

THE WHITE-GRUBS INJURING SUGAR CANE IN PORTO RICO.

I. LIFE-CYCLES OF THE MAY-BEETLES OR MELOLONTHIDS.

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The larvæ of all injurious Scarabæid beetles are known popularly as white-grubs, and those occurring in Porto Rico are injurious either as grub or as adult to the sugar-cane plant, particularly in the drier sections of the Island. An economical way of controlling these grubs is much desired, and it has been with the object of finding some ultimate method of control that the intensive studies of the life-histories of the species have been made.

Up to the present date ten distinct species of white-grubs have been segregated and studied. Of these, four belong to the genus *Phyllophaga* (better known as *Lachnosterna*) and one to the genus *Phytalus* in the tribe *Melolonthini*, while the other five belong to three genera in the tribe *Dynastini*, which includes the large rhinoceros beetles. The present paper deals only with grubs of the first tribe, known as May-beetles, and is an accumulation of data compiled from observations and life-history studies made by the author during the past four years. The work was conducted at the South Coast Laboratory, located near Guánica Centrale, which is in the heart of the district suffering most from the attack of white-grubs.

The life-cycles and habits of the five species of Dynastids will be given in another paper, to follow this.

THE WHITE-GRUB PROBLEM.

Two facts, that sugar is grown over very extensive areas in Porto Rico, under conditions that are ideal for the development and rapid

¹ Especial credit is due Mr. D. L. Van Dine, the first entomologist of the Experiment Station of the Porto Rico Sugar Growers' Association, and his successor, Mr. Thos. H. Jones, for the initial energy given to the study of the white-grub problem in Porto Rico by these gentlemen. The writer wishes to acknowledge the keen interest in the progress of this work and the cooperation given by Dr. L. O. Howard and Dr. W. D. Hunter, of the United States Bureau of Entomology, and by Dr. S. A. Forbes, of the Illinois State University, and their very efficient aid to those who have been detailed to collect parasites in the United States. Credit is also due Dr. Robert D. Glasgow, of Illinois University, for his patience in examining the large series of May-beetles that have been sent him from the Island and in pointing out characters by which they may be separated. The writer wishes to thank Mr. John J. Davis, of West Lafayette, Indiana, for an excellent series of North American species of *Phyllophaga* mounted with genitalia exerted.

multiplication of beetle pests of this sort, and that it is grown continuously year after year on the same ground, without any rotation of crops, render the control of these insects a very serious and very difficult problem. Prior to 1913, the year that the present studies were inaugurated, a considerable amount of experimentation had been made by different parties toward controlling the white-grubs in cane fields, (1) by putting baits, poisons, or fumigants into the soil, (2) by spreading various deterrents on the soil near plants to prevent laying of eggs, (3) by flooding the land with water, or (4) by killing the adult beetles by means of poison sprays applied to the foliage. The results of many of these experiments were negative; and such of them as gave promising results proved inexpedient because of the high cost of materials or of application.

It became increasingly apparent that no hope of a solution of the problem could come from an application of direct methods of control such as these, but that real benefit to the cane-growing industry could come only through the employment of broadly outlined cultural methods of control, based upon an accurate knowledge of the insects' life-histories, or perhaps through the introduction of insect or fungus parasites to prey upon the white-grubs.

Life-history and close field studies of the several species were instituted in May, 1913, and have been continued to the present date. The object constantly in mind has been to determine accurately the length of life-cycles; the time and conditions of oviposition of the eggs; the time of emergence, sexual habits, feeding habits, and habits of flight of the adults; and the inter-relation of these habits and the factors which tend to hasten or retard the time of emergence of the beetles or to affect the amount of damage.

A preliminary report by the author appeared in the Annual Report of this Station for the year 1913-14 (23)¹ and some additional data in the Report for 1914-15 (24). Much of this data is included in the present paper, together with tabulations and graphic charts showing life-cycles, and illustrations showing injury, the early stages, adults and adult parts, parasites, etc., from original photographs.

Methods of control of white-grubs, and results of the introduction of parasites, will be discussed at length in a later number of this publication, when certain experiments and tabulations now in progress will have been completed. Detailed studies of the larval (or grub) and pupal stages, now being made, by which it is hoped

¹ Reference is made by number to "Literature cited," pp. 88-89.

that these stages of the different species may be as easily separated as are at present the adults, will also be presented in another article.

The desire at present is to present the life-cycles of the Porto Rican Melolonthids; to facilitate the separation of the adults of the species, where heretofore they have been hopelessly confused; and to present certain facts in regard to their insect, fungus and bacterial enemies that have come to light in the course of experiments.

WHAT WHITE-GRUBS ARE.

All beetles pass through a metamorphosis consisting of four stages, egg, larva, pupa, and adult, two of which, egg and pupa, are resting stages and the other two, larva and adult, active stages. The growth of the insect is attained during the larval stage; which means that during this stage the most food is consumed, and hence the most damage committed. It is with the larval stage of the May-beetles and "hard backs," known locally as "caculos," that we are concerned. During this period they gain the name of white-grubs (or "gusanos blancos") through their white color, and their habit of grubbing in the soil.

As the term is used in its broadest sense, white-grubs are considered as including the larvæ of all the injurious Lamellicorn beetles of the family *Scarabaeidae* (3). The word is often used in the United States in a more restricted sense, as referring to the grubs or larvæ of the May-beetles, since these in the States far outnumber all other white-grubs combined (4).

White-grubs may be known from larvæ of other beetles by the following characteristics: (1) subterranean habits, living entirely in tunnels in soil or decaying vegetable matter, and moving about very little; (2) by having the body bent roundly toward the ventral side, so that the ends nearly meet, hence poorly adapted to movement above ground; and (3) by their bodies being thick, soft, and usually glossy white or yellowish with sparse hairs, with a brown, chitinous head and strong mandibles adapted for chewing roots and soil, and with six well-developed legs not used for walking.

WHITE-GRUBS INJURIOUS IN OTHER REGIONS.

Larvæ of Scarabaeid beetles are practically universal in their occurrence as pests, being everywhere known as white-grubs. They are particularly destructive, and often multiply in alarming numbers, in parts of the world where cane is grown, due to conditions which greatly favor their development in such localities. Besides Porto

Rico, they have attained great prominence as pests of cane in the islands of Mauritius and Java, and on the continent of Australia.

White-grubs of the genus *Phyllophaga* are best known as pests to crops in the United States, being widely distributed and having a great many species. As many as forty-two species have been recorded from the single State of Illinois, most of them injurious (8). Damage of the grubs to grass lands, lawns, corn, potatoes, and other crops is often very extensive (4), and the adults have been known to defoliate the timber over whole counties (5, p. 270).

A beetle known as *Ligyris rugiceps* is a bad pest of cane in Louisiana, having the habit of boring into the stalks at the surface of the ground. In irrigated sections of the Southwest the large green "June bug," *Allorhina mutabilis*, whose larva is a white-grub, does very great damage to fruit.

In Europe members of the genus *Melolontha*, which is closely related to *Phyllophaga*, have been known for over a century as pests, the grubs of one species (*Melolontha melolontha*) frequently causing so much damage to cultivated crops as to necessitate the gathering of the grubs from the fields by hand. In Russia great damage is caused by both grub and adult of a beetle known as *Anisoplia austriaca* (13).

In Australia several white-grubs of the same tribe (known as *Melolonthini*), notably of the genus *Lepidiota*, are the cause of great injury to cane. As much as a shilling a pint has been paid for the grubs from cane fields by the sugar centrals of Queensland. The principal pest is known as *Lepidiota albohirta* (11).

Five species of white-grub, representing five different genera, are injurious to sugar cane in Java; namely, *Holotrichia helleri*, *Adoretus compressus*, *Apogonia destructor*, *Leucopholis rorida*, and *Lepidiota stigma* (10; 14). Trap lights for the adults are used at night.

Various species of the genera *Anomala* and *Adoretus* are destructive in the Hawaiian Islands, in Japan, and in British East Africa.

In the cane-growing sections of India the roots of the plant are subject to attack by white-grubs that are the larvæ of a beetle known as *Serica assamensis*. Other species of white-grubs have also been reported as injurious in India.

Among island possessions, next to Porto Rico, perhaps the most acute injury to cane by white-grubs has been committed by a species known as *Phytalus smithi* in the islands of Barbados and Mauritius. The adult of this beetle differs but slightly from species of the genus *Phyllophaga*. The species is becoming particularly bad in Mauritius, because of its having been introduced there from Barbados without

the wasp parasite, *Tiphia parallela* (2), which in the latter island tends to hold it in control. To illustrate its abundance in Mauritius (where for a while it threatened to paralyze the sugar-cane industry), in a period of nine months, from August, 1911, to April, 1912, a total of twenty-seven and one-half millions of grubs, pupæ, and adults (mostly adults) were collected from the sugar-cane fields over an area scarcely three miles square surrounding the Botanic Garden (6).

In the West Indies, aside from Barbados and Porto Rico, cane is known to be injured by a species of *Phyllophaga* in Antigua (26) and by grubs of *Phyllophaga patruelis* in St. Kitts (22). The adults of *P. patens* are said to be very destructive to cacao foliage in St. Vincent (19). A bulletin of the American Museum (15) lists 24 species of *Phyllophaga* and 2 of *Phytalus* from the West Indies, 13 of which are credited to Cuba and 4 to Haiti, but none to Porto Rico.

In British Guiana a beetle known as the "small black hard back," *Dyscinetus bidentatus*, which is the adult of a white-grub, is considered a bad enemy of cane, and a related species, *Ligyrrus ebenus*, is occasionally injurious (16). Like the *Ligyrrus rugiceps* of Louisiana, it is the adult stage in which damage is done by these two beetles. *Dyscinetus* sometimes attacks young cane shoots in such numbers as to kill them back as fast as they germinate.

LIFE-HISTORY WORK ON WHITE-GRUBS DONE ELSEWHERE.

Because of their subterranean habits, white-grubs are among the most difficult of insects to rear to maturity and to gain any definite knowledge of their changes, or molts. Outside of Europe, prior to 1916, very few species had been reared to maturity and their life-cycles determined. As late as 1913, a bulletin of the U. S. Department of Agriculture (4), in discussion of the genus *Lachnosterna* (*Phyllophaga*), stated: "There is only one published record, involving a single species, in which an individual belonging to this genus has been reared from egg to adult." Since that date, however, considerable breeding work has been done in Indiana by Mr. J. J. Davis, of the U. S. Bureau of Entomology, to whom credit is due for having successfully reared to maturity from the egg eighteen species of the genus, definitely establishing the length of life-cycle of each (5).

In Australia similar difficulties have confronted investigators in this group of insects. In a bulletin of the Bureau of Experiment Stations of Queensland published in 1914 (9), it is stated: "At first rearing was depended upon to give us evidence of the entire period of development, but we have not as yet succeeded in rearing a single

specimen through its stages, but may succeed in doing so by the time the next beetle season arrives.”

Outside of Europe, and the work done by Mr. Davis in Indiana, the nearest approach to accuracy in establishing the length of life-cycle of a beetle of the group *Melolonthides* is the work done in Mauritius on *Phytalus smithi* by Mr. d'Emmerez de Charmoy (6). He determined the maximum and minimum number of days required for each stage of the life-cycle, but did not determine the length of separate instars of the grub.

So far as known to the writer, nothing has been published heretofore on the larvæ of *Phyllophaga* or related genera which establishes accurately the lengths of instars of the grub.

LIFE-CYCLES OF WHITE-GRUBS.

It has been known for a number of years that the common cockchafer of Europe, *Melolontha melolontha*, whose grub is the worst white-grub pest of that continent, required a period of three years to pass its life-cycle in the latitude of France and southern Germany, and four years in the latitude of northern Germany.

In the United States it has been taken for granted that certain common species of *Phyllophaga*, such as *P. fusca* and *P. fraterna*, because of the regular periodicity of their appearance in numbers every three years, require that length of time to pass the life-cycle (7). Certain other species in the States, appearing regularly at intervals of two years, were supposed to require that length of time to undergo the change from egg to adult (33). Very recently Mr. Davis has definitely ascertained that out of eighteen species of *Phyllophaga* reared from egg to adult in the latitude of central Indiana eleven of them have an invariable three-year life-cycle, one (*Phyllophaga tristis*) has an invariable two-year life-cycle, three have a life-cycle varying from two to three years, and two others a cycle varying from three to four years (5).

The establishment of the fact that all four Porto Rican species of *Phyllophaga*, as well as the single species of *Phytalus*, require but a year or somewhat less to undergo the life changes, will be somewhat of a surprise to students of this group of insects. Yet it is what should be expected in a tropical or sub-tropical climate.

These facts are paralleled, in a measure, by those established by Mr. De Charmoy with regard to the life-history of *Phytalus smithi* in Mauritius—with the difference that he found the life-cycle of that species to occupy somewhat over a year (6).

ENEMIES OF WHITE-GRUBS.

The natural enemies of white-grubs fall into three classes, namely, animals (including birds and lizards), insects (including mites and worms), and plants (fungus and bacterial). A noted French naturalist has said of the common European white-grub that "efficacious animal parasites of the insect are unknown" (29).

Fortunately, in Porto Rico, all three groups of parasites are present; yet as all of these are insufficient to keep white-grubs in check, it is necessary—when other means of control fail—to supplant these, or rather assist them, by the introduction of parasites not already occurring here.

ANIMAL AND BIRD ENEMIES OF GRUBS IN PORTO RICO.

There are in Porto Rico no small mammals known to prey extensively upon white-grubs or May-beetles as do skunks in the United States. Perhaps field mice and rats eat occasional specimens, but as an agency of control they can be of no great economic importance.

An attempt was made in 1913 by one of the sugar centrals of the Island to introduce and acclimate the European hedgehog, quite a number of which were brought over from Germany for the purpose. Most unfortunately, they were liberated in a hot and arid part of the Island, so different from their native humid and shady habitat that they did not survive. In confinement they ate May-beetles voraciously when fed them, but were not seen to burrow deep enough into the soil to reach the grubs; and it is a question if they would have proved of real economic importance as a control measure had they become successfully established.

In Porto Rico insect-feeding lizards are extremely abundant. The majority of these, which belong to the genus *Anolis*, are too small to devour the larger May-beetles. In addition they are diurnal in habit and live entirely above ground, usually upon plant foliage or trees. There is one large ground lizard, however, called "siguana" (*Ameiva exul*), which is largely burrowing in habit and which, it is believed, feeds to some extent upon white-grubs and May-beetles. It inhabits the sandier soils, and by one close observer has been often seen devouring changas, or mole-crickets. Certainly, white-grubs would be far easier prey for it than the active changas; and it is altogether probable that they do constitute a part of its diet.

Of birds, there are at least three species on the Island that are important enemies of the white-grubs and May-beetles, and a fourth that is worthy of mention. These are, in the order of their importance

as enemies of grubs: (1) the Porto Rican blackbird or "mosambique," *Holoquiscalus brachypterus*; (2) the bare-legged owl or "múcaro," *Gymnasio nudipes nudipes*; (3) the little blue heron or "garza azul," *Florida caerulea caerulescens*; and (4) the mangrove cuckoo or "pájaro bobo," *Coccyzus minor nesiotus*. In Bulletin No. 15 of this Station, entitled "Birds of Porto Rico," by Alex Wetmore, the results are given of an examination of the stomach contents of these four species of birds as follows (the figures being the per cent. of white-grub and May-beetle remains to entire contents of all stomachs examined): blackbird, 1.61 per cent.; bare-legged owl, 24.4 per cent.; little blue heron, 1 per cent.; and mangrove cuckoo, .05 per cent. Of twenty-three blackbird stomachs collected largely in cane fields under cultivation, the proportion of white-grub and May-beetle remains to total contents was 9.47 per cent. Certainly, after a day of activity of the birds behind the plows in cane fields, the proportion would be much higher than this.

Another bird, known as the "ani," or "Juda bird," has been often spoken of as eating white-grubs; but the bulletin above referred to does not give account of the finding of any white-grub or May-beetle remains in stomachs of this species. And, moreover, common as the bird is about cane fields, it is a rather shy species and is seldom seen following the plows.

The blackbird, or "mosambique," is placed as the most important bird enemy of white-grubs because of its great abundance in those parts of the Island where the white-grubs are most injurious, namely, in the arid coast districts. It is a very common sight to observe considerable flocks of these birds following the plows and picking up grubs when fields cleared of cane are being broken up. Figure 1, of Plate VI, is from a photograph taken by the author at Santa Rita, near Guánica Centrale, during the winter plowing season. By actual observation and count, it was shown that over 90 per cent of the grubs exposed to light by the plows are picked up by these birds, so that the employment of peons to follow the plows and pick grubs is quite unnecessary in that district. When it is considered that a bird is able to consume more than the equivalent of its own weight of food in twenty-four hours, and that blackbirds during the plowing season of five to six months subsist almost wholly upon grubs, one may appreciate the vast numbers of grubs that they consume.

INSECT ENEMIES OF GRUBS OCCURRING ON THE ISLAND.

Among the insect enemies of the May-beetle larva and related white-grubs there are at least nine species known to occur on the

Island, all native, which makes an unusually good representation as compared with other islands of the West Indies. These fall into three groups, six of them being Hymenopterous (all Scoliid), two of them Dipterous (both Tachinid), and one Coleopterous (Elaterid). Those of the first and last groups attack only the grubs, while the Diptera attack only the adults.

We may add to these four others, all of which have been observed attacking the grubs (or eggs) under laboratory conditions only. One of them is a white nematode, not exceeding 5 or 6 mm. in length, which on several occasions gave trouble by destroying the eggs in experimental jars. More troublesome than the nematodes was a species of minute, globular white mite (*Tyroglyphus* sp. ?), which attacked all stages of the beetles, from egg to adult, and was the cause of a high per cent of mortality in experimental jars and boxes.

Of minor importance were a Staphylinid beetle larva (species undetermined) and a wireworm, the young of an Elaterid beetle (*Monocrepidius* sp.), both of which were observed to feed upon May-beetle eggs in experimental jars. Both were introduced with earth enriched with manure, and it is not believed they would ever cause mortality of eggs under natural conditions in the field.

The following list will serve as a guide to the known white-grub parasites of the Island. The more important of them will be discussed later under the species they attack.

No.	FAMILY	SPECIES ¹	HABITAT	ABUNDANCE
1	<i>Scoliidae</i> ...	<i>Elis sexcincta</i> Fab.	General.....	Common
2	"	" <i>xanthonotus</i> Roh.	Northern.....	"
3	"	<i>Campsomeris dorsata</i> Fab. ...	General.....	Abundant
4	"	" <i>trifaciata</i> Fab. ...	Northern.....	Common
5	"	" <i>pyrura</i> Roh. ...	Southern.....	Rare
6	"	<i>Scolia atrata</i> Fab.	Western.....	"
7	<i>Tachinidae</i> ..	<i>Cryptomeigenia aurifacies</i> Wal.	Northern and Western	Abundant
8	"	<i>Eutricoides jonesii</i> Wal.	Western.....	Rare
9	<i>Elateridae</i> ...	<i>Pyrophorus tuminosus</i> Ill.	Northern and Western	Abundant

¹ The determinations of the wasps (except *Scolia atrata* Fab., which was determined by the Am. Mus. Nat. Hist.) in this list were made by S. A. Rohwer, of the flies by W. R. Walton, and of the beetle by E. A. Schwarz.

The only one of these parasites which has been found hyperparasitized is *Campsomeris dorsata* Fab., a dead adult of which was found at Santa Rita containing a single Dipterous puparium, about 5 mm. long, from which issued, on June 18, 1913, ten small Chalcidids, which have not been determined.

Outside of Porto Rico, *Elis sexcincta* Fab. (?) was collected by the writer in great abundance on Mona Island in December, 1913, where it occurred on the leaves of corn infested with *Peregrinus maidis*. *Campsomeris pyrura* Roh. was taken commonly at Higueral, Santo Domingo, in February, 1914, and a few also were taken on Mona Island.

EFFICIENCY OF WHITE-GRUB PARASITES IN PORTO RICO.

Our knowledge of the white-grub parasites of the Island is at present very limited, and much is yet to be done in the working out of hosts and life-histories of the various species.

Of the nine species of white-grub parasites listed above, there is direct evidence of only one of them destroying the grubs of *Phyllophaga*. This is the Elaterid beetle, *Pyrophorus luminosus* Ill., larvæ of which have been fed upon *Phyllophaga* grubs for long periods in confinement in the insectary. Field observations of this wireworm preying upon white-grubs are still too few to make any definite statement as to its value in white-grub control. The beetle is extremely abundant in the spring and summer on the north and west sides of the Island; if true that it destroys white-grubs under outdoor conditions, its presence may perhaps account in part for the lesser injury from grubs in the sections where it abounds.

Some of our earlier notes (for the year 1911) credit *Campsomeris dorsata* Fab. with being a parasite of *Phyllophaga* grubs (30, p. 36). But in all cases the grub determinations were doubtful. It seems probable that the parasitized grubs in question, if not of *Dyscinetus*, which closely resembles *Phyllophaga* in the larval stage, were of *Ligyris tumulosus* Burm., whose grub is abundantly parasitized at all seasons by *Campsomeris*.

It may develop, with additional observation, that the two species of *Elis* occurring here one or both parasitize grubs of *Phyllophaga* in restricted localities. Yet the strange fact remains that of thousands of *Phyllophaga* grubs collected in cane fields, and examined by the writer, not one has ever been found parasitized by a Scoliid egg or larva.

THE TACHINID PARASITES.

Our present knowledge of white-grub conditions leads to a belief that the most important and active agency in the control of white-grubs in Porto Rico is the work of the two Tachinid flies, *Cryptomeigenia aurifacies* Wal. (Pl. VII, fig. 7) and *Eutrixoides jonesii* Wal., upon the adults. Like the *Pyrophorus* beetle, these flies seem

confined to the more humid sections of the north and west coasts—which may further explain why white-grubs are less abundant and destructive in these sections than on the dry south coast, where there are few or no Tachinid parasites or *Pyrophorus* beetles. An account of the discovery of these two flies will be found on page 37 of the Second Report of the Board of Commissioners of Agriculture of Porto Rico (30). The adult and pupal case of *Cryptomeigenia aurifacies* Wal., which is the commoner species, are shown on Plate VII, figure 7.

INTRODUCTION OF PARASITES.

From many observations and estimates, it is evident that the mortality to white-grubs from parasites in Porto Rico is very low, and that the native parasites are quite insufficient to cope with these pests, which continue to increase wherever cane is grown. The only hope in relieving this condition has seemed to be in the introduction of other white-grub and May-beetle parasites from abroad. Among the first efforts made in the artificial control of the white-grubs of the Island, therefore, were attempts to introduce foreign parasites, which it was hoped would establish themselves successfully on the new host grubs (27, p. 52).

The logical field for securing white-grub and May-beetle parasites was the United States, not alone because they are better known there than elsewhere in the western hemisphere, but also because, in a large territory like the American continent, parasites have wider distribution, and necessary conditions for collection that cannot be encountered in one locality may be met in another. For convenience of handling, collection of grub parasites is usually made of the cocoon stage from the soil, and is therefore done during plowing time. Plowing time in the States shifts from south to north with the advance of the season, thus permitting the collecting to extend over a much longer period than would be possible in limited areas.

Parasite introduction was initiated in 1911 by Mr. D. L. Van Dine, then entomologist of the Porto Rico Sugar Producers' Experiment Station. His reports of the early progress of the work will be found in the First and Second Reports of the Board of Commissioners of Agriculture (29; 30).

An entomological collaborator was employed by the Board for the purpose of collecting living white-grub parasites, or parasite cocoons, in the States and shipping them to Porto Rico in living condition. The position was first held by Mr. C. E. Hood, who began work on June 16, 1911, and later by Mr. Geo. N. Wolcott. The work

was continued up to October, 1914, the majority of the parasites having been collected in the State of Illinois. During this time a total of about 2,500 parasites (including adults, larvæ and pupæ) were received from these workers, and of these a total of about 1,000 parasites were liberated. The great majority of these were wasps belonging to the genus *Tiphia*. (See Plate VII, fig. 8.) In addition to the parasites sent here, a number of cocoons of *Elis* were sent to Mr. O. H. Swezey in Hawaii for use against the white-grubs of those islands.

Following is a list of the better known *Phyllophaga* parasites occurring in North America. From these it was necessary for the parasite collectors to choose those species which could be most easily collected in numbers and sent to the Island.

NORTH AMERICAN PARASITES OF *Phyllophaga* LARVÆ.

1. *Tiphia inornata* Say.—A black Scoliid wasp of wide distribution in the States, and possibly infesting the grubs of several species of May-beetles (7, 21, 35). It is the commonest and best-known American parasite of white-grubs. There are several related species, for the most part feebly differentiated from it. (In Europe a species called *Tiphia femorata* attacks white-grubs of several *Melolonthids* (32); another, *Tiphia parallela*, attacks *Phytalus smithi* in Barbados (18), and *Dyscinetus bidentatus* in Demarara) (16).

2. *Elis (Myzine) 5-cincta* Fab.—A common Scoliid white-grub parasite occurring in the Central States, but more local in distribution than the *Tiphia*. There are other species of this genus found in restricted localities.

3. *Ophion bifoveolatum*.—An Ichneumonid wasp that parasitizes white-grubs, but is far less common in most localities than the Scoliid wasps.

4. *Pelecinus polyturator*.—A Proctotrypoid wasp, the female of which has a very long body, as if for penetrating the soil for oviposition. It has been reared by Professor Forbes from May-beetle larvæ and, being very abundant in timber land in some districts of the Middle West, may be a more important enemy of white-grubs than is generally known.

5. *Sparnopolius fulvus* Wied.—A small Bombyliid fly parasitic upon white-grubs, of only secondary importance, however.

6. *Promachus vertebratus* Say.—A large Asilid fly, larvæ of which are predacious upon white-grubs. The species is said by Mr. J. J. Davis (5) to be a prominent grub enemy in certain parts of Wisconsin. A nearly related species in the East is *Promachus fitchii* O. S.

7. *Microphthalma disjuncta* Wied. *Megaprosopis michiganensis*).—A large Tachinid fly parasite of white-grubs, said to be common in the Central Western States. Mr. Vassiliev reports the same Tachinid as parasitizing the grubs of *Anisoplia austriaca*, and three other species, in southern Russia (32). Another closely related species in the States is *Microphthalma pruinosa*, also of wide distribution.

8. *Mochlosoma (Prosenia) lacertosa* V. d. W.—This large Dexiid fly was reported by J. H. T. Townsend as issuing in great numbers from the puparia in the soil in pasture lands near Colonia García, Chihuahua, northern Mexico, and he was certain they were parasitizing white-grub (29). The determination of the fly was made by Doctor Coquillet. (A related species, *Prosenia siberita*, attacks grubs of *Adorettes compressus* in Java.) (10).

9. *Ptilodexia (Estheria) tibialis* Desv.—Another Dexiid fly, which Davis mentions as parasitizing white-grubs in Texas (5, p. 271).

10. *Pyrophorus* sp.—An Elaterid beetle, very abundant in southern Texas, the larvæ of which are predacious upon a common white-grub of that section.

PARASITES OF THE ADULTS.

11. *Pyrgota undata* Wied.—An Ortalid fly, the commonest and most efficient parasite of adult May-beetles in the Central States, and also generally distributed. Another species, more local in habitat, is *Pyrgota valida* Har. These are nocturnal in habits, as are also the following Tachinid flies.

12. *Cryptomeigenia theutis* Walk.—A Tachinid fly quite commonly infesting the bodies of adult May-beetles in some sections of the United States. The only other representative of the genus known to the writer is the common Porto Rican species, *Cryptomeigenia aurifacies* Wal.

13. *Eutrixa exile* Coq. (*Nemoraea masuria* Walk.)—Another Tachinid fly parasitizing May-beetles. It has habits like the preceding, infesting the beetle body.

14. *Biomyia lachnosternae*.—This Tachinid, identified by Mr. Walton, is the one referred to by Dr. Forbes as *Viviana* sp. in Bul. 116 of the Illinois Agr. Exp. Station, according to Mr. J. J. Davis (5). It was reared from the adult of *Phyllophaga crenulata*.

15. *Sarcophaga helcis* Towns.—This Sarcophagid fly was reared from adults of *Phyllophaga arcuata* collected at Washington, D. C.

INTRODUCTION OF FUNGUS ENEMIES.

Simultaneous with the introduction of insect parasites of white-grubs into Porto Rico, Mr. Van Dine initiated an attempt to introduce certain entomogenous fungi that are known to attack white-grubs and beetles related to the May-beetles in other regions (27; 29) Cultures were received both from Europe and from Hawaii, the species of most importance from the former place being *Botrytis tenella* (or *Isaria densa*), which is reputed to have been used with so much success at one time against the larvæ of *Melolontha* in France (29, p. 42).

From cultures received from Hawaii one species, that known as the Samoan fungus, or green muscardine fungus, *Metarrhizium anisopliae*, was successfully established on the Island, and large numbers of May-beetles were infected by means of soil inoculations (29) (See Pl. IV, figs. 7, 8, 9.) It was later learned that a local form of this fungus had already existed on the Island prior to the introductions from Hawaii, as grubs and beetles infested with the fungus were found in parts very remote from where liberations of spores had been made (12; 30).

Several liberations of the spores of *Metarrhizium* have been made by the pathologists of the Station, Mr. J. R. Johnston and Mr. J. A. Stevenson, the spore material having been grown in large cabinets on a scale surpassed only by the extensive liberations of *Metarrhizium* against the frog-hopper in Trinidad. The results of these liberations have been somewhat variable (25).

METHOD OF REARING GRUBS.

Because of their subterranean habits, white-grubs are very difficult to rear to maturity, and to observe their molts. Living in tunnels in the soil, they are apt to be injured or set back in growth by being disturbed. Difficulty rests also in their requiring so long to reach maturity, their life-cycles in many cases covering a period of more than a year, which promotes the possibility of their succumbing to fungus and other diseases contracted through artificial means.

It is possible that the difficulties of rearing white-grubs in confinement are less felt in the tropics than in temperate climates because of there being no period of cold weather through which the grubs must be given special care and treatment. This advantage, however, is in part counteracted by the increased activity of certain parasitic fungi and other diseases that attack the grubs in warmer climates.

Perhaps the most careful methods of rearing grubs in temperate climates have been worked out by Mr. J. J. Davis at Lafayette, Indiana (5). His method consists, briefly, in the use of flower pots twelve to sixteen inches in diameter and height, or of cylinders made of metal and wire screening, twenty inches in diameter and two and one-half feet in depth, which are inserted into the ground in such a way as to give natural conditions of moisture and drainage. Necessarily cages such as these, even though each many contain several grubs, require a rather large amount of space for the rearing of large numbers of grubs; and it must be remembered that only in the results from rearing large numbers of grubs can accurate data be obtained. Under tropical conditions, where there is no winter to contend with, methods requiring much less space have been found quite satisfactory and in most respects preferable.

Methods of rearing employed by the writer consisted at first in the use of flower pots six inches in diameter and of glass battery jars. The objection to the pots was that they required dumping of the earth in order to view the grubs, which meant disturbance and often injury to the grubs. The objection to the jars was that they allowed for no drainage, and the soil became sour, thus permitting mites and nematodes to breed. Furthermore, in glass jars grubs would seldom remain near enough to the glass to be seen, so there was no advantage gained.

In all respects the most convenient method was found in the use of two and one-half and three-inch round, seamless tin boxes, one and one-quarter inches high. One or two grubs were kept in each box, the larger grubs being kept in larger boxes. These boxes were conveniently kept in piles and tiers, and were opened and the contents examined regularly at intervals of several days to a week or more. Pupæ were examined almost daily. To prevent rust boxes were first lined with a thin coating of paraffin. Moisture was regulated not by adding water to the box, which experience proved was dangerous, but by using sifted earth of the right dampness to begin with, and renewing the earth when it became dry or sour.

Food was supplied by adding a kernel of corn to each box. A new kernel was never added until the old one had been entirely consumed, germinating roots and all, as it was found that greater danger came from over feeding than from under feeding. Too much food in a box always led to an accumulation of mites (*Tyroglyphus* sp.?), which would attack and often sicken the grub, finally causing its death unless the mites were carefully brushed off and fresh earth supplied. In absence of corn, a small section of cane could be fed;

but cane quickly soured and nearly always gave rise to mites, so that use of corn was preferable.

Movements of the grub in a can have a tendency to pack the earth, so that by careful manipulation of a knife blade the top earth may be removed and the grub's tunnel exposed. A tunnel averages three to four times the length of the grub's body; and when one part of the tunnel is opened the grub rushes to the other extremity, so that there is small danger of injury. The grub may thus be viewed without disturbing it to any great extent.

When a grub is first added to a can, the latter is filled even full with sifted (not too fine) moist earth, and with the thumb or finger a pit is compressed in the soil, into which the grub is placed. It is never covered with earth.

There is little to be improved upon in the matter of convenience in the methods described here, provided care is taken; nor is there any more divergence from natural, outdoor conditions than would be the case in using larger boxes, jars, or pots. Check experiments proved that there was no difference in the time of emergence between adults from grubs in tin boxes and adults from grubs outdoors, provided a grub escaped the attack of mites, fungus, or bacterial disease. The presence of these diseases in small boxes was in most cases induced by over feeding, excessive moisture, or careless handling.

Check experiments for each species were run in large outdoor rearing cages, containing a depth of six to ten inches of earth in which was grown cane or corn as food. Cages were of uniform size, three by six feet and three feet high, screen covered with wooden bottoms, set up on posts as protection from ants and rodents. Adults were usually liberated in them in quantity, one species in each, at about the same time that other series were confined in jars for eggs. After a week or so of confinement adults were removed, eggs having been deposited in the soil. The cage remained undisturbed, except to be regularly watered and occasionally replanted to fresh cane or corn, until sufficient time had elapsed for grubs to mature and adults to issue.

In these cages the time required for emergence tallied very closely with the time required for grubs confined in tin boxes, showing that soil conditions in the smaller tin boxes did not change the time of emergence from normal.

In the case of one species, *Phytalus insularis*, no larvæ reared in tin boxes were successfully brought to maturity, so that results obtained

from the large outdoor cages were depended upon in determining the length of the life-cycle.

OVIPOSITION AND HANDLING OF EGGS.

Some difficulty was experienced in determining the possible duration of oviposition by female adults. When beetles were confined "en masse," that is, a number in a cage or jar, there was usually a heavy mortality, which may have been due to the fungus disease, *Metarrhizium*, being able to communicate itself from one beetle to another.

The obstacle to confining females singly for oviposition may be realized when one takes into account the difficulty of giving the beetle sufficient living food material and freedom of movement, and at the same time restricting the amount of soil to a quantity not too large to sift and examine in a reasonable length of time. Beetles had to be confined in numbers, and the earth examined at frequent intervals, to give oviposition records value.

At first beetles were confined over potted plants; but it was found too difficult to extract eggs from among roots without crushing them. Also, the effort of supplying a fresh plant for each beetle at each examination of the soil was considerable.

Later experience showed that a beetle requires neither to fly nor climb in order to maintain a fairly normal existence in confinement. A method devised was to confine each female in a small glass battery jar, four inches in diameter by six inches high, in the bottom of which was placed two inches of moist earth, sifted to a fineness somewhat smaller than the size of the eggs, so that the latter were easily sifted out. The soil was packed lightly with the hand, and a few strips or sections of banana leaf put in above the soil as food for the beetle, being first dipped in water, after which they remained green for two or three days and were relished by the beetles.

It was not found necessary to confine adults in pairs in order to secure fertile eggs. There was no advantage in doing so, as copulation never took place to the writer's knowledge in small jars. Beetles collected immediately following copulation remained fertile for two months or more. No cases were observed of infertile eggs from females confined alone, except those from reared females, which of course had never copulated.

The first method devised for rearing the eggs was to place each one in a small pit made with the head of a match in the flat side of a small ball of damp soil or mud, and to press a tier of these

against the glass on the inside of a jar, around the circumference of the bottom, so as to expose the eggs to view. The space was filled in with sifted soil even with the tops of the earth balls, another tier added, and so on until all eggs of a lot were placed. Corn was not planted then until all eggs had hatched, as otherwise the germinating roots grew into the egg cavities and smothered the eggs or obscured them from view. Eggs were never put loose into a jar and covered with soil, as they must have room to swell, being laid under natural conditions in small cavities made by the female ovipositor which allow for swelling. (See Plate V, fig. 9, and Plate VI, fig. 3.)

A better and simpler method was to place the eggs over damp soil in shallow glass petri dishes. Being tightly closed, and of small size, these dishes maintained the required humidity, and a great many eggs were thus easily attended to and examined in a short time. As the eggs hatched, the young grubs were removed to tin boxes. With this method, care must be taken of two things: one, that the petri dishes remain in a place of little exposure and of uniform temperature; and two, that the soil be sterile, to insure it against mites and nematodes, to both of whose attack May-beetle eggs seem to be very susceptible.

Boxes for grubs just hatched should have the soil sifted, quite moist, and packed very gently if at all. Small pits were made in the soil with a match, and the grubs placed into these; if placed on the surface of soil they are often unable to penetrate. No planting of corn was required in the boxes until grubs were nearly ready to molt, as very young grubs were observed to feed almost entirely upon organic matter in the soil, and seldom to touch roots.

PUPÆ AND EMERGENCE OF ADULTS.

Before pupating, a May-beetle grub assumes a soft, flabby condition, during which it lies inertly on its back at the bottom of the tunnel. This is known as the prepupal stage. Prior to changing to the prepupa, the grub shortens and somewhat broadens its tunnel, making it very hard and smooth on the inside. In the cell so formed it undergoes the change to pupa and then to adult.

Whenever possible, it was found preferable to leave the pupa in its natural pupal cell, simply making an opening in the top of the cell through which it could be viewed. The use of the shallow tin boxes made this possible. When necessary, however, a smooth artificial cell open at the top was made in the soil in a tin box, and

the pupa placed in it on its back. Soil during the pupal stage must be kept uniformly moist, and mites must be guarded against.

In the field, pupation takes place usually at a depth of one and one-half to two feet, which is a foot or more deeper than the larva lives, and this going to a lower level is attributed to an instinct on the grub's part to avoid changes of temperature, and disturbances of the soil by plowing, that would take place nearer the surface. It seems, however, that it is simply a provision to so place the pupal cell that the inactive pupa will not be crowded and eventually smothered by the penetration of roots into the cell, which would undoubtedly take place near the surface of the soil in a field. Grubs in the tin boxes showed no discomfort at being prevented from penetrating to a depth in the soil.

The freshly issued adult (Pl. IV, fig. 6) was left in the pupal cell in the box for several days, to observe its changes in color in reaching maturity. In a week's time or less, before the beetle had shown a desire to leave the cell, a round disc of blotting paper was snugly fitted into the box over the earth and cell, and the box was buried, with lid removed, under several inches of damp earth in a jar or pot, the earth packed somewhat, and a cover or cage put over the top in order to determine the date of emergence from the soil.

SPECIES OF PORTO RICAN MELOLONTHIDS.

All five species of Porto Rican Melolonthids that have been segregated and studied are new to science. The four indigenous species of *Phyllophaga*, or May-beetles, are being described by the author under the names *Phyllophaga vandinei*, *P. portoricensis*, *P. guanicana* and *P. citri*, and the single species of *Phytalus* under the name *Phytalus insularis*.

The characters which distinguish the species are sufficiently marked to readily separate them from allied species occurring on the neighboring islands. In the present paper will be given only the more important characters necessary to distinguish one species from the other.

As the four species of *Phyllophaga* fall naturally into two groups, readily distinguishable by size and other gross characters, and as the two species of each group are restricted to well-defined geographic areas on the Island, one can almost with certainty determine the species by the locality in which it was collected, knowing the appearance of each group. The males of the four species can be separated by the characters shown in figures 4, 5, 6 and 7, of Plate V,

which illustrate the male genitalia viewed from the left side. The characters of the female genitalia are less well defined in the two species of either group, but those of the two groups are quite distinct in appearance, as is shown by figures 8 and 10, Plate V, representing one species of each group.

The species *Phytalus insularis* conforms with the described character separating the genus from *Phyllophaga*. This consists in the tooth of the tarsal claw being situated near the end of the claw, and directed at an acute angle instead of at an obtuse or right angle to it, making the claw what is termed "cleft." This character is more or less variable with other species of *Phytalus*, but holds good in the case of *P. insularis* and *P. smithi* Ar.

A noteworthy fact is that all of the Porto Rican Melolonthids, including *Phytalus*, in common with the species from neighboring islands, possess certain marked characters not occurring in the species from the mainland which have been examined. This would seem to set them apart as belonging to another genus. These characters consist in: (1) the presence, on the inner posterior angle of the femora of the hind pairs of legs, of a longitudinal row of prominent, stout, rather blunt spines, varying usually from three to five in number, and below each spine a long bristle—where in the species of the continent this angle is bare of spines and has few, if any, bristles; (2) the constriction of the transverse, sub-median ridge on the outer face of the back tibiae, which in American continental species is directed downward and bears a prominent row of bristles, or slender spines, into an anterior and a posterior flattened spur, the former bearing from three to five bristles and the latter from one to four bristles; and (3) in the presence, above the posterior flattened spur and less than midway between it and the base of tibia, of another flattened spur, bearing from one to three bristles—which in continental species is indicated, if at all, by no more than a slight elevation above a pit bearing one bristle. Occasionally, in Insular species, there is a third flattened spur above this last, having one to two bristles.

These characters of the rear tibiae occur in the West Indian species of *Phytalus* as well as in *Phyllophaga*, and make it appear that the West Indian species of *Phyllophaga* are a link between *Phytalus* and the *Phyllophaga* of North America.

CHARACTERS IN THE GENITALIA.

It is well known that many species of *Phyllophaga* of the American continent are practically indistinguishable from external char-

acters, and that it is necessary to extract and examine the genitalia in order to separate them. The same is true of Porto Rican species, especially as regards closely related species in either group. Of the two sexes, the genitalia of the male are the more highly specialized, and therefore of greater use in separating species.

The genitalia of a male *Phyllophaga* may be described as a semi-chitinous, tubular, protractile organ whose distal end, for about one-third of the entire length, is enlarged and modified into a collar, or theca, which is parted longitudinally on the ventral side. The theca is articulated at the sides to the upper or proximal portion of the genital organ, the dorsal suture being protected by a tympanum. The distal margin of the theca is nearly circular and cuplike, concealing the fleshy phallus; the ancipital margins on the ventral side are variously modified into corneous hooks or barbs. In many American species of *Phyllophaga*, including such species as *hornii*, *ilicis* and *bipartita*, the theca is greatly modified, becoming articulated on the dorsal side and formed into two highly specialized claspers, which are dissimilar in shape. In other species, such as *quercus*, *rubiginosa* and *forbesi*, the theca is bilaterally symmetrical and more regular in shape, as is the case with Porto Rican species. In none of the American species, however, is the phallus (which may be known as the median lobe of the genital organ) highly specialized as in the species of the Island.

The median lobe of the male genitalia of Porto Rican species bears, normally, a superior, deflexed, acicular process, or spicula, which is roundly bent toward the right, and an inferior pair of adnate, falciform armatures, which cross scissor-like at their bases and re-cross, or at least meet, at their tips. (See Pl. V, figs. 6 and 7.) In the group including the two species of smaller size (*guanicana* and *citri*) the adnate armatures are fused into a single spatha, which is in one case fleshy (*guanicana*) and in the other case chitinous (*citri*). In the group including the two larger species (*vandinei* and *portoricensis*) the adnate armatures are distinct, chitinous, dark brown and shining, the dextral armature superior and the sinistral inferior; they are compressed or cylindrical at their bases and depressed at the tips, which lie one over the other. The distinguishing characters lie in the structure of the tips of these armatures, which are bicuspidate in one (*vandinei*) and spatulate in the other (*portoricensis*).

The female genitalia consist, in American species, of two pairs of flattened plates, an inferior and a superior, the latter extending beyond the former, and above the superior plates, at their suture, a

pubic process of varying form, which is often lacking or concealed. The inferior and superior plates are often fused together. Among Porto Rican species this seems to be the case, and the pubic process is visible only in species of the larger group (*vandinei* and *portoricensis*).

The following key will serve to separate readily the five Porto Rican *Melolonthides*:

KEY TO PORTO RICAN MELOLONTHIDES.

- A. Theca of male genitalia cyanthiform, closed ventrally. *Phytalus*.
- B. Theca of male genitalia collar-shaped, open ventrally. *Phyllophaga*.
 - a. Adnate armatures distinct and chitinous; spicula medial; female genitalia with prominent pubic process. (Group of larger species.)
 - I. Armatures bicuspidate at tip; spicula sharply deflexed. *P. vandinei*.
 - II. Armatures spatulate at tip; spicula roundly deflexed. *P. portoricensis*.
 - b. Adnate armatures fused into a single spatha; spicula dextral; female genitalia without pubic process. (Group of smaller species.)
 - III. Spatha fleshy, surmounted by minute prostrate spinules. *P. guanicana*.
 - IV. Spatha cymbiform, chitinous and polished above. *P. citri*.

Phyllophaga vandinei n. sp.¹

This species has been named for Mr. D. L. Van Dine, the first entomologist of the Experiment Station of the Porto Rico Sugar Growers' Association, who, by reason of his characteristic zeal and energy, was largely responsible for the extensive importations of white-grub parasites and for instigating the work carried on with the sugar-cane white-grubs of the Island in the past five years.

The larva of this species is the worst sugar-cane pest of the Island, and is perhaps one of the three most injurious sugar-cane white-grubs in the world. Its habitat on the Island is restricted to the western end, its farthest east recorded occurrence being at Manatí on the north coast and at Peñuelas on the south. Within this limited territory it has reached, particularly in the Guánica district, such great abundance as to often have caused whole fields of cane to fall prone and to begin to sour in a week's time after damage first became evident. It has made the growing of ratoon cane in the Guánica and San Germán districts impossible, and in addition to the cost of replanting for each crop, has levied a tax upon the centrals for the continued hiring of boys to collect the grubs and beetles that amounts to hundreds of dollars in a single season.

¹ Technical description of this and the other species will be published later.

Cases are on record where over fifty grubs of this species have been spaded out from under a single stool of cane. It is no uncommon occurrence to dig out twenty or more grubs from one cane stool. So prolific is the species that it requires constant vigilance on the part of the sugar centrals of the infested district to keep the insect in check. Boys are paid at a regular rate per quart for beetles collected on the cane foliage by lantern at night, and women are paid by the quart for grubs collected in the plowed fields in the daytime. By these means hundreds of bushels of beetles (see Pl. II, fig. 4) and grubs are collected every season and destroyed, or fed to hogs.

Some idea of the cost of this propaganda may be derived from the following figures, available through the courtesy of the general manager of Guánica Centrale, where accurate records of the daily collections of grubs and beetles are kept:

In seven months of 1914 during which collections of beetles were made (February 27 to September 23), the total collections in five *haciendas* belonging to Guánica Centrale amounted to 2,255,000 beetles, gathered at a total cost of \$833.87.

The collections of grubs for six months of the same year (from November 27, 1913, to May 14, 1914) amounted to a total of 1,662,000 grubs, gathered at a cost of \$1,876.73.

In six months of the following year (March 6 to September 9, 1915), on the same *haciendas* of Guánica Centrale, the collections of beetles amounted to a total of 2,468,000, gathered at a cost of \$1,425.20.

The number of grubs collected in seven months of 1914 and 1915 (from October 29 to May 27) amounted to a total of 2,425,000, gathered at a cost to the central of \$2,018.57.

Figuring 400 beetles to the quart, and 300 grubs to the quart, this makes the rather startling figure of 369 bushels of beetles and 426 bushels of grubs collected in two years from a small district by one sugar central, at a total cost of \$6,154.37.

And still this beetle is not held in check, but appears to continue to increase in abundance. It is small wonder that the sugar-cane growers of Porto Rico have become exercised over the depredations of the "gusano blanco," as the white-grub is known locally.

THE BEETLE.

The adult of *Phyllophaga vandinei* is a May-beetle of normal appearance, smooth and faintly shining in both sexes, but not pol-

ished, tawny to chestnut brown in color, and varying from 17 to 22 mm. in length. (See Pl. IV, fig. 3.) From *P. guanicana* or *P. citri* it is at once separable by its larger size, lighter color and smoother surface. From *P. portoricensis* it is distinct in being confined to a different habitat, as well as by the characters cited in the preceding table.

Unlike most species of *Phyllophaga*, *vandinei* may be found in some abundance in the fields throughout at least eight and often nine months of the year. In the Guánica district, where it has been closely studied, it makes its first appearance during the last days of February, and by the last of March is abundant, remaining so from then up until late in September or the middle of October, when it rapidly decreases in numbers; and by the second week of November few are to be found in the fields. During the two years of 1914 and 1915, figures compiled by Guánica Centrale show that the beetles were most abundant in 1914 from the last of July to early in September, while in 1915 they were most plentiful from the middle of April to early in July. These variations may be due to climatic conditions in individual seasons.

As the life-cycle of the species covers only one year, or a period of ten months for the actual egg-to-adult cycle, and as there is a possible variation (as shown by breeding experiments) in this cycle ranging from seven to thirteen months, it is evident that there must occur an overlapping of broods, to such an extent, in fact, as to distribute the emergence of adults over all of the summer months.

THE LIFE-HISTORY WORK.

As this species is the worst cane pest of the Island, and the ultimate object of all the experimental work on white-grubs was to find a practical method of controlling it, the laboratory-insectary erected for its study, and called the South Coast Laboratory, was located at Santa Rita, midway between Guánica and Yauco, in the heart of the district worst infested by this beetle. Most of the white-grub work was put upon the one species, with the result that its habits and life-history are better known than those of any other species occurring on the Island.

More than twenty individuals of *Phyllophaga vandinei* were reared from egg to adult, and twice as many more were reared successfully to the pupal stage. Many hundreds of eggs from confined adults were kept under observation, and the grubs hatching from them were fed and regularly observed; but a majority of these died

before reaching maturity, some from disease or from the artificial conditions of their confinement, others from wrong handling through ignorance of the essentials for their growth. The total number of eggs, larvæ, and pupæ of this species whose molts and instars were recorded was as follows: Eggs, 1,502; grubs in first instar, 852; grubs in second instar, 209; grubs in third instar, 117; pupæ, 46.

The two charts on Plate VIII show in graphic form the length of the egg to adult period of *Phyllophaga vandinei*.

LENGTH OF LIFE-CYCLE.

The life-cycle of *Phyllophaga vandinei* covers, roughly speaking, one year. The average normal egg-to-adult period covers just ten months. The average from fourteen complete records of single individuals run from egg to adult was 306 days; the average obtained by adding together the average lengths of the three immature stages—the egg, three instars of larva, and the pupa—was 302 days. The disparity is easily accounted for.

The maximum egg to adult period of the fourteen individuals was 395 days; the minimum, 212 days. Or in terms of months, they were, respectively, 13 and 7 months.

Observation has shown that the adult beetle, after issuing from the pupa, may remain in the soil in the pupal cell for a period varying from two weeks to perhaps two months. The period of pre-oviposition of adults was not experimentally determined, because of the refusal of reared specimens to oviposit, and the difficulty of being sure whether specimens collected in the field had just emerged or not. Calculating the pre-emergence period to average a month, and the pre-oviposition period to require close to a month, the species is seen to have a life-cycle of virtually one year.

The possible shortening or lengthening of the egg-to-adult period by three months, which was demonstrated in rearing boxes, and which would shorten or lengthen the entire life-cycle by an equal period, gives the life-cycle of the species a proven variation of nine to fifteen months. This might be still further lengthened by the fact that the egg-laying period of the female may extend over a period of more than a month.

It is very conceivable that an egg laid quite late in the fall might not, under adverse conditions, emerge as an adult until the spring of the second year following; or on the other hand, that an egg laid in spring might, under very favorable conditions, produce an adult in the fall of the same year. This last, in fact, happened in one of

the rearing boxes (see Plate VIII, No. 1211a), although there is no way of knowing whether the adult would have emerged from the ground in the fall, under natural conditions, or would have remained in the pupal cell until the following February or March. All of which readily explains the occurrence of adults in the cane fields throughout most of the year.

THE EGG STAGE.

The average length of the egg stage, from the date it is laid to the date of hatching, was determined as fourteen days. This average was secured from a total of 1,089 eggs, the hatching of which was observed. The maximum length of egg stage was seventeen days, recorded in March, and the minimum ten days, recorded in September.

Description.—The egg of *Phyllophaga vandinei* is opaque and pearly white in color (in that regard resembling the eggs of other species of the genus). When first laid it is slender oblong-oval in shape, about 2.75 mm. to 3 mm. in length by 1.62 mm. to 1.75 mm. in breadth. It swells greatly before hatching, and becomes almost spherical, 3 mm. to 3.25 mm. in length by 2.35 mm. to 2.65 mm. in breadth. (See Plate III, fig. 1.)

Eggs are deposited among roots in the soil in small globular pits, or cavities, which are made by the ovipositor of the female. One egg is laid in each pit and rests at the bottom. (See Plate V, fig. 9.) The earth forming the walls of the pit is cemented or compressed in such a way that even in dry sifted soil the pits usually remain intact, when the soil is sifted, until put under pressure of the thumb. The pit varies from two to three times the diameter of the egg, and serves to maintain a uniform humidity as well as to prevent the soil from touching the egg. When fully swollen the egg does not completely fill the pit, so that when it hatches the grub, which is half again greater in diameter than the swollen egg (see Plate III, fig. 2), has a natural cell in which to move about and begin existence.

THE WHITE-GRUB, OR LARVAL STAGE.

In common with other white-grubs, the larva of *Phyllophaga vandinei* molts its skin three times, passing through three distinct instars. In computing the length of life-cycle the average, maximum, and minimum lengths of each instar were found.

Of fifty larvæ of this species reared from egg to pupal stage, in which the exact dates of hatching of egg and of pupation were re-

corded, the average length of larval stage was 267 days; the maximum, 356 days; the minimum, 179 days. Or, reduced to months, the average length of larval stage was about nine months; the maximum, twelve months; and the minimum, six months. It is at once apparent that the astonishing variation in the length of life-cycle of this species is due to the variation in length of the larval, or grub, stage, the egg and pupal stages showing very little variation in duration. (See charts on Plate VIII.)

Nine out of ten months (or 90 per cent) of the insect's normal life below ground are spent in the larval, or grub, stage. During most of this time the grub is doing actual damage to cane by feeding upon the roots.

The length of larval period, secured by adding together the averages of the three instars, amounts to 266 days. This constitutes a very good check on the above average of 267 days, computed from the whole larval stage of 50 larvæ, since a good many of the grubs from which the instar averages were taken never reached pupation, and conversely, a majority of the grubs whose exact dates of egg hatching and of pupation were recorded, were not observed and recorded as to their molts; so that the two results were taken to a large extent from different series of grubs.

The explanation for fifty grubs having reached the pupal stage, whereas only about twenty reached the adult, lies in the fact that at the time of pupation the grub is particularly susceptible to injury by handling, or by attack of the bacterial disease, *Micrococcus nigrofaciens* Nor. (17). Many grubs while active seemed to resist the disease, which attacked a majority of them, but during the quiescent prepupal stage they succumbed. The presence of mites on the body of a grub would often prevent its pupation, or cause the pupa to be deformed, and the adult would not issue.

The first instar.—Technical descriptions of this and the other instars and stages of *Phyllophaga vandine* will be given in a later issue of the Journal, when detailed studies have been completed. For the present, the plates may be depended upon to give a fairly accurate impression of the size and appearance of the different instars of the grub.

The average duration of the first instar was determined as 36 days; the maximum, 59 days (in December); the minimum, 17 days (in June). The maximum duration was found to be more than three times the minimum. The duration of this, as well as the other instars of the grub, has been shown to be influenced more by the amount of moisture in the soil, and by the presence or absence of mites, fun-

gus or bacterial disease, than by the amount of food provided the grub. (When grubs succumbed to the *Metarrhizium* fungus during the second or third instars, it was found that the earlier instars had been above normal in length.)

From the fact that larvæ of May-beetles are always in a coiled position, and seldom straighten out to crawl as do the grubs of Rutelids and Dynastids, it is very difficult to measure their length. It was ascertained, however, that the length is just double the measurement across the coiled body, so that the length of grubs in the various instars was determined in this way.

At the time of hatching from the egg, the grub of *vandineï* is about 6 mm. long and 1.75 mm. to 1.8 mm. across the head. Before molting to the second instar (see Plate III, fig. 3) it reaches a length of 17 mm. to 18 mm., and the head reaches a diameter of 1.9 mm. to 2 mm. (Pl. V, fig. 1.)

The head does not grow like the body, but that it enlarges somewhat in size may be shown by the following brief table, from actual measurements with sliding calipers from living grubs:¹

HEAD OF FIRST-INSTAR GRUBS.

An average from 5 grubs varying from 5 to 10 mm. in length; head 1.85 mm. wide.

An average from 29 grubs varying from 11 to 15 mm. in length; head 1.96 mm. wide.

An average from 11 grubs varying from 16 to 18 mm. in length; head 2.01 mm. wide.

During the first instar no damage is done by the grub of *vandineï*, since it lives entirely upon vegetable matter in the soil. It is only during the very last days of the instar, or more commonly in the early part of the second instar, that the grub begins to eat living roots.

The second instar.—The average duration of the second instar (see Plate III, fig. 4) was found to be 47 days; the maximum, 103 days; the minimum, 26 days. Or, reduced to months, the average was one and one-half months; the maximum, three and one-third months; and the minimum, somewhat under one month. It is seen that the maximum duration of this instar was more than four times the minimum.

At beginning of the second instar the length of the grub is 17 mm. to 18 mm.; at end of the instar, and just before molting to the third instar, the length is 28 mm. to 30 mm. The average width of head, taken from 43 second instar grubs, was 3.33 mm. (See Plate V, fig. 2.)

¹ NOTE.—Measurements of small objects made with sliding calipers are very apt to average from .1 mm. to .15 mm. above actual size.

An idea of the enlargement in the head during the second instar may be gained by the following figures, taken from measurements of living grubs:

HEAD OF SECOND-INSTAR GRUBS.

An average from 23 grubs varying from 18 to 25 mm. in length; head 3.25 mm. wide.

An average from 20 grubs varying from 26 to 30 mm. in length; head 3.42 mm. wide.

The third instar.—The average duration of the third instar, from records of 25 grubs, was found to be 183 days; the maximum 266 days; the minimum, 78 days. Again, the maximum duration of the instar is more than three times the minimum. Reduced to months, the average length of the third instar is six months; the maximum, nine months; and the minimum, two and one-half months.

Approximately two-thirds of the larval period is spent in the third or last instar, or about three-fifths of the entire life of the immature insect. During more than six months of the year this insect is doing great injury to crops in the soil as a grub. There being no winter in Porto Rico during which the grub is not feeding, its activity as a root trimmer extends not only through five and one-half months of the third instar (allowing one-half month for the quiescent, pre-pupal stage), but also through the month and a half of the second instar, so that the period of injury may easily cover seven months.

At beginning of the third instar (see Plate III, fig. 6) the grub averages about 28 mm. in length, and when full grown (see Plate III, fig. 7) it reaches a length of 40 mm. to 44 mm. The average width of head from 96 grubs measured in the third instar was 5.29 mm. (See Plate V, fig. 3.)

The rate of growth of the head during this instar may be seen from the following table:

HEAD OF THIRD-INSTAR GRUBS.

Average from 30 grubs varying from 26 to 30 mm. long; head 5.13 mm.

Average from 19 grubs varying from 31 to 35 mm. long; head 5.26 mm.

Average from 42 grubs varying from 36 to 40 mm. long; head 5.39 mm.

Average from 5 grubs varying from 41 to 45 mm. long; head 5.45 mm.

The factors which influence the rate of growth in the third instar of the grub are:

(1) Available food supply; *i. e.*, contiguity of abundant living plant roots.

(2) Humidity and texture of soil. Hardness or softness of the

soil naturally retards or facilitates the easy movements of the grub in its constant search for fresh roots. For this reason white-grubs are worse pest in friable than in heavy clay soils.

(3) Temperature (time of year). The length of this instar somewhat increases, as do the others, during the winter months, though at no time of year do the grub's activities entirely cease as result of cold weather, as happens in more northern latitudes.

(4) The presence of disease in the grub. As previously stated, infection with the *Metarrhizium* fungus greatly retards the activity and growth of the grub, as does bacterial infection, thus lengthening the duration of the instar.

(5) Attack by mites, or by other dermal parasites that molest the grub.

THE PRE-PUPAL STAGE.

The so-called pre-pupal stage of white-grubs is the resting period that occurs at the end of the third instar during which the grub is preparing for pupation. It is characterized by a puckering or gathering of the skin, general flabbiness, and a discoloration or yellowing in color (see Plate III, fig. 8). The larva lies on its back, dormant, in a rounded, oblong cell about 35 to 40 mm. long; the body is much flattened and the caudal end rather sharply bent upward; the legs are held stiffly outward, close together, and display little or no movement. There is no molt between the third instar and the pre-pupal stage.

From two weeks to a month prior to the pre-pupal stage, the grub shows the approach to pupation by its sluggishness, by the body becoming yellow, more opaque, and harder to the touch, and by a disappearance of the dark stain at the caudal end of the body resulting from the earthy excretious matter within.

From about a dozen observations of reared grubs, the pre-pupal stage varied from four to seven days. There was in each case an added period of about a week to two weeks during which the grub was sluggish and did not feed, thus indicating its preparation for the pre-pupa.

THE PUPAL STAGE.

When the pre-pupa molts, the pupa is at first white and misshapen; but within twenty-four hours it has assumed its natural shape (see Plate III, fig. 9; also Plate IV, figs. 1 and 2) and shining yellow-brown color. The pupa lies on its back in the cell, and the

crumpled molt skin (Plate III, fig. 9) remains near it, at the caudal end.

The average duration of the pupal stage, from 22 observations, was $21\frac{1}{2}$ days; the maximum, 26 days; the minimum, 17 days.

From thirteen measurements, the average length of the pupa was 25.1 mm., the average width 11.15 mm., and the average breadth of the head 8.18 mm.

A day or two before hatching into the adult, the pupa turns over in its cell and lies with the back upward. In this position the adult is always found in the cell, never with back downward. On a pupa about to hatch the skin is wrinkled, and the white color of the elytra may be seen through elytral sheaths. (See Plate III, fig. 10.) The formation and sculpture of the legs may also be seen through the now transparent pupal skin.

ISSUING AND EMERGENCE OF ADULT.

An adult just issued has only the legs, head, and thorax brown, the elytra being white and soft, and the wings extended their full length beneath the elytra. (See Plate IV, fig. 6.) In a few hours the beetle turns tawny yellow in color, then gradually deepens in shade during the following week.

The term issuing applies to the breaking of the pupal skin, and the exit of the newly formed adult from the pupa; the term emergence applies to the appearance of the beetle above ground. The interim between these two periods is spoken of as the period of pre-emergence, and is the time spent by the newly-hatched beetle in the pupal cavity in the soil—a time very necessary for the chitinous parts of the beetle to become perfectly hard, so that it can dig its way upward to the surface of the ground.

In many North American May-beetles the pre-emergence of adults covers a period of several months—usually from the late summer or fall of one year to the spring of the next. In the Porto Rican species this period extends rarely over five to six weeks, judging from observations.

Because of the fact that most of the confined specimens of *van-dinei* were reared in small tin boxes, in which the adults at time of pre-emergence were disturbed and did not behave normally, our records of pre-emergence are somewhat incomplete. The following notes, however, prove it to extend over a period of two weeks or more:

(1) No. 547.—On July 1 two adults hatched from pupae in earth in a jar,

which were still alive in the cells but had not come to the surface of ground when the soil was dumped, July 30. Time, over 29 days.

(2) *No. 548*.—One female and two male adults, hatched in a battery jar on July 3, 7 and 18, respectively, had not reached surface by July 30, though two of them were still living. Time, over 12 to 27 days.

(3) *No. 1172c*.—A female, issued April 12 in a jar, had not come to the surface on April 28, though still living. Time, over 16 days.

(4) *No. 1219b*.—A female hatched February 15 and had not come to surface through four inches of damp soil by March 10, though still alive. Time of pre-emergence, over 23 days.

DISTRIBUTION OF THE SPECIES.

Phyllophaga vandinei is confined to the western end of the Island, a territory equivalent to about one-third of the area of the Island. Its eastern distribution may be defined, roughly, so far as our present knowledge goes, by a north and south line across the Island through the towns of Manatí on the north and Peñuelas on the south. The type of the species is from Santa Rita, near Guánica.

The analogue of this species at the eastern end of the Island is *Phyllophaga portoricensis*, which is indistinguishable from the former species except by means of the genital characters given in the table. It is indeed possible that the two are but races of one species, for there seems to be a general intergrading of the characters along the geographic line separating the two species. Yet at no time have the two been taken in one locality; and the specific characters are sufficiently recognizable in specimens from the type localities, Guánica and Río Piedras, to set apart the species as quite distinct.

FEEDING HABITS OF THE ADULTS.

All May-beetles feed upon the foliage of plants and trees, and are voracious eaters. The adult of *vandinei* differs from many species of the genus in being a very general feeder, and there are few plants which it will not touch. Feeding is done entirely at night, the adults issuing from the ground at dark, or a little before. After a very brief flight, they alight upon suitable foliage and begin to feed upon the margins of the leaves. Feeding continues until very late into the night, the beetles appearing to be as abundant after midnight as before. Spending thus six hours or more of the night in feeding, they consume quantities of vegetation. Small tress of "quenepa," of "salcilla," and of native china-berry have been found completely stripped of foliage by this species. Cane also suffers from depre-dations of the adults, but not to such an extent as the foliage of certain trees. A common ornamental tree of the south side of the

Island, the casuarina, and another of general use along roads in Porto Rico, the flamboyant, are both very badly attacked by adults of this species. Banana and coconut trees often show acute injury from their feeding. (See Plate I, figs. 1 and 2.)

It has not yet been determined at what hour of the night their feeding terminates, but it must be well toward morning, as they have been collected feeding as late as 2 a. m. Nor is it known whether, at termination of feeding, they fly or drop to the ground. When disturbed in feeding they drop, using the wings usually to carry them a short distance; and this is probably the method employed at the end of the feeding.

So uniformly abundant is *Phyllophaga vandinei* over the infested area that unusual and sporadic appearance of adults in such numbers as to cause bad defoliation in restricted areas is rare. The infestation is general, and usually heavy. Cane foliage may always be found somewhat damaged in the Guánica district and the San Germán valley.

Following is a list of some of the commoner plants and trees occurring in or near cane fields in the infested area, grouped according to their attractiveness to the beetles.

(1) Those greatly relished by the adults—

Flamboyant (*Poinciana regia*); Australian pine (*Casuarina equisetifolia*); almendro (*Terminalia catappa*); salcilla (*Schrankia portoricensis*); quenepa (*Melicocca bijuga*); guasima (*Guazuma guazuma*); China-berry (*Melia azedarach*); tamarind (*Tamarindus indicus*); jobo (*Spondias lutea*); banana (*Musa* sp.); coconut (*Cocos nucifera*); cecropia (*Cecropia palmata*); pig-weed, or bleado (*Amaranthus* spp.); mallow (*Malachra rotundifolia*); and *Petiveria alliacea*.

(2) Those eaten to some extent, but not apparently as much relished as trees and plants in the preceding list—

Sugar cane (*Saccharum officinarum*); guava (*Psidium guajava*); almacigo (*Bursera simaruba*); jaguey (*Ficus lentiginosa*); bucago (*Erythrina glauca*); royal palm (*Roystonea borinquena*); eucalyptus (*Eucalyptus* spp.) (very rarely); Jamaican sorrel (*Hibiscus sabdariffa*); native cotton (*Gossypium* sp.); Guinea grass (*Panicum maximum*); malojillo, or Para grass (*Panicum barbinode*); *Casearia sylvestris*; and *Cordia corymbosa*.

(3) Those which appear to be entirely exempt from attack by the adults—

Hawaiian algarroba (*Prosopis juliflora*); papaya (*Carica papaya*); gallito (*Sesbania grandiflora*); gandul (*Cajanus indicus*); pepper tree (*Schinus molle*); black sage (*Cordia cylindrostacha*); roble (*Tabebuia rigida*); calabash (*Crescentia cujute*); berengena cimarrona (*Solanum torvum*); silk cotton weed (*Calotropis procera*); acalypha (*Acalypha wilkesiana*); *Citrus* spp.; and *Clidemia* spp.

HABITS OF FLIGHT.

During the day the beetles conceal themselves by burrowing into the ground, usually near the bases of trees or large weeds. Often a dozen or more holes may be found around the base of a tree upon which they have been feeding. At night they begin issuing from these burrows at about sundown, and their flight seldom lasts for more than fifteen to twenty minutes.

On one occasion, in October, observations were made at sundown of a large screened cage into which had been put five hundred adults a few evenings before. The beetles began appearing from the soil at 6:25 p. m., were issuing in greatest numbers at about 6:35 p. m., and had practically ceased to appear by 6:45 p. m. The majority took wing immediately upon making their exit from the holes, or crawled up a near-by weed and then took wing; a few climbed weeds and began to feed without flying at all. Nearly all flew westwardly, against the western side of the cage. The flight of the majority lasted until about 6:50 p. m.; the last of them had ceased flying by 7:00.

Adults of this species do not usually fly for long distances. By watching up and down a "callejón" (a bare or grass alleyway 20 to 30 feet wide) between cane fields at about dusk, in a place where infestation by the beetles was known to be heavy, it has been noted that comparatively few of the beetles flew across the "callejón," but that the majority hovered over the cane plants very near to where they had arisen. On various occasions casuarina trees in a Bermuda-grass lawn were watched at dusk, and it was noted that the beetles usually hovered around the trees near whose bases they had made exit from the ground, but never arose high and took direct flight for more distant trees.

Another observation confirmed the belief that the dispersion of *vandinei* by flight is not extensive. In a large outdoor screened experimental cage, 6 by 10 feet in area, into which 2,000 beetles were introduced on April 2, it was observed a week later that the cane growing at the end of the cage where the beetles had been introduced was entirely stripped of foliage, while cane growing at the opposite end was virtually untouched, showing decidedly the slow dispersion by flight.

ATTRACTION TO LIGHT.

Adults of *vandinei* are quite readily attracted to light, as is usual with May-beetles. Experiments were made with a large 500-c. p.

Pitner gasoline lamp, with a view of finding some suitable method of taking advantage of this fact for the destruction of the beetles. The lamp was placed on the roof of a two-story building near the insectary at Santa Rita, and a canvas stretched on a vertical frame was put beneath the light. Since a few individuals often come to an ordinary lamp in a room, it was expected that the Pitner light, with its great power, would attract large numbers. This hope was not justified, as out of twenty-three evenings in July, August, October, and November during which the light was run, beetles were taken on only seven, a total of twenty-four being taken.

The reason for this scarcity of beetles was that the Pitner light was always started about 8 o'clock, and *Phyllophaga* adults are ordinarily only attracted to light during their flight and before they have settled on foliage to feed (before 7:30 p. m.). To have any practical efficiency in attracting *vandine* adults for destruction, a light must be close to the ground, and must be started immediately at dusk, while beetles are flying. It need not be run for over an hour after dark, as time after that is wasted. There have been cases where adults of this species and *portoricensis* have left their feeding on the foliage and flown to a motorcycle headlight as late as midnight or after, but these cases are rare. Almost never, while collecting beetles with a bull's-eye light, have they been known to leave their feeding and fly to the light.

COPULATION.

This species is not often found in copulation in the field, the reason being that collecting is usually done after 8 p. m., while mating takes place before that hour. On one occasion recorded, when collecting was done between 6:45 and 8:25 p. m. (on October 14), out of 79 adults collected on cane, "salcilla" and "malojillo," only one pair was found in copula (at 7 p. m.). Lateness of the season may have accounted for so few being found copulating at that hour.

Pairs were occasionally found copulating on the foliage of small casuarina tress near the insectary. Pairs thus observed on two evenings in April were recorded as follows:

- (1) Copulation began before 7:30; ended at 7:45; duration 15 minutes +.
- (2) Copulation began before 7:30; ended at 7:53; duration 23 minutes +.
- (3) Copulation began before 7:35; ended at 7:45; duration 10 minutes +.
- (4) Copulation began before 7:35; ended at 7:48; duration 13 minutes +.
- (5) Copulation began before 7:35; ended at 7:50; duration 15 minutes +.
- (6) Copulation began before 7:35; ended at 7:50; duration 15 minutes +.
- (7) Copulation began at 7:31; ended at 7:52; duration 21 minutes.
- (8) Copulation began at 7:34; ended at 7:53; duration 19 minutes.

It is evident that copulation of this species takes place quite uniformly between 7 and 8 p. m., or immediately after the cessation of flight, and that the average duration exceeds sixteen minutes. It may possibly be learned, with further observation, that the oviposition of the Tachinid parasites, *Cryptomeigenia aurifacies* Wal. and *Eutrixoides jonesii* Wal., on the adult beetles takes place during the copulation and before the total darkness of night comes on.

OVIPOSITION OF FEMALES.

Oviposition takes place in the soil adjoining the beetle burrows at the bases of trees and plants, where the young larvæ will be immediately among the roots. Exact depth at which eggs are laid in the soil has not been determined, but probably averages from eight inches to a foot, the depth at which beetles are usually found in their burrows.

As stated before, to secure eggs in confinement for the purpose of determining the length of the period of oviposition of females and the average number of eggs laid by a female, beetles were confined both singly and "en masse;" and the results from the two methods did not vary much. The method of confining the females has been described on page 63. No eggs were secured from reared females, unfortunately.

The individual egg-laying records of females of *vandinei* are graphically shown in the two charts on Plate IX. The complete records are given in the following tables:

Egg-Laying Records of Individual Females of *Phyllophaga Vandineci* n. sp.

Exp. Number	Date	Days		Eggs		Days		Eggs		Days		Eggs		Days		Eggs		Lived Days	Laid Eggs	Eggs per Day		
		Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days							
988	8-11	a	14	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	21-28	2	.082	
		b	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14-23	0	.000	
		c	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14-23	0	.000	
		d	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27-48	0	.000	
		e	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27-48	0	.000	
1020	8-26	a	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5-14	0	.000	
		b	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33-54	0	.000	
		c	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-24	0	.000	
		d	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11-17	0	.000	
		e	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11-17	4	.286	
		f	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11-17	0	.000	
		g	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11-17	0	.000	
		h	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-24	0	.000	
		i	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34-54	0	.000	
		j	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17-24	4	.192	
		k	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-27	7	.275
		l	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34-54	3	.068
1032	9-8	a	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8-11	0	.000	
		b	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-27	5	.192	
		c	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8-11	0	.000	
		d	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-27	5	.192	
		e	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8-11	0	.000	
		f	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-27	5	.192	
		g	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8-11	0	.000	
		h	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-27	5	.192	
		i	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8-11	0	.000	
		j	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24-27	5	.192	
		k	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8-11	0	.000
		1052	9-25	a	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-21	0
b	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18-21	0	.000	
c	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23-27	17	.486	
d	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3-6	4	.889	
e	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25-45	6	.171	
f	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25-47	2	.055	
g	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25-47	2	.055	
h	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21-25	0	.000	
i	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6-18	5	.000	
j	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6-18	0	.000	
k	3			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6-18	0	.000
1052	9-25			a	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6-18	0
		b	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6-18	0	.000	
		c	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	74-87	4	.421	
		d	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87-103	19	.238	
		e	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41-56	6	.154	
		f	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41-56	6	.154	
		g	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	74-87	17	.210	
		h	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3-7	0	.000	
		i	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66-74	27	.386	
		j	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7-25	0	.000	
		k	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41-56	6	.154	
		l	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41-56	6	.154	
1052	9-25	m	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23-41	3	.081	
		n	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45-56	30	.604	
		o	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45-56	19	.238	
		p	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25-45	7	.300	
		q	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25-45	7	.300	
		r	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7-25	0	.000	
		s	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66-74	7	.100	
		t	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45-66	23	.414	

Exclusive of reared adults, a total of 75 females were confined singly for eggs, of which number 45 females laid a total of 713 eggs, or an average of 16 eggs each, while 30 females laid no eggs.

Average from the 45 females, .345 eggs per day, or 1 egg each 3 days.

Average from the 75 females, .204 eggs per day, or 1 egg each 5 days.

It is reasonable to believe that those females which did not lay eggs were old females, and were exhausted of eggs before confined. The confined females were collected in the field, and their age from date of first emergence could not therefore be determined. It is believed that the average from the forty females that laid eggs can be taken as nearly the correct or normal figure.

The average length of life of 45 females that laid eggs was 47 days (about one and one-half months); the average length of period of oviposition 11 days (about one and one-half weeks). (The duration of oviposition is taken as including the time between the recorded dates of laying of the first and last eggs in confinement.) As the environment of the beetles in the experimental jars was certainly quite different from that outdoors, it is possible that these figures would be materially lengthened in outdoor or natural conditions.

The greatest duration of the egg-laying period was 42 days (or six weeks), the female laying in that time only 39 eggs, or slightly under one egg per day. The egg-laying period of 25 out of the 45 females was less than one week in duration.

The female that lived the longest in confinement, 95 days (or thirteen and one-half weeks), laid only 12 eggs, all within three days. One female lived 59 days (or eight and one-half weeks) and laid no eggs, being fed, however, during the entire period.

The egg laying of adults is periodical. For instance, in the group of 14 females included in the numbers 1206 to 1219, inclusive, where the average length of life was 56 days, over half of the 188 eggs were laid within six days—between the 30th and 35th days of confinement. Again, in the group of eight females included in the numbers 1284*a* to 1284*h*, inclusive, where the average length of life was 36½ days, over three-fifths of all the 57 eggs were laid in the five days between the 27th and 32d days of confinement. These facts, merely as circumstantial evidence, would make it appear that about a month is required for mature eggs to form in the female uterus after copulation.

The largest number of eggs laid in a short space of time by a female was 35 (see No. 1209), laid in two days, or at a rate of 18 eggs per day.

The data obtained from the females confined "en masse" show that—a total of 1,406 females laid 1,560 eggs in an average period of 6.4 days. Or, reduced to the equivalents of the preceding table of averages:

Average from 60 per cent of females, .29 eggs per day, or 1 egg each $3\frac{1}{2}$ days.
Average from all the females, .172 eggs per day, or 1 egg each $5\frac{3}{4}$ days.

INSECT PARASITISM.

The insects which prey upon this species are the same as those listed for the genus. Probably one of the more important ones is the predacious wireworm, *Pyrophorus luminosus* Ill., the exact value of which, however, as a control of the grub in the fields it is very difficult to ascertain, from the fact that, in digging or plowing, living wireworms are very rarely found adjacent to the grubs they have attacked.

Other important enemies of *vandinei*, in the more northern part of its range, are the two Tachinid flies which parasitize the adults.

As to the large Scoliid wasp, *Campsomeris dorsata* Fab., it has been found that on the island of Barbados the species, though commonly parasitizing and apparently preferring the Dynastid, *Ligyris tumulosus* Burm., is occasionally found parasitizing a common Melonthead, *Phytalus smithi* Arrow (18, p. 56). In Porto Rico this wasp is particularly abundant in the Guánica district, where it has been often found parasitizing *Ligyris tumulosus* grubs. It is possible that it may rarely attack grubs of *Phyllophaga vandinei*; but to the present date none of the records of its attack of this species have been verified; and the fact is patent that, of many hundreds of grubs of *vandinei* examined by the writer, and many dozens reared in confinement, not one has ever been observed parasitized by egg or larva of this wasp. Dry grub remains have been examined attached to numbers of *Campsomeris* cocoons collected at Santa Rita, but none of them proved to be *vandinei*.

The Tachinid flies.—Two species of Tachinid fly, *Cryptomeigenia aurifacies* Walton (see Pl. VII, fig. 7) and *Eutrixoides jonesii* Walton, which have been previously discussed, are known to attack this species and *portoricensis* in the more humid parts of their habitats, and to do much to keep them in check in those localities. A rather large percentage of specimens of *vandinei* collected at Añasco, at the west end of the Island, have been found infested with the pupæ of *Cryptomeigenia*, and a far smaller number with *Eutrixoides*. Collections of pupæ have been made in April, May and September, but doubtless can be found throughout the year. The number of pupæ

found within one dead adult host varies from two to nine, usually four to six. Infested beetles that have died are always found in their burrows in the ground.

Work on the life-histories of the two species is in progress now, but has not yet been completed.

Neither species has been found to occur in the Guánica district, where the damage from *vandineí* is most acute. Attempts to introduce the flies at Santa Rita, using infested beetles taken there from Añasco, were not successful; and it seems probable that the flies do not thrive in a dry climate like that of the south coast.

Attacked by mites and nematodes.—In the experimental jars and boxes some difficulty was experienced in the rearing of eggs of *vandineí* because of attack by nematodes and mites, the latter apparently a species of *Tyroglyphus*. The following brief notes may serve as examples of the manner in which this loss of eggs occurred:

No. 1016.—August 25, eleven eggs, laid since August 17, were put into artificial cells at bottom of a jar. August 26, one egg destroyed, surrounded by a myriad of young nematodes. August 27, two more similarly destroyed. August 30, all the other eggs but four destroyed by the nematodes.

No. 1021.—August 26, fourteen eggs, laid August 18 to 21, were put into damp sifted earth at bottom of jar. August 27, one destroyed by nematodes and mites. August 29, two more destroyed. September 30, last two killed by mites, and being eaten by them.

The injury from the mites was not limited to the eggs, grubs in all instars often suffering badly, even dying, from their attack. The following notes give specific examples of mite injury to grubs:

No. 1049d.—January 28, a grub in second, molted about December 12, heavily infested with mites. February 17, grub died as result, without being able to molt.

No. 1049g.—January 18, a grub in second, molted about December 20, partly covered with mites on head, legs, and front of body. February 25, molted. June 25, sickly, with many mites. June 30, dead, eaten up by mites.

No. 1193.—May 3, grub preparing to pupate put into box. May 22, died before pupating; covered with mites.

No. 1216d.—May 15, grub in first, hatched May 15, has mites. June 2, injured by mites, and died molting to second.

No. 1309a.—June 18, grub hatched since yesterday put into box. July 29, half covered with mites, which prevent its growth. August 9, sickly, with many mites. August 14, died without molting to second.

Eggs devoured by wireworm and Staphylinid larva.—Occasional loss of eggs was experienced in experimental jars from wireworms (*Monocrepidius* sp., undetermined) and from larvæ of a small Staphylinid beetle, introduced into the earth with manure. The following extracts from notes give specific cases:

No. 1032e.—September 24, six eggs, laid since September 17, put over damp earth in a box. September 25, two eggs missing, and a wireworm present, eating a third.

No. 986.—August 14, out of nine eggs, laid August 9–11, placed in artificial cells in earth, two were destroyed by Staphylinid larvæ, which occupied the cavities where eggs had been.

LITERATURE CITED.

- (1) BLATCHLEY, W. S.—1910. *Lachnosterna* (pp. 958–980, fig. 3, pl. 5). In *The Coleoptera or Beetles Known to Occur in Indiana*.
- (2) DASH, J. SYDNEY.—1916. Rept. of the Asst. Supt. of Agr. on the Ent. and Myc. Work Carried Out During the Season Under Review. In Rept. on the Dept. of Agr., Barbados, 1914–15 (pp. 38–41).
- (3) CHITTENDEN, F. H.—1909. *Insects Injurious to Vegetables* (lit. pp. 73–78, fig. 3).
- (4) DAVIS, JOHN J.—1913. *Common White-Grubs*. *Farmers' Bull.* 543, U. S. Dept. of Agr. (pp. 20, fig. 12).
- (5) DAVIS, JOHN J.—1916. A Progress Report on White-Grub Investigations. In *Jour. of Econ. Ent.*, vol. 9. No. 2, 1916 (pp. 261–281 pl. 2).
- (6) DE CHARMOY, D. D'EMMEREZ.—1912. *Rapport sur Phytalus smithi* (Arrow) et Autres Scarabees S'Attacquant a la Canne a Sucre a Maurice, Port-Louis, 1912 (pp. 35, pl. 10).
- (7) FORBES, S. A.—1907. On the Life-History, Habits, and Economic Relations of the White-Grubs and May-beetles. *Bull.* No. 116, Univ. of Ill. Agr. Exp. Sta. (pp. 447–480).
- (8) FORBES, STEPHEN A.—1916. A General Survey of the May-beetles (*Phyllophaga*) of Illinois. *Bull.* No. 168, Univ. of Ill. Agr. Exp. Sta. (pp. 215–257).
- (9) GIRAULT, A. A., AND DODD, A. P.—1915. *The Cane Grubs of Australia*. *Bull.* No. 2, Div. of Ent., Bu. of Sugar Exp. Stations, Queensland (pp. 60).
- (10) GOOT, O. VAN DER.—1915. On Certain Beetle Larvæ Found in Sugar Plantations (text in Dutch). *Med. Proefstation voor de Java Suikerindustrie*, pt. 5, No. 10, Soerubaia, (pp. 60, fig. 13).
- (11) JARVIS, E.—1916. Notes on Insects Damaging Sugar Cane in Queensland. *Bull.* No. 3, Div. of Ent., Bu. of Sugar Exp. Stations, Queensland (pp. 48, four plates).
- (12) JOHNSTON, JOHN R.—1915. *The Green Muscardine* (Metarr-

- hizium anisoplice) *In* The Entomogenous Fungi of Porto Rico, Bulletin No. 10 of the Board of Comm. of Agr. of P. R. (pp. 26-28).
- (13) KULAGIN, N. M.—1913. The Principal Insect Pests of Field Crops in European Russia for the Last Twenty Years (text in Russian). *In* The Year Book of the Dept. of Agr. of the Central Board of Land Administration and Agriculture, St. Petersburg, VI, 1913 (pp. 585-638, pl. 1).
- (14) LEEFMANS, S.—1915. De Cassave-Oerets (The Cassava Grubs). Dept. Nijverheid, Landbouw en Handel. Med. van het Laboratorium voor Plantenziekten, No. 13, Buitenzorg (pp. 118, pl. 7).
- (15) LENG, CHAS. W., AND MUTCHLER, A. J.—1914. A Preliminary List of the Coleoptera of the West Indies as Recorded to January 1, 1914. Bulletin of the Am. Mus. of Nat. Hist. vol. 33, art. 30, pp. 391-493.
- (16) MOORE, W. H. B.—1916. General Report on Insect Pests (of Cane) for the Year 1915. Rept. to Messrs. Booker Bros., McConnell & Co., Ltd., and Messrs. Curtis, Campbell & Co., Demerara (pp. 8).
- (17) NORTHRUP, ZAE.—1914. A Bacterial Disease of June Beetle Larvæ, *Lachnosterna* spp. Tech. Bull. No. 18, Mich. Agr. Coll. Exp. Sta. (pp. 37, twenty-two figs.).
- (18) NOWELL, W.—1915. Two Scoliid Parasites on Scarabæid Larvæ in Barbados. *In* Ann. of Applied Biology, vol. 2, No. 1 (pp. 46-57, pl. 1).
- (19) PATTERSON, WM. H.—1912. Rept. on the Agr. School, St. Vincent. *In* Reports on the Botanic Station, Agr. School, etc., St. Vincent, 1910-11 (pp. 19-24).
- (20) RILEY, CHAS. V.—1869. The White-Grub. *In* First Report of the Missouri State Entomologist on the Insects of Missouri (pp. 156-159).
- (21) RILEY CHAS. V.—1874. The Unadorned Tiphia or White-Grub Parasite. *In* Sixth Report of the Missouri State Entomologist on the Insects of Missouri (pp. 123-126).
- (22) SHEPHERD, F. R.—1916. Work Connected with Insect and Fungus Pests and Their Control. *In* Rept. of the Agr. Dept., St. Kitts-Nevis, 1914-15 (pp. 15-16).
- (23) SMYTH, EUGENE G.—1915. Report of Work at the South Coast Laboratory. Third Report of the Board of Comm. of Agr. of Porto Rico (pp. 40-53).
- (24) SMYTH, EUGENE G.—1916. Report of the South Coast Labora-

- tory. Fourth Report of the Board of Comm. of Agr. of Porto Rico (pp. 45-50, with life-cycle tables).
- (25) STEVENSON, JOHN A.—1916. Work with the Green Muscardine in Report of the Pathologist. *In* Fourth Report of the Board of Comm. of Agr. of Porto Rico (pp. 34-35).
- (26) TEMPANY, H. A.—1916. Work Connected with Insect and Fungus Pests and Their Control. *In* Report on the Botanic and Experiment Stations, Antigua, 1914-15 (pp. 20-22).
- (27) VAN DINE, D. L.—1911. Third Report of the Entomologist. *In* Year book of the Association of Sugar Producers of Porto Rico, 1910-11 (pp. 43-57).
- (28) VAN DINE, D. L.—1912. Report of the Entomologist. *In* Second Annual Report of the Exp. Sta. of the Sugar Producers' Association of Porto Rico (pp. 15-22).
- (29) VAN DINE, D. L.—1912. Progress Report on Introductions of Beneficial Parasites into Porto Rico. *In* First Report of the Board of Comm. of Agr. of Porto Rico (pp. 31-47).
- (30) VAN DINE, D. L.—1913. The introduction of Parasites of May-Beetles into Porto Rico. *In* Second Report of the Board of Comm. of Agr. of Porto Rico (pp. 36-48).
- (31) VAN DINE, D. L.—1913. Report of the Entomologist (with list and bibliography of Porto Rican sugar-cane insects). *In* Third Report of the Porto Rican Sugar Producers' Exp. Sta. (pp. 25-46).
- (32) VASSILIEV, I. V.—1914. Short Notes on *Anisoplia austriaca* Herb. and Methods of Fighting It (in Russian). *In* Memoirs of the Bureau of Entomology of the Scientific Committee of the Central Board of Land Administration and Agr., St. Petersburg, VII, No. 2 (pp. 36, fig. 20, colored pl. 2).
- (33) WASHBURN, F. L.—1908. Destruction of Lawns by the White-Grub. Circular of Information No. 11, Office of State Entomologist, Minnesota (pp. 2, fig. 4).
- (34) WOLCOTT, GEORGE N.—1913. Report on a Trip to Demerara, Trinidad and Barbados during the Winter of 1912. *In* Third Report of the Sugar Producers' Association Exp. Sta. (pp. 47-68).
- (35) WOLCOTT, GEORGE N.—1914. Notes on the Life-History and Ecology of *Tiphia inornata* Say. *In* Jour. of Econ. Ent., vol. 7, No. 5 (pp. 382-389).
- (36) WOLCOTT, GEORGE N.—1915. Report of the Traveling Entomologist. *In* Third Report of the Board of Comm. of Agr. of Porto Rico (pp. 25-40).

EXPLANATION OF PLATES.

PLATE II.

- Fig. 1.—Banana tree stripped of foliage by May-beetles, chiefly by *Phyllophaga vandinei* n. sp.
- Fig. 2.—Leaf of a coconut palm injured by the feeding of adults of *Phyllophaga portoricensis* n. sp.
- Fig. 3.—Salcilla tree (*Schrankia portoricensis*), a wild species abundant in the Guánica district and whose foliage is much relished by adults of *P. vandinei*; adaptable for use in collecting the beetles in large numbers by shaking.
- Fig. 4.—A bushel of adults of *P. vandinei* collected in one evening by nine boys in a cane field at Santa Rita, near Guánica.

PLATE III.

- Fig. 1.—*Phyllophaga vandinei* n. sp., eggs lying over soil, x 2 (the elongate egg marked with an "x" is that of *Pyrophorus luminosus* Illiger, an Blaterid whose larva is predaceous on white-grubs).
- Fig. 2.—*Phyllophaga vandinei* n. sp. grubs just hatched from eggs, x 3.
- Fig. 3.—*Phyllophaga vandinei* n. sp. grubs at end of first instar, x 2.
- Fig. 4.—*Phyllophaga vandinei* n. sp. grub at end of second instar, x 2.
- Fig. 5.—*Phyllophaga vandinei* n. sp. grub in act of molting to third instar, x 5.
- Fig. 6.—*Phyllophaga vandinei* n. sp. grub at beginning of the third instar, x 2.
- Fig. 7.—*Phyllophaga vandinei* n. sp. mature grub (at end of third instar), x 2.
- Fig. 8.—*Phyllophaga vandinei* n. sp. prepupa (grub about to pupate), x 2.
- Fig. 9.—*Phyllophaga vandinei* n. sp. pupa, side view, showing shed larval skin, x 2.
- Fig. 10.—*Phyllophaga vandinei* n. sp. pupa at point of issuing of adult, x 2.

PLATE IV.

- Fig. 1.—*Phyllophaga vandinei* n. sp., pupa, ventral view, x 2.
- Fig. 2.—*Phyllophaga vandinei* n. sp. pupa, dorsal view, x 2.
- Fig. 3.—*Phyllophaga vandinei* n. sp. male adult, x 2.
- Fig. 4.—*Phyllophaga portoricensis* n. sp., female adult, x 2.
- Fig. 5.—*Phyllophaga portoricensis* n. sp. male adult, x 2.
- Fig. 6.—*Phyllophaga vandinei* n. sp. adult just issued from pupa, x 2.
- Fig. 7.—*Phyllophaga vandinei*, n. sp. adult attacked by *Metarrhizium*, dorsal view, x 2.
- Fig. 8.—*Phyllophaga vandinei* n. sp. same, side view, x 2.
- Fig. 9.—*Phyllophaga vandinei* n. sp. larva infested with *Metarrhizium*, x 2.

PLATE V.

- Fig. 1.—*Phyllophaga vandinei* n. sp. heads of grubs in first instar, x 10.
- Fig. 2.—*Phyllophaga vandinei* n. sp. head of a grub in second instar, x 10.

- Fig. 3.—*Phyllophaga vandinei* n. sp. head of a grub in third instar, x 10.
 Fig. 4.—*Phyllophaga guanicana* n. sp., male genitalia, x 6 (with mm. scale).
 Fig. 5.—*Phyllophaga citri* n. sp., male genitalia, x 6.
 Fig. 6.—*Phyllophaga vandinei* n. sp., male genitalia, x 6.
 Fig. 7.—*Phyllophaga portoricensis* n. sp., male genitalia, x 6.
 Fig. 8.—*Phyllophaga citri* n. sp., female genitalia, x 5½ (ventral view).
 Fig. 9.—*Phyllophaga portoricensis* n. sp., egg in pit made by the ovipositor, x 6.
 Fig. 10.—*Phyllophaga portoricensis*, female genitalia, x 5½ (ventral view).

PLATE VI

- Fig. 1.—Black birds (*Holoquiscalus brachypterus*) following a plow in cane field at Santa Rita to pick up white grubs.
 Fig. 2.—*Phyllophaga guanicana* n. sp., egg lying over soil, x 2.
 Fig. 3.—*Phyllophaga guanicana* n. sp., swollen eggs in the natural pits, x 6.
 Fig. 4.—*Phyllophaga guanicana* n. sp., grub at end of second instar, x 2.
 Fig. 5.—*Phyllophaga guanicana* n. sp., mature grub (end of third instar), x 2.
 Fig. 6.—*Phyllophaga guanicana* n. sp., male adult, x 2.
 Fig. 7.—*Phyllophaga guanicana* n. sp., female adult, x 2.
 Fig. 8.—*Phyllophaga citri* n. sp., male adult, x 2.
 Fig. 9.—*Phyllophaga citri* n. sp., female adult, x 2.

PLATE VII.

- Fig. 1.—*Phytalus insularis* n. sp., eggs lying over soil, x 3.
 Fig. 2.—*Phytalus insularis* n. sp., grubs at end of third instar, x 3.
 Fig. 3.—*Phytalus insularis* n. sp., pair of adults, x 3.
 Fig. 4.—*Phytalus insularis* n. sp., head of adult below that of *Phyllophaga vandinei* to show comparative size, x 6.
 Fig. 5.—*Phytalus insularis* n. sp., anal aspect of female adult (with scale in millimeters to show size), x 6.
 Fig. 6.—*Phytalus insularis* n. sp., anal aspect of male adult, x 6.
 Fig. 7.—*Cryptomeigenia aurifacies* Walton, adult (right) and pupal case (left), x 3.
 Fig. 8.—*Tiphia inornata* Say, adult male at right, adult female at left over the cocoon.

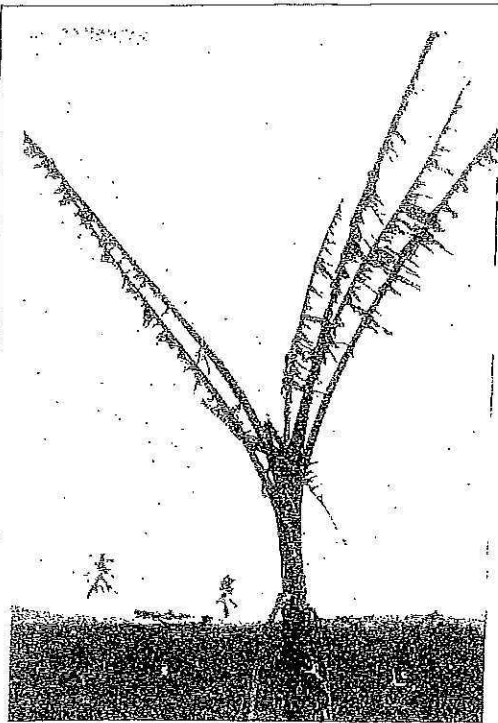
PLATE VIII.

Life-cycles of individual females of *Phyllophaga vandinei* n. sp. in Porto Rico.

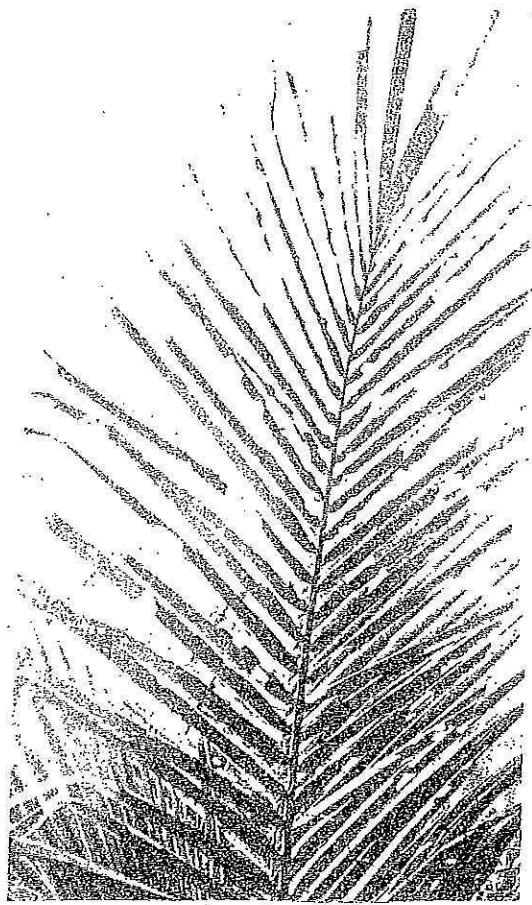
PLATE IX.

Egg-laying records of individual females of *Phyllophaga vandinei* n. sp.

Plate II.—Porto Rican Melolonthids.



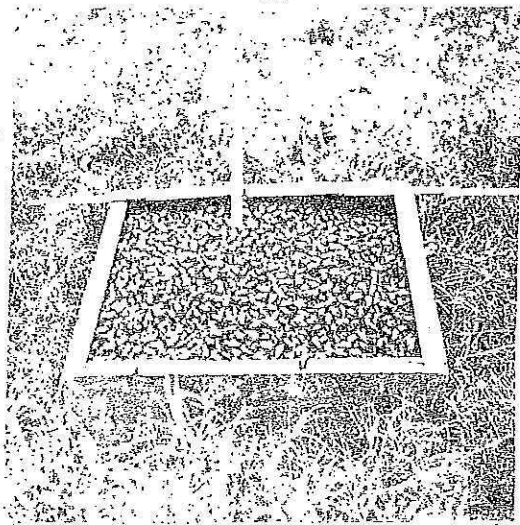
1.



2.



3.



4.

Plate III.—Porto Rican Melolonthids.

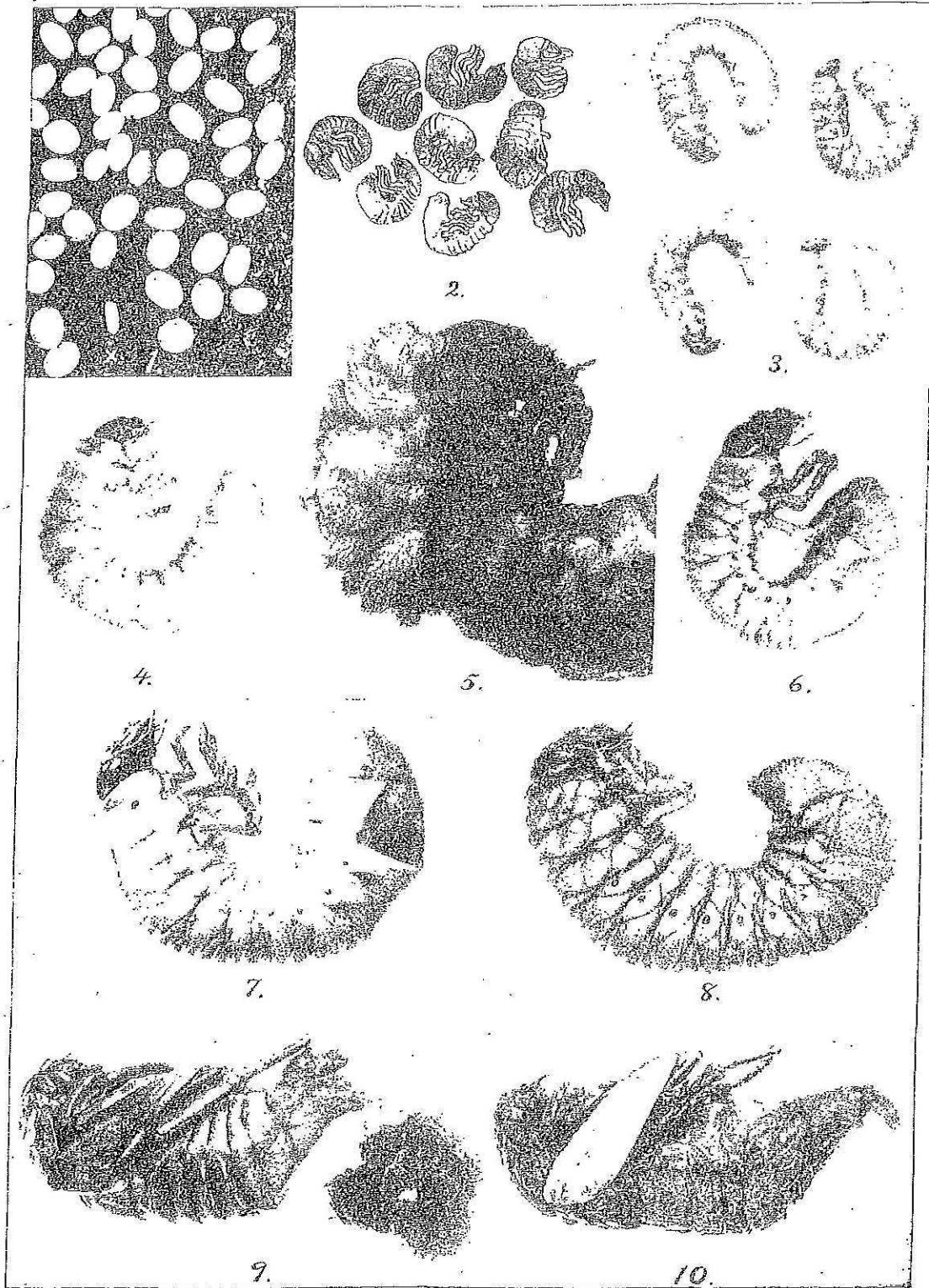


Plate IV.—Porto Rican Melolonthids.

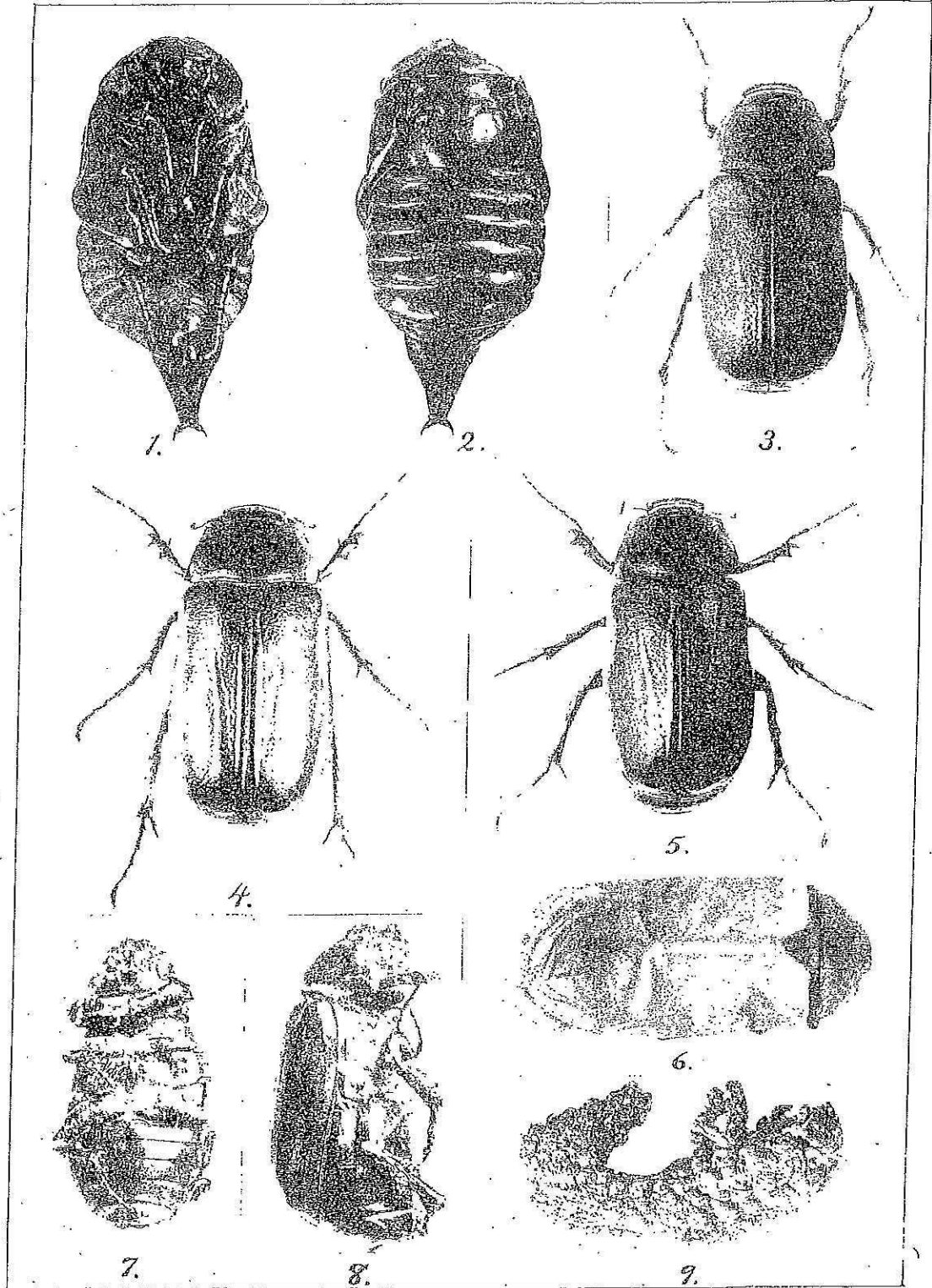


Plate V.—Porto Rican Melolonthids.

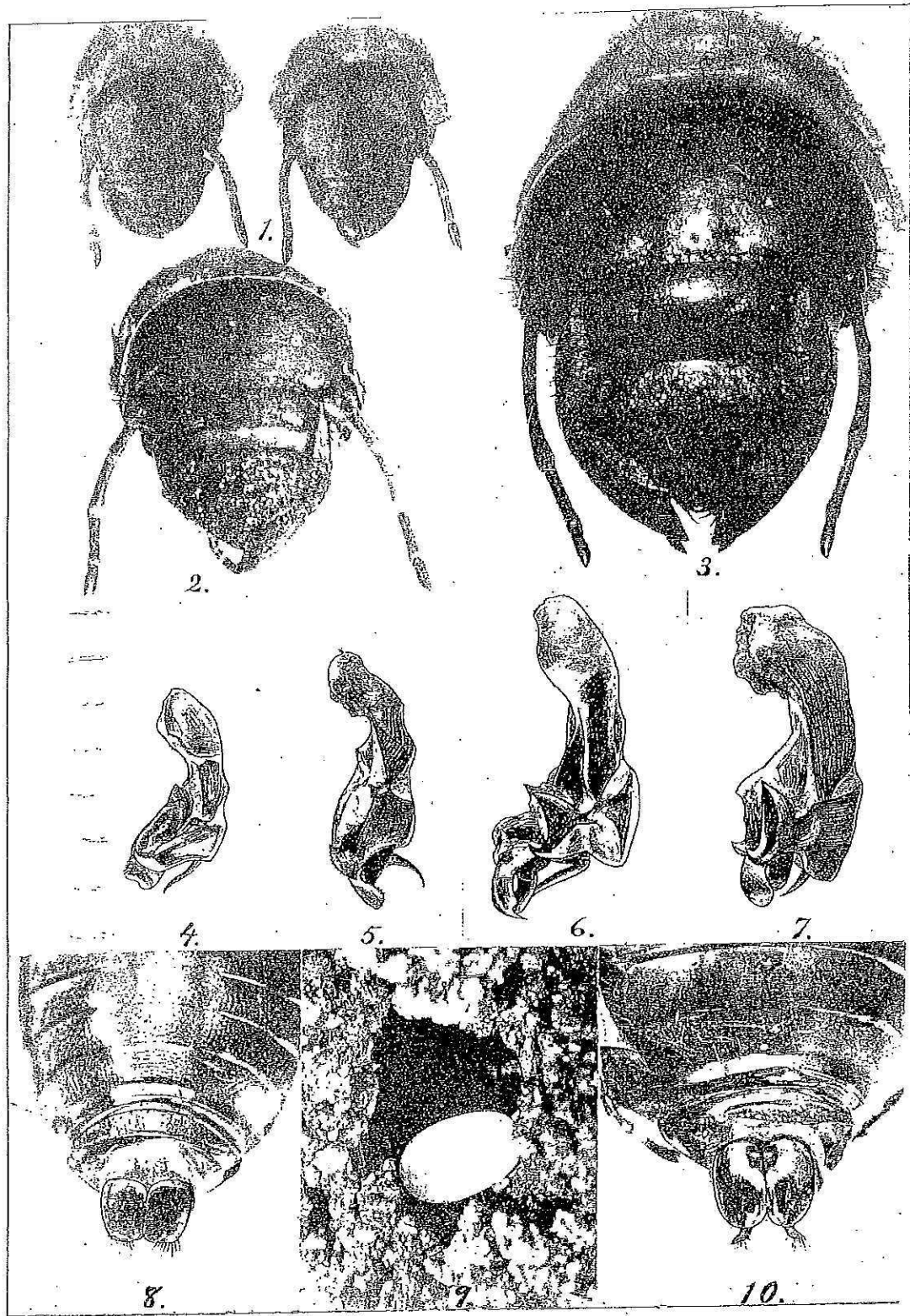


Plate VI.—Porto Rican Melolonthids.

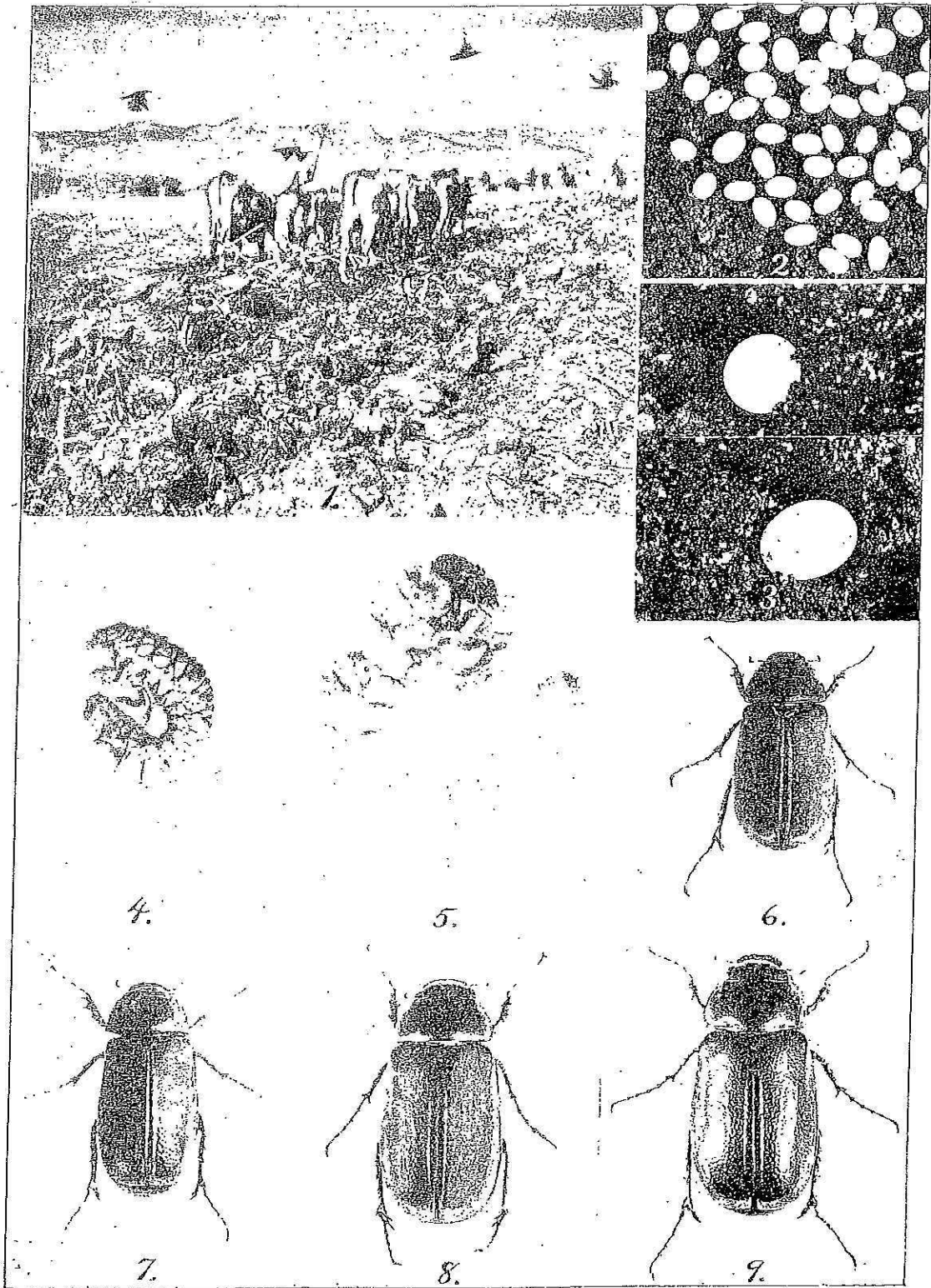


Plate VII.—Porto Rican Melolonthids.

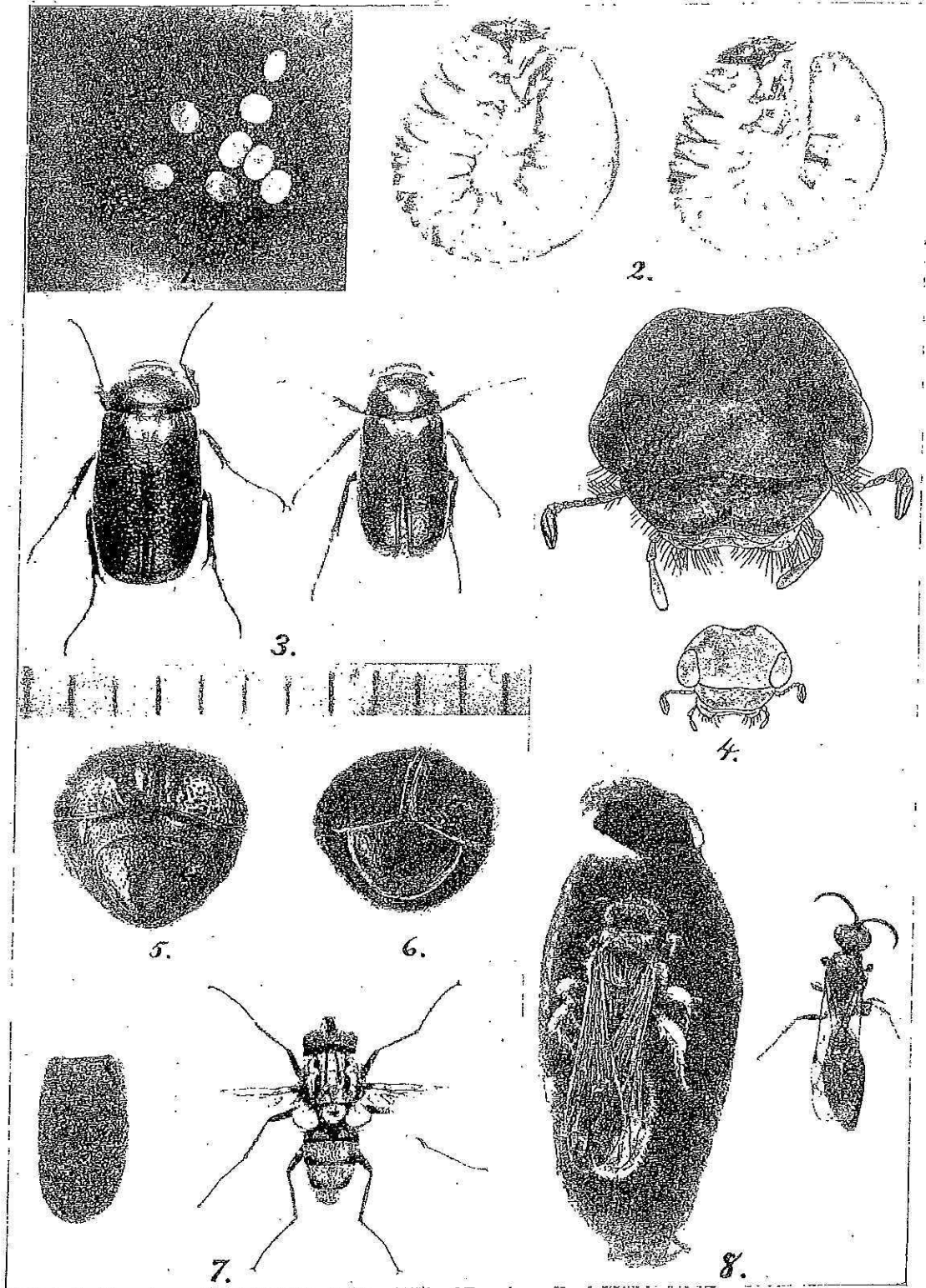


Plate VIII.—Life-Cycles of Individual Females of *Phyllophaga Vandinei* n. sp.
in Porto Rico.

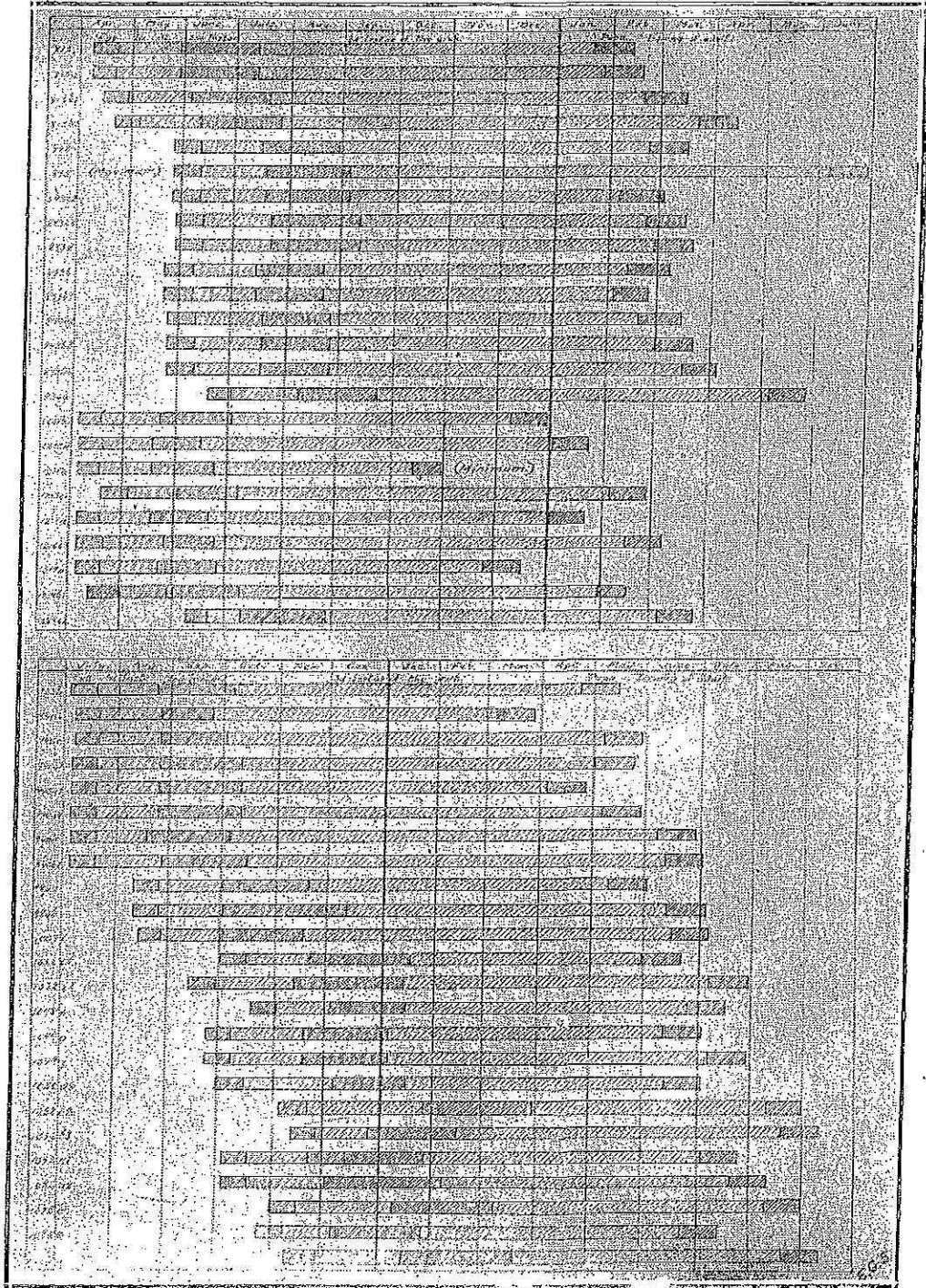


Plate IX.—Egg-Laying Records of Individual Females of *Phyllophaga Vandinei*.

Female No.	Date	Time	Remarks	...
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