

THE WHITE-GRUBS INJURING THE SUGAR CANE IN PORTO RICO.

1. LIFE-HISTORIES OF MAY-BEETLES—Continued.

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THE SUGAR CANE WHITE-GRUB—Continued.

INFECTION BY THE METARRHIZIUM FUNGUS.

Infection of *Phyllophaga vandinei* n. sp.* in the experimental jars and boxes by the green muscardine fungus, *Metarrhizium anisopliae* (also known as *Entomophthora anisopliae* and *Isaria destructor*), has been noted of every stage except the pupa. The number of specimens that developed the disease, as compared to the total number kept in confinement under close observation, may be summed up in the following table:

- Of 853 adults kept in confinement, 81 became infected, or 9.5 per cent.
- Of 1,502 eggs kept in confinement, 10 became infected, or .66 per cent.
- Of 852 grubs, 1st instar in confinement, 3 became infected, or .36 per cent.
- Of 209 grubs, 2d instar in confinement, 3 became infected, or 1.43 per cent.
- Of 117 grubs, 3d instar in confinement, 16 became infected, or 13.67 per cent.
- Of 48 pupae kept in confinement, none became infected.

The majority of diseased specimens were adults, which is possibly accounted for by the fact that they, moving about freely in the jars, are more apt to transmit the disease from one individual to another than are larvae or eggs.

The stage in which the highest per cent of individuals became infected was the third instar of the grub, in which infection was necessarily contracted from the soil, which is believed to have contained large numbers of spores.

The degree of susceptibility to infection by the disease was, among the immature stages of the beetle, lowest in the pupal stage and highest in the third instar of the larval stage.

The following conclusions have been reached regarding attack of

* The habits of this species, and suggestions for control, were discussed in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (pp. 42-47), under the name "*Lachnosterna grande*," and its life-cycle (except pre-oviposition) given in the Fourth Report (p. 47) under the same name.

May-beetles by *Metarrhizium*, as result of the behavior of the fungus in its attack on *Phyllophaga vandinei*:

(1) Judging from its behavior in jars containing numbers of adults confined together, the fungus had every appearance of being transmittable.

(2) In jars containing only two adults, the fungus gave no indication of being transmittable. Out of 25 such jars in which at least one beetle contracted the disease, in only two (or 8 per cent of them) did both beetles of a pair become infected.

(3) In the case of grubs, transmission of the fungus from one grub to another was not possible, since practically all of the grubs that became infected were reared in individual boxes. Infection must have taken place through the soil.

(4) Comparing the infection of adults and of third instar grubs, it appears that a higher degree of infection may be brought about through the medium of infection from the soil than through transmission of the disease by contact. There is no proof that transmission by contact ever takes place.

(5) Attempts to artificially infect grubs by the introduction of dry spores into rearing boxes were unsuccessful.

(6) Since all infected specimens, when found, were at once removed from rearing boxes and preserved, artificial increase of the number of spores in the soil used was certainly very limited. It obviously required a very small quantity of the spores to infect a large number of grubs and beetles.

(7) Spores were at no time introduced into the soil by the writer, so must have existed naturally in the soils of the district where the experiments were made. This was proved by the finding, outside the insectary, of the following insects infected with the fungus:

Aphodius sp., two adults under manure in stock lot.

Canthon sp., a dozen or more adults in an outdoor cage.

Strategus titanus, one adult in an outdoor cage.

Ligyris tumulosus, several adults in an outdoor cage.

Phytalus insularis, several grubs in an outdoor cage.

(The last four species were in separate cages, removed some feet apart, with no intermixing of soil from one to another.)

(8) Shipments of *Metarrhizium* spores were made by Mr. Van Dine, in 1911 and 1912, to Mr. T. C. Murphy of Guánica Centrale, who propagated the fungus extensively on May-beetles in the same *hacienda* (Santa Rita) where the writer's experiments were conducted. Later shipments of spores to the same district were also made by the pathologists of the Station, Mr. Johnson and Mr. Stevenson. This may have accounted for the prevalence of the disease in the insectary.

(9) Neither in grubs nor adults was there, ordinarily, any sickness or other visible abnormal condition immediately preceding death. Often grubs in perfect condition would succumb to the disease in a week's time or less, making it appear that death was caused by the disease alone.

(10) In some cases infection was aggravated by previous attack of the grub by mites or bacterial disease. In case of the latter, the dead grub usually became only in part infected by the fungus, as though the latter were a saprophyte, whereas in grubs perfectly healthy before infection the entire body became covered with mycelium, and later with spores, following death.

(11) Normally, the disease had the effect of delaying molting, or pupation, thus lengthening the instar. The exceptions were: two grubs in first instar that died respectively four and twenty-six days after hatching from eggs; and six grubs in third instar that died within three months after last molting (one in thirteen days and one in two weeks).

(12) In the case of several grubs that died of this disease, it was noted that the preceding instar was above normal in length, indicating that a rather long period of infection by the disease precedes the outward and visible signs of disease.

INFECTION OF GRUBS BY BACTERIAL DISEASE.

✓ A very high fatality of grubs in the experimental boxes was caused, or had every appearance of being caused, by a bacterial disease that is supposed to be identical with a disease described as *Micrococcus nigrofaciens* by Zae Northrup. (See Technical Bulletin No. 18, Michigan Agr. Sta., entitled, "A Bacterial Disease of June Beetle Larvae, *Lachnosterna* spp.") The symptoms of the disease are a turning black, and final dropping off, of one or more of the legs at the joints, and the appearance on the body or head of black, shining spots, or lesions, which increase slowly in size and may cover considerable portions of the body before death finally ensues. These symptoms, as observed in grubs in rearing boxes at Santa Rita, are identical with those described in the bulletin by Miss Northrup. Further reason for believing the two diseases identical may be found in a paragraph of that bulletin, which states: "One hundred per cent of larvae received from Porto Rico (March, 1914) were more or less infected."

After examination of the breeding notes, a careful compilation was made of the data concerning the infection of sugar cane white-grubs (*P. vandinei*) by this disease, and as result it was found that sixty-two grubs were noticeably infected, of which number only three pupated and became adult in spite of the disease. The other fifty-nine died, apparently as a result of the disease.

Only the larval stage is attacked by the disease, eggs, pupae and adults being apparently immune. Of the sixty-two larvae attacked, fifty-nine were in the third instar (which represents 50 per cent of the total number reared), and only three in the second instar. No grubs of the first instar were at any time observed attacked by this disease. This is somewhat at variance with the remark made by Miss Northrup that the younger grubs are the more susceptible.

It is notable that at no time were grubs collected in the cane fields, or elsewhere out-of-doors, found affected by this disease. Yet within a few weeks' time after they were placed in the confinement of boxes, the disease would make its appearance on fifty per cent of the grubs. This

may have been due to one or more of three causes: (1) that the soil used in the experiments contained the disease to an extent above normal; (2) that the confinement produced a predisposition to the disease through mechanical injury, since it is supposed to require an abrasion of the skin in order to permit the bacteria to gain access to the grub's body; or (3) that excessive humidity in the boxes was favorable to the progress of the disease.

The fifty-nine grubs that died in experimental boxes apparently as a result of the bacterial disease were divided into four groups, as follows:

- (1) Grubs with sure signs of infection, that died while still in the larval stage.
- (2) Grubs with lesions, or other signs of the disease, that reached the pupal stage and then died.
- (3) Grubs with lesions or other signs of disease that died, but were also infected with *Metarrhizium* fungus, so that the exact cause of death was uncertain.
- (4) Grubs that showed a characteristic blackening of segments after death, but of which no previous symptoms had been noted.

Of these four groups, forty-five of the grubs fell in the first, four in the second, six in the third, and four in the fourth.

Some idea of the progress of this disease, prior to death of the grub, may be gained by the following records of ten individual infected grubs:

- (1) Jan. 18.—Lesion of $1\frac{1}{2}$ mm. on side.
Feb. 3.—Pupating; lesion is 2 mm. across.
Feb. 8.—Pupated. (Adult issued March 3.)
- (2) Feb. 17.—Has black lesion $1\frac{1}{2}$ mm. in diameter.
May 26.—Same lesion now 2 mm. across; another lesion of 7 mm. Grub died as result of these.
- (3) June 2.—Two right legs with bacterial lesions.
June 30.—Three legs on opposite side now infected.
Aug. 14.—Grub died; discolored.
- (4) June 2.—Right middle leg infected at tip.
June 30.—Same leg half off.
July 3.—Tip of left middle leg infected.
July 7.—Tips of all legs but one infected.
July 26.—Preparing to pupate; sickly.
Aug. 5.—Died without pupating; infected with *Metarrhizium*.
- (5) May 3.—Has one leg with bacterial lesion.
June 7.—Pupated; pupa with tarsi of that leg missing.
June 25.—Pupa died.
- (6) Feb. 5.—Has four small black lesions.
May 26.—Three legs infected, a fourth half eaten off; a lesion of $2\frac{1}{2}$ mm.
May 30.—Grub dead, discolored.
- (7) Feb. 18.—A lesion $1\frac{1}{2}$ mm. one side.
May 26.—Lesion is 2 mm. in diameter.

- June 30.—Two more lesions of 2 mm. on other side.
Aug. 5.—Dead and black, including head.
- (8) May 26.—Tip of one leg with bacterial lesion.
July 7.—Half of same leg off from disease.
Aug. 21.—Grub dead and discolored.
- (9) June 28.—Grub pupating; left middle leg eaten off.
July 2.—Pupa has a left leg, but small.
July 20.—Adult issued, imperfect; died.
- (10) June 27.—Grub has lesion on head; two back legs infected (2d instar).
July 5.—Has molted to third instar; two back legs smaller.
Dec. 11.—Grub dead; discolored.

This bacterial disease can hardly be considered as possessing any great possibilities as a means of artificial control of white-grubs, for as seen by the observations cited above, its action in producing death of the grub is slow, requiring in some cases months, under conditions that may be considered ideal for its development. Whether it ever produces fatality of grubs on a large scale in the fields in Porto Rico, at such times as during periods of heavy rainfall, as it is credited with doing in some sections of the United States, is a question open to further investigation.

THE COMMON WHITE-GRUB.

Phyllophaga portoricensis N. SP.*

This species is the eastern analogue of *P. vandinei* occurring at the western end of the Island. Its distribution covers approximately the eastern two-thirds of the Island, being defined in the west by a line running more or less north and south through the towns of Vega Baja on the north coast and Ponce on the south. So far as at present known, its eastern limit on the Island is defined by the east coast. Specimens that have been recently collected on the Island of Vieques, adjoining Porto Rico to the east, appear to belong to this species, so far as genital characters show, though being somewhat larger and lighter in color.

In spite of its wider distribution, this species has not gained as a pest the prominence of the preceding. Damage by it, while most accentuated in the sugar plantations, is by no means confined to them. Its grub is particularly injurious in coffee groves and pineapple plantations. As pines are usually not plowed up until some time after the main crop is harvested, damage from white-grubs may often go unnoticed, or be attributed to poor soil. We have received fre-

* This species has been mentioned, as a supposed variety of *P. vandinei*, under the name of "*Lachnosterna grande* (northern form)," in the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico, page 48.

quent reports of pineapple fields turning yellow in spots, and when the plants were uprooted the soil was found to contain many white-grubs, which turned out to be the larvae of this species. Coffee groves are subject to attack of this May-beetle due to the fact that they are grown under shade of certain forest trees, the foliage of which is much relished by the beetles. After feeding, the beetles descend to the coffee trees beneath the larger shade trees, burrow down into the soil in great numbers at their bases and there deposit the eggs. Naturally, the eggs are found, and the white-grubs that hatch from them do the damage, in whatever locations the beetles descend into the ground. One of the principal shade trees of coffee is the "guamá" (*Inga lawrina*), and its foliage is often badly damaged by May-beetles of this species. Mr. Van Dine in a note of April 27, 1912, reports the finding of seventy-four May-beetles at the base of a "guamá" tree in a coffee grove, and one hundred and sixteen beetles at the base of one coffee tree near by. It is not uncommon to find thirty or more May-beetles of this species at the base of a coffee tree. The beetles do not feed upon the coffee foliage, but that fact does not, however, prevent the larvae from attacking the coffee roots.

In sugar plantations, this species has been known to do local damage, sometimes even extensive damage, particularly in the Fortuna and Aguirre districts, and at Humacao, Fajardo, and Canóvanas. No doubt there has been damage in other districts, not so far reported. Outbreaks to an injurious extent seem however to be sporadic, and in none of the infested districts mentioned has attack been so severe as to necessitate the continued employment of women and boys to gather the grubs and beetles, as is done in the Guánica district in the case of the preceding species.

THE BEETLE.

The adult very closely resembles that of the preceding species, but is usually somewhat greater in size (averaging 1 to 2 millimeters more in length), darker in color, and with the surface somewhat polished. In these characters it varies greatly. It is at once distinguishable, in the male, by the sexual characters given in the table; i. e., in the aduate armatures of the male genitalia being spatulate at the tip where in *P. vandinei* they are bifurcate.

Like the preceding, the adult of this species may be found in the field during eight to nine months of the year. It appears the latter part of February to early March, and disappears during November. Stragglers are occasionally found in the winter months.

LIFE HISTORY.

While the life-history of *Phyllophaga portoricensis* has not been studied to the extent and with the thoroughness of the preceding species, such studies as have been made clearly indicate that the entire generation of the species is passed in one year, and that there is sufficient variability in the length of life-cycle to give rise to a considerable overlapping of broods, if indeed the species may be said to have broods. The seasons of appearance in abundance seem to depend largely upon conditions of rainfall, which would indicate that the stage of the life-cycle displaying the greatest variation in length, next to the third instar of the grub, is the period during which the newly issued adult is in the pupal cell in the soil, awaiting the proper soil conditions (i. e., of moisture) to dig to the surface and emerge for feeding and egg laying.

A single individual of the species was reared through from egg to adult, requiring for the transformation (from date of laying of egg to date of issuing of adult) two hundred and seventy-six and a half days.

The average time required to undergo these transformations, found by adding together the averages for the several stages of the insect, each secured from a number of records, was 296½ days; the maximum duration, by adding together the maximums of each stage, 343 days; the minimum, 268 days. Reduced to months, these figures show an average egg-to-adult period of approximately 10 months, a maximum of 11½ months, and a minimum somewhat under 9 months. If larger numbers of individuals had been reared through the various stages, the latitude of variation would undoubtedly have been increased.

THE EGG STAGE.

The description of the egg and the method of laying given for the sugar cane white-grub (*P. vandinei*) will serve equally well for this one.

The average length of the egg stage (from date of laying to date of hatching), from records of the hatching of fifty-four eggs kept in confinement, was computed to be 13½ days, with a maximum period of 16 days and a minimum of 12 days. The length of this stage is practically the same as for *P. vandinei*.

THE WHITE-GRUB, OR LARVAL STAGE.

The average duration of the larval stage of *P. portoricensis*, obtained by adding the average lengths of the three instars, proved

to be 262 days, which lacks four and a half days of being the same as the recorded average duration of the larval stage of *P. vandinei*.

The lengths of larval stages of two individuals reared through from egg to pupa were, respectively, 242 and 252 days, both below the average for the species.

The First Instar.—This instar of the grub, computed from six records, had an average duration of 32 days, a maximum of 40 days, and a minimum of 26 days. During this instar the grub increases in length from about 6–7 millimeters, when first hatched, to 18 or 19 millimeters at the end of the instar. The breadth of head varies from 1.9 to 2.1 millimeters.

The Second Instar.—This, computed also from observations of six individuals, had an average duration of 61 days, a maximum of 93 days, and a minimum of 43 days, which makes the second instar of the grub of this species appear to be much longer than the corresponding instar of the sugar cane white-grub. This is due to the small number of individual records upon which the average is based, two of the six having required in excess of two months (one of them over three months) to pass the instar, which is abnormally long. True averages can be secured only from large numbers of observations, which will require additional study in the case of this species. The average length of instar from four records not exceeding two months in length was 50 days, which is nearer a correct average.

In length the grub increases, during the second instar, from about 18 to 30 millimeters, and the head varies in breadth from 3.3 to 3.6 millimeters.

The Third Instar.—This instar of the grub, as in the case of the preceding species, is taken as including the pre-pupal stage and is figured as the time elapsing between the second molt and the date of pupation. The pre-pupal stage seldom exceeds a week in any of the Porto Rican species of *Phyllophaga*.

The average duration of the third instar, from records of two reared grubs, was 169 days. The time required by each of the grubs was respectively, 164 and 174 days. To gain accurate knowledge of the average duration of this instar will require the rearing of additional grubs in confinement.

The length of grub increases in the third instar from about 30 to 46 millimeters, and the head varies from 5.5 to 6.2 millimeters in breadth. The average breadth of head, computed from seventeen grubs of an average length of 39 millimeters, was 5.78 millimeters.

PUPA, AND PRE-EMERGENCE OF ADULT.

The length of duration of the pupal stage of six individuals, was observed and recorded, the average from them being 20.9 days. The maximum was 23 days, the minimum 19 days. The average measurements, from nine pupae, were as follows: length, 27.72 mm.; width at middle, 12.14 mm.; breadth of head, 6.8 mm. It will be seen from these figures that the pupa, like the adult, is somewhat larger in size than that of *P. vandinei*.

We have not as yet secured figures to show the average length of time spent by the adult of this species in the pupal cell, following its issuing from the pupa, before it digs to the surface of the ground. In all probability the time varies from two weeks to a month or more, depending both upon the season of year and the moisture content of the soil. During the winter months the beetle might be expected to spend as much as two or three months in the pupal cell before digging to the surface.

FEEDING HABITS OF ADULT.

The feeding habits of adults of this species, and their preferences as to food plants, correspond exactly with those of its near ally, *P. vandinei*. The beetles feed upon the foliage of a rather wide range of plants, but show decided preference for certain species. Some of these, as for instance, the banana, casuarina, or flamboyant trees, may be almost stripped of foliage by the beetles. Other trees, of larger size or with heavier foliage, such as the almendro, guamá, coconut, breadfruit and trumpet tree, may have the foliage badly eaten, but do not show the injury so much as do the species first named. Some other trees observed or reported to be fed upon to an injurious extent by May-beetles are: bamboo (*Bambusa vulgaris*), avocado (*Persea gratissima*), achiote (*Bixa orellana*), cacao (*Theobroma cacao*), guano (*Ochroma lagopus*), roseapple (*Jambosa jambos*), mango (*Mangifera indica*), and mamey (*Mammea americana*), though it has not been definitely ascertained in every instance whether the species doing the damage is this one.

Besides the trees named above, and those previously mentioned of *P. vandinei*, the following plants are fed upon to some extent by this species: *Ficus laevigata*, *Cordia corymbosa*, *Cordia borinquena*, *Albizia lebbek* and the corozo palm (*Acrocomia media*). Grasses, aside from cane, are not as a general rule eaten. Sugar-cane foliage, though sometimes showing injury from their feeding, is not as a usual thing noticeably damaged, except where other and more palatable foliage is not near at hand.

A strange thing regarding the feeding habits of this species, which has been noted, is that the adults are often found in abundance in the soil at the bases of trees and weeds upon which they do not feed, such as coffee or young citrus trees, or beneath the wild berengena (*Solanum torvum*), while on the other hand they are seldom found at the bases of certain trees the foliage of which they are very fond of, such as banana and coconut trees. This is not due to a deliberate choice of the beetles as to the kind of roots among which to deposit their eggs, but is explained by the fact that the beetles, before retiring to the soil for the day after feeding, take flight and alight upon small trees or weeds, or upon any upright object affording them good foot purchase, down which they crawl to the soil and enter it. Their holes are thus often found around the bases of posts and dead weeds. Banana trees are too smooth to offer good foot purchase, hence are not settled upon; and coconut palms are provided with a heavy abutment of closely interwoven roots at the base that prevent the beetles from reaching the ground from them.

Among trees and plants that are much fed upon by adults of *Phyllophaga citri*, but are shunned by this species, may be mentioned orange, grape-fruit, Acalypha, Grevillea, guava, Lantana, Miconia, Clidemia, Triumfetta and Urena.

FLIGHT, AND ATTRACTION TO LIGHT.

The adults of this May-beetle begin coming forth from the soil very soon after dusk, and before actual darkness. As observed in a large outdoor rearing cage during the month of September, the flight may be said to begin at 7:05 P. M. and to last approximately three quarters of an hour.

The following observations were made on an evening of September first: The first beetles appeared above ground and took wing at 7:05 P. M., and they continued to increase in number until 7:20, then remained heavy in flight until 7:35. A few beetles were still flying when observations ceased at 7:50 P. M.

The adults are occasionally attracted to street lights, but only rarely are more than three or four found around a light at one time. On only one occasion has the writer observed an exception to this rule. On April 15 of the present year, around a strong arc light on the *carretera* at Martín Peña, near Río Piedras, over two hundred adults of this species were observed on the pavement, as late as midnight. The probable cause of their abundance was the close proximity of a number of large laurel trees (*Ficus nitida*), upon which the beetles had perhaps been feeding before the turning on of the street lamps.

COPULATION AND OVIPOSITION.

Copulation takes place immediately upon the cessation of flight, and before feeding begins, normally between 7:30 and 8:15 P. M. In rearing cages it takes place a little earlier, because the flight lasts a shorter length of time than under outdoor conditions. Copulation lasts about thirty minutes.

In the same cage in which the observations on flight were made, the following notes were recorded on an evening of September 2: Quite a number of females were seen at about 8:40 P. M., resting both on the screening and on foliage with the genitalia protruded, in receptive condition. The scarcity of males in the cage accounted for the fact that no copulation was seen. Beetles remain quiet in this position for some minutes before they begin feeding.

Experiments to determine the rate of egg laying of this species are in progress, but have not been completed. The beetle's life above ground is believed to last normally between two and three months, and the egg-laying period to cover in the neighborhood of a month.

INSECT PARASITISM.

The insect parasites of this May-beetle are identical with those of *P. vandinei*, the Tachinid parasite *Cryptomeigenia aurifacies* Walton being the most useful parasite of adults, and the predacious wire-worm, *Pyrophorus luminosus* Illiger, the most efficient insect enemy of the grubs. These two parasites are very doubtless responsible, in large measure, for the fact that this May-beetle has not caused the disastrous and widespread damage to sugar-cane properties on the north and east coasts that *P. vandinei* has caused in the Guánica district, where neither of the two parasites occur.

Unfortunately, all of our notes relating to the Tachinid parasite *Eutrixoides jonesii* Walton, which were made previous to 1916, fail to indicate what species of *Phyllophaga* were the hosts, since at that time the different species were not distinguished. Necessarily, in the Añasco district the host was one of the two species *P. vandinei* or *P. citri*, or perhaps both, and in the San Juan district must have been either *P. citri* or the present species, if not both. Further observations will be necessary to determine the exact host of this fly.

A Scoliid wasp known as *Elis xanthonotus* Rohwer, the female of which is black with a red spot on the thorax and the male black with yellow cross bands, found very commonly in the fall in the vicinity of Río Piedras, may prove to be a parasite of this species or of *P. citri*, or both. Observations have not thus far revealed the host of the wasp.

ATTACK BY THE METARRHIZIUM FUNGUS.

The only stages of *P. portoricensis* which have been recorded attacked by the green muscardine fungus are the adult and the third instar of the larva. From the rearing jars and boxes have been taken at different times, altogether, thirteen adults and two grubs attacked by the fungus. The infected adults all came from two jars, each of which contained a good number of specimens, which would seem to indicate that the disease had been communicated from specimen to specimen. The grubs, on the other hand, were from individual boxes, and seem to have contracted the disease from the soil, which, there is reason to believe, contained an abundance of spores of the disease.

Of a total of twenty-four grubs reared past the first instar in confinement, the death of two by the disease represented an infection of 8 per cent. This may have been higher, as grubs were often preserved in alcohol immediately after their death, giving no chance for possible development of spores of the disease.

The per cent of infected adults, to the total number kept in confinement, was still higher than of grubs, but there is no reason to think that such a fatality results from the disease under normal outdoor conditions, since adults showing the disease have been very rarely found in the field.

THE SOUTH COAST WHITE-GRUB.

Phyllophaga guanicana n. sp.*

This species derives its name from the locality in which the type specimens were collected, namely, the Guánica District of the southwest coast of the Island. So far as observations inform us, to date, the species is peculiar to that district.

As a cane pest, it is of comparative unimportance beside the larger species (*P. vandinei*) frequenting that district. Yet it must be included among the pests of sugar cane, since the grubs occur to a certain extent in the cane fields among those of the commoner species. In the nightly collections of May-beetle adults that are made by boys employed for the purpose there is usually to be found, during the months in which the species is active, a small proportion of adults of *P. guanicana*. Actual counts made by the writer in 1914, at weekly or semi-weekly intervals for a period of three months (from the latter

* This species was first mentioned in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (pp. 42-43), under the name of "*Lachnosterna media*," and a summary of its life-cycle (except pre-oviposition) given in the Fourth Report of the Board (p. 47) under the same name.

part of March to the latter part of June), of the entire nightly collections made by the beetle pickers in cane fields, showed that less than one per cent of the May-beetles collected from sugar-cane foliage belonged to this species, the remainder being adults of the common sugar-cane white-grub (*P. vandinei*).

The following table, which is reprinted (revised) from the Third Report of the Board of Commissioners of Agriculture (page 43), gives the actual numbers of beetles of the two species collected on the various nights:

Santa Rita, 1911		<i>P. guanicana</i> n. sp.	<i>P. vandinei</i> n. sp.
March	30.....	32	2,968
April	1.....	12	2,868
"	6.....	80	5,225
"	13.....	9	3,188
"	20.....	40	2,600
"	28.....	43	2,692
May	17.....	5	1,279
"	24.....	12	1,838
June	1.....	5	2,181
"	8.....	0	2,384
"	14.....	1	1,322
"	21.....	1	1,655
Total.....		240	28,291

The period of activity of adults of this species is much shorter in duration than that of *P. vandinei*. Appearing at about the same time of the spring, during the latter part of February, it reaches a maximum abundance about middle April to early May, then begins to decrease in numbers and entirely disappears from the fields by the middle of July. In fact, usually only a few are to be found after the middle of June. Having a life-cycle of one year, like *P. vandinei*, it is hard to account for the fact that this species confines its appearance in the adult stage to a short season of the year.

Collections of adults recently made by the writer at Yauco and Santa Rita on May 3 and 4 have shown that this species, outside of cane fields, is equally abundant to *P. vandinei* in the Guánica district in the spring of the year. It was noticeable, however, that the beetles fed largely upon trees and plants not frequented by the larger species. They were particularly abundant on the foliage of *Lantana camara*, the black sage (*Cordia cylindrostachya*), and the near tree (*Bucida buceras*), all of which grow in the upland, along fences or scattered through pasture land, and none of which are extensively fed upon by *P. Vandinei*. This leads to the belief that the grub of this species is a sod-frequenter one, preferring dry upland soils, and has not yet taken to the cane fields to any extent.

THE BEETLE.

This species is very easily distinguished from *P. vandinei* by its smaller size and somewhat darker color. The largest individuals are smaller than the smallest of *P. vandinei*. In length the adult varies from 13 to 17 millimeters, in width from 7 to 8½ millimeters. The average length is about five-eighths of an inch.

The thorax of the beetle, in both sexes, is polished, rich mahogany brown; the elytra are somewhat paler, and polished in the female, but covered with a very fine plumbeous pubescence in the male. The species is very readily distinguished from *P. vandinei* by an examination of the genital organs of either male or female. The characters by which the two are separated are given in the table in the preceding part of this paper, and are quite clearly shown in the plate.

LIFE-HISTORY.

This species has received more study in the immature stages than any other, next to *P. vandinei*, due to its occurrence in the Guánica district, where the South Coast Laboratory was located and where most of the white-grub studies and experiments were conducted. Prior to the work done by the writer, the presence of this species in the Guánica district as distinct from *P. vandinei* seems to have been overlooked, as there is nothing in the earlier notes to indicate that two species occurred together there, and no specimens of the species were in the collection of the Experiment Station.

The life-cycle agrees in a general way with those of the two preceding species in requiring one year. The immature stages require approximately nine months.

For some unaccountable reason, while a large number of the larvae, or grubs, of this May-beetle were reared successfully to past the middle of the third instar, only four individuals were successfully reared to the adult. Two others successfully reached the pupal stage, but a great majority died in the latter part of the third instar. Most of the fatalities occurred within a single week of the summer, and it is believed that the tin boxes, in which the grubs were being reared, were allowed to become too hot from resting against a side of the building exposed to the sun.

Of the four individuals reared through from egg to adult, the shortest required between 226 and 240 days and the longest between 321 and 331 days, which displays a range of duration of from eight to eleven months.

The average duration of the egg-to-adult period, obtained as a

sum of the averages of the egg, pupa and separate instars of the grub, amounted to 268½ days, with a maximum of 336 days and a minimum of 207 days. Reduced to months, this gives an average duration of 9 nine months, a maximum of approximately 11 months, and a minimum of 7 months.

It is notable with regard to the life-cycle of this species that no eggs were laid by adults in confinement later than the middle of May, and that all but nine of the total number of eggs were laid in March and April. This shows that individuals requiring the shorter length of time to pass the immature stages would reach the adult stage during the winter months, and would therefore pass the remaining time in the soil as adults until the regular time of emergence (in the latter part of February and March). Those requiring the maximum of eleven months (which would be very few), even though coming from eggs laid in May, would still reach the adult stage the following April, in sufficient time to mate and lay eggs by May again. This may account for the species having but one brood, appearing wholly between February and June.

THE EGG STAGE.

The egg of this species does not noticeably differ from that of *P. vandinei* except in being smaller. When first laid it is slender, oblong-oval, about 2 mm. in length by 1.2 mm. in breadth, and opaque pearly white in color. At the end of ten days it is greatly swollen and less opaque in color; it becomes nearly spherical, being then about 2.4 mm. in length by 2.2 mm. in diameter. Just before hatching, the brown mandibles and the segmentation of the young grub become plainly visible through the shell of the egg.

The duration of the egg stage, from an average of 505 eggs whose hatching was observed in confinement, amounted to 13½ days. The maximum duration was 19 days; the minimum, 11 days.

THE WHITE-GRUB, OR LARVAL STAGE.

As in other May-beetles, the larval period of this species includes four distinct stages: the first, second and third instars, and the pre-pupal stage. Between the first and second instars, and again between the second and third instars, there is a molt of the larval skin, following which the head and legs of the grub increase very perceptibly in size. At the end of the pre-pupal stage there is also a molt, to form the pupa. There is no molt between the last instar of the grub and the pre-pupal stage, and the change from one condition to the other is quite gradual. This change in condition does not take place until

a week to ten days immediately preceding the pupation of the grub. In our figures, therefore, the pre-pupal stage is considered as included in the third instar of the grub.

The average duration of larval period from the sum of the average lengths of the three separate instars, was 233 days; the maximum, 295 days; the minimum, 174 days. Reduced to months, this gives an average duration of $7\frac{3}{4}$ months, a maximum of $9\frac{3}{4}$ months, and a minimum of $5\frac{3}{4}$ months.

The average length of the larval stage, obtained from the six individual grubs that successfully reached the pupal stage, was 245 days, which was twelve days in excess of the average for the species. This was due, it is believed, to the fact that the soil in the cage in which these five grubs were reared was allowed to become very dry at times, for periods of weeks, which retarded the growth of the grubs to a marked degree.

The First Instar.—The average duration of this was 24 days, the maximum 35 days, and the minimum 13 days, computed from a total of sixty records of reared grubs.

In measurement, the first-instar grub varies in length from about 5 millimeters, when first hatched from the egg, to a maximum length of 12 or 13 millimeters.

The average diameter of the head, from measurements of thirty-two grubs whose average length was 11.3 millimeters, was found to be 1.33 millimeters.

The Second Instar.—The average duration of the second instar was found to be 31 days, or just a month; the maximum 39 days; the minimum, 23 days. These figures are from the records of thirty-eight individual grubs reared through this instar.

The length of the grub in the second instar increases from 12 or 13 millimeters just following the molt, to a maximum of 20 or 21 millimeters. The average width of head, from measurements of thirty-three grubs whose average length was 15.7 millimeters, was found to be 2.38 millimeters.

The Third Instar.—The average length of the last instar, taken from six grubs that reached the pupal stage, was found to be 178 days; the maximum, 221 days; the minimum, 138 days. Or, reduced to months, the average was 6 months, the maximum $7\frac{1}{3}$ months, and the minimum about $4\frac{1}{2}$ months.

In length, the third instar grub increases from about 20 to about 31 or 32 millimeters. The average width of head, from measurements of five grubs whose average length was 25 millimeters, was found to be 4.09 millimeters.

From the above measurements of grubs, it will be seen that larvae of this May-beetle may be at once distinguished from those of *Phyllophaga vandinei*, in whatever instar, by simply measuring the diameter of the head with a sliding callipers. Furthermore, by means of the head measurements and a consideration of the locality, the grubs of any of the five species of May-beetle occurring on the Island may be easily distinguished, one from the other, without the need of laboriously studying minor characters, which at best are variable.

PUPA AND PRE-EMERGENCE OF ADULT.

The length of the pupal stage of *Phyllophaga guanicana* was determined as 22 days, recorded from a single pupa. The measurements of this pupa were as follows: length 18 millimeters; width at middle, 7.9 millimeters.

The pupa may be very readily distinguished from that of *P. vandinei* by its smaller size, and its somewhat darker color.

As has been stated before, the length of time spent by the adult of this species in the pupal chamber before emergence is supposed to very often exceed a month, and may perhaps, in cases where the adult issues during November, approach or even exceed three months. No experiments were conducted to determine this fact. In confinement, however, three adults issued during late November and early December; and it is well known that in the field beetles of this species never emerge from the soil during these months.

FOOD PLANTS OF ADULT.

This species, as was mentioned in the beginning, frequents the dry upland pastures and brush land, and is not often encountered in cane fields. It is natural, then, that its food plants should differ considerably from those most palatable to the sugar-cane May-beetle (*P. vandinei*). Among the few trees upon which both species are known to feed may be mentioned the flamboyant, casuarina, salcilla (*Schrankia portoricensis*), guacima, and tamarind.

Among those trees and bushes which are fed upon peculiarly by this species, and are rarely or never eaten by the sugar-cane May-beetle, are the guava (*Psidium guayava*), the ucar tree (*Bucida buceras*), the black sage (*Cordia cylindrostachya*), *Lantana camara* and *Hamelia* sp. All of these are favorite food plants of the beetle.

FLIGHT AND ATTRACTION TO LIGHT.

The flight of this species was observed in a rearing cage at Santa Rita on April 28, 1915. The first beetles took flight from the soil

at 7:06 P. M., the flight was at its height at 715, and ceased at about 7:26. The duration of flight was thus twenty minutes. Perhaps it would be somewhat lengthened under outdoor conditions, with no screening to confine the radius of flight.

No tests were made to determine the usual distance of flight, but it is probably limited largely by the proximity of agreeable food plants, as is the case with the larger species.

This species has the habit, common to all of the May-beetles, of flying to lighted lamps and electric lights in the early evening. At Santa Rita, where the experiments were conducted, it was less commonly taken at light than the larger species, even during its season of greatest abundance, from March to June.

COPULATION.

Records of the time and duration of copulation were made on the same night as the flight observations. The time of joining and separating of three pairs was as follows: (1) started 7:17, ended 8:05, lasted 48 minutes; (2) started 7:22, ended 8:14, lasted 52 minutes; (3) started before 7:24, ended 8:12, lasted over 48 minutes.

From these it appears that copulation usually takes place, at this time of year, between the hours of 7:15 and 8:15, and has an average duration of about three-quarters of an hour.

OVIPOSITION.

To determine the length of life of the adult, the length of egg-laying period and the average number of eggs laid by a female, sixteen pairs of adults of this species were confined separately in jars and fed regularly until their death. They were fed upon strips of banana leaf. Twelve pairs were confined on March 19, the other four pairs on April 6. The female of one pair died within three days, so that the records of only fifteen pairs are used in the calculations. The last female died on May 18.

From the fifteen females, the average length of life of the female adult was found to be 36 days. The longest life was 55 days, or somewhat under two months.

The average length of egg-laying period (the time included between the dates of laying of the first and last eggs) was 19.47 days; the maximum, 41 days; the minimum, 2 days.

The average number laid by a female was 15.6 eggs. The maximum number laid by one female was 40 eggs, which were laid in a period of 36 days, a rate of somewhat over 1 egg per day.

The average number of eggs laid per day, for the beetles' whole life, was .51; the average number per day for the egg-laying period only was 1.19 eggs.

The maximum rate of egg laying was 13 eggs laid in one day by one female. No other eggs were laid by the same female within 10 days before or after the date of laying the 13 eggs.

Comparing this species with *P. vandinei*, it will be seen that the average number of eggs per female, and the maximum length of egg-laying period, is about the same for the two.

The average length of life of a female, and the maximum number of eggs laid in 24 hours, is considerably less for this species than for *vandinei*.

On the other hand, the average number of eggs laid per day, and the average duration of the egg-laying period, is noticeably greater for this species than for *vandinei*. The average female of *guanicana* laid eggs at a rate of one every two days; the average female of *vandinei* laid at the rate of one every three days.

INSECT AND FUNGUS ENEMIES.

No insect parasites or predacious enemies are yet known to prey upon this May-beetle or its larva.

The stages of this insect that became infected by the green muscardine fungus in experimental boxes were as follows: Eight eggs, one grub of first instar, one grub of second instar, and nine (or probably more) adults. The highest per cent of infection was among the adults; the next highest among the eggs. No grubs of the last instar were recorded as infected by the fungus.

THE CITRUS WHITE-GRUB.

Phyllophaga citri n. sp.*

This species receives its name from the fact that, although it feeds upon a large variety of plants, it is distinctly an inhabitant of the citrus orchards, and its larva is a pest that often gives much trouble to young citrus trees. The damage the grubs do to older trees is usually not known, and goes unheeded because of the greater ability of older trees to stand the reduction in feeding roots caused by the grubs. Young trees quickly show the damage of the root trimming done by the grubs. Inquiries that have been made of citrus growers

* This species has been mentioned, as a supposed variety of *P. guanicana*, under the name of "*Tachnosterna medja* (northern form)," in the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico, page 48.

over much of the north and west sides of the Island as to the presence of this May-beetle in their orchards, and the damage done by it, have in many instances brought reply that the damage is considerable, and that little can be done to prevent it, except picking the beetles or grubs by hand or spraying with arsenate of lead. These are said to give only temporary relief.

While grubs of the two larger species, *vandinei* and *portoricensis*, may also be found to some extent at the roots of citrus trees, their occurrence is usually accidental. Adults of these species feed rarely if ever upon citrus foliage, and consequently do not often seek the soil at the bases of citrus trees to lay their eggs.

The citrus white-grub is also a pest of sugar-cane, of pasture grass, and of a variety of other crops. The grubs are sometimes found as abundantly as those of the larger species in cane fields that are being plowed. It is therefore quite as important a general crop pest, in some localities, as either the common or sugar-cane white-grub.

DISTRIBUTION.

This seems to be the most widely distributed species of *Phyllophaga* occurring on the Island. Specimens have been collected at Mayagüez on the west coast, along the entire length of the north coast from Aguadilla to Fajardo, at Lares, Utuado, Aibonito, Cayey, and other towns inland, and on the south coast from Aguirre eastward. Specimens have also been collected on the Island of Vieques, to the east of Porto Rico.

The type of this species is from Río Piedras, in the San Juan district, which is midway (or a little east of midway) of the Island on the north coast. Specimens from other localities do not seem to vary much from the type, though it is possible that future study will reveal the presence of sub-species.

On Vieques Island, where sugar cane is the principal crop, this species is less abundant than *portoricensis*, and therefore less important as a pest.

THE BEETLE.

Superficially, this May-beetle very closely resembles *P. guanicana*. The average size is a little larger, about one millimeter more in length. As in that species, the elytra of the male are covered with a very fine, plumbeous pubescence, that makes it duller in color than the female. The latter differs from the female of *P. guanicana* in having the elytra, instead of uniformly polished over the surface, polished only on the disc back of the middle, while the sides and fore-part

of the elytra are plumbeous as in the male. This character may vary somewhat in individuals of any one locality, but is fairly constant for the species, from whatever locality.

The sure character by which to distinguish this species from *P. guanicana* is in the male genitalia, which has been figured in the preceding section of this paper. That part of the medium lobe of the male genitalia which has been called the spatha is depressed, chitinized and polished above, and unsymmetrical, being curved or hooked upward on the left side, where it terminates in a serrated edge.

The spatha of the male genitalia of *P. guanicana*, on the other hand, is thicker vertically than horizontally, is bilaterally symmetrical, and is fleshy except for two rows of minute, brown, prostrate spinules (directed forward) that form a V on the dorsal surface, and two similar rows, or edges, of spinules on the ventral surface.

LIFE-HISTORY.

Insufficient work has thus far been done on the life-history of this species to warrant saying more than that it is very similar to that of *P. guanicana*. It probably differs in no essential detail.

While the adults of this species appear in the earliest spring (in the last days of February) their occurrence seems to extend over a greater portion of the summer than does that of the other species, for specimens may be found even as late as October.

THE EGG.

In size and appearance, the egg does not differ from that of *P. guanicana*, which has been described. The average length of the egg stage, from a large number of observations, was ascertained to be 12.88 days, or practically 13 days, which is about the same as the egg stage of the other small *Phyllophaga*.

THE WHITE-GRUB, OR LARVAL STAGE.

The ascertained length of the first two instars of the grub was the same as for *P. guanicana*, and it may be expected that the last instar will also prove the same.

First Instar.—From three grubs carried through this instar, the average duration was 24 days, or exactly the same as the duration of that instar in *P. guanicana*. The only recorded measurement of a first instar grub was: length, 13 millimeters; breadth of head, 1.45 millimeters.

Second Instar.—This was observed of but one grub, which required from 30 to 32 days between the first and second molts. The measurements of a single grub in this instar were: length, 22 millimeters; breadth of head, 2.65 millimeters.

Third Instar.—The duration of this instar has not yet been obtained. It is doubtless the same as that of *P. guanicana*. The average dimensions of four grubs in this instar were: length, 28 millimeters; breadth of head, 4.4 millimeters.

THE PUPA.

The duration of pupal stage, from a single observation, was 23 days. The measurements of this pupa were: length, 20 millimeters; breadth at middle, 9.2 millimeters.

FOOD-PLANTS OF ADULT.

Some of the commoner trees and plants of the north side of the Island upon which this species feeds in common with the larger species (*vandinei* or *portoricensis*) are: flamboyant, casuarina, almendro, bucar (*Erythrina glauca*), quenepa (*Melicocca bijuga*), jobo (*Spondias lutea*), sonnadera (*Albizia lebbek*), muñeco (*Cordia borinquena*), and *Cordia corymbosa*. The list is not a complete one, but would include a large number of common forest and fruit trees, on which sufficient observations have not yet been made to know what species attack them.

A few trees and plants on which this species feeds abundantly to the exclusion of the two larger species are: grapefruit, orange, guava, silk oak (*Gravillea robusta*), *Acalypha wilkesiana*, garden rose, *Miconia racemosa*, *Clidemia hirta*, *Lantana camara*, *Triumphetta* spp., and *Urena lobata*. Further observations will lengthen the list.

HABITS OF ADULTS.

The attraction of the beetles to light, and the hours of flight and of copulation in the evening, are practically the same as for the adult of the Guánica white-grub. Flight has been observed up to 7:50 P. M., and copulation up to 8:15 P. M.

Studies are being made to ascertain the average length of the beetle's life, the duration of the period of oviposition, and the number of eggs laid by a female, but are not yet complete.

INSECT AND FUNGUS ENEMIES.

Subsequent to the segregation of the different species of *Phyllo-*

phaga, no accurate observations have been made as to the parasites peculiar to each species; and the earlier notes of the Station do not in any instance indicate what species were the hosts of the parasites reared. It is possible, however, that both species of Tachinid fly, *Cryptomeigenia aurifacies* Walton and *Eutrixoides jonesii* Walton prey upon the adults of this species as well as upon those of the two larger species of *Phyllophaga*.

The predacious wireworm, *Pyrophorus luminosus* Illiger, is as truly an enemy of this white grub as of the two larger species.

The only stages of the species that have been found infected by the fungus are the egg, five of which were found covered with spores in June, in experimental jars, and the adult.

THE LITTLE BROWN MAY-BEETLE.

Phytalus insularis n. sp.*

This May beetle is so much smaller than the four preceding species as to be at once distinguishable from them, even to the layman. The type specimens of the species are from Santa Rita, in the Guánica district, collected by the writer. The species has also been collected at Ñaseo, Garrochales (near Arecibo), San Juan, Río Piedras and La Plata, so that its distribution is probably general over the western two-thirds of the Island. Whether it occurs at the eastern part of the Island is not known. More specimens by far have come from the Guánica district than from all other localities combined.

As both larvae and adults have been collected in the cane fields at Santa Rita, this species is considered among the cane pests. It is not, however, of much importance as a pest either to cane or to other crops, because of its scarcity. The mature grub being no larger than the sugar-cane white-grub is at the end of the first instar, it would require ten or more of them to equal in weight one mature grub of the larger species, and the damage committed by each must be correspondingly small.

Usually, among the grubs gathered in the plowed cane fields at Santa Rita by the grub pickers employed by Guánica Centrale, were to be found fewer than a dozen grubs of this May-beetle to each thousand of the sugar-cane white-grub. Often there were none; only certain fields contained grubs of this species. On the occasion when

* This species was first mentioned in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (page 42), under the name of "*Lachnosterna pequeña*," and a summary of its lifecycle (except the pre-oviposition) given in the Fourth Report of the Board (page 47) under the same name.

the largest recorded number of these grubs was taken from a plowed cane field (tablón 21, hacienda Santa María, Feb. 25, 1915), actual count of a pailfull of grubs gave the following results: *Phytalus insularis* (all 3d instar), 38; *Phyllophaga vandinei* (2d and 3d instar), 970.

THE BEETLE.

The adult is dark, burnished brown with somewhat lighter margins, more noticeable on the thorax. The length varies from $9\frac{1}{2}$ to $11\frac{1}{2}$ millimeters, the breadth about half of that.

While not belonging to the genus *Phyllophaga*, this insect can very rightly be considered a May-beetle, because of its very close relationship to that genus in every particular. In fact, some of the characteristics upon which the genus is founded are so unstable as to cause some specialists to question whether the genus name should be retained. In the writer's opinion the genus is a valid one, because of the marked characters of genitalia, distinguishing it from *Phyllophaga*.

LIFE-HISTORY.

The life-cycle of this species, like the four preceding, covers just one year. In confinement, no grubs were successfully reared to maturity in the smaller boxes, but in a large outdoor cage a large number came through from egg to adult. The eggs from which these came were laid between August 25 and September 25, and the first adults of the new generation were observed in the cage on August 20 of the following year, clearly proving the life-cycle to be one year.

Unfortunately, the soil in this cage was not dug up and examined at the right time of year to find pupae, and preserve specimens of them. The pupa of this beetle is still unknown. On January 19, a part of the soil in the cage was examined, and 60 grubs were found, of which 57 were in the third instar and 3 at the end of the second instar. On April 30 all the soil was examined, and 134 grubs found, all of which were in the third instar, 2 of them dead and covered with *Metarrhizium* spores. No pupae were present at that date.

In the tin boxes, two grubs reached the pre-pupal stage, but both failed to pupate. From them, however, the length of the third instar was ascertained.

If we may estimate the pupal stage of this species as requiring 20 days, adding to this the averages for the other stages and instars, the average duration of egg-to-adult period is found to be 301 days (the same as for the sugar-cane white-grub); the maximum, 316 days; the minimum, 283 days.

THE EGG STAGE.

The average length of egg stage, calculated from the hatching of 146 eggs in confinement, was $11\frac{1}{2}$ days, the maximum 12 days, the minimum $10\frac{1}{2}$ days.

The dimensions of the egg are: when first laid—length, 1.5 mm.; breadth, 1 mm.; when much swollen and shortly before hatching—length, 1.9 mm.; breadth, 1.7 mm.

The eggs of this May-beetle are laid singly in the soil, in tiny pits, of about three times the diameter of the egg, and do not differ in any noticeable detail, except size, from the eggs of *Phyllophaga*.

THE WHITE GRUB, OR LARVAL STAGE.

The larval stage requires, from our figures, an average duration of $268\frac{1}{2}$ days (or about 9 months). The maximum duration, obtained by adding together the maximum lengths of the three instars, was 284 days; the minimum, $252\frac{1}{2}$ days.

No larvae younger than the third instar are found in the fields after the latter part of January; no larvae of the first instar are found after November.

First Instar.—The average duration of this instar, from 30 grubs, was found to be 30 days; the maximum, $39\frac{1}{2}$ days, the minimum, $21\frac{1}{2}$ days. The measurements of the grub in this instar were not obtained, but can be easily estimated from the size of the egg.

Second Instar.—The average length, from records of 10 grubs, was $45\frac{1}{4}$ days; the maximum, 54 days; the minimum, 37 days. The dimensions of the only second-instar grub measured were: length, 10 millimeters; width of head, 1.5 millimeters.

Third Instar.—The length of the last instar, averaged from but two grubs, was 194 days. One of these required $186\frac{1}{2}$ days and the other 197 days to reach the pupal stage.

Of twenty grubs in this instar that were measured, varying from 16 to 22 millimeters in length, the average width of head was 2.63 millimeters.

PUPA AND PRE-EMERGENCE OF ADULT.

The length of the pupal stage has not been determined, but doubtless requires in the close neighborhood of 20 days.

Pre-emergence in the Guánica district at least, where the adults first appear in the fields in August, probably requires a shorter time than in those species which issue during the cool winter months, and wait until spring to emerge from the soil.

SEASONAL DISTRIBUTION.

The season of appearance of the adults seems to vary considerably in different localities. All adults that have been collected at Santa Rita were found between early August and the middle of October. A specimen was collected at Añasco in September.

A number of specimens from La Plata, in the center of the Island, were collected in the middle of June.

At Garrochales, near Arecibo, the writer collected 35 specimens, on one Lantana plant by the road, on April 26.

Single individuals collected by electric light at San Juan and Río Piedras bear the following dates: June 6, July 4, August 25, October 15, November 8 and December 1, thus covering a range of seven months.

FOOD PLANTS OF ADULTS.

At Santa Rita, all specimens collected by the writer were found feeding upon "bledo," or pig weed (*Amaranthus* spp.), or upon "malojillo," or Para grass (*Panicum barbinode*), the majority upon the former. A single specimen was feeding upon "salcilla" (*Schranhia portoricensis*). In experimental cages adults were seen feeding upon corn foliage. No specimens were seen feeding upon cane, though they occurred plentifully in the cane fields, and doubtless the grubs attacked cane roots.

The series of beetles collected at Garrochales were all feeding upon *Lantana involucrata*, though there was a great variety of other vegetables near at hand.

FLIGHT AND ATTRACTION TO LIGHT.

Flight of the species was observed at Santa Rita in a large rearing cage on the night of September 1, 1914. The first individuals left the ground and took wing at exactly 6:55 P. M. The numbers in flight increased most rapidly from 6:55 to 7:00, and continued heavy until nearly 7:10, then gradually dropped off. By 7:20 flight was quite light, but continued to some extent until 7:30, when a very few were still flying. The last beetle ceased flying about 7:35. Most of the beetles flew against the west side of the cage.

All the specimens of this beetle collected at Río Piedras or San Juan have been taken at light, and a very few were taken at Santa Rita at a large gasoline lamp.

COPULATION AND OVIPOSITION.

On September 1 these observations were made:

Pairs began mating at 6:57 P. M. At 7:05 over a dozen pairs were mating. At 7:07 pairs were beginning to separate. At 7:15 the majority had separated. At 7:25 the last pair separated.

And on the following evening, similar observations: First pair united at 6:57; largest number copulating, 7:05; last pair separated, 7:28. Total time consumed, 31 minutes.

Exact records of six copulating pairs on the same night were as follows:

- (1) United, 6:58; separated, 7:06; time spent, 8 minutes.
 - (2) United, 6:59; separated, 7:08; time spent, 9 minutes.
 - (3) United, 7:01; separated, 7:10; time spent, 9 minutes.
 - (4) United, 7:02; separated, 7:12; time spent, 10 minutes.
 - (5) United, 7:01; separated, 7:11; time spent, 10 minutes.
 - (6) United, 7:08; separated, 7:23; time spent, 15 minutes.
- Average length of time spent in copulation, 10 minutes.

Those pairs on or near the ground copulated without taking flight. In no case was a beetle seen to take flight after copulation. As with the species of *Phyllophaga*, they immediately begin to feed after copulation; and if resting on a leaf, the female usually feeds during copulation, the male never. About 50 per cent of the beetles copulated without first taking flight.

The females, in the receptive mood, rest with the abdomen slightly raised, and with the genitalia protruded in a conspicuous florescence, which is pale yellow in color and fully three times as great in diameter at the tip as at base. In this position they rest for ten minutes or longer until a male appears.

No females of this species were confined singly to secure eggs. Females were; however, confined in numbers at different times in jars with food to secure eggs. The average rate of egg laying computed from the eggs thus secured was one egg in three days by each female. At which rate, a female living two months would lay only twenty eggs. This figure may not be accurate since, in confining numbers of beetles together, some eggs are necessarily destroyed by the beetles in boring into the soil.

INSECT AND FUNGUS PARASITES.

No insect parasites have yet been discovered preying upon either larva or adult of this May-beetle.

The only stages of this May-beetle that became infected by the

green fungus were the adults, and grubs of the last instar. No record was kept of the number of adults, but it exceeded a dozen. Of the grubs reared, a rather astonishingly large number became infected, in the jars and boxes, by this disease. Out of 142 third-instar grubs kept in confinement under observation, there is record of 13 becoming infected by this fungus, which is 9 per cent of the total number, a higher per cent than was noted of the grub of any other May-beetle except *Phyllophaga vandinei*.

Summary of Life-cycles and Measurements of May-Beetles and White-Grubs.

THE SUGAR-CANE WHITE-GRUB, *Phyllophaga vandinei* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	16	10	14	1,089	2.87	1.7	.....
Grub, 1st Instar....	59	17	36½	184	6-17	.....	1.94
" 2d	103	26	47	71	16-28	.....	3.32
" 3d	226	78	188	25	27-46	.....	5.31
Pupal Stage.....	26	17	21½	22	23-27	10-12	.....
Total.....	430	148	302	1,391	.....	.....	.....

THE COMMON WHITE-GRUB, *Phyllophaga portoricensis* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	15	12	13½	54	3.0	1.75	.....
Grub, 1st Instar....	40	26	32	6	6-18	.....	2.10
" 2d	93	43	61	6	18-30	.....	3.45
" 3d	174	164	169	2	30-48	.....	5.70
Pupal Stage.....	23	20	21½	5	25-29	11-19½	.....
Total.....	345	265	297	73	.....	.....	.....

THE SOUTH COAST WHITE-GRUB, *Phyllophaga guanicana* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	19	11	13½	505	2.05	1.2	.....
Grub, 1st Instar....	95	13	24	60	4½-12	.....	1.33
" 2d	39	23	31	38	12-20	.....	2.38
" 3d	221	138	178	6	20-32	.....	4.10
Pupal Stage.....	(22)	(22)	22	1	18	7.9	.....
Total.....	336	207	268½	610	.....	.....	.....

THE CITRUS WHITE-GRUB, *Phyllophaga citri* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	13	200	2.12	1.2h	.....
Grub, 1st Instar....	21	3	5-19	.....	1.45
" 2d	31	1	18-22	.....	2.6
" 3d	(178)	0	22-34	.....	4.4
Pupal Stage.....	23	1	20	9.2	.....
Total.....	269	205	.....	.....	.....

THE LITTLE BROWN MAY-BEETLE, *Phytalus insularis* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	12	10½	11½	146	1.45	.90	
Grub. 1st Instar....	39½	21½	30	30	3½-8		
2d ".....	54	37	45½	10	6-14		1.5
3d ".....	197	191½	194½	2	14-22		2.63
Pupal Stage.....	(20)	(20)	(20)	0	12½	5.1	
Total.....	322½	280½	301	188			

* The columns of figures in the above table (which were all obtained by actual observation or actual measurement), numbered from left to right, may be explained as follows:

(1) Maximum duration in days of the immature stages, the totals being the maximum egg-to-adult period for each species, in days.

(2) Minimum duration in days of immature stages, etc.

(3) Average duration in days of immature stages, etc.

(4) Numbers of eggs, grubs, or pupae, averaged to obtain the figures of the first three columns.

(5) Average length in millimeters of each of the immature stages, taken from a number of measurements made with sliding calipers.

(6) Average breadth in millimeters of egg and pupa of the various species, from measurements with sliding calipers.

(7) Average breadth in millimeters of the head of grub in each instar of the five species, from measurements with sliding calipers.

