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The Sheep Fluke

BY

N. A. Cobb

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THE SHEEP-FLUKE:

BY

N. A. COBB.

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July, 1897.

The Sheep-Fluke.

By N. A. COBB.

(With 1 lithographic plate, and 30 illustrations in the text.)*

Introduction.

Bathurst Experiment Farm, 5 April, 1897.

THESE opening paragraphs are to explain how this article came to appear in its present form.

For many years the author has given considerable attention to the parasitic diseases of man and animal. A few years ago he was directed, in his capacity of Pathologist to the Department of Agriculture of the

Colony of New South Wales, to make inquiry into the nature and history of the various parasites of stock. Accordingly, under the

auspices of the Stock Branch of the Department of Mines and Agriculture, he undertook at Moss Vale, and later on at the Bathurst Experiment Farm, to give as much time as his numerous other official duties would allow to unravelling some of these complicated matters. In doing so he has always, and as he believes justly, held up the difficulty of such investigations as a warning against the expectation of early and important results. In regions of research where the greatest naturalists of the past have made but tardy progress, where great and industrious minds applied through long and laborious lives have succeeded in adding to our store of knowledge only here and there an important fact, it behoves the investigator of the present to be very cautious about promising anything greater as the result of his own

*All the illustrations for this article were drawn by Mr. E. M. Grosse under the author's supervision, mostly from photographs taken either by the author or by Mr. Grosse. The lithographic plate alone embodies the results of no less than thirty photographs of the living objects, and is a model of accuracy and completeness, showing as it does the male-bird perched on the edge of the nest, the female in the background, the eggs and young, and a broken down last years nest. The view is from the roof of the author's laboratory at Austermerre, Moss Vale. That well-known landmark "The Gib," near Bowral, 5 miles away, shows through the foliage in the upper right-hand part of the picture.

A number of the sketches were drawn for the *Town and Country Journal* some years ago and appeared in that well-known newspaper.

prospective researches. Though, therefore, the researches at present to be described are not barren of results, some of which have led to recommendations of great practical value, the reader is asked not to expect what is impossible.

Experiment sheep, grazing, Moss Vale.]

is often placed in this curious, and to himself sometimes uncomfortable, position: his clients, the public, whose funds he is using, make such

Even now these pages would not have been laid before the public if the author's wish alone were consulted. For his own part, he would fain have waited until many investigations he has now in hand had yielded their results, so that he might lay before his readers a more complete picture of the life of the scourge he is describing, and so that his recommendations of a practical nature might be even more complete and useful. But a public officer engaged upon scientific investigations

Rounding up sheep to select those marked for experiment.

importunate demands for the benefit of whatever new facts he may have discovered, and

give such forcible reasons for their demands, that he feels bound to comply at the earliest possible moment. Now there is always a time in every investigation during which the result is comparatively certain, though it may require a long time yet to make a complete demonstration. Observe now the rack upon which the scientific public servant is stretched. Suppose he has made an important discovery: his reputation depends upon the freedom of his researches from mistake—and I suppose there is no class of men more apprehensive of mistake, or

The next victim !

more fully aware of how easy it is to make mistakes, and of how common mistakes are. He must resist the public demand for the results of his work, and he must resist the pressure of his own feelings, until he is perfectly certain he is right. He must, it may be, repeat months or even years of work to corroborate his first result, and eliminate all chance of error. He must, in fairness to his scientific confrères, ascertain whether any one of them may not have reached the same conclusion. When torn by these various feelings, and while yet in a state of uncertainty, mayhap he is prematurely ordered by his department to make his results known, and then, as we know from some few conspicuous cases, disastrous results may follow.

Again, the results of an investigation allowed to go forth in dribblets, are much less

Collecting and removing sheep-parasites for examination.

impressive than if reserved and presented in proper connection, and as a whole. This, however, is a matter that concerns the investigator more than it does the public whose servant he is, and any public scientific officer who reserved his results for this reason alone would be justly criticised.

In deference to this latter fact, and the wishes of his confrères, the author submits the following fragmentary observations, with the hope that they may yet appear in a more connected and extended form in a general work on Australian parasites.

Brief Resumé of our knowledge of the Sheep-fluke.

Our knowledge of the sheep-fluke extends back into remote antiquity, and though the older observers knew the disease caused by the fluke rather by its effects than through its cause, it is beyond dispute that at a very early date the disease was assigned to its true cause—a flat, worm-like parasite found in the liver. No doubt other diseases, such as anthrax, were confounded by the ancients with the true liver-rot, as it was often called; but this fact does not obscure the other fact that the parasite was known as the cause of a fatal disease contracted on wet and swampy ground.

As it is the object here to be as brief as convenient, no mention will be made of the numerous and vast epidemics of the past that have swept off sheep by thousands,—it is said even by millions. These details and many others will be left to be dealt with on later pages. Let our first object be to get an accurate general view of the subject, regardless of the less important details. Suffice it to say, then, that whenever these epidemics prevailed, they were accompanied by unusual circumstances of weather or pasturage, and the livers of the dead sheep were invariably found crammed with fluke. (*See* Fig. 6).

These flukes were flat worms, of a flesh or darker colour, capable of varying their shape, but for the most part having a somewhat spade-shaped contour. Some hundreds of these were often found in the gall bladder and ducts of a single liver.

The observation of practical men soon taught them to associate the unusual prevalence of fluke with damp seasons and swampy pasturage, and it was observed that even cattle and other stock grazing on such land became more or less infected with the fluke (always in the liver), though these other animals did not suffer so severely as sheep. The list of animals subject to fluke grew until a dozen or more widely different vertebrates, including man and marsupials, were included in it.

The attention of scientific men having been drawn to this curious parasite, they soon proved that each fluke produced a vast number of microscopic eggs, and that these were to be found in the gall and contents of the intestine, and that they passed into the outer world encased in the dung. What became of them afterwards no one for a long time could say.

Years went by; microscopes were improved, and became more numerous; and at last some acute observers began to remark on the similarity in form of certain so-called animalcules found in snails to the younger stages of fluke found in sheep's livers. Later on, the same and other new observers attracted to the subject found that these animalculæ in the snail were the progeny of other animalculæ, also found in the snail, and that these latter again came from another animalcule to be sometimes found swimming free in the water of the pools where the snails abounded. All these discoveries, however, were so novel and bizarre that there was a long period of waiting

before the facts became widely accepted. What wonder that doubt arose when a few naturalists announced a series of generations so astonishing that it would hardly be more remarkable to say that a horse had begotten a cow, which in turn had given birth to a goat! Yet it turned out that the pioneers were right, and that the fluke in the liver of the sheep was in reality the descendant, two or three generations removed, of the microscopic animal-cule that danced and whirled merrily along in the pools of the sheep pasture.

Finally, the whole matter was cleared up—at least, so it was thought. The eggs of the sheep-fluke taken from dung were artificially hatched, the young were given a chance to penetrate certain species of snails. There they went through their remarkable metamorphosis, came out again, and encysted themselves on the surface of grass, where they were ready to be taken in by any unfortunate sheep that happened along. Once in the sheep's stomach the young fluke was not long in finding its way to the liver, where it took up its abode, and customarily lived to a happy old age, much, however, to the detriment of the unfortunate sheep.

Such in brief is the life history of the sheep-fluke—a history which, though it may now be told by any school-boy in a few flippant words, yet required the thought and work of scores of able men of science in our and the preceding century to establish. Let us not forget to render its due to the memory of these men, who, it is safe to say, never received in their own time any other reward than the grateful remembrance of a few pupils in their

Fig. 6.—Portion of the liver of a sheep, natural size. *a a*, enlarged duct cut open to show the appearance of the parasites known as fluke; these latter are seen at *e e* crawling forth from the various branch ducts exposed, and also at *d d*.

favourite studies, and who are now for the most part beyond the reach of any honors, except those which we pay to the illustrious dead.

While profiting from their discoveries let us not forget who are our benefactors.*

The Sheep-fluke in Australia.

A country swarming with sheep, like Australia, was sure, sooner or later, to suffer from the ravages of the sheep-fluke. From times early in the history of the country down to the present, losses of sheep from this pest have been frequent, especially in certain districts.

It is not the intention here to more than hint at the history of the sheep-fluke in Australia. The reader will perhaps be content with the bare statement that could the losses from this pest all be recovered they would far more than pay the national debt of all Australasia.

It is much more the author's present purpose to ask whether the peculiar conditions of Australia have given rise to any new problems in connection with this pest, and, if so, whether these problems are soluble, and to state a few of the results of his own observations.

Whether Australian conditions have given rise to new problems in connection with the life history of the sheep-fluke is a question that rose prominently in my mind after my inquiry into the life-history of the Australian wheat-rust.† The parallel between the life-histories of rust and fluke, notwithstanding the fact that one is an animal parasitic in other animals, and the other a plant parasitic in other plants, is so curious, and, I venture to think, so instructive, as to deserve consideration.

The fungus commonly known as wheat rust is found in Europe to pass one of the stages of its existence in the tissues of the leaves of the barberry bush. In this latter situation its full growth is attended with the production of two sorts of spores, and these two sorts of spores have given rise in some quarters to the opinion that the fungus in this form is a complete organism in which a sexual reproduction is possible—witness the words *spermogonia* and *spermatia* applied to the so-called male organs and *sporidia* respectively; at any rate, whether this view be entertained or not, no one, I venture to say, will deny that the rust-fungus reaches one of its highest stages of development in the form in which it appears in the tissues of the barberry-bush, and this is entirely sufficient for the purposes of our parallel. The spores of the barberry-leaf-form of rust alighting on the blades of wheat produce a second generation unlike the first, and the spores of this second generation again, later in the season, give rise to a third generation unlike the second, and finally the third generation produces the following spring a fourth, which, when used to infect the barberry-bushes produces the original barberry-rust.

Now, this cycle of generations is as remarkable as that of the sheep-fluke, and curiously like it in a variety of ways. I do not wish to make too much of this analogy, for it is well-known that analogy is often very misleading; but I may justly call attention to the following fact, and with it point a moral. My investigations have conclusively shown that, although the above is a correct sketch of the life history of the wheat-rust in Europe, it is not correct for Australia. There are few barberry-bushes in Australia, and on the few that exist no barberry-rust has ever been seen, from which we can only draw the conclusion that the barberry-rust either does not occur in

* Wagener, Bojanus, von Baer, Steenstrup, de Filippi, Moulinié, de la Valette, Leuckart, Thomas, and many others. † *Puccinia graminis*.

Australia, or is very rare. We are thus driven to the conclusion, now accepted by all scientists in Australia, I believe, that wheat-rust with us habitually *omits one or more of its common European stages*.

It will be no matter for wonder to the reader that after having established the above fact I should be prepared to discover a similar fact in the case of the sheep-fluke, an organisation whose life history is analagous in its complications.

For a long time this suspicion seemed to be supported by my investigations. Australian snails were searched in vain for intermediate forms of the fluke. No observer had ever seen such a thing. Time passed, and still no intermediate form could be found. At last, however, about four years ago, snails containing the intermediate form of some species of fluke, presumably sheep-fluke, were found, and upon careful examination and measurement were found to be indeed the long searched for intermediate form. Accordingly, after thorough study and comparison at intervals lasting through nearly two years, the formal announcement of the discovery was made. The Australian snail harbouring the sheep-fluke turned out to be a different species from the European snail performing the corresponding function. Submitted to competent authorities it was pronounced to be the species *Bulinus Brazieri*, a common and well-known snail whose likeness is herewith presented.

Fig. 7.—A snail that acts as intermediate host of the sheep-fluke in Australia. These are figured from the specimens in which the Australian intermediate stage of the sheep-fluke was first discovered at Austermere, Moss Vale, 1893. Mr. Hedley, of the Australian Museum, determined the species of snail to be *Bulinus Brazieri*.

Fig. 8.—Specimens of the cercaria or tad-pole-like intermediate form of the sheep-fluke found in the snails shown in Fig. 7. These are shown in various natural attitudes, as seen with the microscope. The mouth is well forward, and may be seen in the upper left-hand figures. The large circular ventral sucker is also seen best in the left-hand illustrations. The power to protrude the sucker is indicated in the upper profiles. The drawings are faithful reproductions of the author's original photographs taken in 1893.

This snail may be found, sometimes very plentifully, on the stems of plants growing in fresh water, as well as on other objects above or below the surface of the water. They are essentially fresh water or rather amphibious snails, never being found in an active condition very far from their aquatic home.

A single snail of this species will often harbour several hundred of the *redia* or *cercaria*, as the two intermediate forms of the fluke are respectively termed, a fact which is in accord with those recorded in case of the corresponding European snail.

Such, in brief, is the story of the discovery of the Australian intermediate host of the sheep fluke, a narrative which, in its proper place in these pages, will be again adverted to and enlarged upon. By this discovery, the suspicions of European naturalists that the Australian intermediate host might prove to be another species of snail than that which serves in Europe were confirmed, and the doubts as to whether there was in Australia any intermediate host were cleared up.

It may be permitted us to doubt, however, whether this discovery, satisfactory as it undoubtedly is, goes far enough to warrant us in saying the life-history of the Australian sheep-fluke is essentially identical with that of the European form. There are still many points upon which evidence is wanting before such a statement will have the full warrant of science.

At this point it will be well to state that *redia* and *cercaria* are common in a wide variety of molluscs, there being probably no less than a hundred different species of such intermediate forms already known, many offering a most striking resemblance to those of the sheep-fluke. The mere discovery of such forms in a snail is, therefore, very far from being a proof that the snail harbours the intermediate form of the sheep-fluke.

The foregoing remarks allow us to proceed profitably to a consideration of the preventive and remedial measures that may be successfully adopted by Australian sheep-graziers.

REMEDIE AND PREVENTIVE MEASURES.

THE various remedies and preventive measures which I shall propose are based on our knowledge of the life-history of the sheep-fluke, as narrated in the foregoing pages. After the reader has perused these proposals he will, I think, agree with those who set a high value on the abstruse and difficult scientific researches that have slowly led up to our present knowledge of the nature and phases of the fluke. It will be seen that each remedy is based on some fact in the life-history of the fluke—some fact that has become known solely through the agency of scientific research. As this thought comes home to us it inevitably raises the question, "Who are those investigators who have wrestled so patiently and successfully with this dark problem?" Reader, it would lead too far afield if I should attempt only to name and locate them. Many of them are dead—most of them are unknown and unappreciated beyond a narrow circle of friends, while all of them have gone practically unrewarded. How pathetic it is to compare the great reward a later generation would willingly lavish on a discoverer or inventor with the pittance meted out by his contemporaries, and how short-sighted and poor-spirited are we, to be moved by such a noble impulse towards the distant and dead, yet forget that we ourselves may be playing the very part of those mean old contemporaries.

It must be remembered that in dealing with remedies we are obliged to mention all the various ways in which the fluke evil may be mitigated. No person will, perhaps, be able to adopt all of the following suggestions; nevertheless, none of them are without their uses. Again, no one of them is alone a sufficient precaution. So far as possible they should be all adopted concertedly.

Burning.

Burning off grazing land has become a well-recognised method of "cleaning" it. The reason for the operation is very simple, and it is this: Any small organisms clinging to the herbage, such as the eggs and larvæ of parasites, will be killed by the fire. While this supposition is in the main true, it is well to know whether, and in what way, burning may fail to "clean" the land. So far as fluke is concerned, we have to consider the chances the eggs and larval stages have of escaping the conflagration, and it may be said at once that the chances are by no means few. Most of the eggs that exist in green dung will be left unharmed. Though the surface of the pellets may be scorched, the heat will not penetrate them sufficiently to kill all the fluke eggs they may contain. Moreover, all the excrement lying on bare paths will remain unscorched. Again such excrement as lies in damp places or among incombustible material such as green grass will also escape the fire. When we recollect that it is only from comparatively fresh dung lying in or near water, or at least where it will sooner or later be moved into water, that fluke may be expected to develop, we shall be easily convinced that fire is by no means so cleansing as Australian sheep-owners are wont to believe. The fire cleanses, to a certain extent, so far as it goes; the difficulty is that *the places where it won't go are the very places most requiring to be cleansed.*

Fire should be applied and controlled, not left to accident and allowed to take its own wild course. The sheep-owner who is able, during a time of drought, to burn off his low-lying and swampy places will reap the greatest benefit, and such a course can occasionally be adopted by those who plan for it a sufficient time in advance. Even when most successfully carried out, however, there can be no hope that the fluke will be eradicated. Some, possibly many, eggs, cysts, and snails will be killed; but it is equally true that some will remain to multiply and infest the stock as before.

We must conclude, therefore, that while fire may be made under favourable conditions to ameliorate the fluke trouble for a few months, it cannot be relied upon alone to successfully combat the disease, and that only when utilised in time of dryness and drought, and in conjunction with other measures, is it very effective.

It must not be forgotten that drought alone is sufficient to inflict great injury upon the eggs and larvæ of the fluke, and that this is the reason that sheep often do remarkably well for a season or two afterwards, so well indeed as to have given rise to the opinion among sheep-owners that a drought is not an unmitigated evil.

When burning off for fluke the wise pastoralist will not forget to take into account the effect of the fire upon his pasturage. Fire destroys seeds, which may be useful or baneful, according as they are those of good forage plants or of noxious weeds.

Fig. 9.—Egg of sheep-fluke as found in sheep-dung, and seen with the microscope.

Overstocking.

This is a widely prevalent evil, which results, among other things, in increasing the abundance of fluke. It is very easy to see the reason for this. Overstocked land becomes close fed, so that stock have to nibble very

close to the ground, so close in some cases that they pull their food up by the roots. Such a method of feeding obliges the animal to run a greater risk of taking in the cysts of fluke, and we must add to this the weakened state of the digestion due to improper, and often insufficient, food. I have pointed out before, and may again here repeat, that it is beyond question that perfectly strong and healthy digestion is one of the greatest barriers any animal can set up against the invasion of such parasites as inhabit the digestive canal and its appendages, and which depend on gaining an entrance to the body through the stomach. If the digestive fluid is abundant, strong, and healthy, the chances are considerably against the parasite. On the other hand, a weak digestion is an open door to the parasite. Hence it is that, quite apart from the greater risk of infection through shortness of feed, overstocking is a dangerous practice.

It is well known that stock, more especially sheep, to a certain extent avoid the grasses and other fodder plants growing in swampy places, these plants being less palatable to them. Overstocking, however, often compels the animals to resort to the swampy places for food, when, of course, they run the greatest possible risk of taking in more fluke.

Again, we have to add to the foregoing risk the fact that overstocked pastures often reek with manure, and in consequence the eggs and young of the fluke soon become very abundant, being of course derived from the manure. The more stock, the more manure; the more manure, the more fluke-eggs from which to derive more fluke; the more stock, the more close feeding; the more close feeding, the more poor digestion and weakness, and the more resort to swampy areas; the more indigestion and the more resort to swampy areas, the more the stock become infested from their own superabundant dung. The more fluke the more weakness, the more weakness the more fluke—and so the weary tale goes on, and when the poor animals drop to rise no more, the owner who has overstocked his run is himself largely to blame.

Treatment of Young Sheep.

The losses from fluke depend largely on the manner in which young sheep are treated. Young sheep suffer more from a given number of fluke in the liver than do older sheep. One-quarter the number of fluke that an old sheep would bear with equanimity would kill a lamb. If, therefore, lambs and weaners can be kept comparatively free from fluke a great point is gained. I can never quite conceal my astonishment that this fact is not acted on, and I can only conclude that it is not generally known. The whole case may be briefly stated by saying that whatever regulation can be adopted with benefit to the whole flock will be of even greater benefit to the lambs. Give the lambs the best food, the pick of the paddocks, and be especially careful to keep them away from wet and flukey places. Run no risk with lambs, is the golden rule for the prevention of deaths from fluke.

Water, Water-sheds, Dams, Swamps, Drainage.

There is no fact more firmly established than that fluke require water for their development. All fluke are derived from fluke-eggs found in dung; but these eggs can hatch and develop only in the presence of moisture. The measures I would recommend against fluke are based very largely on these two fundamental facts: Keep the dung away from moisture, and you will have no fluke; keep half the dung away from moisture, and you will have

much less fluke. The management of water is, however, such a complex subject, that it requires to be treated under a variety of heads, such as drainage, watersheds, dams, swamps, &c.

Dams.

There are many objections to dams as ordinarily constructed for sheep in Australia, and some of these objections arise on account of the presence of fluke. The water of any dam to which flukey sheep are given free access will soon contain the free-swimming embryos of the fluke. Sheep-dung containing the live eggs of fluke readily finds its way into the water, and the eggs then soon hatch. It is in this way that the water first becomes contaminated; all the other stages in the history of the fluke follow on naturally enough. So far as dams are concerned, the spread of fluke could be practically prevented by keeping the water free of dung. Now this is a matter to which no attention is paid, largely, I presume, because it is considered not to be feasible.

Let us see.

Few realise from how small an area of land a large dam or tank can be filled. Suppose the dimensions of the water basin of a dam be $2 \times 25 \times 25$ yards—in other words, suppose the capacity of the dam be about 1,000 (to be exact, 1,250) cubic yards. If the annual rainfall be 24 inches, the rain that falls on an area 125 yards square would fill such a tank eight times full in one year. Or, to suppose a more common size, let the tank be 12 yards square and 6 feet deep, and thus contain about 300 cubic yards; then, with the same rainfall, the rain that falls on an area 60 yards square would fill the tank eight times in a year.

It is, of course, impossible to conserve all the water that falls on a given area of land, because a large part of it soaks in and is lost, so far as conservation is concerned, yet it is possible to collect a much larger portion of it than is commonly supposed, and that by a very inexpensive method—namely, the use of ploughed races or gutters. Again, it is needless to say, the proportion of water that can be collected from that which falls depends in a large measure on the nature of the rains; heavy showers producing much surface water, while drizzling rains almost wholly soak into the soil, leaving very little to drain into dams and tanks.

The arrangement of races that would drain a small watershed depends on the slope of the land, but in general will be somewhat as in Fig. 10, where *c, c, c*, are ploughed races leading to the tank, *a*. These may be single or double furrow, preferably the latter in most soils. They are made by

Fig. 10.—Diagram showing arrangement of water-shed, races, tank, and trough such that a pure water supply is assured. The water-shed is fenced off by the fence *b b b b*. The races *f f* keep the ordinary drainage of the paddock from contaminating the water-shed. The ploughed races *c c c* empty into the tank *a*, from which the water is siphoned through the pipe *d* to the trough *e e*.

ploughing two furrows of suitable uniform depth (say) 8 inches, and scooping out the soil and piling it on the lower side of the race, to form a dyke, which increases the carrying capacity of the race.

It is better to locate the races by means of a surveyor's level, as when done "by eye" the races are commonly made unnecessarily steep. A very slight fall suffices if much rain falls, though a light rain is better handled in steep races. A fall of 1 foot in 100 can scarcely be detected by the eye, yet a race with that fall will carry water admirably when there is a good smart shower.

This matter of the fall in the races is one that will repay careful consideration in locating tanks, because upon it depends in no small degree every other detail of the tank.

It is usual to locate tanks in natural depressions—so usual that it seems to have become almost an accepted law that they cannot be located any-

Fig. 11.—The ploughed races *a*, *b*, intercept the water from rain-storms, and run it into the tank *c*, whence it is siphoned into a trough near *d*, outside the fence.

where else. This is, however, a mistaken idea, and anyone having to locate tanks on a station, if he be not something of an engineer, would do well to study the works of competent engineers as illustrated in the water supply of the nearest large towns.

While a natural depression is a model location for a tank, it is not a necessity, and it must be remembered that to secure a suitable natural depression the pastoralist may have to place his tank in an otherwise very inconvenient or unhealthy position. The one necessary natural feature to a tank is a sufficient watershed. Given a sufficient watershed, the remaining features are a matter of engineering, and by engineering I do not mean scientific engineering, but simply taking carefully into account the simple fact that water runs downhill, and this other hardly less obvious fact, that it is better to store water at an elevation than in the lowest places.

However obvious these two principles may seem to the reader, I can assure him that they are very largely disregarded throughout this Colony in constructing tanks for watering stock, for it seems to be regarded as essential to place these tanks in the lowest possible places, and the axiom that water runs downhill seems to be accepted only in case the hill is steep.

This article cannot be devoted to engineering, but a few suggestive illustrations are added to show how a watershed may be secured in various situations where there is no natural hollow. The simplest case is shown in Fig. 11, where the water on a uniform slope is gathered into a tank by simple

Fig. 12.—A tank, *d*, is filled from races running round the two hills *a* and *b*. The tank-water is then siphoned into the trough *e*.

forked races. A second case, Fig. 12, is less simple, showing how water naturally running away from the tank may be turned to account. An apology seems almost necessary for introducing explanations of such simple

Fig. 13.—The water in the dam *a a* is caught on the fenced-off area shown, and then siphoned by means of galvanised piping into the trough *b*. The hollow floating ball *c* opens and closes the tap *d* automatically. In practice, the parts *c* and *d* would be boxed in. The same trough can be made to serve several paddocks which corner together, by placing it under the fence.

devices, and it may be found in the general disregard with which these methods meet among pastoralists.

Having now outlined some of the principles by means of which a tank may be located almost at will, at least in hilly or undulating country, let us see what advantages may accrue from this choice. Foremost among these is the ability to keep the water free from the larvæ of parasites. This may be done

by reducing the area of the watershed and fencing it in so that no dung is ever allowed to contaminate the water. The larvæ of these ubiquitous creatures may, it is true, be blown into the water by winds, but this will be a comparatively rare occurrence. A secondary advantage is that the tank may be placed in an otherwise healthy locality, which is accessible to the stock with a minimum of labour. Instead of compelling the stock to go to the lowest part of the paddock, located, it may be, a mile or two distant in an out-of-the-way, wet, and, therefore, dangerous place, their vital forces could be economised by placing the tank in a healthy spot, readily accessible from all parts of the paddock with a minimum of labour, at a central position and a medium level.

Water fenced off from stock may be led out into a trough by means of a pipe and what is known as a ball-cock, *i.e.*, a cock worked by a hollow copper ball floating on the surface of the water. When the water in the trough gets low, the lowering of the floating ball opens the cock and admits water,

Fig. 14.—Showing a tank, A, whose water-shed, w w w, is fenced off and kept free of stock. The water is siphoned off into the trough B located in the stock paddock.

which, gradually rising, again raises the ball and shuts off the supply. Thus in Fig. 14, the tank A, filled from the fenced-in watershed w,w,w, might have its water siphoned into a trough located at B. The plan of the pipe and trough is shown in Fig. 10, and again in Fig. 13.

Drainage from Camps and Licks.

The pastoralist may frequently with advantage pay more careful attention to the drainage from sheep-camps and salt-licks. These places are much frequented by the stock, and in consequence much manure becomes collected about them. This, of course, means that the eggs of fluke and other parasites of the alimentary canal or its appendages are more numerous here than elsewhere. The tramping of the stock having worn the land bare and smooth for considerable distances roundabout, the water of rain-storms quickly forms rivulets capable of washing these eggs into lower places, where in pools, dams, and streams, they find the conditions requisite for their further development.

The drainage of these places may sometimes be brought under control at a very moderate cost. Races or gutters may be either ploughed or dug, and

so placed as to receive the objectionable drainage and lead it away to places where it can do no harm. If the drainage be conducted outside the stock-paddock so much fertilizer is, of course, lost; but it is better to suffer this loss than a greater one.

This matter of the drainage from sheep-camps is mentioned more particularly because it is not uncommon to see these camps located so as to drain

Fig. 15.—Sheep camp *a a*, and salt trough *b b*, showing how races *c c* could be located to catch the dangerous drainage and conduct it away to a safe place, when otherwise it would contaminate the pasturage of the paddock.

into swampy land, and this combination forms a very perfect incubator for fluke; in fact, it is doubtful if a very much better arrangement could be devised for the propagation of fluke on a large scale. If the stock-owner objects to the loss of manure that would result from conducting the drainage outside his grazing area, he might at least so divert the drainage as to bring it on to the drier parts of his land, instead of allowing it to find a natural lodgment in some swamp, or dam, or water-hole.

I have designed Fig. 15 so as to present these ideas in a more graphic way.

Fence off Swampy Places.

In many parts of the country there are few ways in which more sheep could be prevented from becoming flukey for a given sum of money than by fencing in the swampy areas that serve as natural breeding-places for the fluke. Along the margins of rivers and creeks are found numerous areas of land that are either perennially or periodically "dangerous." By concentrating his attention on these areas the pastoralist may often save himself from very serious losses.

Perennial swamps, if they cannot be drained, can at least be fenced in. Land that is only periodically wet or submerged, if also fenced off so as to be under control so far as grazing is concerned, will very often in the long run be more profitable, for whenever on account of continued rain it becomes "dangerous," *i.e.*, flukey, it can be given a rest, or pastured with the stock

least subject to fluke. Even should the fencing-off result only in ability to keep the young sheep off the infested areas the gain would sometimes—nay, in fluke country, often—far more than pay the interest on the outlay necessary for fencing.

Fig. 16.—Swampy paddock, showing where surface drains, *a, b, c, d*, should be located so as to drain away superfluous moisture that would favour the growth of snails.

Fig. 17.—Square paddock, one corner of which, *a*, has been fenced off on account of its swampy, *i.e.*, dangerous, character.

In laying out a run, the cost of fencing so as to avoid risk from fluke, would oftentimes be no greater than that ordinarily incurred where no attention is given to such matters.

Fig. 18.—Swampy areas *a* and *b* fenced off from the safe paddocks *p.p.f.* There are hundreds of fluke-infested sheep runs in the colder and moister parts of the Colony where the fencing off of these swamps, located on the border of rivers and creeks, would be a paying investment.

Figs. 16, 17 and 18 give pictorial form to some of the suggestions made in the text.

Rotation of Stock.

We often hear of the rotation of crops, but almost never of the rotation of stock; yet where it can be accomplished the rotation of stock is a very good practice. By rotation of stock, I mean the pasturing on the same paddock one after another different kinds of stock. Thus, sheep for a time, followed by horses, and these latter followed again by bullocks. In this place it is only necessary to take note of the advantages derived in decreasing the amount of loss from fluke.

In general each species of animal has its own particular parasites, so that the parasites found in the sheep are not found in the ox, while the parasites of both differ from those of the horse. There are, however, exceptions to this rule. Thus the fluke is found in both the sheep and ox, as well as many other animals. In such an exceptional case, nevertheless, it nearly always occurs that the parasite is very much more common in one of the hosts than in any of the others. As an instance of this, it may be remarked that fluke is very much less common in bullocks than in sheep. In other words, the sheep is the chief host of the fluke.

It is obvious, therefore, that a paddock that has become flukey under sheep may be improved by turning in stock which harbour fluke to a less degree than does the sheep. Bullocks following flukey sheep will, of course, pick up fluke, but fewer of these will come to maturity, and henceforth so long as bullocks continue to occupy the paddock the amount of fluke-eggs will diminish until the paddock would be again fairly safe for sheep. The following rotation may therefore be recommended for a flukey paddock :—

1.— <i>Good.</i>	2.— <i>Better.</i>	3.— <i>Better still.</i>
Sheep,	Sheep,	Sheep,
Bullocks,	Horses,	Horses,
Sheep,	Sheep,	Bullocks,
&c.	&c.	Horses,
		Sheep,
		&c.

The length of time for which each kind of stock should be allowed to occupy the paddock depends on the season, and more particularly on the life-history of the fluke. An entire season, or even two, would be the safest rule to follow, but this, of course, would in many cases be out of the question. In any case the rotation should be arranged so as to bring on the sheep in the dry times if possible.

The foregoing ideas occurred also to the late Dr. Bancroft, of Brisbane though whether his conception antedates mine I must leave in doubt; for while he first placed them in print in one of the Queensland newspapers, I had at an earlier date also publicly expressed them. Furthermore, it is quite possible, so obvious are they, that these ideas may have originated also with previous writers; but if so, the fact has escaped me, and indeed cannot, I think, be well known. There can be no doubt that some form of systematic rotation could be followed with advantage by many pastoralists. Even if rotation is impracticable on all paddocks, it might be applied on those most liable to disease.

Of course the value of these suggestions is very much enhanced by the fact that they apply to other diseases than fluke, as I shall point out in my general report.

Some of the relations of the Australian Fauna to the Fluke-pest.

Has the sheep-fluke any enemies or friends among our native birds and animals? Do any of our native animals harbor the fluke? Do any of them prey upon it? Can we derive any benefit from any of these relationships? These are questions which I have sought, gun in hand, to answer, and with such good effect that I am able to lay before the reader records of facts both interesting and valuable. The indigenous birds and animals and those introduced from Europe have been carefully

"These are questions I have sought, gun in hand, to answer."

examined as they occurred in fluke-infested districts, and record made of their habits, their food, and their parasites. As soon as I had discovered that one of our native snails harbored the intermediate form of the sheep-fluke, the question, "What enemies has this snail?" became important enough to demand special notice, and as I have been fortunate enough to obtain at least a partial answer to this question through observations on native

"Introduced from Europe."

birds, I will begin the account of the relations of the Australian fauna to the fluke-pest by an account of some of these feathered friends.

The Mud-lark and other Snail-eating Birds.

Through nearly the whole of Australia the vicinity of fresh water is enlivened by the presence of the Magpie-lark or Pee-wee, a bird of such considerable size, and such striking black and white plumage, of such engaging manners, and such common occurrence, as to have secured, not only the attention, but also the kind regard of all our country people.

Let us add at once that the cold and critical scrutiny of science not only confirms the favourable impression this bird's appearance and good manners have created, but even heightens his reputation by proving him to be a great benefactor. From being reckoned a rather useless member of the feathered world, our investigations have placed him in the category of the most useful; and as this promotion arose almost solely from an examination into the food-habits of the bird, it may not be thought out of place if we set still another example of a method of studying birds that is now-a-days all too rare.

We require to know much more about the habits of the common birds in their relation to man. Grant that the feathering of rare birds is a very

THE COMMON MUD-LARK OR PEE-WEE.

NATURAL SIZE.

(Also called Magpie Lark.)

interesting study, still it sinks into insignificance when compared with the careful investigation of the history and habits of the commonest birds. The slightest trait of a very common bird is worth much more study than the whole plumage and anatomy of many of the rare specimens on the possession and description of which ornithologists so often pride themselves. To teach the people to take a genuine and intelligent interest in the most common birds is certainly a useful and dignified calling, and at the same time a scientific one; indeed the single examination into the food-habits of a bird demands a high degree of acumen and a wide knowledge of biology, especially of morphology. The exact nature of a wild bird's food can be best discovered by searching a large number of their

The mess-tent, departmental camp,
Bong Bong.

stomachs during various seasons in various localities, and anyone who has attempted to identify the half-digested food-remnants found in such a search will readily agree to my high estimate of the ability required in studying the food-habits of birds. To be able to say at once to what species of beetle this elytron belongs, to what plant these are the seeds, to what caterpillar this head belongs; to be able to say not only whether this half-digested bone belongs to a fish, bird, reptile, or small mammal, but what fish, what bird, what reptile, what mammal, requires scientific ability of no common order; and yet even this is only the beginning of the research—the A B C of the matter.

Appealing to ornithologists to give more of their attention to the habits of our commonest birds is, of course, asking them to grapple with a much more difficult task than counting spots and measuring wings, but would they not find their reward in the superior value of the results, whether considered economically or in a pure scientific spirit, as well as in the keen interest that would be almost universally taken in such researches?

The Australian naturalist who first goes into the bush animated with the ambition to completely portray our common birds in common language—to enter into their humours and to understand their characters, to emulate in a more modern form White, Burroughs, Brehm—will reap a rich harvest if he bring to his task the requisite ability. But we must return to our subject.

The heavy, ungainly flight of the Pee-wee proclaims the air to be not his favourite element. Flap, flap, flap, he laboriously moves along, strikingly in contrast with the graceful arrowy movement of the magpie, particularly as he moves his rounded wings at right angles to his line of flight, while the magpie seems almost to be leaving the tips of his wings behind him.

On his feet, however, the Pee-wee is completely at home, and his walk, whether on the ground or along the limb of a tree, is sprightly and vivacious, displaying a somewhat self-confident elegance, that makes up for his slow and awkward flight. I have observed that in walking his head has something

of the movement characteristic of wading birds, and indeed he is a kind of semi-wader, often walking in water ankle-deep, among aquatic plants along river-banks and in bogs. At all such times he is very alert, and it is difficult to get a good view of him, except through a telescope. He spies me at a distance, and flies up into an adjacent tree, often taking the precaution to fly beyond the tree, and come back into it on the far side, with a kind of swooping curve. He likes to see all sides of a tree before he ventures in. "*Look before you 'light*" is his motto. Like a true comrade, he warns his mates of my presence by a peculiarly-accented call, "*Kee, kee, kee, kee, kee, kee*, pitched about thus,

How often have I paused a second in my work to listen to his sprightly call! It is remarkable how much a bird can do with a simple note or two. Quite a vocabulary is made out of it, suggesting that the step from bird language

"How often have I paused a second in my work to listen to his sprightly call!"

to that of savages is scarcely greater than from the language of savages to that of civilisation. As, however, one syllable can be repeated slowly or quickly, with a rising or falling inflection, loudly or softly, once, twice, thrice, or many times in succession, it is easy to understand how, even where their notes are limited in number, birds manage to talk among themselves indifferently well.

The Pee-wee is not a singer—he is a talker. Linger near his haunts, the close observer soon learns that his notes are not mere caprice. He has ideas, and he has learned how to express them with a single syllable. It is difficult to decide whether this syllable is “kee” or “tee,” but suppose the former. Then “*Kee-e-kee*” seems to be a mere casual, unconcerned cry, signifying as it were, “*Here I am,*” “*All right.*” Excitement, either through alarm or sport, is expressed thus “*Kee, kee, kee,*” or “*Kee, kee, kee, kee, kee, kee,*” many times repeated. This is not, however, the only syllable used by our favourite. “*Ko-lee*” is another and a playful note. One bird being sportively chased by another, sings out “*Ko-lee! Ko-lee!*” much as if jokingly calling for the “*Police! Police!*” A single gurgling note, “*lgl,*” has the quality of the magpie’s song. “*Kee,*” however, is the basis of the language, and is pitched near E, though this varies with different individuals, and even in the same individual it rises or falls somewhat less than a semitone, according to the desired meaning. Thus,

is emphatic, and calls for attention or denotes alarm, the second note having a falling inflection and accented, as if in a final effort of expulsion. Similarly, the single syllable “*kee*” may become “*kee-ch,*” in which the second part is sharpened half a tone. In the playful note “*ko-lee*” the order of the tones is reversed, as follows :—

The syllable “*lgl,*” or “*pulp,*” or “*pull-up,*” is pitched lower :—

All these various notes, of course, have their special meaning according to the occasion on which they are used, but they are rarely uttered from the ground. Conversation is carried on during flight as well as when the birds are perched on a tree or fence, or even while sitting on the eggs or brooding the young.

When he is terrified, our poor little friend is a pitiable sight. His wings raised and trembling with excitement, his voice goes up about an octave, and his cries are loud and in quick succession. This alarm will summon other birds, such as the soldier-bird and magpie. I have observed that this cry of terror is common to a number of species, and this is probably due to the fact that these species have some enemies and sources of danger in common.

It will doubtless excite the reader's amusement to be told that these birds perform accurately-timed duets. This trait is well developed among Australian birds and frogs; in fact, I do not remember to have heard in any other part of the world such good examples of this phenomenon. Witness the comic responsive duet of the Australian Butcher-bird and his wife. Says he, "*What do you drink when you go on a drunk?*" "*Water, water,*" invariably responds his wife, with an ironical and very comical upward inflection. "*O'll tell yer father,*" says he in a rich brogue, upon which she calls for "*Quarter, quarter.*"

Of course, these words and meanings are an imagination of the mere human audience, but of the responsive duet there can be no doubt.

Pee-wee duets are much simpler, but no less marked. The female calls out in a somewhat weaker voice, and less than half a tone flatter than her mate:—

Or the duet sometimes occurs in this form:—

The cause of these interchanges of sound is no doubt oft-times the precaution taken by each bird to make known his whereabouts to his mates, and to assure them of his safety, but they cannot always be explained on this simple assumption, as, for instance, during nest-building, and on some other occasions.

Nesting takes place during October, November, and December, at which season the birds gravitate toward rivers and tanks, the nest being seldom far from water, and usually located in the side of the tree nearest some creek or water-hole, often on a limb overhanging the water. From 5 to 80 feet above the ground on a horizontal or gently sloping limb, often at a fork, built substantially of mud, with no effort at concealment, the nest is typical of its owner—simple, frank, substantial. Any approach to a tree where nest-building is going on is a signal for the birds to silently depart, and they will

not return until all seems quiet. If one goes under the tree and remains there for some time, the birds at last become uneasy, and at intervals fly near, hover and wheel overhead for a few seconds crying out, and then again disappear.

Both sexes take part in building, the male being quite as industrious and expert as the female. The mud and straw (decayed grass or sedge) culms are brought in masses as large as the end of one's finger. The trip and back of (say) 100 yards takes only thirty seconds. The work of building consists in laying the load on and then distributing it. The latter requires skill in treading the top down, and weaving in the projecting straws. The weaving in is done with the beak, which is worked along the edge of the masonry, seizing any projecting straws and by a quick twist turning them against the mud, where they adhere. If by chance any straw is too stiff and repeatedly fails to adhere, and obstinately sticks out, it is pulled out and discarded, the surface of the masonry being thus kept constantly free of projecting straws as the work progresses. When complete the nest is cup-shaped, hemispherical, 5 to 6 inches across and 3 inches deep, and often resembles a knot or excrescence on the limb, the resemblance being sometimes heightened by the similarity in colour. The lining consists of a few straws, and occasionally a feather or two.

At one time during my strolls I entertained myself making some observations on these birds, extending over some weeks off and on, when to my delight a pair of them were so accommodating as to come and build within sight of my laboratory window, as much as to say, "Go-lee! go-lee! You needn't squander such a lot of time spying into the secrets of Pee-weedom. We're going to take pity on you, and show you the whole family history. Go-lee! go-lee!"

I am not quite sure that this is a perfectly frank statement of the case, for I suspect that this particular pair of birds came from a certain willow-tree where during the previous fortnight a succession of tragedies had taken place. A nest had been completed in this willow before my attention was

"At one time during my strolls"—

"Within sight of my laboratory window."

attracted. Matters went on well for a day or two, until one morning the nest was missing; only the basement remained. Who or what the marauder was that tumbled the nest into the water below I could not make out—perhaps it was the wind, which blew strongly those days. These were young and inexperienced birds may be, for I suspect that the older and wiser heads among them build on higher and more inaccessible limbs. This disheartening disaster, however, did not discourage my birds; they began another nest in the same tree, higher up and farther out over the water, thinking no doubt the new location would be free from danger. But, alas! No sooner was the nest done, and one egg laid, than another misfortune befel. The nest stayed well enough this time—it was the egg that went a-missing! I strongly suspected a Butcher-bird that I saw hanging about the neighbourhood, but as I could not fetch the matter home to him I forebore the retribution I have little doubt he deserved. I deliberated a few seconds along the barrel of my gun, but lowered it without pulling the trigger. The Pee-wees loitered about for a day or two longer, hesitating to try fortune again in the fatal willow, and then disappeared.

It was their disappearance from the willow region that marked the advent of my study-window pair, and very likely this was the same unfortunate pair. Their misfortunes appealed to me, and I determined to stand by them in their new venture, seeing that they had, as it were, observed my interest in their affairs, and appealed in this direct manner to my protection.

This time, as if taught by sad experience, they located the nest fully 60 feet from the ground. They did not consult me in this, and I did not understand their language sufficiently well to protest. I would have much preferred a better view of the proceedings, and should have urged that my protection would be somewhat in inverse ratio to their distance from the ground, and I should have argued that in an emergency it would be risky for me to trust my 12 stone weight on so small a bough at such a dizzy height.

However, the nest grew apace. The first day only a little cement of mud was plastered into a fork and along two small branches for a few inches. By night-fall the only indication of a result to a mundane observer was what appeared to be a daub of blackish paint on the grey, smooth-barked boughs. The second day this daub grew to the size of a hen's egg.

Both birds worked industriously, but it was clear that the male took charge of affairs, and plainly thought he knew more about building a house than his wife did. A lady friend remarks to me, with sly sarcasm, that she thinks this is characteristic of males. Frankly, I agree with her fully when she says that women ought to, and often do, know more about domestic architecture than men, and I pause to wonder "Why in the name of domestic bliss, aren't there more woman architects?" Well, Pee-wees evidently hav'n't advanced in this line any farther than mankind has. I must say that Mr. Pee-wee had occasionally some cause for complaint, for the wife did sometimes drop unconscionably large pieces of mortar, which went tumbling pell-mell to the ground. On such occasions he would rush at her and drive her off the bough with actions that said as plain as words, "Here, you're a duffer at that business; let me do it! You go along and bring some more mud!" which she generally did. When she was gone he would sing out occasionally in a high whistle as he plastered away. I fully believe he was calling to her for more mud or straw, as the case might require. "Mud!" he seemed to call, as he paused for a second to inspect his work, or "Straw! Straw!" Occasionally, when both were present at the nest, it was most amusing to hear the male twitter as he stooped over the work, calling

his sweetheart's attention to the beautiful progress they were making. This twitter, which I never heard on any other occasion, resembled that of the swallow, only it was not quite so highly agreeable. "Look, dear, how fine its getting on. It'll be a nest in no time! Let's rush for some more mud!" and off they would go, and be back again in half-a-minute, each with a load of mud. While at work building, either bird, but particularly the male, often whistles once or twice a note an octave higher than the ordinary call, thus:—

to which the mate sometimes answers in the same tone, but more often an octave lower. This whistle is one particularly connected with nesting and brooding, though I believe it to be the same note that is repeated in rapid succession when the birds are extremely terrified; it also occurs as a distinct over-tone in the ordinary call in building. As I have before said, the beak is used as a trowel, and it is frequently wiped on the limb just beyond the bounds of the nest. This is the origin of the muddy markings invariably seen near the nest. The mud composing the bottom of the nest is invariably packed down by treading with the feet.

When the nest is completed, which is often in three or four days, it is allowed to dry and harden before the eggs are laid. From this time on the birds show admirable precaution when approaching the nest. On entering the tree they alight on the outskirts, and tarry a few seconds or a minute, then make a nearer approach, tarrying once more; and finally alight on the edge of the nest, which is used as a door-step.

The eggs are laid in quick succession—four or five eggs are laid in as many days or less. On two occasions I have known two eggs to be laid in the same nest in one day. The usual number of eggs is five, but the number varies from three to six. The male does his half of the incubation, apparently with great cheerfulness, for he may often be heard calling out gaily to his mate as he covers the eggs, facing the breeze that rocks both him and his house up and down and to and fro.

As soon as the young are hatched they are fed on fragments of insects and spiders, among which I note a variety of small wild bees, and grasshoppers. I have never known snails to be fed to the young, though I know they are often devoured by the old birds.

In bringing food to the young ones the old bird invariably uses all the precaution possible, never flying straight to the nest, but first to some remote part of the tree, and, approaching the nest slowly and by watchful stages, at last feeds the young, an operation of a few seconds, and then proceeds to brood them till the return of its mate. This occurs in ten or fifteen minutes, the approach being always in the same cautious manner. The bird that is brooding keeps a sharp look-out, and, peering from side to side, sees its mate returning at a distance; and scarcely has this laden bird reached the tree before the other has left the nest and flown in a most direct and business-like manner for more food. It is evidently a very serious business bringing up a nestful of young ones.

The alertness of the brooding bird is almost incredible. A slight movement of my foot at 50 yards distance was at once detected, and was sufficient to cause the bird to silently leave the nest. I could scarcely credit this at first, and thought it must be a mere coincidence; but no, on repeating the experiment the same thing occurred twice more in succession. At another nest the same thing occurred. The female seemed more alert in this respect than the male.

The young are expert at voiding the ordure over the edge of the nest, and the nest may sometimes be discovered by the ordure on the ground beneath. This leads me to suspect that the building over water may be for secrecy, the ordure being dropped into the water.

The young fly in about a month, and thenceforth look out more for themselves.

In an emergency it appears the parents will attempt to teach the art of flying to quite young birds. A nest containing a pair of young birds unable

"Passing along the banks of a river in a locality frequented by these birds, I have often come upon these favourite trees."

to fly, but one of which could flutter, was placed on the ground. The parents tried to entice the young out of the nest by their cries and motions. The male in particular would stand on a limb near the ground and wave his wings in imitation of flying, and the conclusion was irresistible that he was showing the young what he wanted them to do, namely, to make an effort to fly. Every flutter of the young was encouraged by special cries of the old birds, as much as to say, "That's it!" "Keep on!" "That's right!"

The Pee-wee lives to verify the saying that there are no birds in last year's nests. A nest is never used but once, though a second nest is not infrequently built alongside the first. On several occasions I have seen no less than four nests, on boughs varying from 1 to 6 inches in diameter, in the same tree, all in various stages of decay; and as I have never seen more than one occupied nest in a tree at a time the conclusion is fair that nests are built in succession in favourable trees, perhaps by the same pair of birds.

Passing along the banks of a river in a locality frequented by these birds, I have often come upon these favourite trees, as they may fairly be called, but though I have often tried to fathom the reason for the birds' choice I have never succeeded. Truly, such trees were generally of large size, but why these particular ones and not others equally large, and to me, at least, as attractive, I do not know, and yet I have no doubt there is some very good

reason. I have tried to convince myself that the particular trees chosen were safer from the attacks of crows, hawks, and climbing animals, but with only indifferent success. To be sure, a number of cases seem to support this hypothesis, as, for instance, when I found a number of these favourite trees placed alongside and very near the railway. The contrast between the quiet and unconcern of the mother Pee-wee brooding her young, and the rushing, thundering, shrieking, hideous din of the train a few yards away was laughable and very suggestive. Have we not here a bird that would, if not hunted, take up its abode in our very midst, putting up with our noisiness for the sake of the protection afforded from its natural enemies? It is reasonable to suppose, and, as far as I have observed, actually the case, that nest-robbers, such as birds of prey and climbing animals, are fewer near railways, and may not this account for the location of these particular favourite nesting trees? Where birds are left unmolested, or, rather, where useful birds are left unmolested, some of their number soon frequent the trees near houses and near gardens. The Pee-wee is one of these, and it is disposed to confide in us, relying on our protection. If we only had the sense to appreciate the situation, we might encourage a valuable ally.

The course followed by the eggs and young of these birds is a perilous one. Sharp-sighted robbers circle in the air above by day, and four-footed marauders scramble up from below both by day and by night, and between these, what with hawks, crows, iguanas, and cats, it is no wonder if many a fine brood comes to grief. One season I had nearly half a hundred nests under casual observation, and can testify to a considerable loss from the attacks of these thieves. I suspect that on more than one occasion my tracks were followed up the tree from below. Claw marks on the smooth limbs told a suspicious tale. Where iguanas are numerous, eggs in open nests are not what the life insurance companies would call a safe risk.

An easy way, not well known, to head off these climbing thieves has occurred to me. Nail a broad band of sheet metal round the trunk of the tree. After trying various captive animals, I find that none of the ordinary kinds can pass such a band if it is 12 inches wide, so here is a new use for the ubiquitous kerosene tin. Split the tins open and nail them round the trunks of fruit trees a foot or more above the ground, and the fruit is safe from opossums and all other climbers. The

One of the four-footed marauders gets caught. (Native or marsupial cat, *Dasyurus viverrinus*.)

Tree with sheet-metal nailed round the trunk to ward off noxious climbing animals, such as fruit-eaters and nest-robbers.

same protection could be extended to the nests of useful birds such as the pee-wee, and this, in fact, is why I mention this simple, effective, and inexpensive device. Many a tree could be so protected at a very trifling expense, amounting to no more than the cost of a dozen nails, and the trouble of driving them.

In order that the reader may have a fuller account of our native snail-eating birds I insert here two extracts from Gray's "Birds of Australia," one on the mud lark and the other on the white-fronted heron.

GRALLINA AUSTRALIS (G. R. Gray). "Pied Grallina."

Gracula picata, Lath. Ind. Orn. Supp., p. 29.

Pied Grackle, Lath. Gen. Syn. Supp., vol. ii., p. 130—*Ib.* Gen. Hist., vol. iii., p. 169.

Tanypus Australis, Oppel.

Grallina melanoleuca, Vieill. Anal. d'une Nouv. Orn., pp. 42 and 68.—*Ib.* Ency. Méth. Orn., Part II., p. 693.—Vig. and Horsf. in Linn. Trans., vol. xv., p. 233.

Grallina bicolor, Vig. and Horsf. in Linn. Trans., vol. xv., p. 233.

Grallina Australis, G. R. Gray, List of Gen. of Birds, 2nd Edit., p. 33.

Grallina picata, Strickl. in Mag. Nat. Hist., vol. ii., p. 335.

Corvus cyanoleucos, Lath. Gen. Hist., vol. iii, p. 49?

Magpie Lark, Colonists of N.S.W.

Little Magpie, Colonists of Swan River.

"
Bij-yoo-gool-yeec-de, Aborigines of the lowland, and Dil-a-but, Aborigines of the mountain districts of Western Australia.

"Future research will, in all probability, establish the fact of this bird being universally dispersed over the greater portion of Australia. I have specimens in my collection from New South Wales, Swan River, and Port Essington, all of which are so closely alike that no character of sufficient importance to establish a second species can be detected. Those that came under my observation in New South Wales were never seen very near the coast, but frequented the rich alluvial flats, and sides of the creeks and rivulets of the interior.

"Few of the Australian birds are more attractive than the present, or more elegant and graceful in its actions, and these, combined with its tame and familiar disposition, must ever obtain for it the friendship and protection of the settlers, whose verandahs and housetops it constantly visits, running along the latter like the pied wagtail of our own island; in fact, the two birds, except in size, are very similar. Mr. Gilbert states that in Western Australia he observed it congregated in large families on the banks and muddy flats of the lakes around Perth, while in the interior he only met with it in pairs, or at most in small groups in not more than four or five together; he further observes that at Port Essington, in the north coast, it would seem to be only an occasional visitant, for on his arrival there in July it was tolerably abundant around the lakes and swamps, but from the setting in of the rainy season in November to his leaving that part of the country in the following March, not an individual was to be seen. It is evident, therefore, that the bird removes from one locality to another, according to the season, and the more or less abundance of its peculiar food. I believe it feeds solely on insects of various kinds, particularly aquatic grubs, grasshoppers, and coleoptera generally.

"The flight of the *Grallina* is very peculiar, and, unlike that of any other Australian bird that has come under my notice, it much resembles that of the common pewit of Europe, and is performed with the same heavy flapping motion of the wings; still the flight of the two birds differs materially during their passage through the air, the *Grallina* passing noiselessly and generally in a straight line, while the pewit makes sudden turns and dips—a peculiarity in its mode of flight, which must have been noticed by all who have seen the bird on the wing.

"Its natural note is a peculiarly shrill whining whistle often repeated.

"The nest may be regarded as one of the anomalies of Australia, so unlike is it to anything usually met with; it is from 5 to 6 inches in breadth, and 3 inches in depth, and is formed of mud, which, soon becoming hard and solid upon exposure to the atmosphere, has precisely the appearance of a massive clay-coloured earthenware vessel. As if to attract notice, this singular structure is generally placed on some bare horizontal branch, often on the one most exposed to view, sometimes overhanging water, and at others in the open forest. The colour of the nest varies with that of the material of which it is formed. Sometimes the clay or mud is sufficiently tenacious to be used without any other material, but in those situations where no mud or clay is to be obtained, it is constructed of black or brown mould; the bird appearing to be aware that the substance will not hold together for want of the adhesive quality of the clay, mixes with it a great quantity of dried grass, stalks, &c., and thus forms a firm and hard exterior, the inside of which is slightly lined with dried grasses and a few feathers. The eggs differ considerably in colour and in shape, some being extremely lengthened, while others bear a relative proportion. The ground colour of some is a beautiful pearl white, of others, a slight tinge of buff; their markings again differ considerably in form and in their disposition, being in some instances wholly confined to the larger end, in others distributed over the whole of the surface, but always inclined to form a zone at the larger end. In some, these markings are of a deep chestnut red, in others, light red with large clouded spots of grey appearing as if beneath the surface of the shell. The eggs are generally four, but sometimes only two in number; their medium length is 1 inch and three lines, and their breadth nine lines. It breeds in October and November.

"Although the sexes are very similar in size, the female may at all times be distinguished from the male by her white forehead and throat, a fact I determined many times by actual dissection, thus showing the fallacy of the opinion entertained by some naturalists of their being two distinct species.

"The male has a line over the eye, a patch on each side of the neck, a longitudinal stripe on the wing, tips of the secondaries, rump, upper tail-coverts, the basal two-thirds, and the tips of the tail, under surface of the shoulder, breast, flanks, abdomen, and under tail-coverts, white; the remainder of the plumage black, with a deep bluish tinge on the head, throat, chest, and back, and a green tinge in the primaries and tail; bill, yellowish white; irides, straw yellow; feet, black.

"The female differs in having the forehead, lores, and chin white. The young in leaving the nest have the irides black; in other respects they resemble their parents; but are, of course, far less brilliant in colour."

ARDEÆ NOVÆ-HOLLANDIÆ (Lath.), "White-fronted Heron."

Ardea --Novæ-Hollandiæ, Lath., Ind. Orn., vol. ii, p. 701.—Steph. Cont. of Shaw's Gen. Zool., vol. xi, p. 561.

White-fronted Heron, Lath., Gen. Syn., Supp., vol. ii, p. 304—Phill. Bot. Bay, pl. in p. 163.—Penn. Outlin., vol. iv, p. 128.—Lath. Gen. Hist., vol. ix, p. 127.

Ardea Leucops, Wagl. Syst. Av., Ardea, sp. 17.

Herodias—Novæ-Hollandiæ, List of Birds in Brit. Mus., Mus. Coll., part iii, p. 80.

Wy-an—Aborigines of the lowland districts of Western Australia.

Blue Crane of the Colonists.

"The white-fronted heron is abundantly dispersed over every part of Van Diemen's Land, the Colonies of New South Wales, South Australia, and Swan River; but I have never seen it from the north coast, and consequently infer that it is not found there. Low sandy beaches washed by the open ocean, arms of the sea, and the sides of rivers and lagoons, both in the interior

of the country, as well as near the coast, are equally tenanted by it, consequently it is one of the commonest species in all the countries above mentioned; and may frequently be seen wading knee-deep in the water of the salt marshes in search of food, which consists of crabs, fish, and marine insects. Its flight is heavy and flapping, like that of the other herons, but it runs more quickly over the ground, and his continually moving about when searching for food, and never stands motionless in the water as the true herons do. These active habits are in fact necessary to enable it to capture insects and crabs, upon which it mainly subsists.

Looking for snails.

of Van Diemen's Land. The nest is of moderate size, and composed of sticks and leaves. The eggs are four in number, of a pale bluish-green, $1\frac{7}{8}$ inch long by $1\frac{1}{4}$ inch broad.

"The white colouring of the face and throat is much more extensive in some individual than in others; and the base of the bill, the orbits, and irides are deep-lead colour in some specimens, while in others those parts are pale grey, and the irides pale buff.

"The stomach is very capacious, and the weight of the adult bird about 1 lb. 4 oz.

"Little or no difference is observable in the sexes, but the female is somewhat smaller than her mate.

"Face and throat white; crown of the head and back of neck dark slate colour; sides of the neck, all the upper surface and wings, dark grey, tinged with brown on the wings; primaries and tail-feathers dark slate colour; elongated feathers of the back grey, tinged with brown; elongated feathers of the breast cinnamon-brown; under surface grey, washed with rufous, which tint becomes gradually paler as it proceeds along the abdomen to the under tail coverts; down the lower part of the neck a strip of buff, gradually blending above with the white of the throat, and below with the cinnamon tint of the breast; irides in some lead colour, in others yellow, and in others pale buff; orbits and base of the bill, in some pale grey, in others deep-lead colour; base of the lower mandible of a flesh-colour."

(To be continued.)

[One plate.]

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