harvie Brown and Buckley's "Fauna of Argyll and the Inner Hebrides."[1]

"In this island, where there is a fair stock of native Grouse, their chances of increase have been much assisted by the introduction of fresh blood both from Meggernie in Perthshire and from Yorkshire. About two hundred brace have been introduced," and (writes Mr Bullough) "what is remarkable, they assume the characteristics of native birds. One can always get within shot. Is not this remarkable, seeing that in Yorkshire and Meggernie they are so wild that one cannot get near them in winter? (*in lit.* 1889)." And in a later letter it is said (November 1890): "The new blood has done wonders for the Grouse. We could kill six hundred brace any season now, and three years ago the place would with difficulty yield two hundred."

Referring to Mr Bullough's remark as to these introduced Grouse acquiring the habits of the West Country and insular birds of sitting closely throughout the season (the authors) "believe this habit may have rapidly developed from the fact of the birds having realised that Rum is surrounded by salt water, and that a very long flight would be necessary if they desired to migrate; and last, not least, that the abundant heather in prime condition causes them to feel satisfied with

[1] "A Vertebrate Fauna of Argyll and the Inner Hebrides," Edinburgh: David Douglas, 1892, pp. 155 *et seq.*

their abode. The desire therefore to migrate, or the necessity to seek new pastures, does not exist."

The same authors, in their later work on the Fauna of the Moray Basin,[1] refer to the danger that attends the indiscriminating introduction of new stock to a moor from a district where widely different conditions may chance to prevail.

In Yorkshire, where the Grouse is not so migratory as in Scotland, a sufficient change of blood is obtained by means of driving, for the packs of young birds are constantly being moved about from one beat to another, and get no chance of staying at home on the patch of heather where they were hatched. Thus it would be almost a miracle if they were to seek out and pair with the survivors of their respective coveys, as well as being contrary to the mating instinct of all living creatures.

Probably this constant mixing of the stock is one of the most beneficial results that has followed the introduction of Grouse driving, and it is principally to this that Mr Rimington Wilson ascribes the large numbers and health of the birds on his Broomhead Moor, for there the Grouse do not migrate nor is fresh blood ever introduced by artificial means.[2]

Egg shifting.

Another method of introducing fresh blood is by changing the eggs in the nests. On some moors this has been successfully accomplished, and it is said that the result has been an improvement in the stock; but the operation is a delicate one and entails a great deal of trouble and much disturbance of the ground. Many failures have been recorded, and the practice is not to be recommended.

One great objection to the purchase of eggs or live Grouse for the purpose of improving the stock is that it encourages poaching, and it is feared that moor-owners do not always make sufficient inquiry as to whether the fresh blood purchased by them has been honestly obtained.[3]

[1] "A Vertebrate Fauna of the Moray Basin," Edinburgh: David Douglas, 1895, vol. ii. p. 154.

[2] *Vide* p. 446.

[3] *Vide* p. 414.

Hand-rearing. It is somewhat surprising that so little has been done n the way of stocking moors with hand-reared Grouse, fr Grouse can be reared in captivity almost as easily as pheasant, and it might materially assist the restocking of a moor whih had been hard hit by disease if the gamekeeper had a fe coops of captive chicks, which he could release as soon as th were old enough to find food for themselves.

Summary. These minor expedients may on occasion prove helpf, but they are of little real importance when compared wi the main rules of moor and stock management. These ruls may be summarised as follows :—

Ascertain the number of birds on the ground as early s possible.

Determine what stock of birds can be carried with safe over the winter.

Shoot early and often in a good season; shoot old birs only in a bad season.

Regulate the stock by the number to be left on the groun, and not by the bags obtained.

Some Notes on Broomhead Moor by Mr R. H. Rimington Wilson.

Having fortunately but little experience of epidemics n this moor, the writer can only approach the question of disea in a negative way, and try to suggest some of the conditios which may tend to make a moor comparatively free fro its visits.

In the first place it may be stated that there has been n serious outbreak here since 1874, but that, before this dat, disease in virulent form attacked the moor on an avera once every seven years.

Shooting over dogs was given up about 1870, and te moor was cleared of sheep in 1877.

It may here be remarked that on the first occasion on whih a total of over thirteen hundred brace in a day was made n this moor, the ground was carrying, roughly, a sheep to 4 acres, and this had been the case for many years.

It is hardly necessary to state that the heather has been burned, and the vermin kept down in the most careful manner, and that the moor in all details has had every attention from a most keen and competent head-keeper. The condition of the moor, however, in all essentials remains the same as it has been for the last fifty years and more. The same head-keeper has had charge of it; no fresh blood has been introduced. No drainage has been done, and practically no alterations of importance have been made. There has been only one radical innovation.

Why then the comparative freedom from disease and great increase of stock on this moor? It can hardly be attributed solely to good fortune.

The writer can only conclude that the answer is to be found in the above-mentioned radical innovation—namely, the peculiar system of driving that has been in vogue here for the last thirty-five years.

The driving of Grouse was of course first adopted as being the only means of making the birds accessible. It was only experience that demonstrated the vast and unexpected benefit to the health of the birds that followed its adoption.

In the same way the Broomhead system of driving the birds backwards and forwards over the same set of butts was initiated as a matter of convenience and facility of transport, and with no intelligent anticipation of the results which the writer feels sure have followed, and to which reference will be made.

The killing-off of the old cocks is usually put forward as the chief reason why a moor benefits from driving. No doubt their destruction is desirable, and equally so in the opinion of many is the destruction of the old hens. But this is not the main factor of improvement.

The habit of the Grouse left to themselves is to remain close to their early surroundings, and to marry in their own families, with the natural result of decadence and a falling birth-rate.

Driving upsets the family arrangements, mixes all the birds together, and produces a healthier and more prolific stock.

It is often noticed that a good Grouse crop succeeds a severe winter—Nature's method of producing the same result. The severity of the winter causes the birds to shift their quarters, and the all-important crossing of the blood follows; the possible weeding-out of the weakly birds helping the general situation.

The system of driving as carried out at Broomhead—namely, over one set of butts—obtains to the fullest extent possible, and intensifies all the benefits to be derived from driving.

The coveys pack, the packs are shuffled and reshuffled till the crossing of the blood is thoroughly ensured—far more thoroughly than under the usual system of driving.

Nor is this the only advantage; apart from gastronomic considerations, it will be conceded that it is of the first importance that the older birds should be killed and the younger left for stock.

It is only the older birds that possess the necessary stamina to be so frequently on the wing and to cross the butts—as they are asked to do—six times in the day. Many of the younger birds soon tire, and finding cover and safety, live to form the nucleus of a young breeding stock.

Another advantage under the above system of driving is that the pick-up of both dead and wounded is almost necessarily a very clean one

To sum up, the writer believes the freedom from disease at Broomhead for the last thirty years is mainly to be attributed to the fact that the above system of driving, continued for a series of years, has produced a young stock so healthy and vigorous as to be to a great extent immune to disease. The system, in fact, automatically produces the conditions essential to a well-managed poultry farm—namely, young healthy stock and a constant change of blood.

This moor is divided in its lower half by a deep and wide valley, which thirty years ago the birds rarely attempted to cross. That they now require no provocation to make the passage is evidence of their higher physical condition. There is no possible doubt that their power of flight has much increased in the last twenty years.

The system of driving over one set of butts is suitable, of course, to a very limited number of moors, and even when possible might not be adopted for reasons unnecessary to mention here. The system is mentioned solely as a possible explanation of the remarkable change that came over this moor at a time which coincided with its adoption.

CHAPTER XVI

GROUSE IN CAPTIVITY

Observation area.

In the spring of 1906 the Committee acquired an Observation Area in Surrey on which experiments as to the origin of "Grouse Disease" could be carried out on healthy Grouse.

The site chosen consisted of undulating hilly ground with a sandy subsoil covered with luxuriant heather, and dotted over with self-sown pine trees, very like the fringe of many Scottish moors. The special feature which made it suitable for the purposes of the Committee was the free growth of heather of the type most suitable for the food of Grouse. In order to minimise the danger arising from heather fires, the owner of the ground had wide rides cut through his heather—these rides are cut every spring—with the result that there is a luxuriant growth of young heather every summer. This young heather provided excellent food, while the old heather at the edges of the rides made good cover for the birds during the day.

Coops.

In 1906 six movable coops of wire netting were made, each measuring 8 feet long by 4 feet wide, and 4 feet 6 inches in height—this height was essential to allow of the observers getting into the coops when it was necessary to handle the birds; but for those who wish to try the experiment of rearing Grouse for themselves, 2 feet 6 inches or 3 feet would be an ample height. The coops were furnished with padlocked doors, and strong iron staples were driven into the ground holding the outer bar of the coop close to the ground; this precaution is most important, for unless it is observed small vermin such as weasels and rats would get into the coops and disturb the

Grouse. Even with these precautions the Grouse on the experimental area were much disturbed by vermin, especially foxes, which abound in that part of Surrey; these foxes came prowling round the coops when the birds were sitting, frightening them off their nests. In one case the death of a hen was attributed to a fox frightening her when on the nest, and in her frantic efforts to escape she injured herself against the sides of the coop. Dogs also were a great trouble, disturbing the birds at all hours by day as well as by night.

Each coop was furnished with a piece of tarpaulin, which could be used as a shelter from heavy rain or hot sun as required.

At first the coops containing the Grouse were moved on to fresh ground every two days, being placed on the edges of the rides so as to cover about 5 or 6 feet of young heather, and 2 or 3 feet of sheltering heather; but later, when the Grouse increased in numbers, it became impossible, on account of the labour involved, to move the coops so frequently, and it was found that moving them once a week was quite often enough. In that case, however, the birds had to be supplied with faggots or bunches of fresh heather for food at least every two days; or, better still, every day. Later experience has shown that if these bunches of heather are tied in the coops with the tops of the heather hanging downwards the birds eat it just as well, and even better, than when thrown into the coops loose, and the heather does not become soiled by the birds standing on it.

Another important point is the water supply. All drinking water must be absolutely clean, and this has been ensured as far as possible by using Hearson chicken water-fountains, which prevent the birds from soiling the water.

The question of rearing Grouse on this area did not at first arise, and it was only after experience showed that such a thing was possible that the experiment was tried, and a history of the methods adopted, and the experience gained, may be of interest to our readers.

In 1906 very few Grouse were received, and at the end of that season only four birds were left; of these two were unfortunately killed by a fox, leaving two, a cock and a hen, which were in different coops, the hen having been used for a simple experiment. In 1907 the hen began to lay, and laid ten eggs. Then the keeper put the cock into her coop, and she laid nine more eggs, but at longer intervals between each egg; out of these nine eggs she hatched four chickens. The remaining eggs were fertile, but after the first four were hatched she became restless and left the other eggs. Of the four chickens hatched two escaped, and the other two grew up to be about three months old, when they died.

During the year 1907, thanks to the exertions of those correspondents who kindly supplied the Committee with hand-reared Grouse, far more birds were sent to the Observation Area, and owing to the fact that there was no outbreak of "Grouse Disease" that year, and that no birds were required for experimental purposes by the scientific staff, the Committee had in February 1908 twenty-seven healthy birds; of these two were the old birds received in 1906. The remaining twenty-five birds consisted of eleven hens and fourteen cocks. Owing to the cock birds fighting, three were killed during the spring, but precautions were afterwards taken to prevent deaths from this cause. The stock had now increased to twelve pairs of birds, so it became necessary to increase the number of coops. Six more large ones were added, and six smaller ones, which have proved very useful for the segregation of the birds during the mating season, and also when the hens began to sit, for it has been noticed that when Grouse are confined in coops the cocks will not leave the hens alone on the nests, but are always driving them about; as soon, therefore, as the hens commence to sit, it is necessary to take the cocks away and keep them in coops by themselves. This year then the Committee had twelve pairs of birds. The hens laid very well, and the experiment was tried of taking the early eggs and putting them under foster-mothers, but with fatal results. Two common hens of the ordinary yellow Orpington breed were set on twenty eggs each, and one on seventeen; one hen hatched seventeen chicks and killed them all, the second hen hatched eleven and killed them all, and the third hen ate all the eggs.

Ten young Grouse from late laid eggs were hatched under Grouse mothers, and successfully reared.

In the spring of 1909 a healthy lot of birds were left, and after the sad experience of 1908 with foster-mothers it was decided to let the Grouse hatch their own eggs. They nested well and sat well; but again the experiment was marred by two misfortunes. One hen was frightened by a fox, and injured herself so seriously in her efforts to escape that she was found dead in the morning, and many of the nests being on low ground were washed out and spoilt by heavy thunder-storms just as the eggs were about to hatch; still eleven birds were hatched and successfully reared. Thus in all, up to 1909, in spite of misfortunes, twenty-three birds had been successfully hatched and reared on the experimental area.

In 1908 and 1909 a number of Grouse were received from correspondents, and during both these years, and especially in 1909, a considerable number of birds were used for experimental purposes. At the end of 1909 it was found that there were more birds left on the Observation Area than the keeper could attend to. Six cocks and six hens were moved to another place where the conditions were far more artificial, yet they did fairly well. With these birds the experiment was again tried of hatching under foster-mothers, but again it was not a success; not one chicken being reared. If foster-mothers are to be used experiment seems to show that the ordinary hen is too clumsy; bantams might be more successful.

The Grouse remaining on the Observation Area in 1910 numbered six complete pairs and a few odd birds; these were left to hatch out their own eggs, and did remarkably well. The results are shown in the following table:—

Grouse Hens.	No. of Eggs.	No. of Chickens.
No. 1	7	7
„ 2	11	9
„ 3	9	7
„ 4	7	6
„ 5	12	11
„ 6	14	Put under a foster-mother who ate all the eggs.
„ 7	7	One chicken; other eggs not good.
„ 8	4	Would not sit; eggs put under No. 5 all fertile.

Hens No. 7 and 8 had one cock bird between them. No. 8 would not sit, so her eggs were put under No. 5, and all proved to be fertile, and hatched.

Mating experiments.

The experiment was also tried of mating one cock with two hens; this was not altogether a success. At first two hens (Nos. 7 and 8) were placed in one coop with a cock; but it was found that this was a failure on account of the jealousy of the hens, the stronger and more pugnacious hen would never allow the other to receive any attention from the cock bird, and eventually one of the hens had to be removed.

Another method adopted was that of placing two hens side by side in two coops, and a cock was kept with them and placed in each coop alternately for forty-eight hours. One hen laid seven eggs; the other laid four eggs, but would not sit. The hen with seven eggs hatched one chicken; the four eggs from the other hen were placed under another bird, and all produced chickens.

Coccidiosis.

Out of the forty chickens hatched out seventeen died; all the rest of the birds were healthy and strong. Those that died were all between four and six weeks old; these birds were examined, and were all found to be suffering from Coccidiosis. Coccidia were chiefly found in the duodenum and blind cæca, but many of these young birds also presented symptoms of pneumonia; in these birds coccidian oöcysts were found in the trachea, the bronchi, and the bronchioles. It is quite possible that these coccidian cysts in the bronchioles would be capable of setting up sufficient irritation to account for the pneumonic symptoms observed in the lungs of such young birds. It would seem that Coccidiosis is the greatest danger to be found in the hand-rearing of Grouse, and the precautionary methods recommended in chapter ix. should be carefully borne in mind by those who contemplate hand-rearing on a large scale.

It may be interesting to know how the Grouse were fed. Food.
At first, of course, the feeding was largely experimental; as has already been mentioned the coops were placed where the Grouse could obtain fresh heather for themselves, and it was extraordinary to see the way in which the birds ate the heather. Two birds in forty-eight hours would make the patch of heather contained within their coop appear as if it had been browsed by sheep. Later on the birds were supplied with faggots or bunches of fresh heather, and this was found to answer admirably, for at the place to which the surplus Grouse were sent in 1909 there was hardly any growing heather, and the birds were for the most part kept on bilberry patches, with a few scraps of heather. In addition to heather the birds received a mixture of grain; at first this consisted of dharri, chicken rice, buckwheat, and feed millet, but it was found they did not eat the two last, so latterly only dharri and chicken rice were given. Experience also shows that Grouse are very partial to fresh vegetables, especially lettuce. Attention has already been called to the necessity of a pure water supply.

Another important point is grit. Grouse must have plenty of suitable grit; the best and most natural is white quartz. The Grouse on the experimental area were always supplied with plenty of this grit, and without it they could not have been kept in health. Grit must be supplied from the earliest stage of the bird's existence; it has been found in the gizzard of a Grouse chick not forty-eight hours old.

When quite young Grouse will thrive on hard-boiled eggs and young heather, but the best food for them is fresh ants' "eggs"; care must be taken not to give the ants as well as the "eggs." The method pursued on the experimental area to get rid of the ants is to put the nest in the oven for a very few minutes; this kills the ants, but does not seem to hurt the "eggs."[1]

The full-grown birds on the experimental area remained in splendid condition and plumage. During the four years deaths have been rare among them, and have generally been due to accident or misadventure; the old birds of 1906 were still there in 1911, when the stock was dispersed. Some birds became wonderfully tame, while others seemed always to retain their natural wildness; the cocks, as a rule, were bolder and became tame sooner than the hens. Most of the male birds resent any interference in their matrimonial arrangements, and their resentment is shown in many interesting ways.

On approaching the coops the cocks at once begin to crow, or rather talk; some will mount on the little faggots of heather supplied for food, and strut and talk and crow, swelling out their throats, elevating their supra-orbital combs, drooping their wings and fanning out their tails, as if defending their wives—the whole attitude denoting readiness to fight. In fact, one of the birds has been known at the mating time to follow the keeper's wife (to whom he was usually very attached), out of his pen, pecking at her as hard as he could; while the oldest cock of all, usually quite tame, always attacked the keeper if he entered the coop when the hen was on her nest.

As the birds can be observed at a very close distance the plumage can be studied, and the way in which the wings are carried, and the peculiar fan-shaped form of the tail during the courting process is well worthy of observation.

Mention has been made of the necessity of constantly changing the ground on which the coops are placed; the more often this can be done of course the better for the birds. But it is only fair to say that for the purpose of certain experiments some of the birds were kept on the same ground for months,

[1] Really the pupæ of ants, popularly known as "ants' eggs."

and it did not seem to do them the least harm ; they remained all the time in excellent health and plumage.

Attention may be drawn to one very important point. It would naturally be thought that, because the climate of Surrey is warmer than that of the northern parts of the British Isles, where Grouse live in a state of Nature, the Grouse on the experimental area would nest earlier than the wild birds. The exact opposite is the rule. Every year it has been noticed that the Surrey birds lay and hatch later than Grouse in their natural state. There are several reasons to account for this. In the first place, under the conditions existing on the experimental area the birds are artificially and not naturally mated, and this alone may account for late nesting. It is possible, and very probable, that more extended experiments on mating hand-reared Grouse, in the same manner that Partridges are mated in captivity, might lead to earlier nesting; but it was not possible to make this experiment on the Observation Area. Again the necessity of the constant appearance of the keeper at different times may have made the hen more shy of nesting, and the small dimensions of the coops, keeping the two birds always together, certainly is not conducive to privacy for the hen. So that those who try to keep Grouse and rear them on the lines adopted at the experimental area must not be disappointed at getting late eggs. On the other hand, the results obtained on the Surrey area show that it is within the bounds of possibility to keep Grouse in captivity, and to rear from them in such a manner as to enable owners of Grouse moors to replenish by reared birds any loss their moors may have sustained from excessive mortality in a very bad season.

Since the Committee's stock of captive Grouse was dispersed, the hand-rearing experiments begun by them have been continued by others with a large measure of success, and there is little doubt that it might be successfully developed on commercial lines.

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(*Note*: "f," "ff" = "following" page or pages.)

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SOME NOTICES

OF

THE FIRST EDITION OF

THE GROUSE IN HEALTH AND IN DISEASE

Published August 1911

The Times, *August* 10*th*, 1911.

The primary object of the Committee was to investigate the so-called "Grouse Disease," and they have evidently felt it their duty to take the widest possible view of the problem before them. With the sometimes questioned exception of the St Kilda's wren, a bird of no economic importance, the Grouse is the only bird "peculiar" to Great Britain and Ireland. The present monograph gives the fullest possible account of the bird, both in health and in disease. In fact, apart from man and maybe the frog, it is doubtful if any vertebrate has been so thoroughly investigated. Its life-history, its habits, its home life, its anatomy, its physiology, even its psychology, its weaknesses, its ailments are in these volumes remorselessly revealed.

. . . .

The book is most beautifully illustrated and owes much to the artistic brush of Dr E. A. Wilson, the Field Observer, and the whole appearance of the work is a credit to the publishers. It is also an example of what a few energetic men can produce when unhampered by official restrictions and red tape. The present report is the antithesis of the ordinary Blue Book, yet it has been produced at an amazingly small cost. During the whole of the inquiry the average income expended on the work was but £727 a year, and the whole of the inquiry has not cost more than £4,366, every penny of which has come out of private purses. That this has been done is due in the main to the energy and self-sacrificing devotion to the work of the inquiry shown by the chairman, Lord Lovat, and the secretary, Mr A. S. Leslie.

The Morning Post, *August* 10*th*, 1911.

The "Grouse Disease" Inquiry, which had been undertaken some six or seven years ago by a Departmental Committee of the Board of Agriculture and Fisheries, has issued its report in two volumes, entitled "The Grouse in Health and in Disease." These volumes have been dedicated by gracious permission to the King.

. . . .

The two volumes are lavishly illustrated and beautifully printed, and they reflect great credit on the Field Observer, Dr E. A. Wilson, on the secretary, Mr A. S. Leslie, and, above all, to the chairman, Lord Lovat, whose knowledge and experience and unbounded energy have succeeded in setting a new standard in the books dealing with the health and disease of game birds.

The **Field**, *August 10th*, 1911.

The final report of the "Grouse Disease" Inquiry Committee, which has just been issued, is most interesting, and by far the most complete account of the life-history of the Grouse in health and disease that has yet been published. It is issued in two volumes.

. . . .

The report is full of valuable information both to the sportsman and to the scientist; it is handsomely bound, well illustrated, and will be a welcome addition to all libraries, whether sporting or otherwise.

The **Scotsman**, *August 10th*, 1911.

Taking the two volumes together they form a most remarkable contribution to our knowledge of the natural history of the Grouse, a contribution which is the more remarkable in view of the fact that the whole of the funds available for the purpose have not exceeded £4,366.

. . . .

While at this season of the year there is a temptation to linger over the more practical portions of the report, to do so unduly would give a false impression of the scope and aim of the material which has been gathered together in it, and which makes it perhaps the completest monograph on any bird that has ever been published. Complete as it is, it has opened up many lines of inquiry, many of them of distinct practical importance which still await investigation.

The **Glasgow Herald**, *August 10th*, 1911.

That the inquiry has been thorough in every sense of the term must be apparent to any one who takes up any one chapter—we say any one advisedly—of the twenty-three that make up vol. i., not to mention the maps and the appendices that are reserved for vol. ii., with the fifty-nine full-page plates, mostly in colour, and the copious illustrations in the text. If any further indication of the thoroughness with which the work of inquiry has been carried through should be necessary, we have it in the roll-call of the specialists who have formed the scientific staff, of whom there were fourteen, every one of them eminent in his particular sphere.

The **Dundee Advertiser**, *August 10th*, 1911.

At last the mystery of "Grouse Disease" is solved, and the whole details of the great work which has been carried out by the Committee of Investigation can be found in the two fine volumes published to-day under the title, "The Grouse in Health and in Disease."

. . . .

The book forms a complete monograph on the Red Grouse—no fuller and finer work has ever been bestowed on an individual bird.

. . . .

To the vast class of sportsmen, with no strong scientific bent, the chapters on practical management of Grouse moors by Lord Lovat will appeal most strongly. Never before has the subject been treated in the same exhaustive way, and there can be no doubt whatever that the Grouse has found in Lord Lovat its champion, and from his very apparent love of his subject he will be perfectly satisfied to find his reward in popularising modern and sensible treatment of Grouse ground.

The **Spectator,** *August 12th,* 1911.

The Committee of Inquiry on "Grouse Disease," appropriately enough with the opening of the shooting season, have issued their final report, and they are to be congratulated, not only upon the success to which their labours have led them, but on the admirable form in which they present their conclusions to the public.

. . . .

The Committee have succeeded in their object. They have discovered the origin and the meaning of what has come to be generally known as "Grouse Disease," and incidentally they have made clear a number of points on which there existed doubt and confusion.

Country Life, *August 12th,* 1911.

The final report of the Committee of Inquiry on "Grouse Disease," forms a vastly interesting and exhaustive monograph on the life-history of the Red Grouse both in health and disease, and is undoubtedly one of the most complete and valuable works that have ever been placed before the public.

The **Pelican,** *August 23rd,* 1911.

If all official Blue Books were as interesting, as ably compiled, and as excellently illustrated as Lord Lovat's Grouse Commission Report there would be a greater demand for those particular volumes than at present exists.

The **Illustrated London News,** *September 9th,* 1911.

It is a source of gratification alike to scientists and to sportsmen that the "Report of the Committee of Inquiry on 'Grouse Disease'" is now at hand in the shape of two large handsome volumes, thoroughly illustrated, and printed in artistic style. The real title of the work is "The Grouse in Health and in Disease," so that apart from the main feature of the volumes dealing with the typical bird-ailment, we find in this work a very complete monograph of all that concerns the bird and its welfare.

The **Irish Field,** *September 16th,* 1911.

After very lengthy deliberation the report of the Commission on "Grouse Disease" has appeared in the shape of two weighty volumes, and the delay is to be forgiven in the face of the supreme interest of the work.

The **Lancet,** *September 30th,* 1911.

The report is a model of what such work should be, and is a good example of the way in which scientific medicine is now bound up with every phase of social life.

Nature, *October 26th*, 1911.

Although, as its name implies, the "Grouse Disease" Inquiry Committee was formed to investigate the nature and causes of the mortality which has been so prevalent of late years in the one species of game bird peculiar to the British Isles, it has accomplished a great deal more than this. For in the handsome volumes before us we have the life-history and organisation of the Grouse, coupled with those of the various parasites by which it is infested, described in a manner never before attempted in the case of any other wild bird. This magnificent piece of work, it should be added, has been carried out from start to finish by private effort and enterprise; for although the Committee was officially appointed by the Board of Agriculture and Fisheries in the spring of 1905, its funds have been entirely furnished by private subscriptions. The whole investigation is, indeed, a striking, and we believe, a unique example of what can be done by the combined efforts of sportsmen, gamekeepers, field-observers, and biological experts; and to Lord Lovat, the chairman, and all those who have worked with him are due the gratitude of naturalists and sportsmen, not only in the British Islands, but throughout the world.