New Zealand Practical Handbooks

Farmers' Foes

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IN NEW ZEALAND

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NEW ZEALAND PRACTICAL HANDBOOKS

FARMERS' FOES

IN NEW ZEALAND

AND HOW TO COPE WITH THEM

BY

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PREFACE

Some years ago I prepared for the use of my students a text book of Agricultural Zoology in New Zealand. My publishers, however, considered—very rightly—that the work was so long and so technical as to command only a very limited sale in this country, and that it was written so exclusively for New Zealand conditions as to command no sale at all elsewhere. It has, however, recently been suggested that portions of it had a certain popular interest and should be printed for popular use. These parts have therefore been altered in arrangement and simplified in form, without, I hope, making them entirely unsuitable for use as an adjunct to a formal course in agricultural zoology.

I had prepared a complete list of references, but these would now be quite out of place. Instead, I have introduced into the text the names of Reid, Cockayne, the Kirks, Miller, Reakes, and Tillyard, so that the people who never read prefaces may learn at least the names of those to whom our knowledge of this subject is due.

F.W.H.

Lincoln,
January, 1924.

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Farmers' Foes in New Zealand

Chapter I.

INTRODUCTION.

The animals that are most commonly injurious to farm crops and stock belong to four groups, namely, Flat worms, Round worms, Insects, and the degenerate spiders called Mites and Ticks. The class of Insects, however, comprises four-fifths of all living creatures, and it is, therefore, not surprising that it contains most of the animals injurious to the farmer, nor that there are great diversities among them as to their habits of life, their modes of reproduction, and the means that can be adopted to check their ravages.

An outline classification of insects can be constructed from a consideration of their wings, their mouth parts—that is their method of feeding, and their mode of reproduction—whether they are born alive or as eggs, whether there are caterpillar or grub stages, or whether the young are like their parents.

(1) Most insects have two pairs of wings, though in the great order of true flies these are reduced to a single pair, and in many important groups scattered through various orders, wings are entirely absent, *e.g.*, fleas, true lice, plant lice, scale insects, etc. Certain insects usually wingless become winged at special seasons of the year, and this may be of great importance, as for example, when the wingless cabbage blight becomes winged in autumn, and spreads far and wide to lay its eggs for next season's crop. When two pairs of wings are present, they may be all alike, as in the

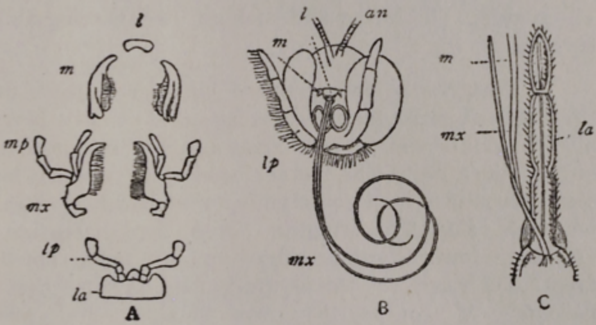
moths and the bees, where all are used for flying, or the front pair may be used merely to protect the hind ones, which alone are membranous and capable of the movements of flight. Thus in the beetles the front pair of wings are horny sheaths often as hard as armour, while the flying wings are membranous, double as long as the front pair, and folded up fan wise and then cross wise so as to tuck under the sheaths. In the locusts and cockroaches the front wings are merely horny, and the second pair not much longer than the first, so that they can be folded straight, and yet receive adequate protection from the sheaths; while in the bugs only the inner half of the front wings is made horny or leathery. These wing characters have been used for naming the various orders of insects—the Greek word *ptera* (wings) with some prefix being used to describe each of the eight orders. Thus the beetles are called coleo-ptera (sheath-wings); locusts, etc., are called ortho-ptera (straight wings); and bugs, etc., are called hemiptera (half wings); all of which terms are explained above.

The variations in wings may be summarized as follows:—

1. No wings.
2. Two wings.
3. Four wings.
    (*a*) all alike.
    (*b*) half the front ones hardened.
    (*c*) the front pair hardened all over.
        (1) the back ones folded straight.
        (2) the back ones folded and then bent over.

(2) The feeding apparatus of insects naturally varies greatly with their manner of life. The jaws bite

sideways and are derived from several pairs of legs crowded round the mouth and modified for different purposes. At least three pairs of legs have been involved in this change, and in the simplest insects such as the native wetas their leg-like form is still discernible. The pairs are called by the names mandible, maxilla, and labium, and while the mandibles are usually strong biting jaws, the other two parts often serve the function of forks to hold the food up



MOUTH PARTS OF INSECTS.
A. Biting mouth. B. Sucking mouth of a moth. C. Piercing and sucking mouth.
l. the upper lip. *m*. the mandibles. *mp* and *mx*. the maxillae. *lp* and *la*. the labium.

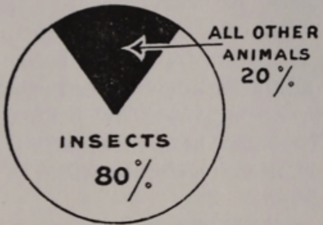
to the mandibles, which tear it to pieces. All the lower insects have these simple biting jaws, and so have the beetles among the higher orders. In other groups each maxilla is modified into a hollowed canal, and the canals from opposite sides being placed face to face a tube is formed up which liquid food can be sucked. Pure sucking mouth parts are found in butterflies and moths, although the caterpillar from which they emerged had biting mandibles. In other groups the labium forms a tube, and the parts of the maxillae form lancets which work within the tube, so that the skin of a plant or animal may be pierced and its juices sucked. This is the case in mosquitoes, plant lice, etc.

It is clear that the method of feeding must have a great effect on attempts at control. An insect that sucks juices of plants cannot be poisoned through its food, but must be killed by a contact spray: a moth can be poisoned only in its caterpillar stage, while an adult beetle may be as easily poisoned as its larva.

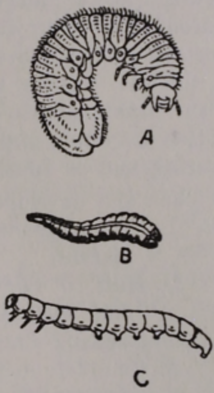
The mouth parts of insects then may be (1) biting, (2) sucking, (3) biting and sucking, (4) piercing and sucking.

(3) Most insects are produced by their mothers in the form of eggs, though they are occasionally born alive, as can be seen by examining a turnip or rape leaf any summer day. The mother aphis may usually be seen surrounded by a dozen young ones, and may often be seen actually bringing forth her offspring. In the lower orders the young that hatch from the eggs are structurally similar to their parents — of course they are smaller, and are usually wingless, but they have the same general form. This is expressed by saying that there is no metamorphosis, in contradistinction to the striking metamorphosis we are familiar with in the flies, butterflies, etc. In the complete metamorphosis of the four highest orders, the young that hatches from the egg bears no resemblance to its mother. It is usually worm-like in form, and is called a *larva*, this being a common name for a young animal structurally different from its parent. Thus the egg of a fly hatches out into a *maggot*—headless and footless, usually white, living on decaying matter, and moving by wriggling. The egg of a butterfly or moth hatches into a *caterpillar*. It has a distinct head and biting jaws, three pairs of jointed legs on the first three

segments, and a varying number of fleshy foot stumps on the hinder segments: it usually lives on leaves of trees, and is coloured brown or green in harmony with its surroundings. The egg of a beetle, or of a bee or wasp, will give rise to what is called a *grub*. The grub of a beetle has biting jaws, and three pairs of legs, but no foot-stumps, while the grub of the bee



Proportion of number of insect species to species of all other animals (after Miller).



VARIOUS LARVÆ.
A. grub. B. maggot.
C. caterpillar.

Arrangement of wings in a beetle.

and the wasp has no legs. It is usually white, and lives in concealed positions.

Whether the larva is maggot, grub, or caterpillar it feeds voraciously, and grows, by repeatedly throwing off its hard outer skin. These more highly organized insects do all their growing in their larval stages, and never grow at all when once their adult form is reached. When the larva is fully fed it goes into a resting stage and becomes a *pupa*, where its skin hardens round it, and profound structural changes take place. When it emerges from the pupa stage it is found that it has in one step become an adult.

Between the most lowly insects where there is no metamorphosis, and the highest where there is this complete metamorphosis characterized by a resting or pupa stage, is an intermediate stage of development, which is found in the dragon flies and other members of that order. The young is a larva — that is it is unlike its parent, but every time it throws its skin it becomes somewhat more like the adult, and never goes through a definite resting stage accompanied by profound structural changes. The stage before the adult is called a *nymph*, and it is an active form instead of a resting one as in the pupa.

Thus the development of an insect may show:—

1. No metamorphosis—the young is like its parent.
2. Half metamorphosis—Larva unlike parents but changing gradually with no definite resting stage.
3. Complete metamorphosis. The larva is a grub, caterpillar, or maggot; then there is a definite resting stage—the pupa—preceding the emergence of the adult.

Using our knowledge of an insect's development, the structure of its wings, and of its mouth parts, we are able to build the following scheme of classification:—

Class Insecta.

Order I.—Aptera (*a*—without, *ptera*—wings).

No wings, biting mouth parts, no metamorphosis. Small simple insects, including the Springtails and Silverfish. This order is often divided into two.

Order II.—Orthoptera (*orthos*—straight, *ptera*—wings).

Usually two pairs of wings, the front ones leathery and the hind ones membranous and used for flying. The hind ones folded straight when at rest. Mouth parts biting. No metamorphosis. Large insects of primitive structure, including Locusts, Grasshoppers, the Mantis, Stick insects, Wetas, Earwigs.

Order III.—Neuroptera (*Neura*—nerves, *ptera*—wings).

The wings are four, all alike, and covered with a network of nerves. The mouth parts are biting. The metamorphosis is incomplete, the active nymphs usually living under water. The Dragon flies, May flies, etc. (The Bird lice also belong here.) This order may be divided into six or eight, but the groups are of little agricultural importance.

Order IV.—Hemiptera (*Hemi*—half, *ptera*—wings).

The wings are various, but in the bugs the inner half of the front wings only is hardened. The mouth parts are developed for piercing and sucking. There is no metamorphosis or occasionally (in the Cicadas and male scale insects) a simple one. The order includes the destructive Aphids and Scale insects, as well as the Bugs and Cicadas, and the True Lice.

Order V.—Diptera (*Di*—two, *ptera*—wings).

The true flies. The back pair of wings is reduced to a vestige. The mouth parts are developed for piercing and sucking, and there is a complete metamorphosis, the larva being a maggot. Two-winged flies of all sorts, including the so-called sheep tick and the fleas, which are sometimes placed in a separate order.

Order VI.—Coleoptera (*Coleos*—a sheath, *ptera*—wings).

The Beetles. The front pair of wings are horny sheaths, and the back ones are folded and bent over. The mouth parts are purely biting, and the metamorphosis is complete—the larva being a grub. By far the largest order of animals known. There are over 3,000 kinds native to New Zealand.

Order VII.—Lepidoptera (*Lepidos*—a scale, *ptera*—wings).

The Butterflies and Moths. Four wings all alike, and all covered with feathery scales producing patterns. Mouth parts adapted purely for sucking. Metamorphosis complete, the larva being a caterpillar with biting jaws.

Order VIII.—Hymenoptera (*Hymenos*—a membrane, *ptera*—wings).

The ants, bees, wasps, ichneumons and chalcids. Highly organized insects, often living in colonies, and many of them parasitic on the lower orders. Two pairs of wings, all membranous, and used for flying. Mouth parts biting and sucking. Metamorphosis complete, the larva being a grub.

Closely allied to the Insects are the spiders. The ordinary spiders must all be considered as useful to man, because they feed upon insects which, as a general rule, are injurious. The degenerate spiders called Mites and Ticks are, however, nearly all injurious, many of them forming serious external parasites on the domestic animals. Spiders in general can be distinguished from insects by their having eight legs, while the insects have but six.

Chapter II.

INSECTS DESTRUCTIVE TO TURNIPS, RAPE, ETC.

With turnips and rape are to be included the other cruciferous plants such as swedes, cabbage, kale. These together cover over three-quarters of a million acres in New Zealand each year, and so make one of our most important crops, being rivalled only by oats, though this crop is now declining in importance.

Cabbage Aphis.—On all the crucifers there is to be found in summer and autumn a small insect usually called "Blight" or "Fly," although this latter name is also applied to another insect that attacks the turnip in its young stages. To this blight we shall give the name of Cabbage Aphis. As it appears in summer or early autumn it is about one-twentieth of an inch long, wingless, and covered with a grey mealy powder. This powder is waxy in its nature, and prevents the insect from becoming wetted with rain. The aphis is never seen to eat the leaves, but it sucks the sap, and when in great numbers causes the leaves to turn yellow and wilt away. Often a large aphis may be seen surrounded by ten or more small ones, and this is just what it looks like, namely a family group. The large one is the mother, the small ones the children: there is no father, these young being produced by the mother alone—a phenomenon which is known as parthenogenesis. All the young ones are females, and in from ten to twenty days they are sexually mature, and produce young in their turn. Taking the period of active reproduction as from November to March, a simple calculation will show that a single individual will multiply a million fold during those months. Each aphis sticks its proboscis into the leaf and sucks the sap, so that it is little wonder that by the time autumn comes the plant is quite dead.

In the days of later summer and early autumn there appear among the common wingless forms a few dark slender individuals with long transparent wings. These become increasingly common, and often take flight on suitable days, and fill the air with their drifting multitudes. At this stage males appear, and they fertilize the winged females, which again take wing and, scattering far and wide, lay thick walled eggs which resist the winter cold, and next spring hatch out into the wingless females with which we started. This is the life history reduced to its simplest terms, and without regard to the subsidiary generations that may be intercalated among the main ones.

Cabbage aphis appears to show preference for our cruciferous crops in approximately the following descending order: Swedes, Brussels sprouts, kohl rabi, common cabbage, rape, turnips, kale. It seems to have much the same appreciation of flavours as human beings and sheep, for it attacks first the more delicate among the cabbage group, and takes rape much worse than kale. This fact greatly limits the utility of a "blight proof" rape or turnip, for if the aphids disliked its flavour, sheep would probably dislike it too. The same fact further explains the widespread use of rape instead of kale, although rape is often entirely destroyed, while kale growing beside it is practically unharmed.

Cabbage aphis thrives best in dry climates and seasons, and, as drought retards the growth of rape, etc., these plants suffer doubly in such conditions. Thus the variety of cruciferous crop profitable in any locality is determined by the amount and incidence of the rainfall either directly, or indirectly *viâ* the aphis. Generally speaking swedes cannot be grown in New Zealand where the rainfall is much under 50 inches, and in such localities, too, the finer cabbages, such as Brussels sprouts, are a very uncertain crop.

The bacterial wet rot of turnips, which causes the whole root to turn into a yellow squashy mass, shows itself in winter after the leaves have been destroyed by aphis. This disease is almost without doubt carried from plant to plant by the insects, and so the loss from this cause must be laid to the charge of the aphis. The wet rot is much less harmful to swedes than to soft turnips, and this is probably because the collar or neck of the swedes allows the aphis to be washed off the root, while the hollow at the top of the turnip allows the insect to shelter and work there and so infect the root.

Cabbage aphis is much commoner here than in England, and is doubtless our most destructive insect. Counting together the actual destruction of crops, the inhibition of growing swedes in the drier areas, and the transference of bacterial soft rot, it is probable that the annual average damage done considerably exceeds one pound sterling per acre, or say £1,000,000 a year.

On a large scale, as on an ordinary farm, it is impossible to kill the aphis—all that can be done is to modify the farm operations, to grow the varieties least attacked, and to depend for winter feed less upon turnips and more upon such crops as Algerian oats, Cape barley, and Italian rye.

The facts that every aphis dies every winter, and that it can travel only in its autumn winged form, are responsible for two important points in the farm management of cruciferous crops in aphis stricken areas. The first is that if a field of turnips has been badly attacked by aphis, yet it is perfectly safe to follow the turnips by rape, and the new crop will not be attacked worse than if it were sown on any neighbouring field. This is because no living aphis will be left in the field attacked, and because the winged egg-laying females in autumn are as likely to have laid their eggs on a neighbouring field as on the one from which they were hatched. The second point is that all crops are likely to reach a certain stage of development before the aphis becomes destructively prevalent, while after that stage the damage will proceed with accelerated velocity. This is because each crop can be attacked only by the aphids that hatch out of the soil on which the crop is sown, and therefore the attack must take a certain time to develop. If, therefore, a crop can be fed off at a certain stage—dependent on its own age and not on the time of year—the full advantage of the crop may be obtained, while if it stands a few weeks longer it may be ruined. This has caused the adoption in certain districts of the excellent practice of sowing rape in breaks—five to ten acres at a time at intervals of a fortnight or three weeks—so that the sheep may be turned on to each break when the rape is just at that stage of maturity as to give a fair bulk of feed, but not to have allowed an excessive accumulation of aphids. Sheep will eat aphis-covered rape and turnips, but it cannot be supposed that such feed is good for them, or that it does not diminish the palatability of the fodder. The close feeding off of an infected area, however, exterminates the aphis, and allows the second growth—such as it is—to come away practically free from blight.

On a small scale, as in kitchen gardens, aphids are easily killed by a spray of kerosene emulsion made as follows:—Dissolve two ounces of soft soap in one gallon of water by heating it, and then gradually pour in two gallons of kerosene vigorously churning the while, by squirting the mixture back into itself through a spray pump or syringe. A thick creamy emulsion will result, and this will keep indefinitely without the kerosene separating out. Just before applying to cabbages, etc., dilute the emulsion with fifteen times its volume of water. Another and perhaps simpler spray is "Sox," and another is "Black leaf 40," which can be bought ready for use at many hardware merchants. The cabbage aphis is preyed on by numerous parasites, but these multiply slowly relatively to the rapid rate of increase of their host. Towards autumn, however, the parasites get the upper hand, and they, together with the falling temperature, exterminate the aphids with startling rapidity, the whole multitude of them sometimes being killed off within a couple of weeks. The most efficient parasites seem to be two fungi, one of which leaves the aphis as a dark green patch hardly recognizable as an insect, so completely has the mould pervaded and surrounded it. The other turns its host into a white fluffy mass. Next to the fungi in efficiency is a small chalcid, a wasp-like insect, which lays its eggs within the aphis. As the parasite develops it causes the host to swell and become a shiny brownish grey in colour, the chalcid finally escaping through a round pin hole plainly visible on the back of the dead aphis. The yellowish brown maggot of a hover fly, and the similarly coloured but very active larva of Micromus, an insect related to the dragon flies, may also be found feeding on the cabbage aphis, but neither of these is sufficiently numerous to produce much effect upon the pest.

Diamond Back Moth.—This is a very common and destructive moth, occurring in thousands among turnips, rape, cabbages, etc., though its quick darting flight often causes it to be overlooked. The wing span is about half an inch, and on the back margin of each is a whitish marking with zigzag edges, so that

Diamond back moth, adult caterpillar and cocoon. All both natural size and magnified. (After Theobold.)

when the two margins approach each other, as in the position of rest, a series of diamond shaped markings are formed running down the insect's back.

The female lays her eggs, about twenty in number, on the leaves of turnips, etc., and from these caterpillars hatch out after about nine days. The caterpillars eat voraciously, living and feeding on the under side of the leaves, or especially in the heart of the host plants. The middle tissues of the leaves having been eaten, the upper epiderm breaks away as it withers, leaving large holes, which, becoming confluent, show considerable areas of the leaf to have been eaten. By the time they are full grown the caterpillars are about half an inch long, and green or somewhat reddish in colour. They move with a slow creeping, or a quick wriggling motion, and frequently drop themselves by a silken thread to the ground. After feeding for three weeks the larvae pupate, spinning for themselves open network silken cocoons, which are fastened to the undersides of the leaves. After about seventeen days the pupae emerge, as perfect moths, which appear not to feed at all, and the females of which lay their eggs on the third to the seventh day of their lives. The complete life cycle thus occupies about fifty-three days, or say eight weeks.

The moth is common in England, where it does damage extensive enough, but apparently not to be compared with what is often experienced here. It is a common thing to see whole fields of turnips with their leaves stripped to the midrib. As a result the turnips cease growth at the root, and put forth new leaves, which, drawing on the scanty supply of stored up food, leave the root almost valueless as fodder for stock. The loss due to diamond back moth is hard to estimate, since it is usually combined with loss due to aphis, but it probably runs to £500,000 per annum.

No means of checking the increase of the moth has been reasonably successful. In the kitchen garden the most serious damage is done to cabbages, etc., planted out in autumn for winter development, because at that time of year the insect is very plentiful, and the small plants are easily destroyed. Arsenical sprays alone are useless, but combined with kerosene emulsion so as to distribute the poison over the waxy cabbage leaf some success is achieved. Probably the best material to use is "Black leaf 40" or "Sox." It costs only about 1d. a gallon as applied, and if sprayed on with force it kills wherever it touches.

The great destruction in the fields is partly due to our growing cruciferous crops in our gardens. The moth spends the winter in the pupa stage or possibly as the moth, but at any rate moths may be seen flying as early as the first of September. Each female living then may have a progeny of 200 moths by January first, and these spreading from the gardens to the fields lay their eggs on the young turnip crops just in the rough leaf. If it were not for garden grown cabbages, etc., there would be no food for the grubs during the spring and early summer, and so but few moths would attack the main crop in autumn. This is the reason why fields of turnips in isolated localities are free from diamond back moth.

Brown Beetle or Grass Grub. This well-known insect is most commonly associated in the minds of farmers with its depredations in its grub stage on the roots of grass, and it is therefore as a pest of grass that it will be fully described.* In its adult or beetle stage, however, it feeds ravenously during the nights of November and early December—choosing chiefly warm mild nights. It is common to see the leaves of plums, willows, etc., all jagged edged from the attacks of these beetles, and on some occasions millions may be seen feeding in orchards. The few weeks during which the adult beetles feed coincide with the appearance of the young turnips above the ground, and so turnips in the smooth leaf stage form one of the common foods of the brown beetle. This damage is usually ascribed to "fly"—because in England a small beetle called turnip fly feeds on the turnips in a similar stage. This "fly" has, however, probably never been introduced into New Zealand, and if it had it would not be likely to have been seen

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See page 25.

by farmers, as it is only one-twelfth of an inch long.

When turnips are taken by brown beetle the only remedy at present adopted is to sow the crop again, and it is a common experience to have to sow even a third time. If in any locality such experiences become very frequent it is a sure indication that the turnips are being sown too early, and that the feeding stage of the beetle in that particular locality must be allowed to pass before it is safe to sow.

The beetle attacks mangels as well as turnips, and it may easily be seen on the leaves at night with a good light such as an acetylene bicycle lamp.

Chapter III.

PARASITES OF THE CEREALS AND GRASSES.

Hessian Fly.—This minute insect is shaped like a miniature Daddy Longlegs, and is only about one-twentieth of an inch long. It lays its eggs on the leaves of wheat and barley (not oats) in early spring, and the maggots that hatch out crawl down the blade and ensconce themselves between the leaf sheath and the straw at about the second knot from the ground. There they suck the sap from the tender straw, and thereby cause a shrivelling of the grain. As the straw hardens the maggot goes into the pupa or resting stage, when it is reddish brown in colour, one-fifth inch in length, and not unlike a small grain of linseed. At the same time the weakened straw often breaks or bends at the point of the maggot's attack, and this injury is the first sign the farmer has of the presence of Hessian fly in his crop. Search for the cause of the injury will almost always reveal the linseed-like pupa, which is thus by far the best known stage of the insect's life history.

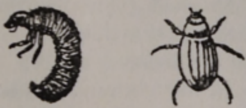
These pupae remain in the stubble, or are carted and threshed with the straw, depending on whether they happen to be below or above the binder cut. In either case they produce young Hessian flies to bring forth, either in the same autumn or next spring, a new generation of destructive maggots.

Hessian fly can nearly always be found in the wheat and barley growing districts, but it is rarely that it causes sufficient damage to necessitate the adoption of remedial measures. For many years in succession it attracts no notice, and then suddenly it will cause damage amounting to one or two or very occasionally to six or eight bushels per acre.

While cure of an infected crop is impossible it is easy to kill the pupae and prevent a recrudescence of the pest next year. The stubble should be cut either very short, and then the straw and chaff burnt, or very long, and then the stubble itself burnt. The former way is probably the easier, and is practicable with low quality straw such as that of barley; while the latter is the more effective if a good burn can be secured. The prospective value of the straw and the ease of securing a stubble burn are the deciding factors.

It is to be noted that oats are immune from attack.

Wheat Eel Worm.—Among the grains of certain samples of wheat may be found black balls, rounder and somewhat smaller than the wheat grain but obviously derived from it. These diseased grains are much like the seed of the common European weed named corn cockle, and therefore the disease is often called "ear cockle" in England. If one of the diseased grains is cut open, its skin will be found to be thick and tough, and to contain a small quantity of a white substance rather softer in consistency than the starch that should fill the grain. If this white material is placed in water and examined under the microscope it will be found to consist of thousands upon thousands of immature eel worms all tangled together, and usually showing movement in the water. If such a grain is sown the outer husk rots, and the



Grass grub, and the brown beetle its parent. Natural size. (After T. Kirk).

Eel worm of wheat and diseased grains, greatly magnified. (After Theobold).

The "Caterpillar," and its parent moth. (After Hudson.)

young worms are liberated into the soil. They penetrate the stems of the surrounding plants of healthy wheat, and ascend them during the growing period. When the wheat plant flowers the worms enter the forming grain and there become sexually mature; by this time they are about one-eighth of an inch in length. The sexes pair, and the females lay about 1,000 eggs each, the eggs soon developing into the young worms that fill the grain as it ripens.

Wheat eel worm is increasingly common in New Zealand, and diseased grains may always be found in the cleanings of wheat at the flour mills. The commonly adopted practice of periodically sowing machine dressed seed doubtless keeps down the disease to a considerable extent. If wheat containing a small quantity of ear cockle is used for seed in two or three successive seasons the disease may assume serious proportions; for instance, in about 1910 there was received from Timaru a sample of wheat containing 12% of ear cockle. Millers are careful to remove diseased grains, as their presence is fatal to the quality of the flour.

Prevention of the disease consists merely in refraining from sowing seed in which any diseased grains are to be noticed, or in having them removed by running the seed through the cylinders to be found in every good seed cleaning plant.

Caterpillar, or Army Worm.—There is a heavily built, grey, night-flying moth common in our lighted rooms on summer evenings. It is named *Melanchra composita*, and is a native of New Zealand.* It lays its eggs among the grasses and produces a caterpillar about an inch and a half in length, and of a delicate yellowish brown shade, marked with faint longitudinal lines. These caterpillars are sometimes exceedingly numerous, and appear to move in definite directions, whence some have called them by the American name of "army worms." They are found in grass paddocks and in crops of oats and barley. The grass is eaten probably in large quantities; in oats the branches of the heads are eaten off: and in barley the whole heads are nipped off, the damage usually taking place just before the crop is ripe, but often continuing after the grain is in stook. The caterpillar is so well protected by its colour that its presence in a field is often not suspected till the damage is done, and sometimes not till the mangled

*An American species (*Cyrphus unipunctata*), also occurs in New Zealand and is very destructive, particularly in the South Island.

insects smear the canvasses of the binder or block the riddles of the threshing machine.

No plan has ever been adopted for saving a crop when it is once attacked, and preventive measures are hardly justified by the severity of the attacks now experienced. In the early days "the caterpillar" was much more common than it is now, although it is still plentiful in the North. Ditches several feet in depth and width are pointed out as having been seen full of caterpillars, and there are well authenticated stories of their having held up railway trains owing to making the lines slippery with their crushed bodies. In such times preventive measures were very commonly adopted, and consisted chiefly of ploughing a furrow across the line of march with its steep side towards the threatened field and then running a roller along the furrow when sufficient caterpillars had collected; or in driving mobs of sheep to and fro over fields or along roads where the armies were marching. The grand scale preventive measure, however, consisted in the introduction of insectivorous birds, a plan that has been so successful as to have relieved us now of all but sporadic attacks. The utility of birds and the possible recrudescence of the caterpillar pest was made evident a year or two ago in South Canterbury, where a flock of sea birds was noticed for several days on the bank of a water-race. Inspection disclosed an army of caterpillars on the march blocked by the water-race, and the sea birds taking full advantage of the blockage. They were eating their fill, vomiting it up, and eating their fill again.

The Grass Grub or Brown Beetle.—This is one of our commonest beetles, and one of our most destructive insects to introduced crops, though itself a native of these islands. The adult beetle is about half an inch long, oval in shape, brown in colour, and may be seen and heard in large numbers on the warm evenings from the first week in November till the end of December. It apparently spends the daylight hours hidden among the grass, and just at dusk "wheels its droning flight" towards its feeding grounds, which are orchards, willow trees, turnip, and mangel fields. It feeds all night upon the leaves, and while the harm it does to grown trees is but negligible, its effects on turnips and mangels are often disastrous (p. 20).

The eggs are laid at the roots of grass, the longest grass available being most favoured. The grubs hatch out, and, burrowing into the earth, begin to eat the roots, and by May they have grown so strong and eaten so much that their presence in the soil is made evident by the death of the grass on the surface. The grubs are at this time about three-quarters of an inch long, white in colour, with brown heads and strong biting jaws; the body is clumsy and strongly curved, the last two segments being swollen and dark in colour owing to the earth contained therein. In burrowing through the soil they make it very friable, so that a horse may sometimes sink up to the fetlocks at every step while travelling across a dry grass field. The grass is completely killed, and may be scraped away in large sheets by a sweeping action of the foot. The extent of the damage has never been measured, but the area of grass destroyed each year in New Zealand must run into many thousands, or perhaps tens of thousands of acres.

From May till September the affected areas increase in size, and then the grubs feed less actively and the grass grows more vigorously, so that the damage ceases. By the first week in October the majority of the grubs pupate (though a few remain over till next season) and of course eat no more. The pupal stage lasts about six weeks so that the adults emerge early in November.

This is the life history of the vast majority of individuals, though isolated specimens may show wide departures from the average. The efforts to control this insect may be directed towards the grub, the pupa, or the adult.

While in the ground the grub is quite secure. No application of foreign matter will kill it without killing the grass as well. Rolling is quite useless either for killing the grub or for preventing its travels; for example, a few grubs may be laid on the soil, covered with say a quarter of an inch of loose earth, and then tramped on with one's whole weight, without inconveniencing them in the least; and, again, grub patches may be seen to spread over marks left by the wheels of traction engines. Where rolling has been reported as beneficial then the action must have been not injurious to the grub, but beneficial to the crop. The rolling of a grub infested cereal crop will press the earth round the damaged plants and allow them to strike fresh roots, while the fact that grass laid down with oats is sometimes found to persist only where the big wheel of the binder has passed, is explained by the greater vigour of growth where the compression has induced water to travel up to the roots of the moisture-starved grass. Cold will not kill the grubs, as they have frequently been frozen stiff and brittle, and then crawled away as soon as thawed out. They will also survive a considerable period of immersion in water-logged soil. The only means of destroying them is to encourage gulls, starlings, and mynahs to follow the plough when turning over lea land in winter; but while one is glad to see them follow the plough, means of encouraging their presence are not very obvious. Starlings will also scratch and bore in unploughed land in search of grubs.

In the pupal stage *Odontria* still cannot be hurt while it is buried, but it is very vulnerable to any attack that disturbs the soil; while the grub is very difficult to crush the pupa is fragile to the highest degree, and the mere passing of the plough through the ground kills a large proportion of them. Working the land in October then, does not free the land from grub, for its period of destructiveness is passed, and it would leave the soil in November in any case, but such working kills large numbers of pupae that are potential beetles, ready to lay eggs in December to infest next winter's grass land.

The practice of ploughing badly grub eaten pastures in spring as a preparation for rape drilled in October or November is one of the best means of controlling grass grub.

In the adult stage the beetle may both be prevented from laying her eggs, and may in certain cases be killed. It was mentioned earlier that the eggs are most frequently laid in the longest grass, and the many times that fields shut up for hay cut in December are next season badly grub infested is sufficient proof of this. Of two adjacent fields or farms the one fully stocked and the other understocked in December, the understocked one will always be found the worse attacked by grub next winter. Another example of this is the fact that grass laid down with rape is comparatively free from grub next winter, just because the grass is not long in December, and the lambs feeding the rape then trample the eggs and so prevent their developing.

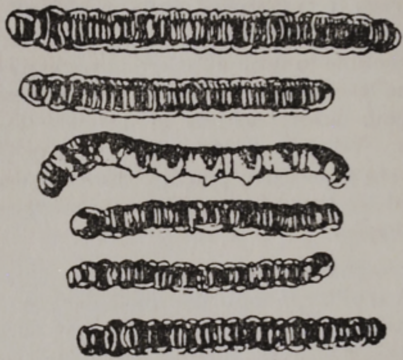
In certain localities the beetles fly freely to fires lit just at dusk on warm evenings in November and

December. In the Ashburton and Rangitata districts this plan is particularly successful, and there was exposed to view in Christchurch a few years ago a sugar bag full of partly burned beetles that had been scooped up from round a burnt pile of gorse; the totally burnt beetles must have been still more numerous. There are many reports of equally successful trials of this method, and yet in other localities where the plan has been given the most elaborate and careful trials it has proved quite resultless.

Italian and perennial rye grasses are amongst the most susceptible to grub attack, and perhaps cocksfoot among the least, and this fact might be kept in view when laying down pastures in districts where grub is serious. When a paddock otherwise in good condition shows grub eaten patches, these may sometimes be covered by broadcasting and harrowing in a little seed in October.

Porina.—This has been called "The Subterranean Grass Caterpillar," but the zoological name is so much shorter and simpler that it might be generally employed. We have nearly half a dozen native Porinas, but their habits are so similar that they will be described as one.

They are moths, greyish brown, strongly built, an inch or more in length, and commonly fly into our lighted rooms from early summer onward. Their eggs are apparently laid in the grass, for in autumn and winter their caterpillars are common in the soil, whence they emerge at night to feed upon the grass. The caterpillars reach a length of over two inches. and are mottled brown and dark green in colour. They make their presence known in a field by little heaps of castings somewhat larger than the ordinary worm castings, and differing from them in being powdery instead of cemented together into a more or less cohesive mass. The boring into the soil which results in the extrusion of these castings is doubtless beneficial, but the habit of eating the grass is distinctly injurious. Like most caterpillars they are voracious feeders, and when at all numerous they clear the grass right out, leaving the soil bare. Their superficial effect is then much like that of the grass grub, which is often blamed for the ravages of porina.



Caterpillars of *Porina*: natural size. (From Cockayne.)

With the caterpillar, however, the grass is bared off, and does not lie dead on the surface, the ground is not left spongy, and finally, the castings are perfectly obvious.

In about October the caterpillars pupate, forming a somewhat hard, brown, wriggling pupa. In November these work themselves out of the ground, and the moth emerges, leaving the empty pupa case a conspicuous object lying on or protruding from the surface of the soil.

No method of control suitable for farm practice has yet been devised. Their habit of feeding on the surface at night made it at first appear that rolling attacked fields after dark would kill out the caterpillars, but they are excessively shy, and rapidly withdraw into their burrows when disturbed by light or noise.

On lawns, etc., Cockayne has found good results from emulsifying three parts of carbon bisulphide and one part of phenol, then using two ounces of this mixture in two gallons of water and applying it through a watering can to one square yard of grass. More recently he has used arsenate of lead in considerable quantities as this does not hurt the grass but poisons the top layers of the soil.

No natural agents, the encouragement of which might reduce Porina, have been noted, except that the moths are strongly attracted to light, and that the caterpillars are always drowned and lie dead in the pools of fields flooded by heavy rains.

Chapter IV.

INSECT PESTS OF COMMON FRUIT TREES.

Note.—The pests here described are treated from a farmer's, not from a fruit grower's, point of view.

Codlin Moth.—This is an introduced insect which is best known in its caterpillar stage, when it lives inside the fruit of the apple. The adult is a small moth of about three-quarters of an inch wing span, with brownish fore-wings each showing a bright copper-coloured spot near the tip. The moth is common in orchards from October to December, laying her eggs on the forming fruits. The caterpillar hatching out from the egg eats its way to the core of the apple, usually entering from the calyx end. It lives within the fruit for several months, in some localities showing no sign of its presence, but elsewhere boring a hole to the cheek of the apple through which its droppings are passed out. Sooner or later, however, this hole is always bored, and the caterpillar leaves the apple, lowering itself to the ground by a silken thread, if indeed the apple has not already fallen prematurely owing to the internal injury it has suffered. On its escape the larva, now half an inch long, and pale pink in colour, seeks

Codlin moth. Natural size. (After Theobold.)

a suitable place for pupation, either under a tuft of grass, or much more commonly under the bark of the tree, whose trunk it re-ascends. Here it spins a dirty white silken cocoon; some of the grubs change immediately to pupae from which a second lot of moths emerge, but others do not pupate until the following summer when the moths emerge to lay their eggs just after the petals have fallen.

In the case of orchards where rough grass is allowed to grow, fowls and pigs turned out among the trees account for large numbers of the caterpillars as they escape from the apples, and from a farmer's point of view White Leghorn fowls and Berkshire pigs are the most efficient spray pump.

In cultivated orchards the caterpillars may be trapped as they ascend the trees by tying near the ground folds of cloth or sacking, under which the caterpillars pupate; if the bands are placed in position early in January, and burnt in April, very many pupae will be destroyed. Much the most common method of attacking the codlin moth is, however, to spray with arsenate of lead, stirring three pounds of the paste thoroughly with one hundred gallons of water. To be completely effective the spray must be applied thrice, first shortly after the petals have fallen, and twice thereafter at intervals of three or four weeks. Arsenate of lead is a poison, and the caterpillar entering the apple takes a bite of the arsenate left upon the fruit. This spray may be mixed with lime-sulphur commonly used for Red Mite (v. p. 37), which is usually to be found on apple trees, so that both pests may be checked in one operation.

Woolly Aphis or American Blight.—This little insect lives on the bark of apple trees, on which it produces gnarled swellings and cracks, within which the aphis lives. On casual inspection the cracks seem to be filled with a white down, but on closer examination the down is found to consist of waxy threads growing from and almost obscuring a dark coloured slow moving aphis, not unlike that found on the cabbage. Mature and young females may be found in company, the winged males being rarely seen. The young insects leave the crack where they were born, and ascend the tree to find a place where the bark is thinner. Here they suck the sap and produce boil-like swellings, which develop into a new series of wounds. During the winter many of the aphids descend from the stem, and, entering the ground, live on the roots of the trees. This has led to the practice of grafting nearly all our apples on to Northern Spy or Majetin stocks, these two varieties having sap that is most distasteful to the aphis. The parasites are thus forced to spend the winter above ground, and so a good many are killed by cold, though most of them, especially in the North Island, find sufficient shelter in the cracks that their attacks have produced in the bark of the tree.

Some of the best apples, for example Cox's Orange Pippin, are particularly susceptible to woolly aphis. Others, such as Northern Spy, are practically immune. Winter spraying with red oil emulsion, one in ten, is the generally recommended procedure, though it must be confessed that the results leave much to be desired. The treatment is the more effective as the spray is applied with the greater force, so as to search the crevices in which the aphis hides. For summer use there is recommended the nicotine spray called "Black leaf 40." It must be applied with force or it will be repelled by the waxy covering of the insect, but it has the advantages that it can be used at any season of the year, and may be combined with any other spraying material in common use.

In 1921 Dr. Tillyard, of the Cawthron Institute, introduced to New Zealand *Aphelinus mali*, a chalcid parasitic on woolly aphis. Owing to the excellent methods used to prevent the liberation of parasites of the *Aphelinus* there is every prospect of the introduction proving a success. Numerous offspring of the first introduction have been captured in Nelson, and last year (1923) distributed to scattered localities throughout New Zealand. There is good hope that woolly aphis will soon be reduced to a negligible quantity.

Numbers of other aphids occur at times upon our farm or garden plants, and often destroy them entirely. There is a black one found on the peach and the apricot, and the same or a superficially similar one on the Japanese plum; a green one lives between the young folded leaves of the peach; a reddish one and a green one live on the rose; a green one on celery, and another on carrots; a black one occurs on chrysanthemums; a sooty black one, called the "collier," lives on beans and tares; a brownish black one lives on the leaves of grasses of various kinds, and a white waxy one on their roots; indeed, few of our cultivated plants are entirely immune from their attacks, while many of them suffer regularly. The aphids that are green or reddish in colour are so delicately tinted to harmonise with the leaves on which they live that the dying of the plant is often the first indication of their presence. The black ones are most conspicuous, and, as would be expected, are distasteful to birds. Many of these aphids can be destroyed, or at least prevented from doing damage by merely washing them off their host plant by a spray of water applied with force. When this fails soap suds made with Sunlight soap may prove effective. In most cases, however, the best spray is "Black leaf 40," which kills where it touches, but which must be applied with force to the waxy form. Sox is equally useful.

Apple Mussel Scale.—This insect is best known as a small structure about one-eighth of an inch long, dark brown in colour, and shaped like a mussel shell. It is common on the branches of neglected apple trees, and in bad cases on the fruit as well. The form thus seen consists of the mature female insect and a nursery, for if it be lifted up any time during the winter it will be found full of pearly white eggs. These hatch in early November into winged males, which are rarely seen, and wingless females which are very common. These are white in colour, not much bigger than a pin's point, and provided with six legs, a pair of antennae, a pair of red eyes, but no wings. They crawl up the tree seeking for an unoccupied patch of tender bark, and in the course of this migration are fertilized by the male. On reaching a suitable spot they stick their probosces through the bark and commence to suck the sap—and will never more leave this position. Eyes, legs, and antennae thus become superfluous, and so are absorbed, while a shelter of waxy material is secreted from the insect's back—much in the same way as the woolly aphis secretes waxy threads. This shelter is many times bigger than the insect itself, and the spare space is used for the storage and development of the eggs. At the narrow end of this nursery the insect itself may be seen with a good glass, especially if the shell is first dissolved away by soaking for ten minutes in a solution of caustic potash. The presence of the proboscis may be demonstrated by prizing the insect and nursery off the bark broad end first, when the whole structure will remain dangling from the bark by the proboscis.

The adult insect dies before winter is over, but the numerous (40 to 60) young ones carry on the next generation. Trees are often smothered with them, and their development badly checked.

The New Zealand orchardist controls apple mussel scale by spraying in winter with red oil emulsion—a preparation sold by most hardware merchants with suitable instructions for its application. A very effective spray is "Woburn wash" which was evolved after most laborious trials at Woburn Abbey.

Copper sulphate	$1\frac{1}{2}$ lbs.
Quicklime	$\frac{1}{2}$ lb.
Water	$9\frac{1}{2}$ gallons
Kerosene	5 pints.
Caustic soda	$2\frac{1}{4}$ lbs.

Dissolve the copper sulphate in one gallon of water, put the lime in ten gallons of water or so, stir once or twice, and let settle. Draw off $8\frac{1}{2}$ gallons of clear lime water, and add the copper sulphate solution; now add the kerosene and churn, and a perfect emulsion will result (v. p. 17). Add the caustic soda powdered just before using. The emulsion may be made ten times this strength, and diluted just before use.

In Canterbury, at least, a chalcid has during the past twelve years been parasitising the apple mussel scale, so that it has almost disappeared from some districts.

Red Mite and **Red Spider.**—Two small spider-like mites go by these names among New Zealand fruit growers. They are smaller than a pin's head, and red or somewhat darker in colour. The red mite is very commonly distributed on apple and plum trees, and lives by sucking the sap—often causing the leaves to turn quite brown in early autumn, and giving the tree a very sickly appearance. The eggs are laid in irregularities in the bark, especially in the crinkles at the base of the fruit spurs. They are bright blood red in colour, but are so small that they cannot be seen separately except by a lens, the naked eye appearance being merely that of a red smear. The red spider passes the winter in the adult state and spins a fine web over its eggs.

Red mite is attacked by spraying in the winter with red oil emulsion or what is better, lime-sulphur, (v. p. 33), and the treatment is to some extent efficacious, since it has been proved that a three minute immersion in the emulsion is fatal to the eggs. In spraying, however, only a few eggs can receive the equivalent of a three minute immersion, so a good many hatch out in spring. They are then attacked with lime-sulphur, which kills every mite it touches. The difficulty is that when the leaves are on the tree it is almost impossible to reach every mite. Lime-sulphur is commonly mixed with arsenate of lead when this is used for codlin moth, and the repeated spraying for the moth keeps the mite well in check, as the two pests need attention at exactly the same seasons.

Pear and Cherry Saw Fly—Pear Leech or Slug.—These various names are applied to a black slimy grub about three-quarters of an inch long, living on the upper surface of the leaves of the pear, cherry, and hawthorn. The parent of this grub is a small black insect belonging to the Hymenoptera, and its egg-laying apparatus consists of a pair of saw-like structures, by means of which it cuts holes in the leaves of trees and deposits its eggs in the wounds thus made. The egg hatches out into a grub, which leaves the hole in the leaf and crawls on to its upper surface, where it eats its green parts and often does considerable damage.

Usually the fruit ripens despite the loss of green matter in the leaves, but sometimes the attack is so severe on pears as to prevent their growing to more than half size; the defoliation of cherries usually takes place after the fruit is ripe, but it must check next year's crop, and in the case of hawthorns there must be a considerable diminution of growth. When the grub is full grown, which is about four weeks from egg laying, it falls to the ground and undergoes a resting stage there; in about fourteen days the adult again emerges and lays a new crop of eggs. The adult is rarely seen, as it is only about one-eighth of an inch in length, but it is common in infested orchards. The whole life cycle occupies less than two months, and so there is more than one brood per summer.

The grubs, owing to their slimy nature, are very intolerant of dust, and T. Kirk records an instance of a hawthorn hedge being badly attacked by saw fly grubs on the side which was towards a lawn, but perfectly clear on the other side which faced a dusty street. This indicates that lime, ashes, or any other fine dust will remove the grubs, but the dust must be applied more than once. A very effective remedy is to spray with hellebore. Mix one ounce white hellebore powder with one quart of boiling water, and allow the infusion to stand for some hours. Then add sufficient water to make two gallons, and apply. This will kill every grub it touches. Arsenate of lead, prepared as for codlin moth (v. p. 33) is equally effective, but somewhat slower in its action.

Currant Clearwing.—This is a moth which will hardly be recognized as such because certain areas of its wings are transparent. Its wing span is about two-thirds of an inch, the wings dark in colour, and the body purplish black with golden rings. The moths appear in November and December, and lay their eggs on the leaf buds of currant trees. The caterpillar that hatches bores into the centre of the branch and then begins to tunnel up and down the pith, turning it black wherever it travels. At the end of September it is ready to pupate, and so bores a hole that would admit a wheat grain, through the wood to the exterior of the branch. The pupa then forms and lies in the pith cavity near the hole, and through it the adult emerges when summer comes.

Currant trees, or at least red and white currants, have somewhat pendant branches, and these frequently break where they are weakened by the perforation made by the borer. The result is a tree whose branches barely clear the ground, and from which the fruit is very difficult to gather. Since the borers are all within the stems at pruning time it is clear that they can be destroyed by pruning to below the lowest of the black tunnellings, and burning the prunings. The pest is somewhat local, and may often occur in one orchard and not in another a mile away. Thus remedial measures as above suggested are usually successful.

CHAPTER V.

INSECT PESTS OF STORED GRAIN, OF FLAX AND TIMBER.

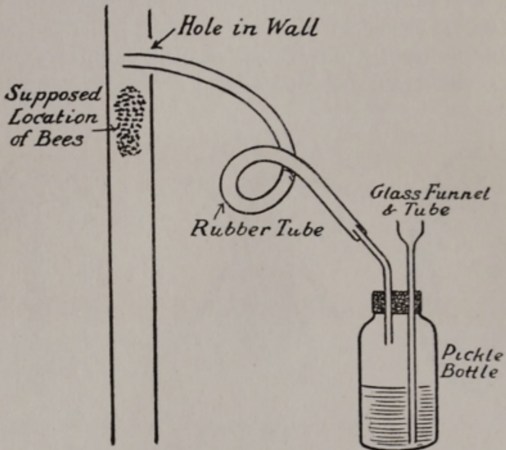
Grain Weevil.—This insect belongs to the beetle family, and is brown in colour and under a quarter of an inch in length. It attacks stored grain, chiefly wheat and barley. The female bores a small hole in the grain and lays a single egg there, and the resultant grub completely hollows out the grain before emerging through a round hole, and taking on the adult form. The perfect beetles, too, eat the grain, and so vigorous are their attacks that they rapidly destroy large quantities of it. Wheat and barley used in the same season as they are harvested are not often seriously affected, for the beetle takes six weeks to complete a generation, and that only in the warmest season of the year. Grain, however, that is held over to the next season is often rendered worthless, and instances are recorded of the weevils leaving one store and marching to another in such numbers as to make it worth while to play a hose on the streets to wash them away.

Grain weevils are easily killed by the use of carbon bisulphide, an evil smelling liquid, which rapidly gives off a poisonous vapour which penetrates to every part of the store in which it is used. The building should be tightly closed by pasting strips of paper round the crack of doors and windows, and then

Wheat Weevil.

saucers should be placed high up in the building and the carbon bisulphide poured into them at the rate of one pound of the fluid for every forty cubic feet of space to be fumigated. The vapour is heavy, and sinks to the bottom of the building, and so all cracks near the floor must be carefully closed. After twenty-four hours doors may be opened and complete ventilation secured before anyone lingers in the room or before a light of any kind is introduced—the vapour being highly explosive as well as unwholesome.

Carbon bisulphide is useful for killing any insects in enclosed spaces, such as cloth moths in cupboards, bees in the walls of houses, etc. Its heaviness, however, sometimes makes it ineffective since it may not penetrate to all parts of the enclosure. Much more deadly to insects, but equally deadly to man if carelessly used is *Hydrocyanic acid gas.* For every three hundred cubic feet of space to be treated take 1 oz. water and 1 oz. concentrated sulphuric acid,

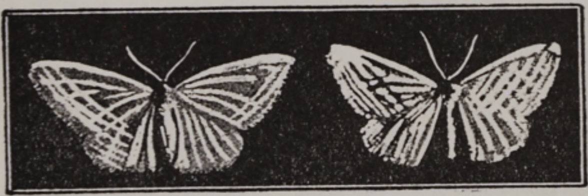


Removing Bees from Wall of House

and mix in a cup or jug—add acid to water not water to acid—never more than half filling the receptacle because of the violent frothing that will afterwards take place. Into the mixture drop one ounce of potassium cyanide. The gas that is given off must not be inhaled on any account, as a single breath of it is poisonous. The room or store thus treated must be closed and locked for twenty-four hours and then carefully ventilated before it is entered. Potassium cyanide is a deadly poison, and must be guarded with care.

This gas is most effective in all closed spaces. For killing bees in the walls of houses one uses the apparatus shown in the sketch.* The cyanide and water are mixed first, and the sulphuric acid poured in when everything is in position. This operation should be performed at night, when all the bees are at home, and also at a time when the house is empty of human inmates.

Flax Grub.—This is a pale delicate moth of about one and a half inches wing span, which has increased enormously of recent years in flax swamps. The



Moths of flax grub. Natural size. (After Miller.

caterpillars are about an inch long, and have a single pair of foot stumps. They live by day in the rolled up dead flax leaves, and at night feed upon the outer side of the flax leaves, from which they gouge out narrow strips of tissue, thus greatly injuring the fibre; the loss from this cause has been computed by Miller at £120,000 in certain years. It is considered that the draining of the flax swamps has tended to the increase of the grub, and that the best chance for its control lies in the discovery of some hymenopterous parasite.

Flax Edge Grub.—A heavily built night-flying moth, with brownish wings one and a half inches across. Its caterpillar is about one and a half inches

*As the gas is lighter than air the hole should preferably be bored below where the bees are thought to be.

long, with a pale pinkish yellow tinge and with five pairs of foot stumps. It lives by day in the rolled up leaves of the native flax, and at night crawls on to the living leaves and eats notches out of their edges, producing a very familiar disfigurement of the leaf. It is fairly common all over New Zealand, but has not become a serious economic pest.

White Pine Borer.—The destruction of timber caused by this little beetle is sometimes ascribed to "Dry Rot," although this name belongs to a fungoid disease of quite a different nature. The beetle of the borer is introduced or cosmopolitan, one-sixth of an inch long, brown in colour, oval in shape. It may be noticed on the walls and ceilings of affected houses in the month of December, and perhaps a week earlier and later. The females lay their eggs in cracks of dry timber and the grubs hatching out, bore tunnels through the wood, often reducing it to a mere shell into which a pocket knife may be thrust up to the hilt. The timber most affected in New Zealand is the white pine (*Kahikatea*), and to a less extent kauri. Other timbers are occasionally attacked. Towards the end of November the grubs are full fed, and bore a hole, about the size of a turnip seed, to the outer air, and at this time drop a whitish powder from their holes, which are most frequent on unpainted timber

Flax leaf injured by flax grubs. (after Atkinson) and in dark positions. Shortly after the hole is made the adult insect emerges.

In the early days white pine was largely used for houses, studs, joists, lining, and flooring. Such houses early fell into decay so that this timber was no longer used, and most of the grub-eaten houses have now been dismantled. Occasionally, however a few affected boards may be noticed, and these would be best removed. The removal should take place between March and September, when all the grubs are in the wood, and the timber should be at once burnt. The joists or studs should be sprayed with arsenate of lead at say one pound of the paste to thirty gallons of water before fastening on the new boards.

It is in furniture, however, that the borer nowadays probably causes the most trouble, the backs of wardrobes, chests of drawers, etc., being frequently affected. Here again white pine should be removed if possible, but if it is not possible the wood should be sprayed or sponged with an insecticide. Cockayne recommends a mixture of creosote and benzine, using one part creosote to five of benzine; or dissolve two naphthalene moth balls in half a pint of benzine. One of these dressings should be applied three times over, from the beginning to the end of December. The dressing of timber is designed to poison the old grubs as they eat their way out of the wood, or the young ones as they eat their way in. When the powdery dust is seen falling from the holes a little of one of the above mixtures squirted in with an oil can will kill the occupant of the hole, and a great number of the adult beetles can be accounted for by merely crushing them with the finger as they rest upon the walls in December, for they are practically motionless during the hours of light. They fly freely at night, at which time they lay their eggs.

The sound known as "the death watch" commonly heard in the midnight quiet in borer infested houses is to be ascribed to this insect tapping the wood with its jaws, either as a mating call by the adults, or by the grubs within the wood sounding for a safe direction in which to bore.

CHAPTER VI.

PARASITES OF SHEEP AND CATTLE.

Blow Flies or Sheep Maggot Flies.—There are numerous blow flies in New Zealand, and they are always worst in tussock and bush country. Several of them cause annoyance in houses, and also lay their eggs in the dags or stained wool round the breech of sheep, especially lambs. The maggots, hatching out from the dags, burrow towards the skin, which they often penetrate, causing offensive and troublesome sores. An investigation by Miller showed that the chief offenders in New Zealand are the yellow blow fly, the green bottle, and the blue bottle in that order. The yellow blow fly is much the size and shape of a blue bottle, but is brownish above and covered with golden hairs underneath. It lays its eggs, or its living young, on meat, etc., as well as on wool, the blowing of wool being apparently a habit recently acquired. This fly was introduced from Australia, where its ravages are very much worse than here.

The green bottle is somewhat larger than the house fly, is common about stables and sheep-yards, and is plainly distinguished by its green or coppery metallic lustre. In Europe (whence it was introduced to New Zealand) it is easily the worst of the sheep blow flies, but here its frequency is shown by the following figures. Miller bred out thirty-three lots of blow fly maggots sent in dags from all parts of the country, and obtained fourteen lots of yellow blow flies, ten lots of green bottles, five lots of blue bottles, and four uncertain.

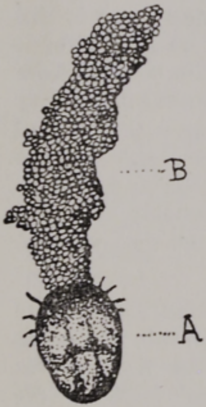
This shows that green bottles are more troublesome than their numbers would indicate. Blue bottles, too, of more than one species are seen to be dangerous to sheep.

In Australia many kinds of traps and other devices are used for reducing the number of sheep maggot flies; but here careful dipping and crutching are agreed upon as preventives of attack. Spraying the crutch with 0.2 per cent. arsenious oxide after crutching of sheep that are scouring gives considerable protection. Nevertheless, Miller records that many correspondents estimate the death rate in their localities as one per cent. of their flocks, and if the sheep are left uncrutched at from five to ten per cent. The usual experience is that there is no actual mortality, but all sheep farmers will be glad to know that last year (1922) Miller liberated in New Zealand a chalcid that in Australia parasitizes the flies that are the worst sheep blowers here.

Sheep tick.—This insect is more properly called "sheep ked" since the name "tick" is generally used for a different class of animals; but the name sheep tick is universally employed in New Zealand. The insect is well known, being found on practically all sheep. It is quite wingless, about quarter of an inch in length, and has a brown or bluish bag-shaped abdomen. It sucks the sheep's blood, and produces an irritating sore that is especially severe on lambs. It can move with considerable agility, and easily passes from one sheep to another. It cannot, however, live for more than about four days off the sheep, as Curtice proved, though he was able to keep certain specimens alive as long as he wished by feeding them daily on the back of his hand, an operation that produced greater irritation to his skin than being bitten by fleas or mosquitoes. The pupa cases are oval, reddish brown structures, usually attached to the wool by a gummy substance. They are commonly called eggs, but are obviously not so, for the egg of a fly produces a maggot, while these structures produce adult sheep ticks. Each female produces about four pupae, and these hatch out in three or four weeks. The living ticks reported as being found in bales of wool opened for scouring, are specimens newly-hatched from pupae packed with the wool. The invariable remedy for sheep tick in New Zealand is dipping, a process which is always satisfactory if the dip is properly mixed. The irregular shape of many dips makes it hard to estimate their capacity, and doubtless many dips are mixed too weak. It is a good plan to take a living tick, wrap it in a piece of wool, immerse the whole for a few minutes in the dip, and then leaving it on the ground for say five or ten minutes, see whether the tick is living or dead. Dips that are allowed to stand often become quite useless as insecticides.

That dipping and rational treatment will exterminate sheep tick is proved by the experience of Mr. A. Matthews, who annually shears some thousands of sheep on his run in the south-eastern corner of Wellington province. He states that no living tick has been found on any of his sheep for many years.

That the majority of farmers never eradicate sheep tick but merely control it, is probably chiefly due to the fact that some dips kill the adult ticks but not the pupae, so that these hatch out and re-infect the flock. It would pay farmers to try if their dip does kill the pupae, by keeping a few of them dipped and undipped, in a box in a warm place, and seeing if the dipped pupae hatch out. With certain dips used at the strength recommended by the makers, pupae certainly do escape destruction. In this case the dip should be strengthened, or if that is injurious to the sheep, the dipping should be repeated in four weeks so as to catch the newly hatched ticks.



A. Mature female tick.
B. Her eggs.

Bird louse of the sheep, magnified 20 diameters. (after Neumann)

True louse of the ox, magnified 25 diameters. (after Neumann.)

The other contributory causes to the maintenance of tick in our flocks are—(1) Using too weak a dip—this is specially common in sheep treated at public dips. (2) Buying in sheep either undipped or merely dipped for sale. (3) Postponing dipping till too late after shearing so that the length of the wool protects some few ticks or pupae. (4) Dipping only part of the flock at a time, and leaving the rest because they are apparently clean; or in hill country, leaving stragglers undipped, which comes to the same thing. (5) Having neighbours that dip appreciably later than oneself. (6) Turning dipped sheep back into a field where they were running before, so that they are possibly re-infected by ticks that have fallen to the ground: the knowledge that ticks can live only four days off the sheep should govern procedure in this respect.

But for these causes there is no reason why we should not exterminate tick as completely as we have done scab. Scab is a much worse disease than tick; it was once rampant all over New Zealand, and it still occurs frequently in England. Yet we got rid of it entirely by taking reasonable measures, and we have not had to spend a penny on scab for the last thirty years or more. We could do the same with tick, and exterminate it in a single season if reasonable methods were adopted. It costs us about £150,000 a year to dip our sheep. Twice that sum reasonably expended in one single season would free us from that expenditure for ever.

Sheep Lice.—Lice are generally small insects quite wingless, of slow motion, living on the skin of various animals. They suck the blood (true lice) or eat epidermal products such as hair and feathers (the bird-lice), but in either case are capable of setting up severe scab-like sores. Though usually so small as to be difficult to see, they are sometimes up to a quarter of an inch long, *e.g.*, the pig louse. Each kind of louse keeps to its own kind of animal, and cannot live elsewhere, indeed they often keep to their own part of the body. Thus, in man, for instance, there are three species of lice, one living on the head, one in the clothes, and one on the inguinal regions.

In sheep the commonest is a round-headed louse, but two other kinds have been found. They are easily controlled by proper dipping. When lice occur on other animals they may also be washed or sprayed with sheep dip properly diluted.

Lice, like fleas and other external parasites, have developed resistance to crushing to a remarkable degree. An interesting experiment may be made with a pig louse by placing it on a table and then loading it with weights. It usually carries about four pounds and then bursts audibly. This load equals about one hundred and twenty pounds to the square inch—the load of a good steam boiler. The hardness has been secured of course simply by natural selection. The softer ones were crushed and left no offspring to inherit their softness. The harder ones survived, and their offspring are like them.

Lung Worm of Sheep and Calves.—This is a disease that causes an enormous number of deaths among hoggets each spring, and there is little doubt that these deaths would be largely avoided if the life history of the parasite were more commonly understood.

In winter there may be found in the windpipe of young sheep and especially lambs a number of worms, thin and threadlike, some about two inches, and others three inches in length. These are the sexually mature lung worms, the smaller ones being the males. At this stage they cause no trouble to the sheep, but immediately after mating the females produce enormous numbers of young, each about a quarter of an inch in length. These make their way into the innermost recesses of the lung, block up the air spaces there and cause the lung to become hard and liver-like in colour and texture. The young sheep now shows symptoms of choking, and coughs constantly and painfully. There is a thick mucous discharge from the nostrils, and masses of mucous are often coughed up. From this point on, the affected animal may die or recover, but whichever happens to the sheep, the worm is provided for. The matter coughed up by the sheep contains the immature worms from the lungs, and falling upon the damp earth, they live there for several weeks—it is not known exactly how many—and go through certain stages of development. This stage of the life history is obscure: it is asserted by some that the worm enters other animals, such as earth worms, by others that it develops merely in the soil, but it is agreed that the young worm must be ejected from the windpipe of the sheep to complete its development, and that it is from the soil or grass that the next crop of lambs is infected.

By some means then, the partially developed worms gain access to the windpipe of the new season's lambs, and then burrow into the mucous membrane lining the passages of the lungs. Thus small lumps are formed in the membrane, and in these lumps the worms develop still further, finally emerging as the sexually mature lung worms with which we started.

Adult and young worms may sometimes be found at all seasons of the year, but most commonly the adults inhabit the windpipe at the beginning of winter, and the young in their multitudes occur at the beginning of spring, then causing the coughing, emaciation, and death that so seriously deplete our flocks.

The case of lung-worm is pre-eminently one in which prevention is easier than cure. (1) Any sheep coughing with lung worm will infect any pasture on which it grazes. (2) The infection of the pasture will last the longer the damper it is. (3) The younger sheep will be the more likely to contract the disease. Bearing in mind these three facts the following procedure will prevent the continuation of the trouble:—

(1) All affected sheep should be separated from the rest of the flock as soon as, and for as long as,

coughing is noticed. (2) Affected sheep should be put on the driest land available so that the young worms coughed up may die as soon as possible. (3) If it is unavoidable that sound sheep be grazed on the field grazed by the affected sheep within a month after coughing has ceased, then the new occupants should be mature sheep and not lambs.

Cure consists in giving the affected hoggets fresh young feed—bran and crushed oats added to young grass and fresh water having an apparently good effect. Of special remedies the best recommended is as follows:—Add one part of turpentine to sixteen parts of fresh milk and shake thoroughly till the two are mixed in a perfect emulsion. To each sheep give two to four ounces according to age. Repeat in four days.

There are two further points to be noted:—(1) The mortality attributed to lung worm is often primarily caused by stomach worms, which reduce the condition to such an extent that a little lung worm cough means death. (2) Calves as well as lambs are preyed upon by lung worm, and therefore affected lambs should not be run with sound calves, nor *vice versâ*. Affected calves should be given the same treatment as lambs, viz., isolation, good feed, and turpentine. The dose for a two months old calf is one teaspoonful of turpentine well shaken in two tablespoonfuls of milk—the dose repeated in seven days. For older calves the dose should be increased proportionately.

Stomach Worm of Sheep.—These worms are white or slightly pinkish in colour, from three-quarters to an inch in length, thread-like in shape, and occur in the fourth stomach of the sheep—especially in young animals. While other worms usually occur in the various parts of the intestinal canal at the same time as the stomach worm, yet this is the commonest species, and the emaciation of sheep when worms are present is usually ascribed to this species, because it occurs in thousands while the others are in tens or twenties. When the stomach is freshly opened the worms may be seen wriggling about in all directions, and are present in all stages of development. When present in large numbers they cause emaciation, debility, and death, and it is stated that in North Auckland, during the winter of 1918, the loss of lambs from this cause amounted to fifty per cent. of many flocks.

As stated above, the worms are present at any time in all stages of development. Thus the males and females are always pairing, and the females, laying eggs which are passed down the intestine and dropped with the dung. The eggs then are picked up by other sheep grazing in the same field, and hatch immediately on reaching the stomach. It is, however, chiefly in young sheep, and chiefly in winter, that they produce serious digestive disturbances.

Treatment is almost exactly as for lung worm. Separate the sick from the well; give pure water and good food, such as bran, crushed oats, and fresh young grass; drench with turpentine, and watch the dung to see if worms are expelled, and if not, repeat the dose in four days. Shut the dosed sheep up with good feed till the worms are passed, and then let out on to a young pasture, where they will immediately begin to pick up condition again. In his recently published work on the *Diseases of Farm Animals in New Zealand*, Colonel Reid deals fully with this parasite, and recommends the cure invented in South Africa, consisting of bluestone and sodium arsenite.

Cattle Tick.—Cattle suffer from lice, and calves from lung worm, and their treatment has been mentioned under the appropriate parasite of sheep.

On cattle, however, there occurs a kind of parasite that is not found on sheep here, viz., a true tick—not the specialised insect loosely called a "tick" on sheep—but a specialised spider to which group alone the name "tick" is properly applied.

The cattle tick in its most familiar form is black, and round, indeed not very much unlike a small black currant, in size and shape. Close examination will show its four pairs of legs that at once place this animal among the spiders and ticks. This is the sexually mature female, gorged with blood from the ox on which it is living, and filled with eggs ready for laying. She falls from her host and lays on the ground her batch of eggs—varying in number from four to fifteen thousand. From these hatch little six-legged larvae, brown in colour, and about the size of a pin's head. These are very active, and cling on to any passing animal, and there commence to suck the blood of their host. The parasite goes through various other stages, reaching first an eight-legged but sexually immature stage while clinging to its host, and then still on the host or possibly again on the ground other pre-maturity stages until we again return to the engorged gravid female with which we started. The male, and the earlier stages of development of the female are rarely noticed.

Cattle tick does a certain amount of harm to cattle, as all external parasites must do to their hosts. But it is looked upon much more seriously than lice or sheep "tick" is, because in other countries, notably Texas and Queensland, animals with cattle tick also suffer from a severe, often fatal, disease called Texas fever or red water. The tick and the disease are so constantly associated that they were long looked upon as cause and effect, but now it is known that the disease is caused by a microscopic organism living in the blood, and that it is carried from one ox to another by the tick. Thus two distinct organisms are necessary for the production of the disease, one causative and the other distributive.

Cattle tick was first recorded in New Zealand from Canterbury in 1905, then in North Auckland at intervals from 1907 onwards, but in 1918 it apparently increased rapidly, and caused a good deal of alarm.* The cattle tick at present infests the districts of the Auckland Province north of a line through Hamilton (approximately). However, no sign of the disease that this tick distributes has ever been observed in New Zealand, and so the fear of tick is dying out. Still, large numbers of ticks on a beast will lower its condition, interfere with its milk yield, cause deterioration of several shillings in the value of a hide, and possibly cause the death of an animal already suffering from other forms of sickness. Picking off all ticks seen, and spraying of infected animals is therefore recommended by the Agricultural Department, the substance Reakes used being Stockholm tar sprayed on to the affected portions of the skin through a cheap spray pump known as the "Faultless."

The fact that ticks spend part of their lives on the ground makes their extermination by spraying the cattle a tedious and laborious process, but it is somewhat shortened by burning the rough grass in gullies, etc., so as to burn as many immature ticks as possible.

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*Myers (N.Z. Agric. Journal, Aug. 1923) shows that our tick is probably of Indian derivation, that it is different from the disease carrying Australian and American species, that it occurs on many animals including man, the hare, sparrows and larks, and that it may not have been in N.Z. before 1910.

Chapter VII.

PARASITES OF THE DOG, HORSE, AND MAN.

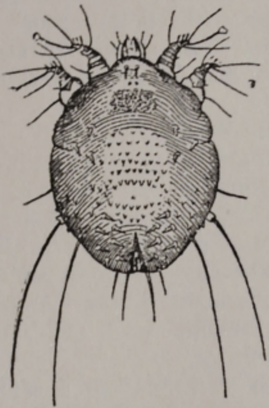
Mange or Scabies.—This disease is caused by a mite, a microscopic member of the class of animals best known as the spiders and ticks. The most widely spread form of mange, itch, or scab occurs on man and all the domestic animals. The mite burrows in tunnels just under the skin. An intense irritation is set up, accompanied with the formation of scaly sores, and falling of hair.

Among clean and well groomed animals the disease is rare, but when attention to cleanliness is relaxed, and when crowding is unavoidable, mange often breaks out with alarming violence. War conditions exactly suit the parasites so that in the late war mange caused more unfitness among the horses than any other form of illness. Among the men in the trenches too scabies was a continued source of discomfort and illness.

The disease is fortunately rare in New Zealand owing to our generally clean conditions of life.

Red Mange is caused by another mite which is almost worm-like in appearance and is quite microscopic, being only one-seventy-fifth of an inch in length at its longest. It lives in the hair follicles of animals, chiefly the dog, causing the falling of the hair, and the appearance of red patches, first at the elbows, hocks, eyes and toes. The patches spread over the body and become purulent in places, especially round the eyes. The disease is very hard to cure, owing to the deep seated position of the parasite. Any dog showing signs of it should be immediately isolated and its kennel purified by washing with kerosene. The affected patches and the areas round them should then be well and constantly rubbed with a mixture of sulphur and lard. Reid recommends squeezing the pustules daily and then rubbing with balsam of Peru one part, alcohol four parts.

Dog mange is common only where dogs are crowded and chained for long periods in somewhat



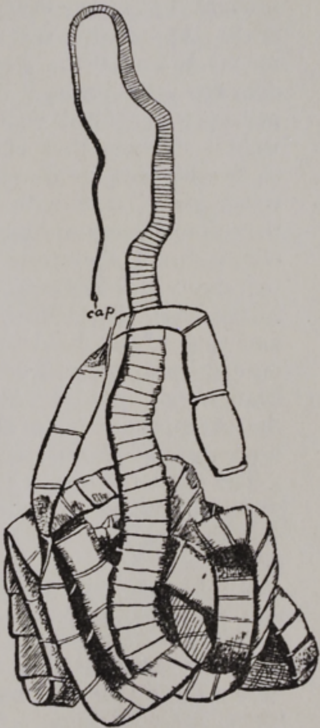
Mange parasite magnified
100 diameters.

Head of tape worm
greatly magnified.
(after Parker.)

insanitary conditions, and so occurs chiefly in shepherds' and rabbiters' packs. On the ordinary farm where only a few dogs are kept mange is not at all common, the condition ascribed thereto being frequently induced by throwing dogs into sheep dips that have not been sufficiently diluted. Dogs cannot stand as strong a dip as is used for sheep.

Tape Worm, Hydatids, etc.—The dog is the host of at least fourteen different kinds of tape worm; man has eight or ten kinds of tape worm maturing in his own body; and the sheep has four or five kinds. One common worm of the dog will be described as a type of them all.

Toenia coenurus is a tape worm of from twelve to sixteen inches in length. It is about half an inch wide and one-twelfth of an inch in thickness so that it looks exactly like the piece of tape from which it takes its name. It is quite white in colour and lives in the dog's intestine, attached to the intestinal wall by a small head-like structure provided with microscopic suckers and hooks. The body is composed of about fifty or a hundred segments which float about in the intestine. The animal has no mouth or intestines, but merely absorbs the food already digested for it by its host. Each of the segments, however, contains a complete set of male and female reproductive organs, and when the eggs are fertilised by the sperms from the same or a neighbouring segment, they develop rapidly so that the end segments become mere swollen masses of eggs. These segments then break off, and are passed with the dog's droppings. If this happens to be where a sheep grazes within a few days, the sheep picks up the eggs, which immediately commence a new existence within the



Human tape worm. Natural size.
(After Leuchart.)

new host. The eggs are provided with six small hooks, by means of which they bore through the sheep's intestine and into a blood vessel. They are carried along by the blood stream until they are brought up in a very small capillary where they stick. Apparently any egg sticking elsewhere than in the brain of the sheep, dies; at any rate if it does reach the brain, it develops into a cyst, a transparent water filled bladder reaching the size of a walnut or even that of a golf ball. On the wall of this bladder are developed some hundreds of tape worm heads, each with its suckers and hooks, and then development entirely ceases. Nothing more can happen until the worm gets back into a dog. If the sheep is killed and the head split and thrown to the dogs, the bladder worm is eaten by the dog, and each of the heads on the wall of the cyst will develop into a tape worm in the dog. Even if the head is not split, the bladder worm may so soften the sheep skull as to allow the dog access to the brain, and so the life cycle is completed.

The animal in which the reproductive stage of the worm is passed is called the main host, in this case the dog, and the host of the bladder worm or cystic stage is called the intermediate host, in this case the sheep. In all cases of tape worm the main host preys upon the intermediate host.

Toenia coenurus does a certain amount of harm to the dog it inhabits and also affects the sheep on whose brain it lives. The pressure on the brain causes the sheep to walk in circles, to fall frequently, and usually ends in causing death. This disease is called "Sturdy" or "Gid." It is not at all common in New Zealand but is occasionally found. It has been described here as a good example of the structure and life history of a tape worm.

Toenia echinococcus or **Hydatids.**—The dog very frequently, perhaps universally, harbours a very small tape worm that bears the above name. It is only one-fifth of an inch in length, and as fine as a thread of silk, so that it is almost sure to be overlooked among the contents of a dog's intestine or among his droppings. This tape worm consists of only three or four segments, but the last one is continually dropping off full of eggs, and a new one is continually growing to take its place. The eggs may thus get into grass or especially into water that a dog has fouled, and so may be picked up by man or rabbits or sheep or oxen. In any of these animals the bladder worm stage may develop, most commonly on the liver. From the walls of, and within, the primary bladder, new bladders may arise, until scores of smaller bladders are formed, and the original one, turgid with fluid, is perhaps as big as one's two fists. In this stage it is well known as an hydatid cyst. Its being found in rabbits and on sheeps' livers easily explains its finding its way back into the dog.

Hydatids is now not an uncommon disease in some parts of New Zealand, and it is obvious that cur dogs harbour *T. echinococcus*, and that some people drink from insanitary pools. The actual operation for the removal of a hydatid cyst is quite simple, but pus forming organisms seem very commonly to enter and develop in the surgeon's wound, so that the healing is often a tedious process.

Another tape worm of the dog passes its cystic stage in rabbits and hares, and still another its cystic stage in sheep and cattle. It is remarkable that we allow dogs to go on infecting human beings, sheep and cattle with dangerous diseases when we might easily be rid of the lot. An annual drenching of dogs will remove all their tape worms, and all their capacity for harming both their main and their intermediate hosts. The simplest formula is: fast the dog for twenty-four hours and then administer a mixture consisting of a drachm (about a teaspoonful) of freshly ground areca nut powder, and two ounces of castor oil. Leave the dog tied on a clean floor till he is purged. Examine

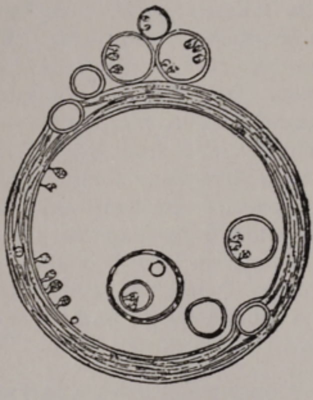


Diagram showing formation of tape worm heads and of secondary cysts. About natural size. (From Neumann)

Tœnia echinococcus.

his droppings for tape worms and especially for their heads. Burn the droppings or bury them deeply. If tape worm segments are found, but not the heads, then the treatment should be repeated in a week. The quantity (one drachm) of areca nut mentioned is that suitable for a sheep dog. Smaller animals require less.

This not very laborious process should take place once a year or oftener, and it would probably be well for this country if a quiet but steady course of instruction were given to those concerned until it became compulsory to drench dogs in the same way as it is to dip sheep. The drenching could be carried out by the dog tax collectors, whose visits might then not be considered so gratuitously unpleasant as is now the case.

The Horse suffers from lice (v. p. 50), from mange (v. p. 57), and from two not very important tape worms. Besides this it harbours several *Round Worms* of which the commonest only is here described. It lives in the small intestine, is white in colour, and reaches a length of nine or ten inches in the female and six inches in the male. It is frequently seen among the dung of horses and certain of its characters can easily be made out. It has a three lipped mouth at one end, and four lines running equidistant along the body, through which a very much coiled threadlike tube can usually be seen. This is the ovary, if it be a female that is examined, and its great size prepares one for the fact that thousands of eggs are laid each day at certain seasons. (Compare the related worms at pages 22 and 51). The eggs pass out with the dung and fall on to the ground or into water, so that they are taken up by other horses where they develop in the intestine of their new host.

This worm is very common, up to 1,800 having been found in a single horse. The harm it does is usually not very great, for it is found in numbers after death in horses which in life gave no sign of its presence. However, young horses harbouring very numerous worms often incur digestive troubles. A change on to soft green feed or even a course of feeding with carrots will remove considerable numbers. If worms are persistently discharged the whole of them may be removed by administering (for a draught horse) two ounces of turpentine in a pint of raw linseed oil, or in linseed gruel, but this treatment should not be adopted if the horse is already scouring. Of course the animal should be tied up during the treatment so that the worms will not be scattered where other horses may pick up their eggs.

Horse Bot Fly. Two species are common in New Zealand, one with smoky and the other with clear wings. In the females the abdomen is tapered off to form an ovipositor and this is the only sex we commonly observe, because it alone follows horses for the purpose of egg laying. In the hot days of summer, the females lay their eggs in the long hairs of the shoulder, knee and fetlock, as well as on those under the jaws. This action annoys horses greatly, though it is difficult to see why, as the fly frequently does not go near the skin while laying her egg. The large white eggs are easily seen hanging on the hairs, from which they are very difficult to remove. The tiny maggots hatch from the eggs, and tickling the skin are licked off by the horse, or fall direct into his feed box: in either case the maggot finds its way to the stomach where it develops into the well known bot, about half an inch in length, pink in colour, and encircled with seven or eight rows of spines. By means of two hooks the bot fastens itself to the wall of the stomach, where it assimilates the food swallowed by the horse. The bots are found attached only to the cardiac or upper portion of the stomach; but in early spring they release their hold and so may be found all through the stomach, in the intestine, and even hanging round the anus. They fall on the ground where they pupate; and emerge again as perfect flies in the hottest days of summer. The extent of the injury to the horse by bots is a matter of considerable doubt. When a horse dies and bots are found in its stomach these larvae are often looked upon as the cause of death, but that view is shown to be wrong when a horse has died from specific accident, and its stomach is still found lined with bots. In post mortem examinations bots are sometimes found to have perforated the stomach wall, but there is some evidence that the perforation has occurred after death, instead of being the cause of it. On the whole it may be said that every horse is parasitized by bots, and that they usually do no harm. In certain cases however (one came under observation in 1920) bots passing down the intestine may become temporarily attached in a group so as to block the intestine, and cause a fatal obstruction.

There seems to be no means of removing the bots from the stomach—they will remove themselves in spring.

The flies however cause great irritation to the horse, and anything that reduces the annoyance is worth trying. Among the best plans is to tie a cloth to the headstall in such a way as to cover that part of the jaws where the fly usually lays.

Human Parasites. Man suffers from many tape worms as well as being the intermediate host of the small tape worm of the dog, (p. 61), from three kinds of lice (p. 50), from scabies (p. 57), but all of these are more or less within the realm of the medical man. Only the flies which infest our houses may be considered as belonging to the domain of agricultural zoology.

The House Fly. This is excessively common wherever human beings dwell. The female lays her eggs in any kind of decaying animal refuse, but where horse dung is available that is chosen in preference to all other laying grounds. Horse dung should therefore always be used as a trap for the control of flies. About one hundred and fifty eggs are laid; and the maggots hatching out in twenty-four hours feed on the decaying matter, and in favourable circumstances are full grown in five or six days, when they turn into the familiar oval brown pupae, about a quarter of an inch in length. After a week, they may, in favourable conditions of temperature, emerge as full grown flies, which then migrate to the stables and our dwelling houses. Anyone that has once seen a manure heap squirming with maggots, and has realized that each maggot will turn into a fly to fall into his tea, or share his bread and jam, is unlikely to tolerate flies in his house in future. Besides being dirty, flies are dangerous as carriers of disease, especially typhoid or enteric fever, and the notable absence of these diseases during the late war, was due largely to the efficient fly control exercised by the medical corps.

By far the best way to attack the house fly problem is to search for the dung heaps in which they breed, and kill the maggots there. Where there are more than sixty horses, enough heat can be generated in the manure itself to kill the maggots, but in smaller quantities the manure should be thoroughly watered with some arsenical poison such as sheep dip, Murton's being one of the most satisfactory for this purpose. It should be used at double the strength used for dipping sheep and applied to the manure when it is about three days old, that is when the maggots are all hatched and lively. Manure placed in definite pits where it can be evenly spread and tramped so that the heat will bring all the maggots to the surface, is the most easily and efficiently treated. Adult flies should be trapped in pig sties and stables to prevent their reaching the house, and the best means to this end, is to smear tangle-foot upon wires about three feet long, and hang these from the ceiling of the buildings. Tangle-foot is made by boiling together until quite dissolved twelve ounces of castor oil and twenty-seven ounces of resin. After a week's exposure on the wires the mixture becomes useless, and the wires should be cleaned by burning them, and then recoating with the tangle-foot, which will have to be warmed to partly liquefy it again. Large numbers of the wires should be used in the outbuildings, and then a few (with a bit of cotton wool stuck on the lower end to prevent any drip) hung in the kitchen to keep the flies down within the house. Smearing the wires is a somewhat sticky business, but it is best done boldly with the hand, which can afterwards be cleaned by washing with kerosene. This method of trapping by wires was invented by Professor H. B. Kirk of Wellington and everyone that has seen it tried is loud in praise of its superiority over all other traps.

The few flies that after this treatment may still be found in living rooms may be satisfactorily and entertainingly treated with a fly swat or flywhisk purchasable at any ironmongers.

On the whole flies in a house are a sign of dirty conditions and are quite unnecessary.

Stable Fly. This is superficially much like the house fly, but is distinguishable by its greyish spotted abdomen, and by its strong proboscis sticking out frontwards from under its head. The stable fly uses this proboscis for piercing the skin and sucking the blood and so causes excessive annoyance to horses, cattle, and occasionally to man as well. It usually sticks to the stable where it may account for eighty per cent. of the flies seen, while the dwelling house two hundred yards away provides only two or three per cent. of these flies, the remainder being common house flies. This is a fortunate circumstance, because the droppings of the stable fly are almost ineradicable by any amount of scrubbing, from wood-work, books, etc.

The methods before suggested for discouraging house flies, apply to the stable fly equally well.

Blow Flies. Two large blue blow flies are common in houses, as well as a golden haired one that has been mentioned on p. 46. Of the blue bottles one is a native and the other introduced, but both, as well as the yellow one, have the same habits of laying their eggs on meat and other animal matter. They are all very much more common in tussock and bush country than on cultivated land or in the towns. They are easily killed in houses by means of window troughs, tin vessels about an inch wide, an inch and a half deep, and as long as the window pane is wide. The trough is partly filled with water, with a film of kerosene poured on top of it, and then placed with one edge pressed close against the window pane. The blow flies fly or walk up the window pane, but blunder down again and almost invariably fall into the trough and are killed. These troughs are most efficacious, and may be bought at hardware shops, or made to suit special windows.

CHAPTER VIII.

SOME FRIENDS

Chalcids. These have frequently been referred to in the preceding pages, but there has been no opportunity sufficiently to dilate upon their service to man. It has been stated that of the total number of animals in the world, four-fifths are insects, and some of these are known to breed at prodigious rates. The example of the cabbage aphis may be quoted, a single individual multiplying a million fold during the summer months. It is clear that we should often be over-run with various insects unless there were some definite check upon their increase. The check is in part provided by chalcids which are wasp-like insects provided with stinging ovipositors, by means of which they lay their eggs within some other insect. The egg develops into a grub which eats out the interior of its host. Many of the chalcids are almost too small to be seen by the naked eye, but the good work they do is none the less for that.

Ichneumons, closely related to the chalcids, are often quite large and handsome insects, easily distinguishable by their ovipositors. The good done by these two, and by the parasitic flies of the same order as the house fly, cannot be over-estimated. The winter moth, a destructive European caterpillar, is parasitized by no fewer than sixty-three species; from 1,694 Hessian flies there were bred out fifty-eight more parasites than flies; four different species have been bred from the Diamond back moth caterpillars in New Zealand; a single rape leaf examined during the writing of this page showed over nine hundred aphids bearing in their backs the small, round hole from which a chalcid had escaped. And so on. The introduced parasites are themselves parasitized in many cases, and if the secondary parasite were once allowed to

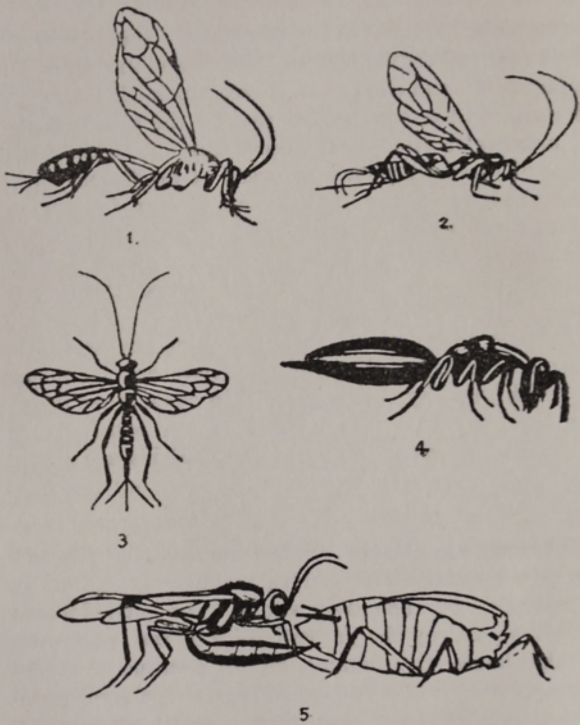


Fig. 1: Paniscus productus, female, natural size. Fig. 2: White marked Mesostenus, female, X2. Fig. 3: Lissopimpla semipunctata, female, natural size. Fig. 4: Wingless Parasite of White Pine Borer, natural size. Fig. 5: Parasitic Wasp attacking Cabbage Aphis, X16.

escape, the good expected from the primary would be almost entirely neutralized.

Ladybirds are also useful insects, although the ones found generally on our farms can make no impression on the aphids the farmer commonly suffers from. The cottony cushion scale is a native scale insect that is completely controlled by *Novius cardinalis* —a native or Australian ladybird, and the blue gum scale at one time did great damage, until its parasite *Rhizobius ventralis* was introduced from Australia.

Humble Bees. These well known insects were introduced to New Zealand for the purpose of cross fertilizing red clover flowers so that seed might be produced. The corolla tube of the red clover is ten millimetres in depth, and at the bottom of this tube the nectar lies: no insect with a proboscis less than ten millimetres in length then can reach the nectar, and therefore no such insect will visit red clover, and no seed will be produced by its agency. It was because several species of humble bees have proboscis of over ten millimetres in length and therefore visit red clover freely that their introduction to this country was first proposed. The humble bees show the same colonial instincts and the same differentiation into queen, workers, and drones, as do the hive bees, but the division of labour is less pronounced, the instincts are more rudimentary and the life history is considerably different.

All the individuals met with in spring are fertilized queens which have lain dormant during the winter. The queen gathers nectar and pollen, and working it up into a mass lays a certain number of eggs among it, enclosing them in a spheroidal cell. Other cells are added to the first, the queen doing all the work of gathering food, forming the cells, and feeding the larvae. After about a month the young bees emerge as sexually incomplete females or workers, and these now perform the offices of labourers, architects and nurses while the queen leaves her home less and less frequently and finally devotes all her attention to egg laying. Some of the workers, which are all much smaller than the queens, become sexually mature and assist their parent in egg laying. In early autumn drones, that is males, and new queens, are produced but the colonies never become very populous, from one hundred to three hundred occupants being the rule. By autumn the young queens are fertilized and take shelter in some hole in the ground, while the whole of the rest of the colony dies off. The young queens pass the winter in a dormant state and awake next spring to start a new colony.

The above life history will explain why it was impossible to introduce humble bees to New Zealand before the advent of the frozen meat trade.

The only time that the bees can do without food is in winter, and the fertilized queens that are to be found then must be persuaded that winter still holds sway while they are passing through the tropics and on to the New Zealand summer. Dormant queens then were captured in Britain in November, were surrounded by ice all the way to New Zealand, and were liberated here in the succeeding February. The chance of an importation being successful clearly depends on the length of the autumn, for the queens have to start a new colony and go through all their stages up to the production of young queens before winter sets in. Thus there have been several importations of humble bees that have not managed to establish themselves, and the first successful importation appears to have been made by the Canterbury Acclimatization Society in 1885.

Three species or varieties were imported and liberated at that time, and these are now numerous all over New Zealand, while no other species has ever been captured although they have formed a great proportion of earlier or later importations.

As mentioned before the depth of the red clover corolla is ten millimetres and so the value of the bees now found in New Zealand can be deduced from the length of their proboscis. The colouring varies greatly—the bands being golden or white or disappearing altogether in individuals produced by the same queen. The following classification is therefore only a general one, and has no reference to the minute characters of the reproductive organs which alone allow the species and varieties to be differentiated with certainty.

Bombus terrestris. Large in size and common. One gold band on thorax, as well as two on abdomen. Length of tongue nine millimetres.

B. hortorum. Somewhat smaller. Two gold bands on thorax as well as two on abdomen. Length of tongue twelve millimetres.

B. hortorum variety *harrisellus.* Black all over. Length of tongue twelve millimetres.

It will thus be seen that only the last two mentioned varieties are useful for fertilizing red clover. How useful they are may be seen from an experiment made at Lincoln College in 1896, when several separate patches of clover were covered with wire cages whose mesh would admit all insects smaller than humble bees. A typical result was:

Seeds on enclosed two square yards ..	2
Seeds on adjacent two square yards ..	17,201

While humble bees are useful in producing red clover seed, the total work the bees in any locality are capable of performing has definite limitations, so that in practice it is usually found that a farmer obtains as much seed from ten acres of clover as from fifty. This is explained in part at least by the death of all the worker bees each autumn.

It has been pointed out that *Bombus terrestris* has but a short proboscis, and is therefore unable to fertilize flowers with deep corollas. It has however, in common with all the bees, strong biting jaws, and with these it bites through the base of the corolla of many garden flowers, including beans, so that it can obtain the nectar, although it does not fertilize the flower. This in itself does little damage as the flower continues to produce nectar until it is fertilized, but the biting of the corolla sometimes accidentally injures the ovary and so hinders the setting of seed. In a fifteen acre field of beans eighty-six per cent. of the flowers were bitten and the loss on the whole crop due to this biting was estimated at six per cent. Red clover flowers also have their corollas pierced, probably by the same bee, but the damage caused thereby has not been ascertained.

Earthworms. There are numerous native earthworms as well as two or three imported ones. On cultivated fields the introduced are very much the commoner, while on tussock or fern country the large natives are usually the only ones to be found.

All earthworms are composed of a large number of segments. Their mouth is at one end and the anus at the other: they eat grass for food and soil for the purpose of deepening their burrows. The saddle-like thickening somewhere on the anterior third of the body has to do with the egg-laying process. All earthworms are hermaphrodite, that is have male and female sexual organs in the one individual, the male glands opening a few segments forward of the female ones. When two worms pair, which they do at night, they apply themselves to each other head to tail and each fertilizes the other. The eggs are later deposited in an elastic capsule secreted from the saddle-like thickening before mentioned, and placed in the ground, where the capsule looks something like a wheat grain at first, but afterwards turns black and brittle. Although only one worm usually emerges from the capsule, multiplication can take place very rapidly. The earthworm lives in a tube or burrow in the soil, and during the night partly leaves its hole, and feeds on decaying leaves, and on retreating before daybreak it pulls leaves, etc., down into its burrow, partly to serve as food, but chiefly to block the entrance to the hole. This habit greatly hastens the decay of vegetable matter and assists its turning into humus. Worms usually live a few inches under the soil surface, but when conditions of moisture and temperature are suitable they deepen their burrows by eating the soil and ejecting it in the form of castings on the surface soil. The period during which these castings are deposited varies greatly in different localities, but in general may be said to embrace all the seasons when there is sufficient soil moisture. The cumulative effect of the eating of the lower layers of soil and its deposition on the surface is one of the most striking of common natural phenomena. Many counts taken in the South Island indicate that on an average grass field twelve tons of soil are scattered on the surface each year, and that this provides a new surface layer a quarter of an inch thick. Darwin's figures for England are slightly less than these, viz., ten tons and one-fifth of an inch. Urquhart's investigations in Auckland in the seventies and eighties of last century showed that in the most favourable circumstances the deposit amounted to two-fifths of an inch a year. Doubtless the vegetation of a field influences its earth worm population. It is stated that at Moumahaki there were 2,000,000 worms per acre in a grass field, and

3,000,000 per acre in an adjoining lucerne field, and that further the active worms were 40 per cent. more numerous in the latter case.

The total effect of these activities is to open up and aerate the soil, to alter its mechanical composition, to greatly modify the growth of the grass by the application of top dressing, and finally to bury any object lying on the surface of the soil. Layers of lime, brick dust, charcoal, etc., scattered on the grass, may always be found after a few years forming a definite layer an inch or two below the surface. Stones, such as Maori implements, or in England such as Roman buildings, will thus in course of time be buried to the depth to which worms customarily work, say eighteen inches or so, and the whole surface layer of soil in an old field must have passed many times through the intestines of succeeding generations of worms. Of the 43,000,000 acres occupied in New Zealand 41,000,000 are under grass, and so it is probable that on the whole more cultivation is done by the earthworm than by the plough.

The Hedgehog.—Hedgehogs are very common in Canterbury and Otago and in the North Island, for their crepuscular and nocturnal habits render observation of them somewhat difficult. For instance, a farmer near Christchurch had never seen a hedgehog on his farm, until one day he found twenty-four while cutting a single crop of oats.

The hedgehog is one of the farmers' greatest friends, for it feeds almost entirely on insects, of which it must devour stupendous numbers. The droppings of hedgehogs may often be found on fields and lawns, black cylindrical pellets about one and a half inches by a half. An examination of such a pellet will show that it is composed almost entirely of the wings of beetles and moths, wing cases of the brown beetle (v. p. 25) being especially conspicuous in November and December. A count of the contents of one such pellet showed that it contained the remains of 430 beetles. Grubs and slugs are also included in its diet, and so are the eggs of ground birds, such as the lark. It is perfectly true that hedgehogs are to be found in poultry runs, and will certainly eat hens' eggs and probably young chickens. But since the hedgehog sleeps all day and wanders abroad by night only, it is surely easy to protect chickens and sitting hens from the visits of so large an animal, and as for eggs, the housewife that does not collect them before nightfall needs little sympathy if she loses them.

Insectivorous birds must be looked upon as among the farmers' chief friends. Starlings and mynahs, rooks and magpies must find the great majority of their food by destroying grubs and other forms of insect life. Even if some of them do eat a little fruit or seed, these depredations can extend for only a few weeks in the year. Even the sparrows must do an enormous amount of good compared with the few bushels of grain consumed at harvest time. During the rest of the year they are eating waste food or weed seeds, and during the breeding times both parents are busy carrying insects to their voracious nestlings.

Pests of various sorts have a distinct tendency to be worse in new countries. Man comes and brings with him new plants, which provide new and unaccustomed food to native insects, which thus multiply far beyond their original proportions—for example, the brown beetle. Or he introduces a new insect which multiplies freely in the absence of the bird that kept it in check in its home country—or in the absence of its accustomed parasite—for example, the blue gum scale. Or he introduces a new bird to keep down the insects, and the bird increases disproportionately because the birds and beasts of prey that live on it in its home land have been left behind—for example, the sparrow is much commoner here than in England owing to the absence of owls. Thus man is continually upsetting the balance of nature, and continually having to take steps to restore that balance: parasitic insects such as chalcids, and insectivorous birds such as starlings are among the most useful counterpoises.

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ERS' FOES IN NEW ZEALAND