



Systematics, Morphology and Biogeography

## Description of immature stages of *Hoplia mexicana* Harold and *H. squamifera* Burmeister (Coleoptera, Melolonthidae, Hopliinae)



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### ABSTRACT

Third stage larvae and pupae are described based on specimens collected in Mexico: Oaxaca (Cerro Zempoaltepetl), and Chiapas (Amatenango), respectively. Pupal characters are described for the first time for American Hopliinae. Habitus images and figures of diagnostic characters as well as comments on the differences between these larvae and those of *Hoplia callipyge* LeConte, 1856 and *H. equina* LeConte, 1880, the only Hopliinae larvae previously known in New World, are also included.

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### Introduction

The immature stages of world Hopliinae are poorly known. Partial descriptions exist for the third instar larvae of the North American species *Hoplia callipyge* LeConte, 1856 (= *H. oregona* LeConte, 1856; = *H. cazieri* Boyer, 1940) and *H. equina* LeConte (Ritcher, 1949). Additionally, there are larval descriptions for some Russian species of the genus *Hoplia* Illiger, 1803 and the central European *H. philanthus* (Fuessly, 1775) (Medvedev, 1952; Hürka and Bílý, 1966). Micó (2001) redescribed the larva of *H. philanthus* and described that of *H. chlorophana* Erichson, 1848, based on specimens from Spain, both with detailed illustrations. Ansari et al. (2006, 2008) detailed the life cycle of *H. philanthus* and commented about the importance and biological regulation of this turf pest.

Larvae of North American species of *Hoplia* may be characterized as follows: head without stemmata; labrum symmetrical; maxillary stridulatory area with row of 9–11 short teeth with anteriorly directed points; lacinia with longitudinal row of 3 unci, distal 2 unci fused basally, subapical uncus much smaller; epipharynx with plegmatia, plegmata quite short; proplegmatia present or absent; epizygum absent; haptomerum with single helus; dexiophoba and

laeophoba absent; haptolachus without microsensilla; spiracles of abdominal segments 1–3 similar in size, spiracles of segments 4–8 much smaller; anal opening Y-shaped; raster consisting of subtriangular teiges of 30–60 fairly long hamate setae with curved tips; claws of fore legs large and falcate, claws of middle legs much reduced in size, claws of hind legs minute or absent (Ritcher, 1966). Larvae of European species of *Hoplia* share all of the above cited characters, except: maxillary stridulatory area with row of 12–14 short teeth with anteriorly directed points; lacinia with subapical uncus large; epipharynx without proplegmatia; spiracles of abdominal segments 4–6 diminutive (Micó, 2001).

During recent years, we had the opportunity to rear many scarab larvae collected from forest soil, grasslands and corn fields of south-eastern Mexico, and some of them belong to species of *Hoplia*. This material allowed us to describe in the present paper the third instar larvae for *H. mexicana* Harold, 1869 and *H. squamifera* Burmeister, 1844, for which the immature stages were unknown. We also describe the pupae of these two species, a life stage that was unknown for any New World hopliine scarab.

### Material and methods

Throughout the descriptions and discussions, we follow terminology employed by Ritcher (1966) and Morón (1986). Drawings of diagnostic structures were made using a Leica stereomicroscope

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associated with a camera lucida at 0.8–5.0× magnification. Measurements were taken using an ocular micrometer (Leica microsystems, Germany). Voucher specimens were deposited at Colección proyecto Diversidad en Sistemas de Cultivos, El Colegio de la Frontera Sur (ECOSUR), and Colección Entomológica, Instituto de Ecología, A. C. Xalapa, México (IEXA).

## Taxonomy

### Descriptions

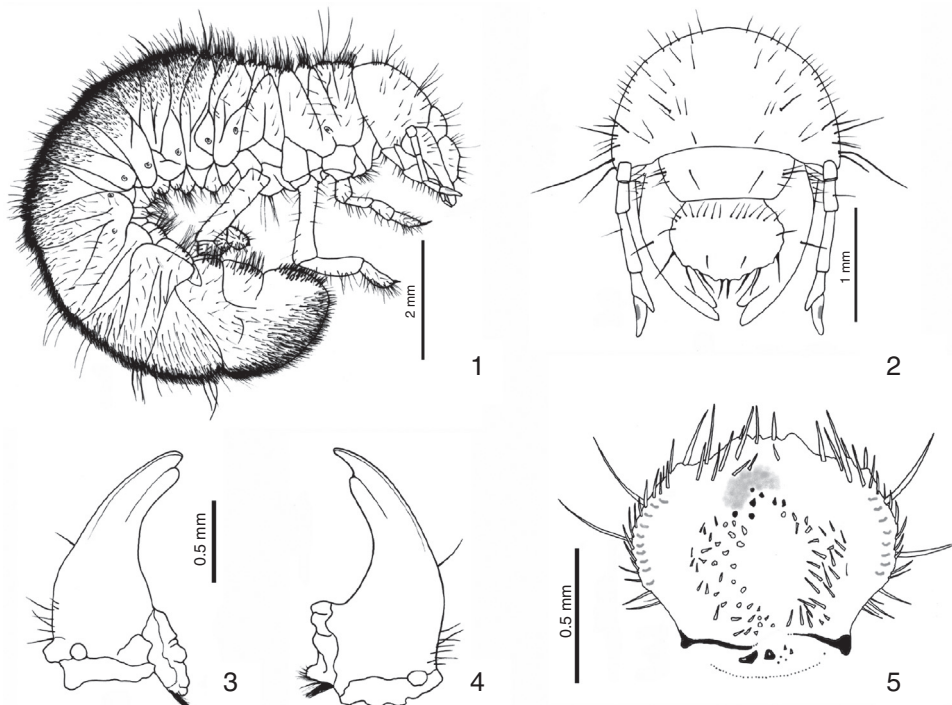
#### *Hoplia mexicana* Harold, 1869

*Third instar* (Figs. 1–11 and 13). Description. Head (Fig. 2). Maximum width of head capsule: 1.8–2.0 mm. Surface of cranium smooth, with scattered minute punctures, pale yellowish. Frontal and epicranial sutures hidden. Frons with 2 exterior frontal setae, 3–4 posterior frontal setae, 1 anterior frontal seta, 1 anterior angle seta, 3 dorsoepicranial setae, 8–9 epicranial setae on each side and 7–9 setae behind each antennal support. Clypeus with 2 central setae and 4 lateral seta on each side. Labrum nearly symmetrical with rounded lateral margins irregularly bordered, anterior margin projected forward with irregular border, 6–7 posterior setae, 1 central seta and 3–4 lateral setae on each side. Stemmata absent. Epipharynx (Fig. 5) 1.0–1.1 mm wide, 0.8–0.9 mm long, epizygum absent and zygum as a irregular, ovate, reddish yellow plate. Haptomerum weakly raised, with 4 heli; each plegmata formed by 8–10 short plegmata; proplegmata absent. Each acanthoparia with 10–12 spinose setae. Dexiophoba and laeophoba absent. Dexiotorma narrowed, slightly sinuose. Laeotorma elongate and narrowed, with sclerotized plate unciform, raised. Sense cone short. Crepis weakly defined. Left chaetoparia with 28–30 spinose and medium size setae mixed. Right chaetoparia with 30–36 short, stout setae. Mandibles (Figs. 3 and 4) without ventral stridulatory area; scissorial area in both mandibles without distal blade. Right mandible with 1 small preapical tooth, inner margin simply curved, and distal lobe (M1) of molar area scarcely developed. Calx short. Left mandible with 1 small preapical tooth,

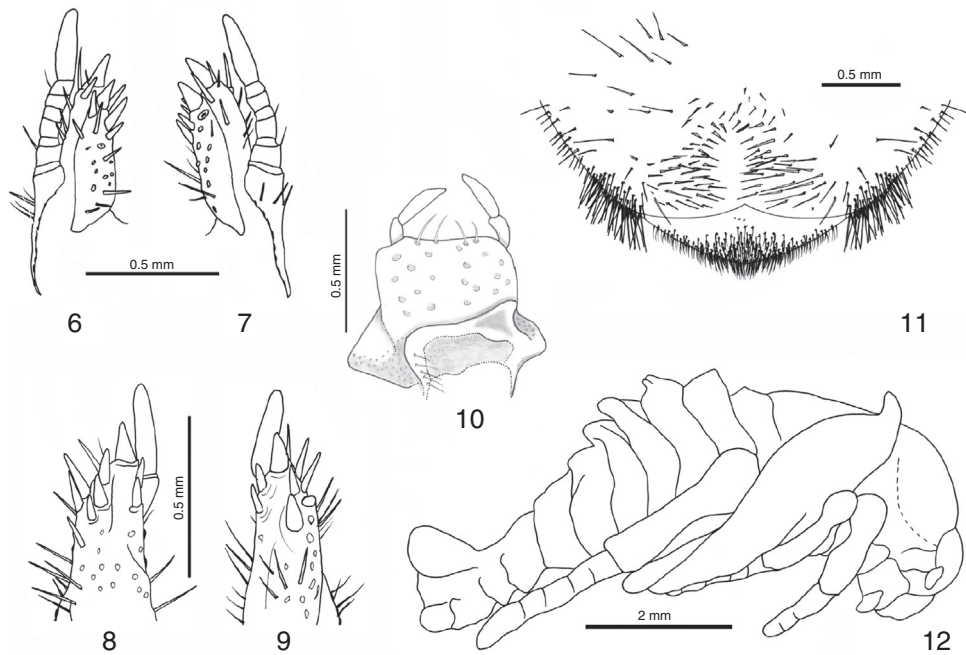
inner margin simply curved, brustia moderately setose. Acia absent. Maxillae (Figs. 6–9). Mala with 1 uncus on apex of galea, 3 unci surrounded by 3–4 stout heli on apex of lacinia; stridulatory area with 8 small teeth with anteriorly directed points. Hypopharyngeal sclerome (Fig. 10) asymmetrical with raised and curved projection on the right side. Fourth antennomere elongate, with distal half narrowed, with 1 ovate, dorsal sensory spot on basal half and 2 ventral sensory spots.

Thorax. Respiratory plates light yellow, scarcely curved, “C” shaped (Figs. 1 and 13) 0.12–0.14 mm long, 0.10–0.11 mm wide, bulla small, slightly raised, rounded, distance between lobes longer than dorso-ventral diameter of bulla; microscopic holes of respiratory plate elongate-oval in outline and arranged in irregular transverse rows. Lateral sclerome of pronotum not defined. Pro-prescutum with 20–22 long setae regularly distributed; proscutum with 8–9 slender long setae; mesoprescutum with transverse row of 10–12 long setae; mesoscutum with 12–16 setae; mesoscutellum with row of 8–10 slender long setae; metaprescutum with transverse row of 12–16 mixed short and long setae; metascutum with 10–12 setae; metascutellum with transverse row of 10–12 mixed short and long setae (Figs. 1 and 13). Protarsal claws long, narrowed, sharply pointed, with 1 prebasal inner seta and 1 lateral external seta, moderately longer than mesotarsal claws; mesotarsal claws long, sharply pointed, with pre-basal and lateral setae; metatarsal claw short, rounded, with 2 setae, much shorter than mesotarsal claws. Apical metatarsomere shortened, rounded, with ventral side clearly convex.

Abdomen. Respiratory plates light yellow, slightly curved, “C” shaped; on segments I–IV with similar diameter, 0.12–0.13 mm long, 0.10 mm wide; plates on segments V–VII are slightly smaller, 0.10–0.11 mm length, 0.09 mm width. Plate on segment VIII is smaller than preceding. Dorsa of abdominal segments I–VI each with dense vestiture of yellow stout, short setae; dorsa of segments VII–IX with transverse rows of 20–28 slender, short setae. Venter of abdominal segments I–VIII with transverse rows of 14–18 slender, long setae; venter of segment IX with transverse rows of 12–16 mixed short and long setae.



**Figs. 1–5.** Third instar larva of *Hoplia mexicana*. 1, lateral habitus. 2, head, frontal view. Mandibles, ventral view: 3, left. 4, right. 5, epipharynx.

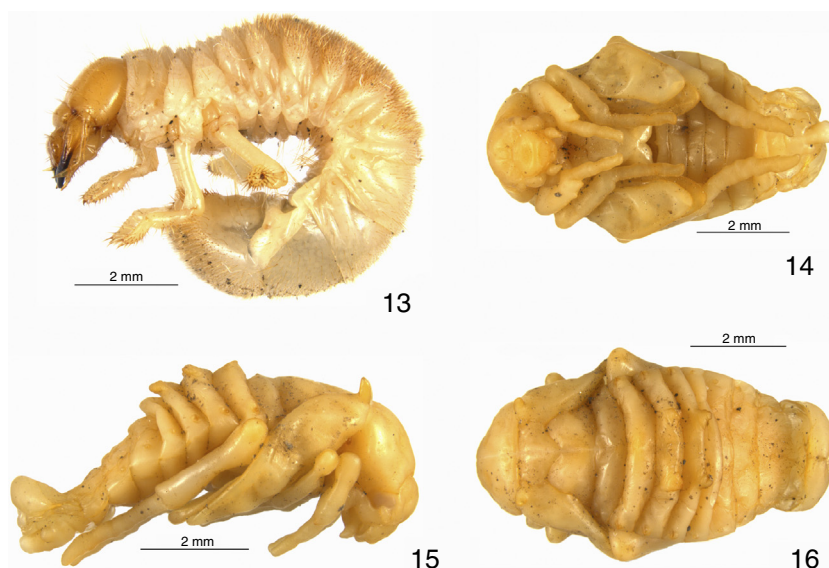


**Figs. 6–12.** *Hoplia mexicana*. 6–11: third instar larva. Maxillae: dorsal view: 6, left. 7, right. Mesial view: 8, left. 9, right. 10, labium and hypopharynx. 11, raster. 12, MALE pupa, lateral view.

Raster (Fig. 11) with each palidia formed by 9–11 pali, convergent toward basal and distal extremes, septula wide, oval; tegilla with 20–26 short, stout setae; campus with 14–18 slender, short setae; barbula much more densely setose. Dorsal anal lip with dense vestiture of short setae. Ventral anal lip with scattered short setae toward sides and distal border narrowly notched at middle. Anal slit “Y” shaped. Approximate dorsal body length 16–17 mm.

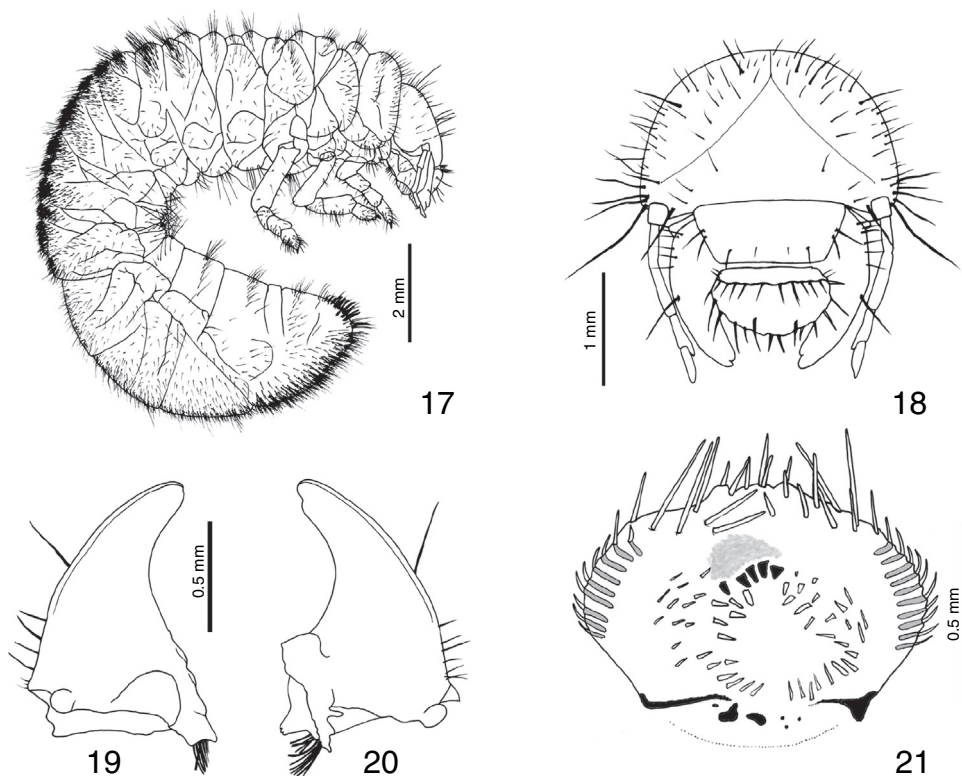
Description: body length 7.5–7.8 mm. Widest width 4.4–4.5 mm. Head. Surface glabrous, strongly deflexed; frons convex with two rounded prominences; clypeus widely concave on the center; labrum, mandibles, maxillae and palps discernible; antennal theca briefly expanded, stout with apex rounded; eyes small (Fig. 14). Thorax: surface glabrous. Pronotum convex, surface slightly irregular, anterior angles prominent, posterior angles rounded. Meso- and metanotum well-differentiated. Elytral

and posterior wing thecae closely appressed, curved ventrally around the body; elytral thecae with irregular depressions and large, prominent, humeral tubercles (Figs. 12 and 15); thecae of the wings slightly longer than elytral thecae. Protibiae with apical and preapical tubercles clearly developed. Meso and metatibiae with apical tubercle. Abdomen: segments I–VI clearly wider and shorter than the distal segments VII–VIII, without dieneiform organs, but segments II–IV with pairs of prominent tubercles and segment V with increased posterior border (Figs. 12 and 15–16). Pleural lobes rounded. Spiracle I elongate, with fine peritreme and covered by wing thecae; spiracles II–IV ovate and high, prominent, with narrow sclerotized peritreme; spiracles V–VIII closed. Sutures between segments VIII and X not complete, partially fused. Last segment slightly pruinose, without urogomphi.



**Figs. 13–16.** *Hoplia mexicana*. 13, Third instar, lateral view. 14–16: male pupa. 14, ventral view. 15, lateral view. 16, dorsal view.





**Figs. 17–21.** Third instar larva of *Hoplia squamifera*. 17, lateral habitus. 18, head, frontal view. Mandibles, ventral view: 19, left. 20, right. 21, epipharynx.

Last abdominal segment of male with large dorsal and lateral rounded prominences, and genital ampulla ventrally exposed (Figs. 12 and 14–16); female without such prominences at the apex of abdomen.

**Specimens examined.** Four third instar larvae, four pupae and two exuviae of third instar larvae reared to adults, collected at Mexico: Oaxaca: Santa María Tlahuitoltepec municipality, Cerro Zempoaltepetl, 2400 m, 8-VI-2010, A. Ramírez col. (IEXA).

**Comments.** The third instar larvae of *H. mexicana* resemble those of *H. callipyge* and *H. equina*, but *H. mexicana* has 4 heli on haptomerum, and palidia with well-defined septula. *Hoplia callipyge* and *H. equina* each have 1 helus on the haptomerum and only subtriangular teges of long hamate setae with curved tips. The dense setiferous vestiture on the dorsum of abdominal segments I–VI and the sides of the last segment, aid in distinguishing *H. mexicana* from the known larvae of other Mexican melolonthine scarabs. Projections on the humeral area of the elytra and the middle of the abdominal segments of the pupae of both sexes may act as auxiliary supports during pupal development. These projections possibly aid in regulating humidity near the body wall. This type of structure is also observed in pupae of some Scarabaeinae (Edmonds and Halfpter, 1978), and Ceratocanthinae (Morón and Arce, 2003).

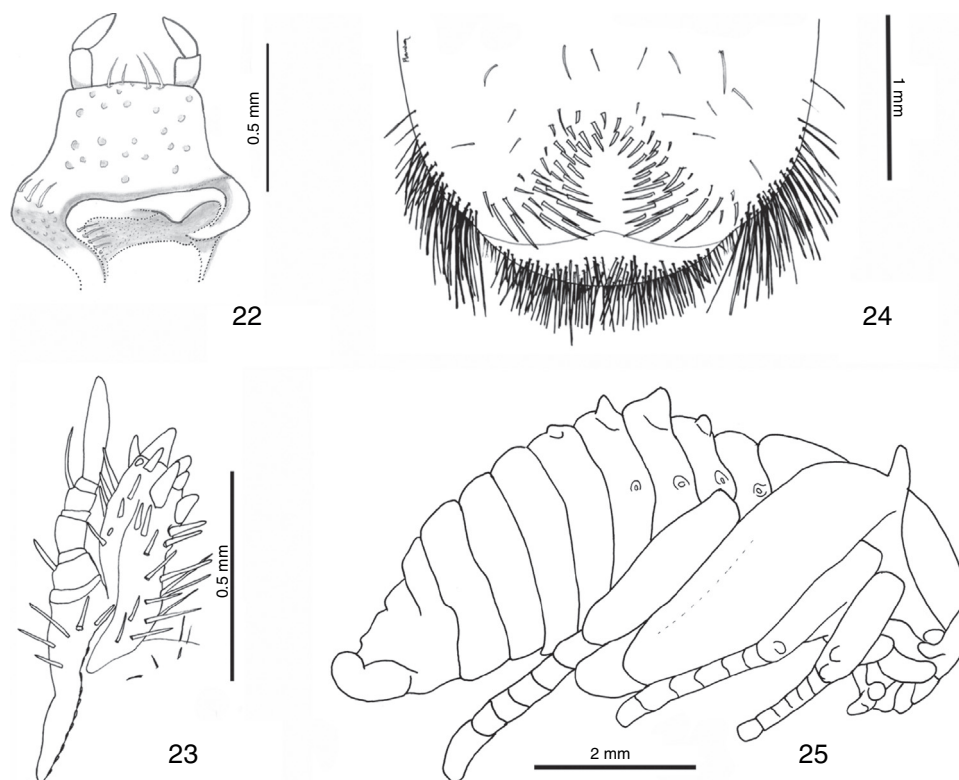
**Biology.** *Hoplia mexicana* is known only from the northern mountains of the Mexican state of Oaxaca, at localities with elevations between 2300 and 2500 m. Larvae have been collected in rich organic soil of oak and coniferous forest. Adults are rarely attracted to electric lights during summer, and their host plants are unknown.

*Hoplia squamifera* Burmeister, 1844

**Third instar** (Figs. 17–24). **Description.** Head (Fig. 18). Maximum width of head capsule: 2.1–2.4 mm. Surface of cranium smooth, with scattered minute punctures, pale yellowish. Frontal and epicranial sutures hidden. Frons with 2 exterior frontal setae, 1 posterior frontal seta, anterior frontal seta absent, 1 anterior angle

seta, 3–4 dorsoepicranial, 14–18 epicranial setae on each side and 6–8 setae behind each antennal support. Clypeus with 2 central setae and 4 lateral setae on each side. Labrum nearly symmetrical with rounded lateral margins irregularly bordered, anterior margin projected forward with irregular border, basal transverse keel with 5 posterior setae, 1 anterior-central seta and 5–6 lateral setae on each side. Stemmata absent. Epipharynx (Fig. 21) 1.6–1.9 mm wide, 1.0–0.2 mm long. Epizygon absent and zygon as irregular, ovate, reddish yellow plate. Haptomerum weakly raised, with 4 heli; each plegmatia formed by 9–10 short plegmata; proplegmatia absent. Each acanthoparia with 9–10 spinose setae. Dexiophoba and laeophoba absent. Dexiotorma narrowed, slightly curved. Laeotorma elongate and narrowed with sclerotized plate unciform, raised. Sense cone short. Crepis weakly defined. Left chaetoparia with 30–34 spinose and medium size setae mixed. Right chaetoparia with 28–30 short, stout setae. Mandibles (Figs. 19 and 20) without ventral stridulatory area; scissorial area in both mandibles without distal blade. Right mandible with 1 small rounded, preapical tooth, inner margin simply curved, and distal lobe (M1) of molar area scarcely developed. Calx short. Left mandible without preapical tooth, inner margin simply curved, brustia moderately setose. Acia absent. Maxillae (Fig. 23). Mala with 1 unculus on apex of galea, 3 unci surrounded by 3–4 stout heli on apex of lacinia; stridulatory area with 10–11 small teeth with anteriorly directed points. Hypopharyngeal sclerome (Fig. 22) asymmetrical with curved projection on the right side. Fourth antennomere elongate, with distal half narrowed, with 1 ovate, dorsal sensory spot on basal half and 2 ventral sensory spots.

**Thorax.** Respiratory plates light yellow, scarcely curved, “C” shaped (Fig. 17) 0.11–0.15 mm long, 0.10–0.12 mm wide, bulla small, slightly raised, rounded, distance between lobes longer than dorso-ventral diameter of bulla; microscopic holes of respiratory plate elongate-oval in outline and arranged in irregular transverse rows. Lateral sclerome of pronotum not defined. Proprescutum with 14–18 long setae regularly distributed; proscutum with 5–6



Figs. 22–25. *Hoplia squamifera*. 22–24: third instar. 22, labium and hypopharynx. 23, left maxilla, dorsal view. 24, raster. 25, female pupa, lateral view.

slender long setae; mesoprescutum with transverse row of 8–9 long setae; mesoscutum with 10–12 setae; mesoscutellum with row of 6–8 slender long setae; metaprescutum with transverse row of 9–12 mixed short and long setae; metascutum with 8–10 setae; metascutellum with transverse row of 6–8 mixed short and long setae (Fig. 17). Protarsal claws long, narrowed, sharply pointed, with 1 pre-basal inner seta and 1 lateral external seta, moderately longer than mesotarsal claws; mesotarsal claws long, sharply pointed, with pre-basal and lateral setae; metatarsal claw short, rounded, with 2 setae, much shorter than mesotarsal claws. Apical metatarsomere shortened, rounded, with ventral side clearly convex.

Abdomen. Respiratory plates light yellow, slightly curved, “C” shaped; on segments I–IV with similar diameter, 0.13–0.14 mm long, 0.11 mm wide; plates on segments V–VII slightly smaller, 0.11–0.12 mm long, 0.10 mm wide. Respiratory plate on segment VIII smaller than plate on preceding segment. Dorsa of abdominal segments I–VI each with dense vestiture of yellow stout, short setae; dorsa of segments VII–IX with transverse rows of 18–20 slender, short setae. Venter of abdominal segments I–VIII with transverse rows of 10–12 slender, long setae; venter of segment IX with transverse rows of 10–12 mixed short and long setae. Raster (Fig. 24) with each palidia formed by 10–12 pali, convergent toward basal and distal extremes, septula wide, oval; tegilla with 24–30 short, stout setae; campus with 14–16 slender, short setae; barbula densely setose. Dorsal anal lip with dense vestiture of short setae.

Ventral anal lip with scattered short setae at sides and distal border narrowly notched at middle. Anal slit “Y” shaped. Approximate dorsal body length 16–18 mm.

**Pupa (Figs. 25 and 26).** Description: body length 7.8–8.1 mm. Widest width 4.5–4.6 mm. Head. Surface glabrous, strongly deflexed; frons convex with two rounded prominences; clypeus



Fig. 26. Male pupa of *Hoplia squamifera*, with third instar exuviae on its abdominal apex.

widely concave on the center; labrum, mandibles, maxillae and palps discernible; antennal theca briefly expanded, stout with apex rounded; eyes small (Fig. 25). Thorax: surface glabrous. Pronotum convex, surface slightly irregular, anterior angles briefly prominent, posterior angles widely rounded. Meso- and metanotum well-differentiated. Elytral and posterior wing thecae closely appressed, curved ventrally around body; elytral thecae with irregular

**Table 1**  
Main characters in the pupae of some American genera of Scarabaeoidea. D.O., dioneiform organs; H.P., humeral projections; P.P., pronotal projections; T.P., tergal projections; U, urogomphi.

Subfamilies	Genera	P.P.	H.P.	D.O.	T.P.	U	References
Melolonthinae	<i>Phyllophaga</i> Harris, 1827	No	No	No	No	Yes	Morón (1986)
	<i>Polyphylla</i> Harris, 1841	No	No	No	No	Yes	Morón and Nogueira (2015)
	<i>Clavipalpus</i> Laporte, Castelnau, 1832	No	No	No	No	Yes	Neita-Moreno et al. (2012)
	<i>Demodema</i> Blanchard, 1850	No	No	No	No	Yes	Morón and Salvadori (2006)
	<i>Isonychus</i> Mannerheim, 1829	No	No	No	No	Yes	Neita-Moreno et al. (2012)
	<i>Macrodactylus</i> Dejean, 1821	No	No	No	No	Yes	Ramírez-Salinas et al. (2011)
Hopliinae	<i>Manopus</i> Laporte Castelnau, 1840	No	No	No	No	No	Neita-Moreno et al. (2012)
	<i>Hoplia</i> Illiger, 1803	No	Yes	No	Yes	No	Present publication
Rutelinae	<i>Anomala</i> Samouelle, 1819	No	No	Yes	No	No	Micó et al. (2003)
	<i>Macraspis</i> MacLeay, 1819	No	No	Yes	No	No	Morón and Paucar-Cabrera (2003)
	<i>Chlorota</i> Burmeister, 1844	No	No	Yes	No	No	Jameson and Morón (2001)
	<i>Chrysophora</i> LeP. & Serville, 1828	No	No	Yes	No	No	Pardo-Locarno and Morón (2007)
	<i>Leucothyreus</i> MacLeay, 1819	No	No	Yes	No	No	Pardo-Locarno et al. (2006b)
Dynastinae	<i>Ligyris</i> Burmeister, 1847	No	No	Yes	No	No	Ramírez-Salinas et al. (2004)
	<i>Ancognatha</i> Erichson, 1847	No	No	Yes	No	No	Ramírez-Salinas et al. (2004)
	<i>Coelosis</i> Hope, 1837	No	No	Yes	No	No	Pardo-Locarno et al. (2006a)
	<i>Golofa</i> Hope, 1837	No	No	Yes	No	No	Morón (1995b)
	<i>Dynastes</i> Kirby, 1825	No	No	Yes	No	No	Morón (1987)
	<i>Aegopsis</i> Burmeister, 1847	No	No	Yes	No	No	Neita-Moreno et al. (2014)
Cetoniinae	<i>Euphoria</i> Burmeister, 1842	No	No	No	No	No	Ramírez-Salinas et al. (2001)
	<i>Hoplopyga</i> J. Thomson, 1880	No	No	No	No	No	Morón and Arce (2002)
	<i>Gymnetis</i> MacLeay, 1819	No	No	No	No	No	Morón and Arce (2002)
	<i>Neoscelis</i> Schoch, 1897	No	No	No	No	No	Nogueira et al. (2004)
Trichiinae	<i>Inca</i> LePeletier & Serville, 1828	No	No	Yes	No	No	Morón (1983)
	<i>Archedinus</i> Morón & Krikken, 1990	No	No	Yes	No	No	Morón (1995a)
Orphninae	<i>Aegidium</i> Westwood, 1846	No	No	No	Yes	Yes	Morón (1991)
Ceratocanthinae	<i>Ceratocanthus</i> White, 1842	Yes	Yes	No	No	Yes	Morón and Arce (2003)
Aphodiinae	<i>Termitodius</i> Wasmann, 1894	No	Yes	No	Yes	Yes	Reyes-Castillo and Martínez (1979)
Scarabaeinae	<i>Phanaeus</i> MacLeay, 1819	Yes	No	No	Yes	No	Edmonds (1967)
	<i>Eurysternus</i> Dalman, 1824	No	No	No	Yes	No	López-Guerrero and Morón (1994)

longitudinal striae and large, prominent, semiconical humeral tubercles (Figs. 25 and 26); thecae of the wings slightly longer than elytral thecae. Protibiae with apical and preapical tubercles clearly developed. Meso and metatibiae with apical tubercle. Abdomen: segments I–VI clearly wider and shorter than the distal segments VII–VIII, without dioneiform organs, but segments II–IV with pairs of prominent tubercles and segment V with thicker posterior border (Figs. 25 and 26). Pleural lobes rounded. Spiracle I elongate, with fine peritreme partially covered by wing thecae; spiracles II–IV ovate and high, prominent, with narrow sclerotized peritreme; spiracles V–VIII closed. Sutures between segments VIII and X incomplete, partially fused. Last segment slightly pruinose, without urogomphi. Last abdominal segment of male with dorsal and lateral rounded prominences, and genital ampulla ventrally exposed (Fig. 26); female without such abdominal prominences (Fig. 25).

Specimens examined. Seven third instar larvae, collected at Mexico: Chiapas, Amatenango del Valle municipality, El Madronal, 2400 m, 20-I-1997, corn field, C. Ramírez col. (IEXA). Two pupae and 2 exuviae of third instar larvae reared to adults, with same data, except 24-X-2005 (IEXA). Two third instar larvae: Chiapas, Amatenango del Valle, 28-X-1996, corn field, C. Ramírez; 4 third instar larvae with same data, except 4-XI-1996; 5 third instar larvae 24-IX-2001 (IEXA, ECOSUR).

Comments. The larvae of *Hoplia squamifera* resemble those of *H. mexicana*, but lack antero-frontal setae, have 9–10 wide plegmata on each plegmatia, and have wide septula, whereas *Hoplia mexicana* have 2 antero-frontal setae, 7–8 narrow plegmata on each plegmatia and narrower septula.

Pupae of both *Hoplia mexicana*, and *H. squamifera* lack urogomphi and dioneiform organs. This fact is very interesting because, as far as we know, no other scarab group possesses such a combination of characters. For instance, with the exception of *Manopus biguttatus* Laporte, 1840 (Neita-Moreno et al., 2012), known pupae

of Melolonthinae have urogomphi and lack dioneiform organs (Table 1). On the other hand, known pupae of Rutelinae and Dynastinae, lack urogomphi but, in contrast, have dioneiform organs (Morón, 1993). With the combination of these characters, and the unique paired supporting organs in the humeri and tergites, the pupae of Hopliinae are very distinct from other subfamilies of Melolonthidae. Description of the pupae of many other genera of Melolonthidae surely will offer more characters to be tested in future phylogenetic analyses of Scarabaeoidea.

Biology. *Hoplia squamifera* has been recorded from the Mexican mountains of northern Chiapas and Oaxaca states, southern Veracruz state, and in western Guatemala at localities with elevations between 1200 and 2100 m. Larvae have been collected in soil of corn fields in northern Chiapas, Mexico. Adults are frequently attracted to electric lights during spring and summer, but their host plants are unknown.

#### Conflicts of interest

The authors declare no conflicts of interest.

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