

THE LARVAL TAXONOMY OF NINE ARIZONA SPECIES OF THE
GENUS PHYLLOPHAGA, SUBGENUS PHYLLOPHAGA

by

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ABSTRACT

Larvae of nine species of Phyllophaga, subgenus Phyllophaga, of the beetle family Scarabaeidae, in The University of Arizona collection, were studied for the purpose of describing the known species which occur in Arizona. The larvae were dissected and the epipharynx and raster of each removed and studied on depression slides. Drawings were prepared of each of the structures. Eight of the nine species are described and figured for the first time.

A consideration is made of the relationships and interrelationships of the species with respect to the taxonomic groupings of the adults as established by Sanderson. New groups are proposed for the larvae, based on the characters of the epipharynx and raster.

INTRODUCTION

White grubs, the larvae of the beetle family Scarabaeidae, have been rather extensively studied in the United States, due to damage that many of the species cause to the roots of grass, grain, and numerous vegetable crops. Ritcher has recently (1966) provided a comprehensive summary of the classification of this important family. The genus Phyllophaga, of the subfamily Melolonthinae, includes many of the damaging species. The larvae of this genus have been studied extensively in the eastern United States, especially by Ritcher (1940) and Böving (1942). Identification of the larvae of the Arizona species of Phyllophaga has been hampered by the fact that only one of the species known from the state, Phyllophaga vetula Horn, has been included in published studies (Böving 1942). Sanderson (1958) has shown that the affinities of the Arizona species of this genus are largely with the fauna of Mexico. As there has never been a study of the larvae of Phyllophaga in that country, it has not been possible to make even tentative identifications by comparison with descriptions of related species.

This thesis deals with the larvae of nine Arizona species of Phyllophaga, subgenus Phyllophaga. Eight of these are described and figured for the first time. All five of the most abundant species of the subgenus indicated by Butler and Werner (1961) are included. The key to species, descriptions, and figures presented here should permit

identification of all of the species of major economic importance in the state.

MATERIALS AND METHODS

The specimens used for study are from the larval collection of the Department of Entomology, The University of Arizona. Most of them were obtained by Drs. George D. Butler, Jr., and Floyd G. Werner from 1958 to 1961, and by Dr. Werner during 1968. The earlier collections were made by sampling larvae in the field and rearing representative individuals to the adult stage. Part of each sample was preserved at the time, but final identification depended upon the examination of characters on the larval exuviae associated with reared adults. If only a few individuals of a species were found, rearing was attempted on the entire collection. As a result, only the larval exuviae are available for study for some species. The 1968 collections were based on larvae reared from the egg stage, the eggs being obtained from adults collected in the field and fed in cages until oviposition had taken place.

Larvae of known species were first examined with a stereoscopic microscope, and obvious differences and similarities were noted. Then the two parts of the larva that have been used most extensively in the taxonomy of the group, the epipharynx and the raster, were removed for closer study. These parts were first cleared by boiling in concentrated KOH solution for five minutes and then placed in glycerin on depression slides. Both intact larvae and larval exuviae could be treated in this way. General examination of exuviae is difficult because the

cuticle is considerably compressed and wrinkled when it is pushed off by the pupa.

The slide-mounted structures were studied with a stereoscopic microscope at magnifications of from 12 to 100 diameters. Ranges are indicated for the following features: the number of setae on the head capsule; the number of plegmata, crepidal punctures, and the filaments of the laeophoba and dexiophoba on the epipharynx; the number of setae and teeth on the mandibles and maxillae; and the number of hamate setae on the raster. These ranges are due mostly to the difficulty in distinguishing the various setae and structures. Many of the structures are very close together and in some cases overlapping, so that exact numbers become nearly impossible to determine. Some of them grade into other structures at the ends of the series.

The figures were prepared by placing the structures in the depression slides on a Bausch and Lomb Tri-Simplex microprojector and tracing the image produced. In order to obtain a clear image in the projector, the structures were mounted with the surface to be studied ventral. The image was therefore reversed and had to be corrected by reversing the tracing on the final drawing.

A CONSIDERATION OF THE CLASSIFICATION

Larvae of the family Scarabaeidae are soft bodied and generally C-shaped, with well developed, sclerotized head and thoracic legs. The abdomen is usually swollen toward the apex, with the cuticle transparent enough to disclose grey internal structures in this region. The body is usually colored from white to cream, giving rise to the common name "white grubs," and the head and legs from yellow to dark brown. The spiracles are cribriform (crescent-shaped) and biforous (with a crescent-shaped, perforated plate, the secondary opening, partially surrounding the closed primary opening which forms a thickening known as the bulla) (Snodgrass 1935). The dorsa of the meso- and metathorax and most of the abdominal segments have transverse plicae or folds that divide the segment into three (sometimes two) secondary segments or annulets (Peterson 1951). The larvae of a closely related family, Passalidae, can be distinguished by the lack of annulets and by the opening of the spiracular crescents being directed posteriorly on the abdomen. Larvae of the family Lucanidae can be distinguished from those of Scarabaeidae by having the last antennal segment much reduced in size.

Larvae of the subfamily Melolonthinae, which includes the genus Phyllophaga, have the galea and lacinia of the maxillae fused proximally and either separated distally or tightly fitted together, lack a distinct ventral stridulatory area on the mandibles, and usually have

the anal opening angulate or 'Y'-shaped (Ritcher 1966). The angulate or 'Y'-shaped anal opening is sufficient for the identification of the subfamily among the white grubs found in the soil or around roots in Arizona. The only other subfamilies that have the anal opening other than simple and transverse live in association with manure or carrion.

The larvae of the genus Phyllophaga can be distinguished from the other genera of Melolonthinae that occur in Arizona by the following combination of characters: anal opening distinctly 'Y'-shaped, the ventral anal lip with a sagittal cleft or groove; raster with or without a pair of longitudinal palidia; the epipharynx with a distinct epizygm, and five or more heli in the haptomerum; and the maxillae with stridulatory teeth that are short and truncate.

The only other melolonthine larvae with longitudinal palidia that occur in Arizona are members of the genera Polyphylla and Macro-dactylus. Polyphylla larvae have the anal opening angulate but the ventral anal lip not cleft, lack an epizygm on the epipharynx, and have the maxillary stridulatory teeth sharp-pointed and much longer than wide. In the last larval instar they are much larger than Phyllophaga larvae. Macro-dactylus larvae look very much like some small Phyllophaga species. They differ in possessing eyespots on the head, which are always absent in Phyllophaga, in having only a single row of four heli on the haptomerum of the epipharynx, and in having the claws of the metathoracic legs not conspicuously shorter than those of the other legs.

The two known species of Phyllophaga that lack palidia have the raster composed entirely of uniform, curved hamate setae. The only other genus in the Arizona fauna that has such a raster is Hoplia. Ritcher (1966) describes the larvae of this genus as having a single helus on the haptomerum of the epipharynx, and the claws reduced in size on both the middle and hind legs. Adults of this genus have been collected in the White Mountains of Arizona, but no larvae are available for study. The larvae of this genus should be much smaller than those of Phyllophaga, because the adults are quite small.

Larvae of the two currently recognized subgenera of Phyllophaga in the Arizona fauna can be distinguished by the use of the following key, which is based on Ritcher's (1966) key and on specimens in The University of Arizona collection.

Key to Subgenera of the Genus Phyllophaga

Spiracles of abdominal segment 8 much smaller than those of segment 7, which are at least as large as any in the series. Palidia present, with the pali directed mesally, or completely absent. OR: Spiracles of abdominal segments 6-8 reduced in size and pali directed laterally. -----
----- subgenus Phyllophaga

Spiracles of abdominal segments 6-8 or 7-8 reduced in size. Palidia present, the pali directed mesally. -----
----- subgenus Listrochelus

As defined in the preceding key, the subgenera conform with the currently used concepts of the classification of the genus as based on adult characters (Sanderson 1958, and Butler and Werner 1961). The adults of the subgenus Phyllophaga have the tarsal claws cleft, or toothed and at most with fine denticles on the lower margin between the base and the tooth, and lack a transverse ridge on the back of the head next to the pronotum. Adults of the subgenus Listrochelus have the lower margins of the tarsal claws pectinate or denticulate for nearly the length of the claw, and often also toothed, especially in the female. Most species have a transverse ridge on the back of the head. Only the species of the subgenus Phyllophaga are considered in this thesis.

Key to Species of Phyllophaga (Phyllophaga)

The following key to species must be considered as preliminary, as it includes only nine of the twenty species of the subgenus known from Arizona. As previously mentioned, the key contains the five most abundant species; it should therefore serve for the identification of any larvae found in damaging numbers. The larvae studied were found to have the following characters in common: no sensilla present among the chaetoparia on the epipharynx; lacinia of maxillae with a longitudinal row of three stout unci, bordered anteriorly by three stout setae and posteriorly by a single seta; and claws of prothoracic legs long and sharply pointed, of mesothoracic legs slender, and of metathoracic legs reduced to small knobs.

1. Spiracles of abdominal segments 8 much reduced in size,
 those of segment 7 as large as any in the series. ----- 2
 Spiracles of abdominal segments 6-8 reduced in size.
 Pali of palidium directed laterally. ----- latidens
- 2.(1) Raster without palidia. ----- 3
 Raster with palidia, the pali directed mesally. ----- 4
- 3.(2) Epipharynx with more than 5 proplegmata. Known in
 Arizona only from the Chiricahua Mts. ----- beckeri
 Epipharynx with less than 5 proplegmata. (Only second-
 instar larvae available.) Known in Arizona from
 the Santa Catalina Mts. to the Mogollon Rim, but
 not from the Chiricahua Mts. ----- ignava
- 4.(2) Epipharynx lacking proplegmata. ----- 5
 Epipharynx with distinct proplegmata. ----- 6
- 5.(4) Raster with more than 25 hamate setae on each side of
 palidia. ----- vetula
 Raster with less than 25 hamate setae on each side of
 palidia. ----- lenis
- 6.(4) Pali arranged in a regular, single row in each pali-
 dium. ----- 7
 Pali very irregular, forming a partial double row in
 each palidium. ----- 8

7.(6) Each palidium with less than 10 pali. An abundant species in desert areas of southeastern

Arizona. ----- sonora

Each palidium with more than 10 pali. A scarce species in southeastern Arizona, primarily

from the oak zone. ----- pallida

8.(6) Pali nearly conical and sharply pointed. Less than

15 hamate setae on each side of palidia.----- bilobatata

Pali laterally compressed, nearly knifelike, and

broadly curved. More than 15 hamate setae on

each side of palidia. ----- lobata

DESCRIPTIONS OF THE SPECIES

The terms used in the following descriptions are defined and illustrated by Ritcher (1966). All specimens studied are in the University of Arizona larval collection.

Phyllophaga (Phyllophaga) lenis Horn

The following description is based on ten third-instar larvae collected by F. G. Werner at Tucson, Arizona, August 18, 1961. Associated, reared adults of this species identified by F. G. Werner.

Head yellow-brown, 3.3 to 3.5 mm wide. Frons set with a transverse band of 12-14 setae on the anterior margin, 2-3 setae on each side of the posterior-frontal area, and a single long seta at each anterior angle. Dorso-epicranial area with 2-3 setae on each side of dorso-epicranial sulcus. Labrum nearly symmetrical. Epipharynx with zygum and epizygum well developed. Proplegmatia absent. Plegmatia distinct, with 13-14 plegmata on each. Haptomerum set with an anterior curved row of 7, and a posterior row of 3-4 stout heli. A row of 5 short, knoblike heli is present anterior to the major rows. Haptolachus with 5-6 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brushlike filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 16-18 setae at base of molar structure. Left mandible with a patch of 6-8 setae in the dorso-molar region. Each maxilla with a regular row of 12-14 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 much reduced in size from preceding spiracles. Raster with 2 prominent palidia, narrowly separated anteriorly, diverging at the middle, and converging behind. All pali directed mesad. Septula teardrop-shaped. Pali 2 to 3 times as long as wide, somewhat flattened and sharply pointed, with 23 on right side and 18 on left, separated in palidium by nearly the width of their bases, to nearly touching. The number of pali in each palidium was constant in the ten specimens studied, with no variance in number at all. One preseptular hamate seta is present. Teges set with 18-20 heavy hamate setae on each side of palidia. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

Phyllophaga (Phyllophaga) vetula Horn

(Figs. 2, 11)

The following description is based on ten third-instar larvae collected by F. G. Werner at Madera Canyon, Santa Rita Mountains, Arizona, October 14, 1960. Associated, reared adults of this species identified by F. G. Werner.

Head golden-brown, 3.4 to 3.6 mm wide. Frons set with a transverse band of 10-12 setae on the anterior margin, 2-3 setae on each

side of the posterior frontal area, and a single long seta at each anterior angle. Dorso-epicranial area with 2-3 setae on each side of dorso-epicranial sulcus. Labrum nearly symmetrical. Epipharynx with zygum and epizygum well developed. Proplegmatia absent. Plegmatia distinct, with 13-14 plegmata on each. Haptomerum set with an anterior curved row of 7, and a posterior row of 3-4 stout heli. A row of 5 short, knoblike heli is present anterior to the major rows. Haptolachus with 5-6 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brushlike filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 25-30 setae at base of molar structure. Left mandible with a patch of 6-8 setae in the dorso-molar region. Each maxilla with a regular row of 16-18 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 much reduced in size from preceding spiracles. Raster with 2 prominent palidia, nearly touching anteriorly, slightly diverging at the middle, and converging behind. All pali directed mesad. Septula teardrop-shaped. Pali 2 to 3 times as long as wide, somewhat flattened and sharply pointed, 25 in each palidium, separated within a palidium by the width of their bases. No pre-septular hamate setae present. Teges set with 35-40 heavy hamate setae on each side of palidia. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

Phyllophaga (Phyllophaga) beckeri Moser

(Figs. 3, 12)

The following description is based on four third-instar larvae collected by F. G. Werner at the Southwestern Research Station, Portal, Arizona, August 20, 1962. Associated, reared adults of this species identified by F. G. Werner.

Head golden-yellow, 2.8 to 3.0 mm wide. Frons set with a transverse band of 8-10 setae on the anterior margin, and a single long seta on each side of the midline in the posterior frontal area. Dorso-epicranial area with 2-3 setae on each side of the dorso-epicranial sulcus. Labrum nearly symmetrical. Epipharynx with zygum and epizygum well developed. Proplegmata consisting of 3 distinct, short proplegmata anteriorly, and 4 heavy but obscure proplegmata posteriorly. Plegmata distinct, with 12-14 heavy plegmata on each. Haptomerum set with an anterior row of 6 heli, and a single stout helus in a posterior median position. A row of 6 short, knoblike heli is present anterior to the major row. Haptolachus with 5-6 crapidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brushlike filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 8-10 setae at base of molar structure. Left mandible with a patch of 4-6 setae in dorso-molar region. Each maxilla with a regular row of 12-14 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 much reduced in size from preceding spiracles. Raster without palidia, set with 28-30 heavy hamate setae, with equal numbers on each side of midline. The setae are not in rows or otherwise organized. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

Phyllophaga (Phyllophaga) latidens Schaeffer

(Figs. 4, 13)

The following description is based on four third-instar larvae collected by F. G. Werner and G. D. Butler at Carr Canyon in the Huachuca Mountains, Arizona, April 5, 1961. Associated reared adults of this species identified by F. G. Werner.

Head golden-yellow, 2.2 to 2.4 mm wide. Frons set with a transverse band of 10-12 setae on the anterior margin, 2-3 setae on each side of the midline in the posterior frontal area, and a single long seta at each anterior angle. Dorso-epicranial area with 2-3 setae on each side of dorso-epicranial sulcus. Labrum nearly symmetrical. Epipharynx with zygum and epizygum well developed. Proplegmatia elliptical, each proplegmatium consisting of 12 broadly curved, heavy proplegmata, plus 2-3 short, indistinct proplegmata behind. Plegmatia distinct, with 10-12 plegmata on each. Haptomerum set with an anterior curved row of 6, and a posterior row of 2-3 stout heli. A row of 6 short, knoblike heli is present anterior to the major rows. Haptolachus with 3-4 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to

laetorma. Dexiophoba set with 8-10 brushlike filaments anterior to mesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 18-20 setae at base of molar structure. Left mandible with a patch of 4-6 setae in dorso-molar region. Each maxilla with a regular row of 14-16 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segments 6, 7, and 8 reduced in size from spiracles of preceding segments. Spiracles on segment 8 about one-half as large as those on segments 6 and 7. Raster with 2 prominent palidia. All pali directed laterad. This is the only species of this genus known to have the pali directed in this manner. Septula straight but diverging anteriorly to form an open bell. Pali stout, flattened, somewhat leaf-shaped, with 12-14 on right palidium and 13-16 on left. Margins of pali roughly serrate in some cases. Last posterior palus in each palidium out of line. Teges set with 12-15 hamate setae on right side of palidia and 18-20 on left side. No preseptular hamate setae present. Anterior margin of each anal lip bordered with 4-6 slender hamate setae.

Phyllophaga (Phyllophaga) bilobatata Saylor

(Figs. 5, 14)

The following description is based on four larval exuviae, from larvae collected by F. G. Werner and G. D. Butler, 6 miles west of Montezuma Pass in the Huachuca Mountains, Arizona, April 4, 1961, and reared to the adult stage. Adults identified by F. G. Werner.

Frons set with a transverse band of 8-10 long setae on the anterior margin. Dorso-epicranial area with a single seta on each side of midline. Labrum slightly asymmetrical. Epipharynx with zygum and epizygum indistinct. Proplegmata broadly elliptical, with 14 broad, curved, and one indistinct, proplegmata. Plegmata distinct, with 12-14 plegmata on each. Haptomerum set with an anterior curved row of 6, and a posterior row of 2-3 stout heli. A row of 6-8 short, knoblike heli is present anterior to the major rows. Haptolachus with 4-6 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 3 stout, fused, branched filaments anterior to laeotorma. Dexiophoba set with 8-10 brushlike filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 18-20 setae at base of molar structure. Left mandible with a patch of 18-20 setae at base of molar structure. Left mandible with a patch of 4-6 setae in dorso-molar region. Each maxilla with a regular row of 16-18 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal setment 8 much reduced in size from preceding spiracles. Raster with 2 prominent palidia in irregular rows, which are nearly doubled in some areas. All pali are directed mesad. Septula irregular but nearly straight. Pali stout and nearly conical, 1 to 2 times as long as broad, somewhat curved at tip and sharply pointed. Right palidium with 23-25 pali, and left with 19-21. No pre-septular hamate setae present. Teges set with 10-12 heavy hamate setae

on each side of palidia. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

Phyllophaga (Phyllophaga) sonora Saylor

(Figs. 6, 15)

The following description is based on four third-instar larvae collected at Tucson, Arizona, September, 1960, by F. G. Werner. Associated, reared adults of this species identified by F. G. Werner.

Head bright yellow, 2.5 to 2.7 mm wide. Frons set with a transverse band of 8-10 setae on the anterior margin, a single seta on each side of the posterior frontal area, and a single long seta at each anterior angle. Dorso-epicranial area with 3-4 setae on each side of the dorso-epicranial sulcus. Labrum slightly asymmetrical. Epipharynx with zygum and epizygum well developed. Proplegmatia broad and elliptical, each with 10 broad and 2 additional indistinct proplegmata. Plegmatia distinct, with 10-12 plegmata on each. Haptomerum set with an anterior curved row of 6, and a posterior row of 3-4 stout heli. A row of 6-8 short, knoblike heli is present anterior to the major rows. Haptolachus with 4-5 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brushlike filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 16-18 setae at base of molar structure. Left mandible with a patch of 8-10 setae in dorso-molar

region. Each maxilla with a regular row of 12-14 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 much reduced in size from preceding spiracles. Raster with 2 short, narrowly separated palidia. The tips of opposing pali nearly overlap. Septula straight. Pali 2 to 3 times as long as wide, sharply pointed and slightly curved at tip, and broadly separated within a palidium by 4 to 6 times the width of their bases. Each palidium with 5-6 pali. Teges set with 22-25 hamate setae on each side of the palidia. No preseptular hamate setae present. Anterior margin of each anal lip bordered with 2-3 slender hamate setae.

Phyllophaga (Phyllophaga) pallida (Horn)

(Figs. 7, 16)

The following description is based on one second-instar and one third-instar larva reared from adults collected by F. G. Werner at Italian Canyon in the Patagonia Mountains, Arizona, August 16, 1968. Adults identified by F. G. Werner.

Head golden-yellow, 2.9 mm wide in third-instar larva. Frons set with a transverse band of 12 setae on the anterior margin, 2 setae on each side of the posterior frontal area, and a single long seta at each anterior angle. Dorso-epicranial area with 3 setae on each side of dorso-epicranial sulcus. Labrum slightly asymmetrical in second-instar larva. Epipharynx with zygum and epizygum fairly well developed. Proplegmatia present but indistinct, with 8 obscure, broad proplegmata each. Plegmatia distinct, with 8-10 plegmata on each.

Haptomerum set with an anterior curved row of 5, and a posterior row of 3-4 stout heli. A row of 6-8 short, knoblike heli is present anterior to the major rows. Haptolachus with 3-4 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brush-like filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 12-14 setae at base of molar structure. Left mandible with a patch of 3-4 setae in dorso-molar region. Each maxilla with a regular row of 12-14 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 much reduced in size from preceding spiracles. Raster with 2 prominent palidia, with opposing pali overlapping each other by more than one-fourth their length. Pali narrow, curved, sharply pointed, 3-4 times as long as wide, 10 in number on the right palidium and 12 on the left. No preseptular hamate setae present. Teges set with 28-30 hamate setae on each side of palidia. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

Phyllophaga (Phyllophaga) lobata Fall

(Figs. 8, 17)

The following description is based on two larval exuviae from larvae collected by F. G. Werner and G. D. Butler at Upper Pinery Canyon in the Chiricahua Mountains, Arizona, on April 8, 1961, and reared to the adult stage. Adults identified by F. G. Werner.

Frons set with a transverse band of 8-10 setae on the anterior margin, a single seta on each side of the posterior frontal area, and a single long seta at each anterior angle. Labrum slightly asymmetrical. Epipharynx with zygum and epizygum well developed. Proplegmatia long and elliptical, with 14 short, broadly curved, and one indistinct proplegmata on each. Plegmatia distinct, with 10-12 plagmata on each. Haptomerum set with an anterior curved row of 5, and a posterior row of 3-4 stout heli. A row of 6-8 short, knoblike heli is present anterior to the major rows. Haptolachus with 4-6 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brush-like filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 10-12 setae at base of molar structure. Left mandible with a patch of 4-6 setae in dorso-molar region. Each maxilla with a regular row of 15-17 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 reduced in size from preceding spiracles. Raster with 2 prominent palidia, with 2 irregular rows of pali in each. Septula nearly elliptical, with species of opposing pali nearly touching. Pali sharply pointed, broadly curved, 2 to 3 times as long as wide, and separated within each palidium by from less than the width of their bases to 4 to 5 times their width. No preseptular hamate setae present. Teges set with 18-20 hamate setae on each side of

palidia. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

Phyllophaga (Phyllophaga) ignava Horn

(Figs. 9, 18)

The following description is based on two second-instar larvae reared from eggs. The gravid female adults were collected by F. G. Werner at Molino Basin in the Santa Catalina Mountains, Arizona, on July 28, 1968. Adults identified by F. G. Werner.

Frons set with a transverse band of 4 long setae on the anterior margin, and 2 setae on each side of the posterior frontal area. Dorso-epicranial area with 2-3 setae on each side of dorso-epicranial sulcus. Labrum nearly symmetrical. Epipharynx with zygum and epizygum indistinct. Proplegmata short and broad, with 4 heavy proplegmata on each. Plegmata indistinct. Haptomerum set with an anterior curved row of 5, and a posterior row of 3-4 stout heli. A row of 6 short, knoblike heli is present anterior to the major rows. Haptolachus with 8-10 crepidal punctures and 2 macrosensilla. Pedium with a short laeophoba of 6-8 branched, flattened filaments anterior to laeotorma. Dexiophoba set with 8-10 brushlike filaments anterior to nesium externum.

Dorso-exterior region of right and left mandibles without setae or pits. Right mandible with a patch of 15-18 setae at base of molar structure. Left mandible with a patch of 3-4 setae in dorso-molar

region. Each maxilla with a regular row of 12-14 truncate stridulatory teeth bordering on stipes.

Spiracles on abdominal segment 8 much reduced in size from preceding spiracles. Raster without palidia. Teges set with 45-50 heavy hamate setae, with approximately equal numbers on each side of the midline. Anterior margin of each anal lip bordered with 3-4 slender hamate setae.

A CONSIDERATION OF THE RELATIONSHIPS AND
INTERRELATIONSHIPS OF THE LARVAE

Sanderson (1958) established taxonomic groupings for the adults of the Arizona species of the subgenus Phyllophaga based on the tarsal claws and genitalic characters. The following section of this thesis is concerned with these groupings as they relate to the larvae of the studied specimens.

Sanderson's anodentata group retains its relationship in the larvae of lenis and vetula, as it does in the adults. Both of these larvae have the proplegmata absent on the epipharynx. It is at this point, however, that the groups begin to separate as to their relationships. His blanchardi group, which includes beckeri and latidens, is apparently not tenable in the larvae. The larvae of latidens have the spiracles on abdominal segments 6 to 8 reduced in size from the preceding spiracles, an unusual raster, with the pali directed laterally, and the epipharynx with a large number of proplegmata. Those of beckeri have only the spiracles on abdominal segment 8 reduced, as is normal in the subgenus, no palidia on the raster, and a small number of proplegmata on the epipharynx.

Sanderson's obsoleta group, which includes bilobatata, sonora, and pallida, holds together in the larvae to a fair degree. The larvae of bilobatata have very irregular rows of pali in the palidium, whereas in sonora and pallida the palidia are simple and the pali in single

rows. The epipharynx of bilobatata has the zygum and epizygum indistinct, rather than well developed as in the others of the group, and it has the laeophoba of the epipharynx shortened to a series of 3 heavy, branched filaments. Larvae of sonora and pallida have a similarity in most of their characters that is matched by adult similarity.

The last of Sanderson's groups that was studied is his ignava group. This group does not hold together at all in the larvae. The two available larvae, of ignava and lobata, have very different characters in both the raster and epipharynx. The larvae of lobata have a very irregular raster with double rows of knifelike pali in the palidia and a large number of proplegmata on the epipharynx. The larvae of ignava have no palidia on the raster and have a small number of obscure proplegmata on the epipharynx. They are most similar to the larvae of beckeri.

Since the larvae did not, in general, fit into the categories as established by Sanderson (1958), it was decided to establish new groupings on the basis of larval characters. The following groups are proposed, as based on a combination of larval characters.

Sanderson's anodentata group remains intact, to include lenis and vetula, for larvae that have no proplegmata on the epipharynx. The beckeri-ignava group includes those larvae that lack palidia on the raster and have the proplegmata present but reduced. The sonora-pallida group includes those larvae that have the proplegmata well developed on the epipharynx, and palidia consisting of simple, single rows of pali on the raster. The bilobatata-lobata group includes those

larvae that have proplegmata well developed on the epipharynx, but which have very irregular, often double, rows of pali in the palidia on the raster. The larvae of latidens do not fit into any of the above mentioned groups and are considered to form the latidens group. The larvae of this species are distinguished by having the spiracles on abdominal segments 6 to 8 much reduced in size from the preceding spiracles and by having the pali in the palidia of the raster directed laterally.

SUMMARY

A thorough study of the nine known Arizona species of Phyllophaga, subgenus Phyllophaga, was made to establish a basis for the identification of the larvae of this group. Eight of the species are described and figured for the first time. A tentative key to the known species is included. Sanderson (1958) established taxonomic groupings for the adults, based on tarsal claw and genitalic characters. These groups were studied with respect to their relation to the larval groupings. It was found that only Sanderson's anodontata group is substantiated by larval characters. The remaining larvae are assigned to new groups based on characters on the raster and epipharynx. The larval groupings indicated are:

anodontata group: those larvae without proplegmata on the epipharynx.

beckeri-ignava group: those larvae without palidia on the raster.

sonora-pallida group: those larvae with simple palidia on the raster and proplegmata present on the epipharynx.

bilobatata-lobata group: those larvae with irregular rows of palia in the palidia of the raster and proplegmata present on the epipharynx.

latidens group: a single species, latidens, distinguished from all known Phyllophaga (Phyllophaga) by having the spiracles on abdominal segments 6 to 8 reduced in size from the preceding spiracles and by having the pali of the palidia on the raster directed laterally.

APPENDIX

ILLUSTRATIONS OF RASTERS AND EPIPHARYNXES USED FOR IDENTIFICATION
OF PHYLLOPHAGA (PHYLLOPHAGA) LARVAE

Fig. 1. Phyllophaga (Phyllophaga) lenis Horn.
Raster of third-instar larva. (38x)

Fig. 2. Phyllophaga (Phyllophaga) vetula Horn.
Raster of third-instar larva. (38x)

Fig. 3. Phyllophaga (Phyllophaga) beckeri Moser.
Raster of third-instar larva. (38x)

Fig. 4. Phyllophaga (Phyllophaga) latidens Schaeffer.
Raster of third-instar larva. (38x)

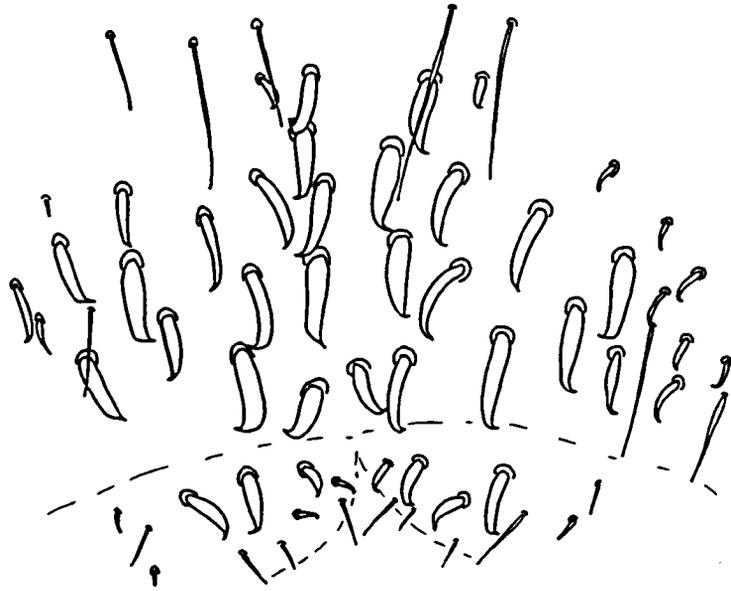


Fig. 3

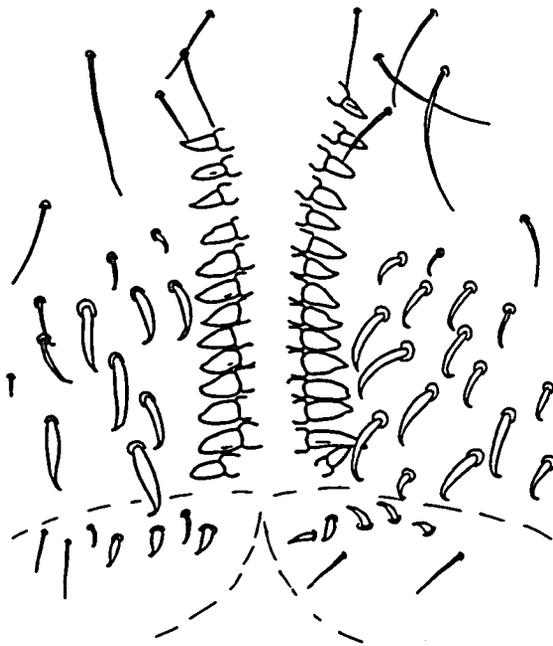


Fig. 4

Fig. 5. Phyllophaga (Phyllophaga) bilobatata Saylor.
Raster of exuviae of third-instar larva. (38x)

Fig. 6. Phyllophaga (Phyllophaga) sonora Saylor.
Raster of third-instar larva. (38x)

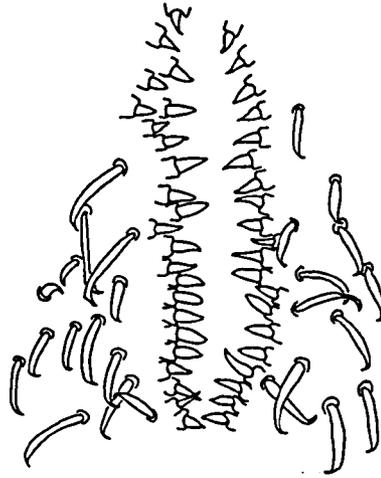


Fig. 5

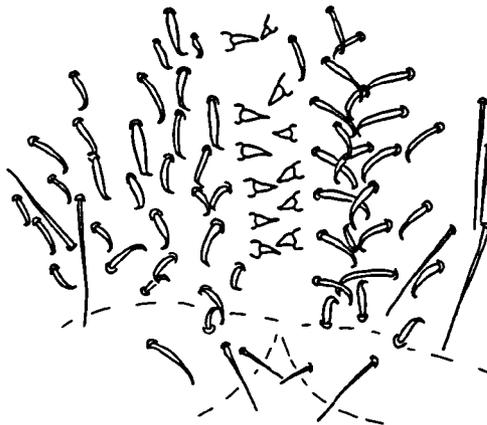


Fig. 6

Fig. 7. Phyllophaga (Phyllophaga) pallida (Horn).
Raster of third-instar larva. (38x)

Fig. 8. Phyllophaga (Phyllophaga) lobata Fall.
Raster of exuviae of third-instar larva. (38x)

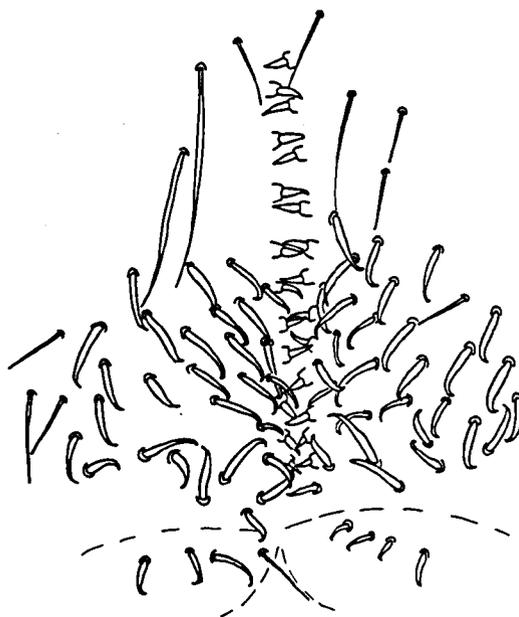


Fig. 7

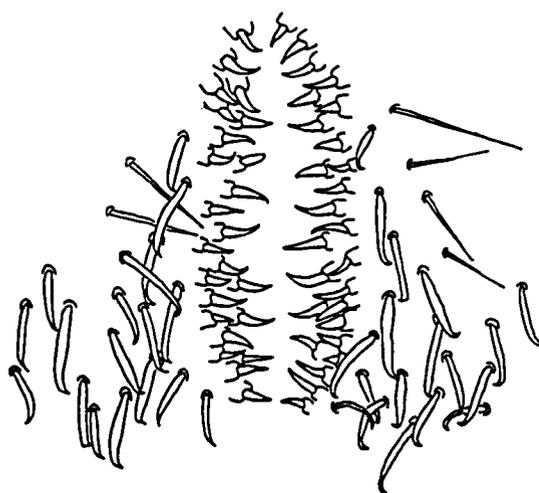


Fig. 8

Fig. 9. Phyllophaga (Phyllophaga) ignava Horn.
Raster of second-instar larva. (38x)

Fig. 10. Phyllophaga (Phyllophaga) lenis Horn.
Epipharynx of third-instar larva. (28x)

Fig. 11. Phyllophaga (Phyllophaga) vetula Horn.
Epipharynx of third-instar larva. (28x)

Fig. 12. Phyllophaga (Phyllophaga) beckeri Moser.
Epipharynx of third-instar larva. (28x)

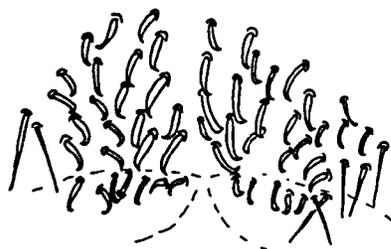


Fig. 9



Fig. 10



Fig. 11

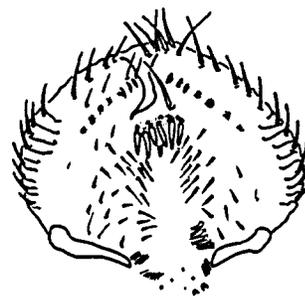


Fig. 12

- Fig. 13. Phyllophaga (Phyllophaga) latidens Schaeffer.
Epipharynx of third-instar larva. (28x)
- Fig. 14. Phyllophaga (Phyllophaga) bilobatata Saylor.
Epipharynx of exuviae of third-instar larva. (28x)
- Fig. 15. Phyllophaga (Phyllophaga) sonora Saylor.
Epipharynx of third-instar larva. (28x)
- Fig. 16. Phyllophaga (Phyllophaga) pallida (Horn).
Epipharynx of second-instar larva. (28x)
- Fig. 17. Phyllophaga (Phyllophaga) lobata Fall.
Epipharynx of exuviae of third-instar larva. (28x)
- Fig. 18. Phyllophaga (Phyllophaga) ignava Horn.
Epipharynx of second-instar larva. (28x)



Fig. 13



Fig. 14



Fig. 15



Fig. 16



Fig. 17

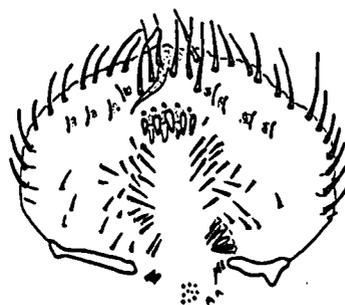


Fig. 18

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