THE AGRICULTURAL PESTS OF THE SOUTHERN PROVINCES, NIGERIA.

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(Plates XVII–XXV).

The following notes embody the results of observations made during a year of service (May 1913 to May 1914) as the Entomologist in the Agricultural Department of the Southern Provinces, Nigeria. They do not, however, pretend to cover more than a very limited area of the Western Province, for on account of the desirability of beginning the work by making myself acquainted with local conditions by a careful study of the insect problems at the head-quarters of the Department, at Moor Plantation, Ibadan, I suggested that the first few months of my tour should be spent there, hoping afterwards to be afforded an opportunity, which unfortunately was not forthcoming, of making a more general survey of the insect pests of the country. I have confined my remarks to insects which are to be looked on as real pests, and have made no reference to the bionomics of other insects which I have observed to be associated with the indigenous flora. I have classified the pests according to the plant attacked, and have added to my account of each notes as to the measures found useful in dealing with them.

Cotton Pests.

Insects attacking the Leaf.

Cotton plants at an early stage were frequently attacked by a leaf-miner, which proved to be the larva of a small Tineid moth, *Acrocercops bifasciata*, Wlsm. (Plate xvii, fig. 10). Good material for study was obtained in the laboratory, where a pot experiment was practically ruined by these pests. The larva generally took a course characteristic of other leaf-miners (Plate xviii), but frequently, when several were present, an extraordinary effect was produced, the whole upper epidermis being lifted up to form one large blister. It is noteworthy that even the cotyledons were often attacked, the consequence being that the vitality of the little plants was very much impaired. The pest is readily destroyed by pinching affected leaves, but if a plant is badly attacked, it is wiser to destroy it.

A species of mite, dull red in colour, was detected in very great numbers, late in the season (January), running about under a very delicate web on the underside of the leaves. The leaves attacked presented a characteristic yellowish mottled dry appearance and ultimately fell. The mite appears to bear a very close resemblance to the notorious " red spiders " of the genus *Tetranychus*, which have been credited with the spread of various fungus diseases, the American " black arm " in particular. My colleague Mr. C. O. Farquharson, M.A., B.Sc., the Government Mycologist, expressed the opinion that these mites are probably responsible for the spread of " cotton rust " and of a pink *Fusarium*, an organism which is probably concerned in the causation of a disease resembling " black arm " with which the native varieties, and to a less extent imported varieties, of cotton were badly attacked. Mites very similar to these, if not the same, were found abundantly under the leaves of the various species of *Canavalia* and on certain bush plants. No treatment against cotton mite was devised, the question as to the rôle they actually play in the spread of disease being still *sub judice*.

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Colonies of the cotton aphis, *Aphis gossypii*, Glov., which produce a characteristic wrinkling and infolding of the margins of the young leaves, were abundant early in the season (August), but were soon thoroughly checked by natural enemies, the chief of which were found to be Coccinellid beetles, *Chilomenes lunata*, F., *Chilomenes vicina*, Muls., and *Hyperaspis pumila*, Muls., all of which preyed, both as larvae and imagos, on the aphids. The larvae of three species of Syrphid flies, *Syrphus nasutus*, Wied., *Paragus borbonicus*, Mcq., and *P. longiventris*, Bezzi, and the larva of a lace-wing, *Micromus timidus*, Hagen, also ate them voraciously. By far the worst pest feeding on cotton leaf was the short-horned grasshopper, *Zonocerus variegatus*, L. Immense swarms of nymphs appeared suddenly, all about the same time in November, and entirely defoliated numerous plants. But though cotton appeared to be the favourite food, the pests were practically omnivorous and attacked, in addition to a large variety of wild plants, other plants under cultivation, young maize, young Para rubber, cassava in particular (Plate xix), bananas, and a variety of ornamental plants, especially *Acalypha*. Cacao was occasionally attacked, but fortunately was not a favourite food.

The insects gradually scattered as they attained maturity, and in late January completed the last ecdysis (Plate xxv, fig. 2), after which they were to be seen *in coitu* everywhere, and shortly afterwards new swarms of larvae appeared.

The multiplicity of food-plants and the enormous numbers of the pest made the question of dealing with them a difficult one; moreover it was felt that the use of Paris green, whether as a spray or as a dusting powder, was undesirable from the ginners point of view. Chromate of lead, prepared as recommended by Lefroy, was therefore used in spray form as the lesser evil and it certainly had a deterrent effect, causing the majority of the insects to migrate to new feeding grounds and killing a few. Since the insects are gregarious through the greater part of the life-cycle, it is possible that a trial of d'Herelle's virus might have yielded valuable results, but a supply could not be obtained in time for that season.

The leaf-roller, *Sylepta derogata*, F., occurred abundantly early in the season, about November, on certain imported varieties, American Upland in particular, but were much less numerous on the native cottons, the so-called Ishan and Meko varieties. Tachinid parasites, possibly of two species, an Ichneumonid, *Xanthopimpla punctata*, F., and some BRACONIDAE were bred out from the pupae, but were not numerous enough to be effective in checking the pest. An attempt was therefore made to cope with it by the use of insecticidal sprays, which did not however prove a success, owing to the difficulty of getting the poison on to the rolled-up part of the leaf, on which the caterpillar mainly subsists. Resort was therefore had to hand-picking by small native boys, who collected at the same time the various cotton stainers.

The larvae of the Limacod moth, *Parasa infuscata*, Wichg., were not uncommon, and green half-looper Noctuid larvae were found from time to time, but were not responsible for any great damage, being kept down by the agency of a species of Eumenid wasp, *Eumenes maxillosa*, de Geer, a black household insect very common in the Ibadan district, which stored the larvae as food for its grubs in great numbers, five or six being often found in each of the seven or eight cells composing its nest.

Various beetles, a Lagriid, *Lagria villosa*, F., and the Eumolpid *Syagrus calcaratus*, F., in particular, were found to cause a certain amount of leaf damage.

Insects attacking the Stem.

Two species of scale-insects, *Hemichionaspis minor*, Maskell, and *Pulvinaria jacksoni*, Newst. (Plate xxi, fig. 1) were found on cotton stems, neither in any great

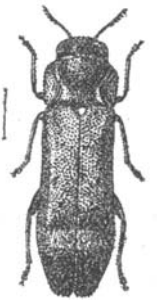

Fig. 1. *Pseudagrilus sophorae*, L.

abundance. The former, a small insect occurring in such great profusion on particular plants as to give at a distance the impression that the branches might have been dusted with a white powder, was frequently found also on a fibre plant, *Urena lobata*, L., on okra (*Hibiscus esculentus*, L.) and various other Malvaceae, and on a species of *Ipomoea*, but, as the season went on, it was much checked by both larvae and imagos of a Coccinellid beetle, *Chilocorus schiödtei*, Muls., which occurred abundantly, and had a gregarious tendency, even pupating close together. The *Pulvinaria*, a species recorded also as a cotton pest in Uganda, was much less numerous, being found here and there only in a ten-acre plot of Griffin cotton.

The larva of a small green Buprestid beetle, *Pseudagrilus sophorae*, L., (fig. 1) caused considerable damage and some loss of plants owing to its habit of boring the stems. The appearance produced in the plants was characteristic. When a young plant was attacked general stunting and distortion with shortening of the internodes was produced, and the uppermost leaves failed to attain full size, though the lower ones were to all intents normal in this respect (Plate xx). Young plants attacked did not as a rule die, but often went on to produce undersized imperfect bolls. Older plants became sickly and tended to shed their leaves. On examination of the stem of such a plant the point of entrance of the grub could usually be found near the ground, so that it is here, in all probability, that the parent beetle deposits its egg; the grub then bores in the cambium for 3 or 4 inches to and fro in a very characteristic zigzag manner, filling up the tunnel behind itself with pink sawdust-like excreta. The course it takes in the cambium explains how it is that the plants do not die as a result of the attack but suffer only from impairment of vitality. The larva then proceeds to tunnel straight up in the wood for a distance of about 12 inches, usually in the main stem, but often in one of the larger limbs, and when full-fed penetrates to the pith cavity, where it comfortably pupates in a little bed on the soft pith, though occasionally in the wood. In due course it turns into a beetle, which reaches the outer world by boring, such holes of egress being readily found high up on the stem of the plant.

No method of coping with this pest, other than by destruction of affected plants, was devised. Another stem-borer found late in the season was a Lepidopterous larva, possibly an Aegeriid.

Insect Pests attacking Cotton Roots.

The larvae of a Lamellicorn beetle, recorded for the first time in 1910 by Jemmett as attacking cotton roots, were responsible for the loss of a number of plants. The symptoms of their presence were a gradual withering of the leaves, which then turned red and fell, a slow drying of the stem, premature opening of the bolls, and ultimate death of the plant. The roots of the plant were then found to be decorticated, and there was usually a redundancy of new tissue at the junction of the healthy and attacked parts.

With a view to combating the pest, experiments in the application of a 1 in 200 aqueous solution of carbon bisulphide to the roots by means of the Gastine apparatus were undertaken in collaboration with the Assistant Director of the Department, and the results were distinctly promising, some plants which were apparently dying having subsequently put out new leaves and recommenced to grow. The plot of cotton especially attacked by this pest had borne a similar crop in the previous season. Doubtless the loss would have been less had there been a change of the crop on it, for the beetles and their larvae possibly lie dormant in the ground during the unfavourable conditions of the dry season.

Insects attacking Cotton Bolls.

The red bollworm, *Diparopsis castanea*, Hmp., occurred abundantly. The life-history of this well-known insect has already been worked out by several entomologists, and my observations accord with what I have read, but there is one important feature characteristic of the insect in Nigeria, namely, that whereas in the majority of cases pupation lasts eight to ten days, yet a small number of instances occur in which the pupa may lie dormant in the ground for many months. Some of these bollworms which buried themselves in earth in my laboratory in October were still in late May, when I came away, in the resting pupa condition, though moving actively at a touch, obviously a provision of nature to ensure the preservation of the species through the adverse conditions of the dry season.

The life-history of *Earias biplaga*, Walk., the other common bollworm, was not definitely worked out, though larvae of all ages were from time to time found not only in bolls, but at an earlier stage in flower-buds. They were found also feeding on the eaves and in the seed-pods of the fibre plant, *Sida carpinifolia*, L., also of the family Malvaceae, as well as on the leaves of several bush plants.

The full-fed larva, which measures about ¾ inch in length, is dull brown in colour and is characterised by the presence of four pointed tubercles on each segment, so situated as to form dorsal and sublateral longitudinal rows. The colour of the larva, the presence of these tubercles, and the fact that it is often found as a leaf-eater seem to indicate that its boll-boring propensities are a recent development, probably dating from the cultivation on a large scale of cotton in the country.

Though no natural enemies were discovered in the case of *Diparopsis*, a species of Eumenid wasp, *Rhynchium ventrale*, Sauss., a black insect with a red tip to its abdomen, was found to act asan important check on *Earias*. This Eumenid was for a very long time confused by myself with other very similar insects, *Synagris calida*, L., *S. spiniventris*, Ill., and *Rhynchium synagroides*, Sauss., until I noticed a wasp on the wing carrying an *Earias* larva. It was seen to enter a cylindrical tube of mud

attached to a wall, and on breaking this away a boring was discovered, which was found to lead into a branching passage enclosing several closed cells, in which were Noctuid larvae of two species, *Earias biplaga*, and a form unidentified. Further observation led to the discovery of many similar tunnels, and in the light of this fact I observed the wasps in the cotton fields, and found them actively searching for this particular prey.

Two other species of bollworm, *Pyroderces simplex*, Wlsm., and a new species of the family GELECHIADAE, described by Mr. J. H. Durrant under under the name of *Mometa zemiodes*, gen. et sp. nov. (see p. 243), were also studied. Though *Pyroderces* was quite abundant, and is now for the first time recorded from Nigeria, it was obtained as long ago as 1885 in the Gambia by Sir Gilbert Carter, where also the larva was found attacking maize. A full description of the insect by Mr. J. H. Durrant has already appeared in this *Bulletin* (Vol. iii, pt. 2, p. 206, Aug. 1912).

Both these two bollworms are small bright pink caterpillars which were found for the first time in June abundantly in belated bolls on plants of the previous season, but were not seen again until the cotton season was well advanced.

Whereas *Diparopsis* and *Earias* bore into unopened bolls and eat away both the immature lint and seeds, the two pests under consideration confine themselves solely to the seeds in opened bolls, eating out the substance till only the husk remains; they are not therefore productive of damage to the same extent as the other forms, though their activities continue even when the unginned cotton is stored away in bags and they may be found alive in seed even after ginning. The larvae were found occasionally also in waste seed scattered about the ginnery.

Both the larvae are much subject to attack by a Chalcid parasite, *Chalcis olethrius*, Waterston, sp. nov. (see p. 257), many of which were bred out in the laboratory. No method of controlling the pests other than by collecting and destroying affected bolls was devised. At the end of the season, when the plants are pulled up and destroyed, the soil should be carefully and thoroughly dug up and turned over with a view to exposing the aestivating *Earias* pupae.

During the dry season the Pyrrhocorid bug, *Dysdercus superstitiosus*, F., was found in some numbers, many even then *in coitu*, sucking up the secretion from the nectaries of *Urena lobata*, and at this time they appeared to be able to thrive on almost any food, whether of animal or vegetable origin, for eight or ten were noticed feeding on a dead and sun-dried lizard and a batch of young nymphs was found on sheep's excreta. They are able to support themselves also on various fallen and dried bush seeds. Later on these cotton stainers were to be found in large numbers feeding on the heads of guinea corn, fifteen feet high, where it was impossible to reach them, and even on ordinary grass panicles. A very decided preference was shown for okra, a few plants which happened to be growing near cotton and with their fruit at a more advanced stage, being simply covered with the insects.

It is a rather singular fact that the black-banded cotton stainer, *Dysdercus nigrofasciatus*, Stål, previously reported as a fairly abundant pest, did not appear until late December, and then only in very small numbers; neither were the two remaining stainers, *D. melanoderes*, Karsch, and *Oxycarenus dudgeoni*, Dist., at all numerous.

The latter was found to be a late season pest, breeding in opened bolls and attacking the seeds. It was frequently found in lint removed from the bolls put aside for the purpose of ginning. The enormous numbers of *D. superstitiosus* (49,000 were collected in November from 46 acres) were to be accounted for, in my opinion, by their swarming in from the farms and bush adjoining the plantation, attracted to their favourite food-plants.

A fact of much interest is that *D. superstitiosus* and *D. melanoderes* occasionally interbreed, for a male of the former species was taken *in coitu* with a female of the latter from which eleven offspring, all *superstitiosus*, were reared in the laboratory, a result in accordance with Mendelian expectation. The life-cycle in the laboratory, from egg to imago, occupied 29 days only, though a previous observer has recorded 68 to 72 days as its duration, and it seems to me quite probable that under natural conditions with an abundance of fresh food the period would be even shorter. My own observations confirm a previous statement that *superstitiosus* oviposits in the ground and not, as would be expected, on the food-plant, and the newly hatched larvae feed on any cotton debris they can find, and then, crawling up the stems, find their way to the bolls.

Small nets were successfully employed for collecting immature wingless stainers, which, congregating on bolls and at the extremities of the branches, were readily shaken off. Many were shaken by small boys into wide-mouthed tins containing water and a small amount of kerosene, a method suitable for the native farmer. The large stainer net, as used in the West Indies, was thoroughly tested, but was not found to have any real practical value against the Nigeria insects, for the adult stainers only fell off when the plant was shaken excessively, to such an extent as to render damage probable, and more often than not they took to flight instead of falling. Moreover, the methods of cultivation and the habit in growth of the cotton plants under trial did not permit the ready use of such an appliance.

Hand-picking seems likely to prove the most efficacious method of controlling the pest. By hand-picking 49,453 stainers, the great majority of which were mature breeding insects, with 7,081 larvae and 2,120 pupae of the leaf-roller, *Sylepta derogata*, were collected in the month of November from the 46 acres under cotton, at a cost of £4, so that if the labour of small boys is utilised, the method can hardly be considered an expensive one. Probably if a larger gang than ten had been put on to the work earlier in the season, the results would have been even more effective. Hand-picking has the advantage also in that other pests, *e.g.*, the leaf-roller, can be dealt with at the same time ; but for the method to be really effective, it would be essential that there should be co-operation, year after year, among all the farmers in the cotton districts. Evidence of the value of the measure was afforded by the excellence of the cotton grown, which, in spite of attack by these pests in hordes, was yet awarded by the British Cotton Growing Association the prize annually offered for the best cotton grown in countries in which they have interests.

Some General Remarks on Cotton.

Mixed cultivation, as was pointed out by Jemmett in 1910, certainly has the advantage of decreasing the spread of insect pests. Other Malvaceae should obviously not be planted in the vicinity of cotton, unless it is intended to collect pests on them,

for *Urena* and the various species of *Hibiscus* serve to attract them almost as much as cotton itself, and moreover the cotton scales flourish on all these plants. Okra, in particular, might probably be planted with great advantage as a trap crop by means of which early collecting of stainers and leaf-rollers could be carried out, for the latter breeds as freely on this as on cotton.

It was noticeable at Moor Plantation that hybrid cottons planted in long narrow plots between belts of maize were relatively free from insect attack as compared with that planted in broad open fields, and it seems highly probable that this freedom from insect attack was due to the influence of the tall maize in preventing the wafting abroad of the odours which serve to attract insects either to feed or to oviposit.

Many visits were made to native farms for the purpose of studying their cotton. Native farmers do not as a rule appear to appreciate that one good sturdy plant is likely to produce better and more abundant bolls than a number of feeble, undersized plants, and they often have as many as eight or ten sickly plants all springing from the same spot, a condition noticeable even on farms actually adjoining Moor Plantation.

The farmer habitually leaves the lint unpicked long after the bolls have burst open, his idea being to gather it all in at one picking instead of by repeated pickings. It then becomes stained and deteriorated in quality, the result being that the cotton stainer gets some unmerited blame, and the commercial repute of the lint is likely to suffer unnecessarily. Well after the cotton season, in May, it was noticeable that on many farms the cotton plants were still left in the ground and that late bolls were unpicked and were absolutely infested with bollworm, stainers and other pests.

It is highly desirable that all old plants should be pulled up and burnt, with a view to keeping down these insects, but if the plants are allowed to remain for a second season, the old bolls should certainly be destroyed, when picking is not being regularly carried out. Legislative measures to enforce these precautions have been brought in in all the great cotton-growing centres.

Cacao Pests.

Insects attacking Cacao Leaf.

Colonies of a species of Psyllid, *Udamostigma tessmanni*, Aulm. var., occurred frequently on the growing shoots of young plants and were successfully combated by brushing with kerosene emulsion.

Black Aphids were found from time to time on the stems of young yellow pods, and on the under side of young leaves, producing a characteristic infolding of the margins, axial rotation of the leaf, and unusual crispness of the leaf substance. At Agege, the cacao centre of the Colony, 12 miles north of Lagos, the larvae of two species of Syrphid flies and the larvae of a Lacewing, preying exclusively on the Aphids, were found in abundance. Many of the aphis colonies, composed both of imagos and immature forms, were found to have died *in situ*, as if from disease, so that the natural agencies checking the pest were thoroughly effective.

Young plants were to some extent attacked by the grasshopper, *Zonocerus variegatus*, already mentioned as a cotton pest, but the principal insect scourge, as in previous years, was the Rutelid beetle, *Adoretus hirtellus*, Castn., which feeds by night, nvariably attacking young plants, and hiding by day, often about the roots. A

second leaf-eating beetle, found in some numbers in the early morning was a Melolonthid, *Trochalus carinatus*, Schönh.

A species of basket worm, the larva of the Psychid moth, *Metisa sierricola*, White, (Plate xxiii), was to be found occasionally eating cacao leaves. The wonderful power possessed by the legless, wingless females of this family of attracting the males was repeatedly shown by the assembling of males, often to the number of forty or fifty and always in the early morning, to a newly emerged captive female.

The caterpillar of the Arctiid moth, *Diacrisia maculosa*, Cram., was also found attacking the leaves, and is probably the most important pest next to *Adoretus*. The larvae of a small Noctuid moth, *Earias citrina*, Saalm., were also observed on the leaves of young cacao plants. Though larvae of the Hesperid, *Rhopalocampta forestan*, Cram., have been recorded as cacao leaf pests in Nigeria, they were not in evidence on cacao during the past season, though they were collected in large numbers from a bush plant by the Eumenid wasp, *Synagris spiniventris*, Ill., which stores them exclusively as food for its larvae. The red tree ant, *Oecophylla smaragdina longinoda*, Latr., which occurred on the larger plants abundantly and is highly combative, probably plays a most useful part in keeping off the various insect pests other than COCCIDAE. Its presence probably accounts for the fact that only young plants which it does not frequent, are attacked by leaf pests, for the latter do not cause appreciable damage to older and well established plants.

In regard to the measures adopted against the leaf-eaters, in the wet season the plants were dusted with a mixture of Paris green and lime, a measure attended with good results. Later on, spraying with chromate of lead solution was adopted instead, owing to the liability of Paris green to scorch the young and tender leaves.

Insects attacking the Stems.

The only stem-borers found were the larvae of the Megalopygid moth, *Eulophonotus myrmeleon*, Feld. (Plate xvii, figs. 7, 9), the only representative of the MEGALOPYGIDAE known to occur outside America. The larvae usually tunnel medium-sized branches, causing a gradual impairment of vitality, so that the leaves droop, then wither and fall, and the branch itself ultimately blackens and dies. The cause of the condition is readily determined by finding at the junction of the healthy and diseased parts of the branch a circular orifice, covered up with sawdust-like droppings held together with silk, which leads into a tunnel containing a white maggot-like larva or a brown, spiny pupa. It is unusual for the main stem to be attacked. In the Onipe district, about 15 miles due south of Ibadan, this species occurred in abundance, nearly every tree yielding one or two specimens.

These boring pests are well known to the farmers in the cacao-growing district, and it is their practice to lop affected branches, leaving them on the ground. This probably makes little difference to the well-being of the borers, which can thrive in freshly dead wood if moisture is present, so that to destroy the pests it is necessary to burn such branches ; though if found before much damage is done, an easy method is to push a flexible wire up the tunnels, subsequently plugging and tarring the hole. With a view to killing the larvae tunnelling in main stems, injections of carbon bisulphide were made into the bore-holes and they were then immediately plugged with a pellet of clay and tarred. This measure also seemed to be attended with good results.

The boring beetle recorded as attacking cacao on the Gold Coast was not found, though special search was made for it.

Some of the trees at Agege, in September, showed evidence of attack by other insects, probably Lepidopterous larvae, which had fed in the deeper layers of the bark. No specimens were then obtainable, but the offender is almost certainly the larva of an Aegeriid moth, the damage being precisely similar to that produced by larvae of this family on the cashew and on a species of *Albizzia*, such as, *Melisomimas metallica*, Hmp., sp. nov. (see p. 245). Such larvae are particularly subtle in their mode of attack, for they eat away the deeper layers of the bark, re-inforcing the superficial layers on the underside with silk, which prevents any very obvious surface indications of the mischief which is proceeding, the result being that areas as large as the palm of one's hand are eventually denuded. The material covering the pest was scraped away, and then the exposed surface was tarred with a view to preventing fungus attack.

The notorious bark-sapper, *Sahlbergella theobroma*, Dist., a Capsid bug figured and described by Dudgeon in a previous number of this Bulletin (vol. i, p. 60, Plate viii) from specimens taken on the Gold Coast, occurred sparingly in the Onipe district, near Ibadan. It is, as I was informed by Mr. C. O. Farquharson, the Mycologist, who is familiar with the insect, a serious menace to the cacao in the Eastern Province, a district which I was not afforded an opportunity of visiting myself.

Small Bostrychid beetles and their larvae were found occasionally boring in dead cacao limbs. It may here be said that beetles of this family in Nigeria are to be found boring in living as well as in dead wood, quite commonly in *Hibiscus rosasinensis*, and in *Melia azedarach*, a fact at variance with the usually accepted account of their habits.

Cacao Scale-Insects.

Several species of this family, some of which have been noted as pests in other cacao-growing areas in Africa, were found, though none occurred in any great abundance. A *Dactylopius*, either *longispinus*, Targ., or *virgatus* var. *madagascariensis*, Newst. (Plate xxi, fig. 2), was found here and there on the growing shoots of young plants at Moor Plantation and on the flower-stalks and small pods at Agege. As has been recorded elsewhere (Trans. Ent. Soc., 1913, p. 475) both these scales are effectively checked by the larvae of the Lycaenid butterfly, *Spalgis lemolea*, H. H. Druce, which was actually carrying out this useful work at Agege. At Moor Plantation this scale was successfully treated by brushing the affected area on each plant with kerosene emulsion, a method which in the case of small plants is certainly less prejudicial than spraying.

Stictococcus sjöstedti, Newst., one of the recognised cacao pests of Western Africa, was found both at Moor Plantation and at Agege, at the latter place protected by the large red ant, *Oecophylla*. The natural enemies of this scale already recorded in Nigeria (Trans. Ent. Soc. 1913, pp. 491 and 493) are the larvae of the Noctuid moth, *Eublemma ochrochroa*, Hmp., and of the Tortricid, *Tortrix callopista*, Durrant. A third larva was also found eating the same species of *Stictococcus* on the fruit of a species of *Napoleonica*. At Moor Plantation, though not at Agege, this scale showed evidences of parasitism by Chalcids.

Another *Stictococcus, S. dimorphus*, Newst., occurred on cacao at the Agege plantation, especially on the new shoots, and less on the native farms, a fact doubtless to be accounted for by the use for shade purposes of the pigeon pea plant, *Cajanus indicus*, on which this particular scale is to be found in great profusion. It was greatly checked by a Noctuid larva, *Eublemma scitula*, Ramb., of the sub-family ERASTRIINAE, the larva, as in the case of *E. ochrochroa*, concealing and protecting itself under a shield largely composed of the shells of its victims.

Another scale, which was common on pigeon pea and found from time to time on cacao, was a species of *Icerya* (Plate xxiv, fig. 1).

Insects attacking the Pods.

A small Lymantriid caterpillar was found sparingly eating the superficial layers of the cortex, but doing little direct damage, though probably paving the way for fungus attack.

Fig. 2. *Araecerus fasciculatus*, de G.

Some Anthribid beetles, *Araecerus fasciculatus*, de G., were bred from larvae boring in the husk and a Lepidopterous borer, the larva of *Characoma stictigrapta*, Hmp., (Plate xvii, fig. 6) was also not uncommon. The caterpillar of this insect bored exclusively in the husk, its track being betrayed by patches of black rot of the superficial layers, consequent on the undermining, and by the discharge through various rounded apertures of frass held together by silk. When full-fed, the larva spins a cocoon in the thickness of the husk and there pupates.

The scale-insect *Stictococcus dimorphus*, Newst., occurred fairly frequently on the larger pods, more particularly on those of the yellow Amelonado variety, where they were assiduously guarded by the red ant (Plate xxii). This scale causes the cortex of the pod to rot in small black circular areas, on which a white floury amorphous powder, possibly due to the drying of some secretion, is found after the scale has fallen off, and it certainly paves the way for fungus attack.

Some Trypetid flies, *Ceratitis nigra*, Grah., were captured in great abundance in the cacao fields at Agege during a short visit in late April, but did not permit of an investigation into their relation to the pods. Another undetermined species was also obtained in the same neighbourhood, ovipositing in the fruit of a bush plant.

Termites.

White ants eating away dead wood on the cacao trees at Agege were numerous. No species attacking living wood was found, though, as the dead material is eaten

away, it is probable that more and more of the living material behind it gradually dies owing to the removal of the protective covering, or from fungus attack, so that from small beginnings serious damage may be produced.

It has been a vexed question in the colony as to whether any of the species of termite will attack the roots of living cacao and rubber. From such observations as I have been able to make I see no reason to suppose that this is the case, except in a very dry season, when they may attack living tissues for the sake of the moisture in them.

Dead plants on native farms are rarely removed until they become infested with termites, and frequently in the case of dead trees no definite cause other than this can be seen, but I was informed by the Mycologist that the termites almost invariably follow close behind fungus disease, the presence of which the native farmer of course has not appreciated.

One of the large black Ponerine ants, *Paltothyreus tarsatus*, F., plays a useful part in attacking and carrying off termites on every possible occasion.

The termites were successfully combated by means of the "Universal Ant Destroyer," a machine by means of which arsenical and sulphurous vapours, with a mixture of carbon monoxide and dioxide, are pumped into the termitarium.

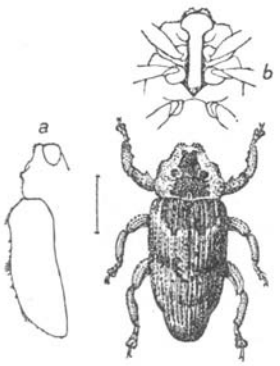

Fig. 3. *Paremydica insperata*, Fst.; *a*, dorsal outline; *b*, head and thorax seen from below.

Fig. 4. *Balanogastris kolae*, Desbr.

Insects attacking Kola.

A Delphacid, *Pundaluoya simplicia*, Dist. (see p. 242), was found quite commonly in all stages of development at the tips of young shoots. They were treated by brushing with a weak kerosene emulsion. Young nursery plants were, like cacao, much attacked by the *Adoretus* beetle, which produces the same characteristic damage to the leaf, and by various grasshoppers, the chief of which was *Zonocerus variegatus*, L. A considerable variety of other leaf-eaters were found, but none was responsible for any great damage. The usual stomach poisons were employed against these pests. Kola nuts, both on the tree and in store, were considerably attacked by weevils, *Paremydica insperata*, Fst., and *Balanogastris kolae*, Desbr., which in turn were parasitised by an Ichneumonid.

Insects Attacking Coffee.

Only one leaf-eater of any importance, the larva of the Drepanid moth, *Metadrepana glauca*, Hmp. (Plate xvii, fig. 4), was found, and this solely at Agege. The caterpillar is dull green, with a lighter coloured bulbous expansion of the thorax, and a long black whip-like tail.

The Coreid bug, *Riptortus tenuicornis*, Dall., previously recorded as a pest, was not in evidence this year on coffee, though it was obtained in great numbers on a small low-growing Leguminous plant.

Various scale-insects, *Stictococcus* in particular, were found on young shoots, but by no means in abundance, and were protected by the *Oecophylla* ant.

Maize Pests.

Leaf-eaters.

The most important pests attacking maize in the leaf were Lepidopterous larvae. The life-history of one of these, *Prodenia litura*, F., was worked out. The female parent deposits her eggs *en masse* on the underside of a maize leaf, protecting and concealing them with a downy material composed of hairs and scales from her abdomen. The larvae hatch in three days, and immediately commence to eat away the superficial layers of the leaf so that it exhibits translucent patches and becomes withered; they then gradually scatter and as they become stronger eat away the whole thickness of the leaf. When about two-thirds grown, at the 13th to the 16th day, the larvae, which are brown, show a tendency to conceal themselves in the heart of the plant; this is of interest as showing a possible step towards the development of actual boring habits. It is at this stage that most damage is done, for often the only indication of their presence is the withering up and ultimate death of the growing shoot, which on examination is found to be eaten through towards the base. When full-fed, towards the middle of the fourth week, the larva buries itself in the ground and, forming an earthen cocoon, pupates, the fully developed insect appearing about eight days later.

The larva of the Noctuid *Cirphis loreyi*, Dup., and that of a species of *Plusia* were found frequently on maize leaves, and there were quite a number of other species not sufficiently numerous to be considered pests. Two species of Lymantrid caterpillars devote their attention to the silk, eating it away flush with the apex of the cob, an attack which, if it occurs before fertilisation has taken place, must lead to total failure of the cob. The earwig, *Elaunon erythrocephalus*, Oliv., was responsible for some damage to green maize. The species seems to be of gregarious habit, isolated specimens being rarely found, and their attack on a plant produces a very characteristic appearance, which, when once seen, can always be detected at a glance. The growing shoot loses tone, droops and becomes withered, and on separating the leaves one finds earwigs congregating in and about holes bored into the leaves and stem. This leads to the plant dying back as a rule, but it seems to recover and recommences to grow, and as the new leaves attempt to force their way through the holes in the old ones, they become restrained and distorted. These earwigs actually breed on the plants, and it is no uncommon thing to find a female parent brooding over a batch of ten to fifteen light yellow eggs, or much agitated at the prospect of danger menacing the young family over which it mounts guard with exemplary solicitude.

Pests attacking stems and cobs.

The chief of these was a dirty-grey caterpillar, the larva of the Noctuid moth, *Sesamia calamistis*, Hampson (Plate xvii, fig. 1). Another species, which is almost equally numerous, is the larva of the Pyralid moth, *Eldana saccharina*, Walk. (Plate xvii, fig. 2), a white maggot-like caterpillar with black head and prothoracic plate. A third borer found occasionally in the stems was the larva of the Noctuid, *Busseola fusca*, Hampson (Plate xvii, fig. 3), which is one of the principal borers in maize in South Africa. The effect produced by these borers varied with the age of the plant. Young plants withered and sometimes died, but older plants survived, though they showed the results of the attack by their stunted growth and withered appearance, and by the failure of the cobs to develop and mature satisfactorily. A large number of malformed cobs examined at Agege showed larvae, pupae or pupa-cases at the core.

When plants bearing cobs are attacked the caterpillars seem to prefer the cob to the stem, but the mode of attack is different in each case. *Sesamia* usually feeds away at the heart of the cob, not as a rule touching the seeds, and when full-fed, pupates in this situation. The damage done to the seed is therefore indirect. *Eldana*, on the other hand, prefers to eat the grains, through which it tunnels here and there, pupating eventually in a white silken cocoon, firmly bound up in the seed, though such cocoons may sometimes be found between the layers of the husk.

The two common species, *Sesamia* and *Eldana* are both checked by a Tachinid fly, which was especially abundant at Agege, though its influence as a check was found to be reduced owing to its being itself much subject to attack by Chalcid parasites—a new species of the family ENCYRTIDAE. A fact of great importance is that these two larvae were to be found even in maize stems left standing in the field long after the cobs had been picked. These stems often possess vitality enough to put out new green shoots, which may continue to grow for weeks after the cobs have been removed. The larvae of *Sesamia* and of *Busseola* were also found as borers in the stems of the coarse grass found so abundantly in the Ibadan district, and moths from larvae in the grass were bred out in the laboratory.

The bright pink larva of another Noctuid works havoc in a particularly subtle way, by feeding just inside the apex of the cob on the silk, which may then fall out. Fortunately its attentions were not limited to young silks, but extended also to older ones, in which case as the seeds were already fertilised it could do little harm. When full-fed these caterpillars spun their cocoons in the remains of the silk and these were readily obtained by gently pulling the silks, which then usually came away quite easily in one's hand. These larvae are frequently parasited by TACHINIDAE, the pupae of which were often found in the cocoons, but the Tachinid pupae in turn are often infested with Chalcids. This pest was much more abundant in Agege than in the Ibadan district.

Towards the end of the maize season a further caterpillar pest, the larva of the Pyralid moth, *Mussidia nigrivenella*, Rag. (Plate xvii, fig. 5), was to be found here and there in the almost ripe cobs. Some importance is to be attached to it in the field, for this insect is one of the chief pests attacking stored grain and is indeed responsible for almost as much damage as the various grain beetles, infection in the first place taking place in the field, and subsequent generations feeding up in the store.

The pests which cause most damage to maize in the fields are the cob and stem borers, with which it is almost impossible to deal directly, though, as pointed out by my predecessors, their numbers could certainly be reduced by a cleaner system of farming. The maize on the native farms is as a rule allowed to remain in the field long after it is ripe, so that it becomes infested with caterpillars and weevils; it should unquestionably be harvested as early as possible and then the husks and stems should be disposed of. The native practice of leaving the stems still standing in the fields and of training up the yam vine on them cannot be too strongly discouraged, for, as already pointed out, the borers continue to feed and thrive in these partly dead stems. When the cobs are stripped, also, the husks are littered about, many containing larvae and pupae of pests.

The ideal method of disposing of maize refuse would be to burn it, but as this was felt to be undesirable from the point of view of sound farming, a series of experiments were made with a view to testing how far the burial of refuse, or its inclusion in compost heaps would result in destruction of the pests. It was found that borers in maize and guinea-corn refuse perished when it was buried under a few inches of earth in the wet season, when doubtless bacterial action and other fermentative changes set up in the fluids in the stems would accelerate their death. Formation of the refuse into a compost heap was also equally effective.

The problem of the control of these pests therefore resolves itself into (*a*) harvesting as early as possible, and (*b*) clean farming; and if these are practised, there are likely to be fewer pests in stored grain.

Pests Attacking Stored Maize.

On my arrival in late May, maize in the store was found to be severely attacked by the common grain weevil, *Calandra oryzae*, L., the Tenebrionid *Tribolium confusum*, the Trogositid *Tenebrioides mauritanicus*, L., and by a fourth smaller brown beetle, in addition to the larvae of the Pyralid moths, *Mussidia nigrivenella*, Rag., and *Ephestia cautella*, Walk., and all these pests reappeared in great force in the new maize almost as soon as it was stored. None of the field pests other than these was found to attack stored maize.

As showing the remarkable instinct possessed by these pests for finding food for themselves and their offspring it may be mentioned that, in early November, five sacks of sound maize, apparently free from insects, were placed in the laboratory. On the following day maize beetles and moths were observed to be flying in at the windows, at once settling on the sacks, and there was a gradual and constant invasion subsequently, so that at the end of December the grain was absolutely riddled by them. A large number of little Chalcids were then discovered in the maize and it was subsequently found that they were breeding freely in larvae of *Calandra*, though owing to the enormous numbers of these beetles they were not effective as a check. These parasites belong to a new species of *Meraporus* (family Pteromalidae) which will shortly be described by Mr. James Waterston.

The harvested grain was placed in a seed store, the window frames of which were filled with copper mosquito gauze for ventilation purposes. In March, a dense mass of the moths *Ephestia* and *Mussidia* could be seen early each morning flying up and down on the outside in an endeavour to find an entrance, and settling down quietly

as the day advanced to wait till night-fall before resuming their activities, eventually dying in such numbers that handfuls could be gathered on each sill.

With a view to estimating the relative increase of, and the damage done by, *Calandra* and *Tribolium* respectively, the following experiments were conducted. On 27th October, half a pound of thoroughly sun-dried new maize was placed in a well closed glass jar with fifty *Calandra*. When examined again on 30th December, the maize, shaken free of debris produced by the attack, was found to have lost 1½ oz. in weight, and though only 40 per cent. of the seeds had been attacked, 420 weevils and a large number of larvae were found.

On the same day half a pound of maize was placed in a sealed jar with 50 *Tribolium*. On 30th December the grain, shaken free of debris, had lost 2 oz. in weight, and though the beetles, exclusive of larvae, had only increased to 167, the grain had suffered to the extent of about 65 per cent., a much greater damage therefore than in the first experiment. The explanation of this appears to be that *Tribolium* bores into a grain, deposits an egg or feeds, and then goes on to another grain, whereas *Calandra* will contentedly feed away and oviposit in a single grain. It was found in the laboratory that a single grain of maize contains sufficient nourishment to support a female *Calandra* and her developing offspring for five weeks, at the end of which time her mature offspring may number five or six, all of which have fed up on this one grain. These results were not obtained in the case of *Tribolium*, though in one case a single mature insect was bred out in the course of a month from one grain, which also supported the female parent during this time.

Further experiments show that, though both *Calandra* and *Tribolium* are found in cobs in the field, yet *Calandra* does not seem to have the power, possessed by *Tribolium*, of boring through the unbroken sheath of the cob. *Calandra* placed on such a sheath in glass tubes, mouth downwards, died a lingering death after ten to fifteen days without having pierced it, whereas *Tribolium* very soon disappeared into the cob. In all probability, therefore, *Calandra* obtains access to the cob through the opening at the apex from which the silk has dropped out, or through holes made in the sheath by borers.

A few experiments were made in the hope of finding if possible a sacking material proof against *Calandra* and *Tribolium* for the storage of fumigated maize, but the only fact established was that the weevil does not penetrate a coarse drill, though unfortunately *Tribolium* has no difficulty in doing so.

As has been already noted, the Pyralid moth, *Mussidia*, is a formidable pest in stored maize. The larva when first hatched bores into a grain and eats out the soft nitrogenous radicle at the apex, leaving the harder part untouched, so that a grain attacked comes to resemble in shape a small double tooth with two fang-like processes. When this is finished, if the grain is still on the cob, it gradually tunnels along the whole length of a row, eating away the softer portions and leaving the hard shells, and it pupates eventually in a silken cocoon in this tunnel. There is often no surface evidence of the damage which is proceeding.

When shelled maize is attacked the caterpillar spins grains together and then bores through the mass. Silk web with characteristic damage is to be looked on as infallible evidence as to the presence of this moth. A rough estimate of the damage done by the pest was obtained by placing, on 30th October, four female moths in a jar

containing 8 oz. of sound maize. Oviposition took place at once and a few days later a large number of larvae hatched out. At the end of two months, on 30th December, two generations had completed their life-cycle; the maize, shaken free of debris, had lost 25 per cent. in weight, and 50 per cent. of the grain showed evidence of attack. For the purpose of freeing the seed maize at Moor Plantation from these insect pests, it was fumigated, after preliminary experiments, with carbon bisulphide, employed as suggested by the Imperial Institute, at the rate of 5 lb. per 1,000 cubic feet of space, and fumigation of each batch was made to extend over five days, by which time it was anticipated that, even if the eggs of the pest had not been killed, the larvae would have hatched out and perished.

These anticipations seemed at first to be fully realized and for some time there were no signs of living pests. But at the end of about three months, greatly to my surprise and disappointment, weevils and grain beetles reappeared in some of the sacks. I then made a careful examination of the fumigating bins, and discovered defects both of construction and of material by which the success of the fumigation might have been vitiated. Moreover, on turning my attention to the store itself, I found numerous slits in the boarding of the roof, by which any number of insect pests might subsequently have entered. As a result, the pests increased to such an extent that further fumigation was urgently called for. Unfortunately the double fumigation affected the germinating powers of most of the seed, but I am confident that if the operation could be carried out under favourable conditions in properly constructed receptacles, and if the grain were kept subsequently in a well-made store, adequately ventilated, a single fumigation of the strength recommended would suffice to exterminate entirely all forms of the pests.

At the suggestion of Mr. A. H. Kirby, the Assistant Director of Agriculture, and in collaboration with him, experiments were made as to the value of the fumigation of grain against insect pests with carbon dioxide. In default of more suitable apparatus, kerosene tins were filled with infested grain and carbon dioxide was driven in, the tins being then sealed. At the end of ten days the tins were ventilated and again sealed. The results were entirely satisfactory, no living pests being found months later, and the germination percentage being very high. I wish to take this opportunity of thanking Mr. Kirby for his very valuable suggestion.

When tried on a larger scale in one of the bins the results were not so good, but I subsequently found a large crack in the floor by which the gas doubtless leaked out prematurely.

Insect Pests of Rubber.

Para rubber plants were singularly free from insect attack, the only leaf-eater found being the omnivorous grasshopper, *Zonocerus variegatus*, which attacked young nursery plants, those that were not well shaded being far more damaged by these sun-loving pests than those which were more sheltered.

The large cricket, *Brachytrypes membranaceus*, Drury, which sometimes fed on the roots of young plants, was responsible for a slight loss, but it was preyed on by the fossorial wasp, *Chlorion xanthoceros*, Illig., var. *instabilis*, Sm., which thus acts as a valuable natural check.

Funtumia elastica is attacked by two Lepidopterous leaf-eaters, the larva of a species of Sphingid moth of the genus *Nephele*, which is much parasitised by Braconids,

and the larva of the Pyralid leaf-roller, *Glyphodes ocellata*, Hmp., which is found especially on young plants.

A borer, probably a beetle larva, is found occasionally at work towards the base of trees, tunnelling under the bark and causing an exudation of latex.

Funtumia pods, when open, were found to contain a variety of insect pests. The larvae of the Pyralid moth, *Entephria sexpunctalis*, Hmp., were found tunneling whole rows of the seeds close to their attachment to the placenta, and the little beetles *Berginus tamaricis*, Woll., occurred in some numbers feeding on the seeds. Some of the pods were filled with almost incredible numbers of the Lygaeid bug, *Arocatus continctus*, Dist.,* the larvae of which were feeding on the seeds, the imagos being found in immense swarms under the leaves.

Insects Attacking Ground-nuts.

These were fairly free from insect pests, the only leaf-eater found being the larva of the Psychid moth, *Metisa sierricola*, White, mentioned under cacao (Plate xxiii). The scale-insect, *Ceronema africana*, Macfie, was found abundantly on a few plants (Plate xxiii).

Insects Attacking Beans.

Young plants in July were much attacked by various species of beetles. Of these the Lagriids, *Lagria villosa*, F., and *L. viridipennis*, F., were responsible for large irregular holes in the leaves, while the Galerucid, *Ootheca mutabilis*, Sahlb., seemed to limit its attention to the young shoots, eating half through the stem so that withering took place.

As this crop is grown in Nigeria only as green manure, and as Leguminous plants stand the action of insecticides badly, it was thought undesirable to use the spray on them, and so boys were instructed in the art of collecting the pests by means of light sweep nets, a method which was found to work satisfactorily. As showing the abundance of the pests it may be mentioned that 797 were obtained in two days by two small boys in this way.

In early December, the height of the dry season, the two Lagriid beetles were found in great numbers, aestivating in the axils of a Bromeliaceous plant. In the store the bean seeds were to some extent attacked by an undetermined beetle of the genus *Bruchus*.

Pests of Pigeon Pea.

Though this plant is of small economic importance in Nigeria, being grown only for the purpose of shading young cacao, it is of considerable importance as a food-plant in the East, and thus some study of the pests attacking it in Nigeria has seemed desirable. Moreover, as will be seen, several of the insects found on it are also injurious to cacao.

The scale-insect, *Ceronema africana*, found also on ground-nut plants, was abundant (Plate xxiv, fig. 2). The *Pseudococcus* found on cacao (Plate xxi, fig. 2) was to be found here and there and another cacao scale, *Stictococcus dimorphus*, Newst. (Plate xxii), was very numerous. A species of *Icerya* (Plate xxiv, fig. 1) was also found from time to time. Leaf-eaters of many kinds were found and the seed also was attacked

* For a figure of this species see p. 242.

by various larvae, the chief of which were the larva of the Pterophorid moth, *Marasmarcha atomosa*, Wlsm., that often yielded Braconid parasites, and the larva of the Lycaenid butterfly, *Lampides boetica*, L., The latter, of the usual green onisciform type, was guarded by various ants, *Camponotus akwapimensis* in particular, a group of which at the mouth of a tunnel in one of the pods invariably indicated the presence of the larva within. Larvae of another undetermined moth were also not uncommon, boring in the pods.

The gregarious froghopper, *Ptyelus grossus*, F., occurred both in the nymphal and imaginal states, feeding on the stems, which were so drained that frequently a constant stream of fluid trickled to the ground.

Insects Attacking Oil Palms.

A little weevil (*Calandra oryzae*, L.) was found in some numbers boring in an oil palm scorched by repeated bush fires. Evidence that it had reached living tissues was shown by the constant dripping of sap, which attracted a host of other insects, ants especially, but few of the pests could be obtained owing to the difficulty of getting them out of the hard tissues in which they had embedded themselves.

No other pests attacking oil palm were found in Nigeria, but it may be mentioned, in passing, that in the course of some entomological investigations on my way home, in late May, in Cotonou, Dahomey, weevils in almost incredible numbers were found feeding on the fresh male flowers of the palm, hundreds being taken in a few minutes.*

Pests of Sweet Potato.

No pests were found in the field other than the larva of the convolvulus hawkmoth, *Herse convolvuli*, L., which fed on the leaves. The tubers in the store were considerably attacked by two species of weevils, *Cylas brunneus*, F., and *C. puncticollis*, Boh., all stages of which could be found in cavities in the substance (Plate xxv, fig. 1).

My thanks are due to Mr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, for editing the proofs of these notes and for obtaining for me the identification of the majority of the insects mentioned. For the identification of most of the Lepidoptera I am indebted to Professor E. B. Poulton, F.R.S.

*[These weevils all belong to the genus *Derelomus*, there being no less than four species among them. The most abundant was *D. kamerunicus*, Fst., and the remaining three species appear to be undescribed.—Ed.]

Explanation of Plate XVII.

Fig. 1. *Sesamia calamistis*, Hmp., p. 209.
2. *Eldana saccharina*, Walk., p. 209.
3. *Busseola fusca*, Hmp., p. 209.
4. *Metadrepana glauca*, Hmp., p. 208.
5. *Mussidia nigrivenella*, Rag., p. 209.
6. *Characoma stictigrapta*, Hmp., p. 206.
7. *Eulophonotus myrmeleon*, Feld., ♂, p. 204.
8. *Duomitus armstrongi*, Hmp., p. 245.
9. *Eulophonotus myrmeleon*, Feld., ♀, p. 204.
10. *Acrocercops bifasciata*, Wlsm., p. 197.