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DESCRIPTION, DIFFERENTIATION, AND BIOLOGY OF THE FOUR LARVAL INSTARS OF *ACANTHOSCELIDES OBTECTUS* (SAY) (COLEOPTERA: BRUCHIDAE)

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ABSTRACT

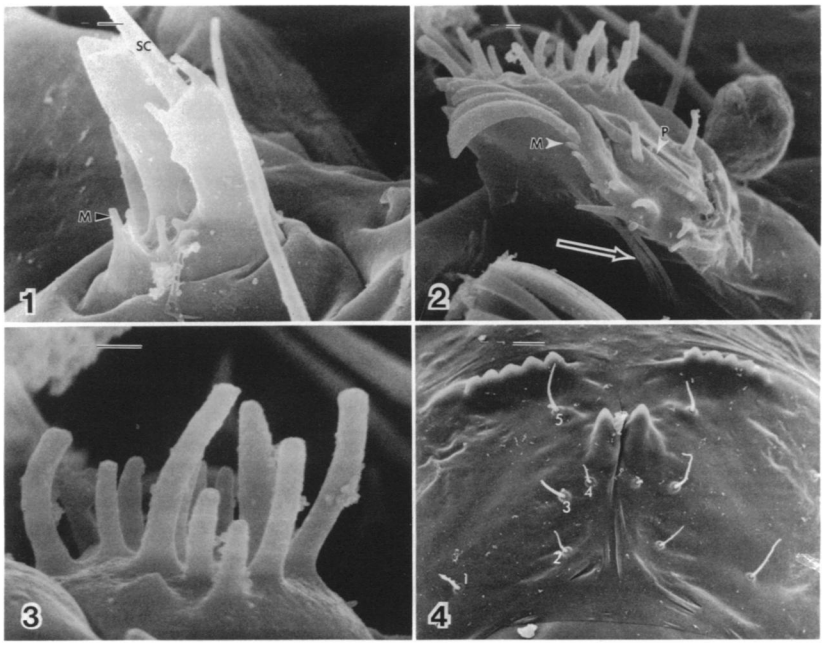
The four larval instars of *Acanthoscelides obtectus* (Say) are distinguished and described. Scanning electron micrographs and/or line drawings of the head capsule, antenna, clypeolabrum, epipharynx, maxilla, labium, leg, spiracle, and anus are provided. A sensillum placodeum and interdigitating macrotrichia, both on the maxillary palpus, are shown for the first time. Cuticular receptors are identified and their suspected functions are correlated with known larval activities both before and after they penetrate the seed.

Despite the interest shown toward the adult, little has been published about the immature stages of *Acanthoscelides obtectus* (Say). Fine structure of the egg chorion, however, is known (Fig. 2 of Biemont *et al.* 1981), and differs from that of other known forms (Pfaffenberger *et al.* 1984). The first larval descriptions of *A. obtectus* (Riley 1891, 1892; Chittenden 1898; Darboux and Mingaud 1902) were cursory and incomplete. Kunhi Kannan (1923) was first to integrate larval description with functional morphology. His work was followed shortly thereafter by more useful contributions of Böving (1927), Böving and Craighead (1930), Box (1928), Daviault (1928), Zacher (1930), and Larson and Fisher (1938). The many inaccuracies in the above works probably are the results of limitations of light microscopy. Aside from the contributions made by Pfaffenberger (in press) and Pfaffenberger and Johnson (1976), little has been published in the last 45 years on larval morphology of this species.

The purposes of this paper are to: (1) correct earlier errors in description, (2) provide, for the first time, SEM views of the larval instars, (3) show new morphological characters, (4) describe or redescribe the four larval instars and provide, for the first time, means to distinguish among them, and (5) identify various cuticular receptors and suggest probable functions.

MATERIALS AND METHODS

Larvae of *A. obtectus* were obtained from a culture at Northern Arizona University in 1973. Scanning electron micrographs of eggs are available (Biemont *et al.* 1981). Pupae were not obtained and therefore are not included in this work. During the interim larval specimens were preserved in 70% ethanol. For scanning electron microscope (SEM) studies they were subjected to a dehydration series (90%, 95%, absolute ethanol), critical point dried, coated with gold-pallidium and examined using a ISI-100B SEM at an accelerated voltage of 15 KV.



Figs. 1–4. *Acanthoscelides obtectus,* first instar. 1, antenna showing microtrichia (M) and s. chaeticum (SC); bar = 1 μm. 2, lacinia of maxilla, showing microtrichia (M), sensillum placodeum (P), and interdigitating macrotrichia (arrow); bar = 1 μm. 3, sensilla basiconica on maxillary palpus; bar = 1 μm. 4, prothoracic plate showing paired (pairs indicated by numbers) sensilla trichodea, paired teeth of median arms and five teeth on each posterior arm; bar = 10 μm.

Larva of *Acanthoscelides obtectus* (Say)

First Instar (Figs. 1–7)

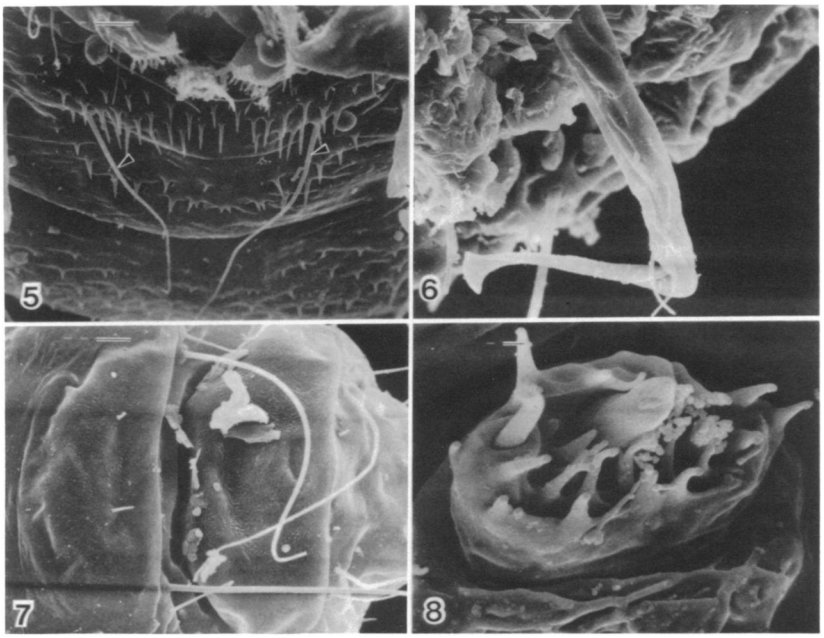
Body: 0.3 mm wide by 0.8 mm long, cyphosomatic, width greatest in meso- and metathoracic segments tapering to minute tenth abdominal segment. Cuticle white except for pigmented prothoracic plate. Head capsule most heavily pigmented on and near mouthparts.

Ocelli: Single, present at junction of frontal suture and mandibular base, between antenna and mandible (as in Figs. 9, 29).

Antenna (Fig. 1): One-segmented, telescopic, composed of one enlarged medial, and one smaller lateral sensilla basiconica. One elongate sensillum chaeticum (SC, Fig. 1) emerging from stalk-like base arising from distomedial antennal surface. Microtrichia (M, Fig. 1) few in number and present as single row on distoventral surface.

Clypeolabrum: Labral portion with 10 blunt-tipped sensilla trichodea, eight setae arranged in peripheral C-shaped arc, remaining two setae located anteromedially within arc (as in Figs. 21, 43); one sensillum ampullaceum along medial base of posterolateral pair of sensilla trichodea (as in Fig. 10, solid arrow), microtrichia absent along distal margin. Clypeal portion with convex base and concave distal margin (as in Figs. 9, 43), bearing sensillum trichodeum with subtending sensillum ampullaceum in each posterolateral corner.

Mandible (as in Figs. 9, 29): Monocondylic, with awl-shaped chewing surface, lateral surface with two sensilla trichodea.

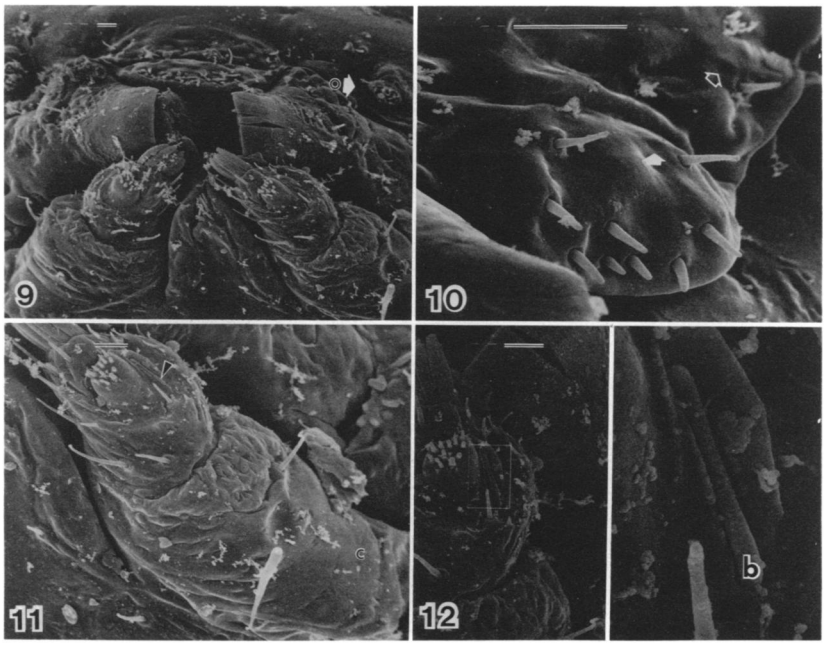


Figs. 5–7. *Acanthoscelides obtectus,* first instar. 5, metathoracic sternite showing elongate s. trichodea (darts) and sclerotized pointed projections (perhaps microtrichia); bar = 10 μm. 6, metathoracic leg; bar = 10 μm. 7, sclerotized eighth and ninth abdominal tergites showing short and elongate s. trichodea; bar = 10 μm. Fig. 8, right antenna of second instar; bar = 1 μm.

Maxilla (as in Figs. 2, 9, 11, 23): Cardo present, membranous stipes asetiferous with two sensilla trichodea on sclerite; palpifer with twelve sensilla trichodea, two on opposite sides of elongate sensillum placodeum (as in Fig. 11, black dart), remaining sensilla distributed along distoventromedial to ventrolateral surface. Elongate sensillum placodeum (as in Figs. 11, 12) embedded along dorsolateral surface of palpus, distal end of palpus terminating in 13 sensilla basiconica (as in Figs. 3, 13), sensillum ampullaceum present on lateral surface (as in Figs. 24, 38). Five interdigitating, elongate, macrotrichia (arrow in Fig. 2) arising from oral surface of stipes (three) and lacinia (two) (Fig. 2). Microtrichia (see M in Fig. 2) emerge beside larger, spatula-like sensilla chaetica.

Labium (as in Figs. 15, 16, 46): Submentum (as in Figs. 23, 46) transversely elongate, narrow and C-shaped, flanked proximally by pair of mediolateral sensilla trichodea; mentum (as in Figs. 23, 46) proximally round, with pair of narrow arms separated by tear-shaped, nonsclerotized cleft, converging toward narrow distal end, with single, unsclerotized islet bearing one sensillum trichodeum near base of each arm, distal end of each arm with sensillum trichodeum, subtended proximally by sensillum placodeum and terminating in cluster of microtrichia (as in Fig. 16), basal half of mentum bordered laterally by pair of sensilla trichodea (of which one sensillum is at least 1.5 times longer than other).

Prothoracic plate (Fig. 4): X- or H-shaped, with anterior, median, and posterior arms and five pairs of associated sensilla trichodea; anterior arms flanking four pairs of sensilla trichodea, one pair (#1; Fig. 4) distolateral, one pair (#2) distomedial, one pair (#3) proximolateral, one pair (#4) proximomedial; tooth formula 1 + 0 + 5; median arms



Figs. 9–12. *Acanthoscelides obtectus,* second instar. 9, facial view showing ocellus (O), clypeolabrum (top center), pair of enlarged mandibles, paired maxillae, and labium (bottom center); bar = 10 μm. 10, clypeolabrum showing s. ampullacea of clypeus (hollow arrow) and labrum (solid arrow); note absence of microtrichia on labral margin; bar = 10 μm. 11, maxilla showing sensillum placodeum (dart) and cardo (C); bar = 10 μm. 12, sensillum placodeum (b) on maxillary palpus; bar = 10 μm.

with single tooth; midway between teeth of median and posterior arms is pair of sensilla trichodea (present, but not evident in Fig. 4, is sensillum placodeum with subtending sensillum trichodeum medially; as in fig. 22G of Pfaffenberger and Johnson 1976); each posterior arm with five teeth.

Leg (Fig. 6): Two-segmented; length of appendage and distance between members of a pair increasing with each succeeding pair; pair of elongate, decurved sensilla trichodea located on distolateral margins of each basal segment; distal segment terminating in laterally expanded, flattened tarsus.

Thoracic sternites (Fig. 5): Each with pair of long sensilla trichodea and transverse rows of posteriorly directed, sclerotized projections.

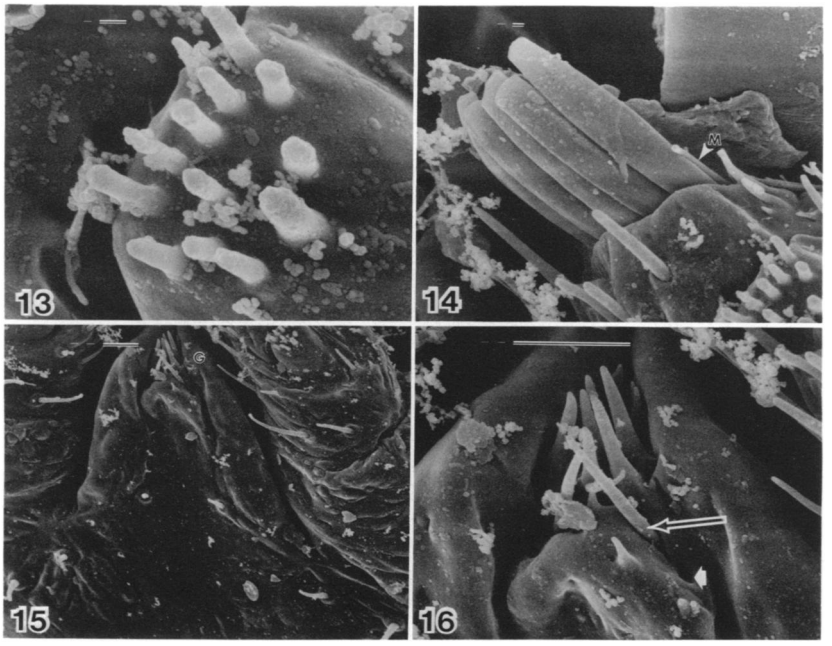
Abdominal tergites: Eighth and ninth segments with sclerotized, transversely broad oval plates.

Spiracles: Thoracic and abdominal (as in Figs. 17, 18, respectively) with concentric opening, atrium armed with few sclerotized projections, both partially surrounded by several C-shaped, sclerotized rings, some bearing small, sclerotized projections.

SPECIMENS EXAMINED: 31, recovered from stock culture in 1973.

Second Instar (Figs. 8–19)

Body: 0.8–1.2 mm wide by 1.2–1.4 mm long, fleshy, C-shaped (as in Fig. 28). Cuticle white except for lightly pigmented prodorsum. Head capsule lightly pigmented with deeply pigmented mouthparts.



Figs. 13–16. *Acanthoscelides obtectus*, second instar. 13, sensilla basiconica on maxillary palpus; bar = 1 μm. 14, maxillary lacinia showing spatula-like setae and microtrichium (M); bar = 1 μm. 15, labium showing glossae (G); bar = 10 μm. 16, tip of labial prementum (flanked by paired glossae) showing cluster of microtrichia nearly concealing pair of s. trichodea (hollow arrow), and sensillum ampullaceum (solid arrow); bar = 10 μm.

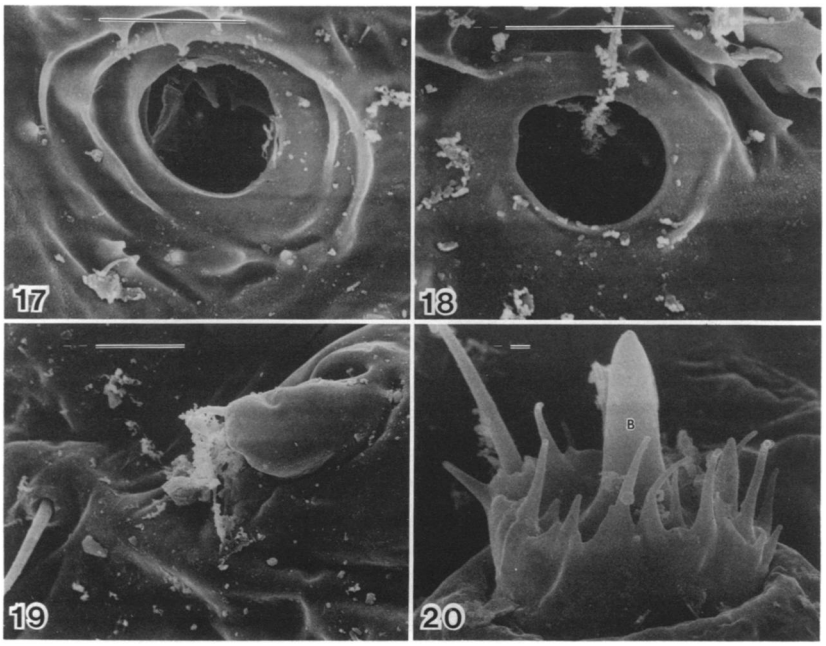
Ocelli (as in Figs. 9, 29): Single, at junction of frontal suture and mandible.

Antenna (Fig. 8): One-segmented and telescopic; with multiple rows of short microtrichia on distoventral surface and single row of short microtrichia distodorsally; one enlarged medial and one smaller lateral sensilla basiconica. Single elongate sensillum chaeticum arising from stalk-like base, latter emerges from distomedial antennal surface.

Clypeolabrum (Figs. 9, 10): With transversely oval sclerite and 10 blunt-tipped sensilla trichodea (an occasional mutant will bear only nine, Fig. 10), eight sensilla trichodea arranged in peripheral C-shaped arc, remaining two setae (1 seta in mutant, Fig. 10) located anteromedially within arc (as in Figs. 21, 43); one sensillum ampullaceum present (solid arrow, Fig. 10) along medial base of posterolateral pair of sensilla trichodea, microtrichia absent from distal margin. Clypeal portion with convex base and concave distal margin (as in Figs. 9, 43), bearing sensillum trichodeum with subtending sensillum ampullaceum in each proximolateral corner.

Mandible (as in Figs. 9, 29): Monocondylic, with awl-shaped chewing surface, lateral surface with two sensilla trichodea.

Maxilla (Figs. 9, 11; see also Figs. 23, 45): Cardo present (as in Figs. 11, 45); membranous stipes asetiferous with two sensilla trichodea on sclerite; palpifer with 12 sensilla trichodea, two on opposite sides of elongate sensillum placodeum (black dart, Fig. 11), remaining sensilla distributed along distoventromedial to ventrolateral surface. Elongate placoid sensillum (Figs. 11, 12) embedded on dorsolateral surface of palpus dorsal to sensillum ampullaceum (as in Fig. 24), distal end of palpus terminating in 13 sensilla basiconica (Figs. 11, 13); lacinia terminating in five spatula-like setae (Fig. 14), with mandibular surface bearing numerous, decurved microtrichia (cf. Figs. 11, 14).



Figs. 17–19. *Acanthoscelides obtectus,* second instar. 17, thoracic spiracle; bar = 10 μm. 18, first abdominal spiracle; bar = 10 μm. 19, metathoracic leg; note terminal s. trichodeum; bar = 10 μm. 20, third instar antenna showing enlarged s. basiconicum (B) (with smaller s. basiconicum to the right); bar = 1 μm.

Labium (as in Figs. 15, 16, 23, 46): Submentum transversely elongate, narrow and lunate-shaped, flanked proximally by pair of mediolateral sensilla trichodea, latter separated by width of mentum; mentum proximally round, with pair of narrow arms separated by tear-shaped, unsclerotized cleft, converging toward narrow distal end with single, unsclerotized islet bearing one sensillum trichodeum near base of each arm, distal end of each arm with sensillum trichodeum, subtended proximally by sensillum ampullaceum (as in Fig. 16, solid arrow) and terminating in dense cluster of microtrichia (Fig. 16), basal half of mentum bordered laterally by pair of sensilla trichodea (one 1.5 times longer than other); glossae (as in Fig. 23, G) exceed in length arms of mentum.

Leg (Fig. 19): Fleshy with four vague segments; terminating in single sensillum trichodeum.

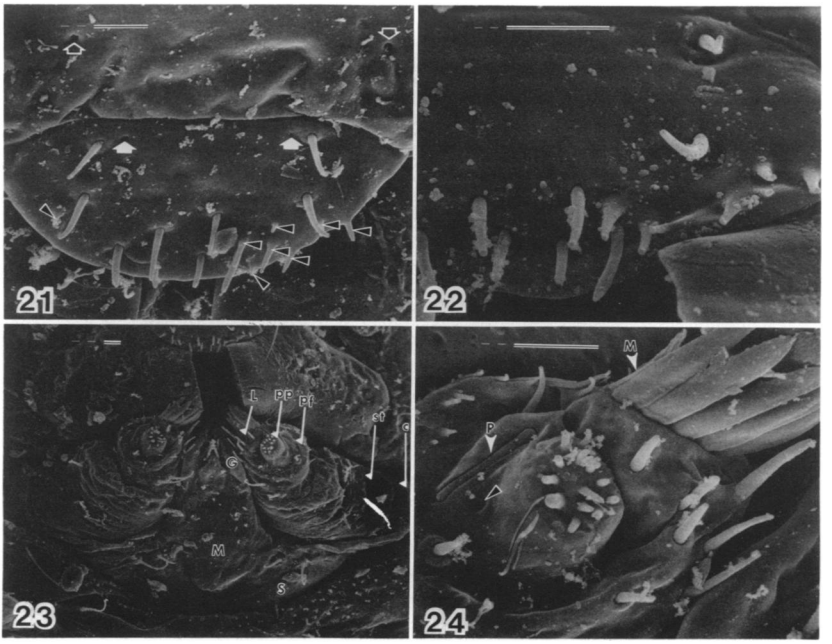
Spiracles: Thoracic (Fig. 17) and abdominal (Fig. 18) spiracles with concentric opening, atrium armed with few sclerotized projections; C-shaped sclerotized ridges evident in peritreme, particularly on thoracic spiracle (Fig. 17).

SPECIMENS EXAMINED: 20, recovered from stock culture in 1973.

Third Instar (Figs. 20–27)

Body: 1.2–1.6 mm wide by 1.4–2.4 mm long, fleshy, C-shaped (as in Fig. 28), width greatest in thoracic segments with abdominal segments tapering from broad base to minute tenth segment. Integument white to yellowish-white with slight pigmentation on prodorsum. Head capsule most heavily pigmented near mouthparts.

Ocelli (as in Figs. 9, 29): Single, at junction of frontal suture and mandible.



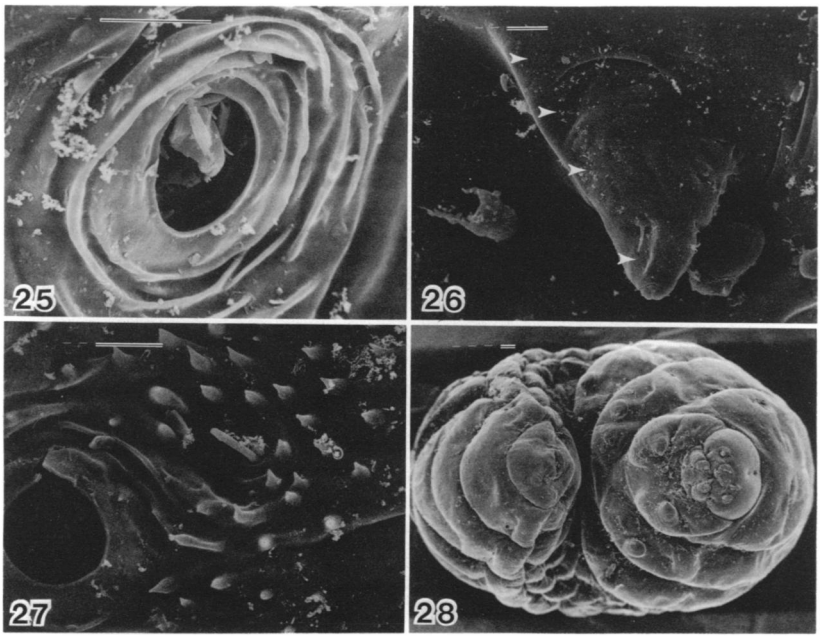
Figs. 21–24. *Acanthoscelides obtectus,* third instar. 21, clypeolabrum showing s. ampulacea on clypeus (open arrows) and labrum (solid arrows), and microtrichia (darts) on labrum; bar = 10 μm. 22, labrum showing articulating base of s. trichodea and non-articulating base of microtrichia; bar = 10 μm. 23, maxilla (c—cardo, st—stipes, pf—palpifer, pp—palpus, L—lacinia) and labium (S—submentum, M—mentum, G—glossa); bar = 10 μm. 24, maxillary palpus and lacinia showing elongate s. placodeum (P), s. ampullacea (dart), and microtrichium (M); bar = 10 μm.

Antenna (Fig. 20): One-segmented, telescopic, with one enlarged medial and one smaller lateral sensilla basiconica; base from which elongate sensillum chaeticum emerges subequal to base row height of microtrichia (cf. Figs. 1, 8, 20); multiple microtrichial rows evident on distodorsal surface.

Clypeolabrum (Figs. 21, 22): Labral portion with transversely oval sclerite and 10 blunt-tipped sensilla trichodea, eight arranged in peripheral C-shaped arc, remaining two located anteromedially within arc (as in Figs. 21, 43); one sensillum ampullaceum present (solid arrows, Fig. 21) along medial base of each posterolateral pair of sensilla trichodea; small microtrichia on distolateral margins (darts, Fig. 21; nonarticulating base, Fig. 22). Clypeal portion narrow and transversely elongate with enlarged, rounded lateral ends, proximal border convex with concave distal margin (as in Figs. 21, 43), bearing sensillum trichodeum with subtending sensillum ampullaceum in each proximolateral area.

Mandible (as in Figs. 23, 29): Monocondylic, with awl-shaped chewing surface, lateral surface with two sensilla trichodea.

Maxilla (Figs. 23, 24): Cardo present (C, Fig. 23); membranous stipes asetiferous with two sensilla trichodea on sclerite. Palpifer (pf, Fig. 23) with 12 sensilla trichodea, two on opposite sides of elongate sensillum placodeum (Fig. 24), remaining sensilla distributed along distoventromedial to ventrolateral surfaces. Palpus (pp, Fig. 23) with elongate sensillum placodeum on dorsolateral surface (P, Fig. 24), sensillum ampullaceum (as in Figs. 24 (dart), 38) located ventral to elongate sensillum placodeum, distal end terminating in 13 sensilla basiconica. Lacinia (as in Figs. 23, L; 24) terminating in five



Figs. 25–27. *Acanthoscelides obtectus,* third instar. 25, thoracic spiracle; note increasing number of folds in peritreme; bar = 10 μm. 26, metathoracic leg (4 segments marked by darts); bar = 10 μm. 27, first abdominal spiracle; note bordering integumental projections which surround s. trichodeum; bar = 10 μm. 28, ventral view of fourth instar habitus (note transverse anal opening); bar = 100 μm.

spatula-like setae, mandibular surface bearing numerous, decurved microtrichia (M, Fig. 24).

Labium: Submentum (S, Fig. 23) transversely elongate, narrow and lunate-shaped (as in Fig. 46), flanked proximally by pair of mediolateral sensilla trichodea, latter separated by width of mentum (M, Fig. 23); mentum proximally round, with pair of narrow arms separated by tear-shaped, membranous cleft (as in Fig. 46), converging toward narrow distal end, single unsclerotized islet with one sensillum trichodeum appearing near base of each arm, distal end of each arm with sensillum trichodeum, subtended proximally by sensillum ampullaceum (as in Fig. 16, solid arrow) and terminating in dense cluster of microtrichia, basal half of mentum bordered laterally (as in Fig. 46) by pair of sensilla trichodea (one at least 1.5 times longer than other); glossae (G, Fig. 23) exceeding in length arms of mentum.

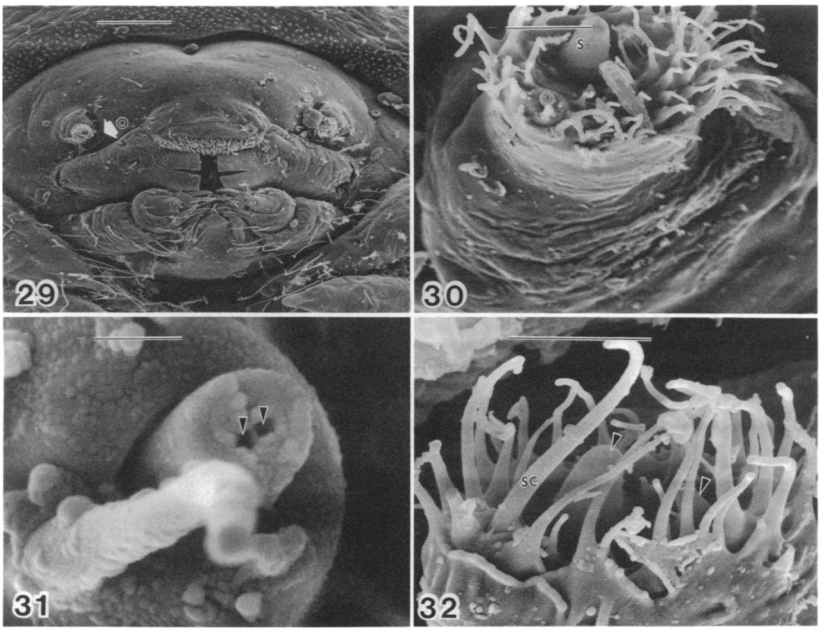
Leg (Fig. 26): Segmentation vaguely apparent, four-segmented with two (one lateral, one medial) sensilla trichodea at border of ultimate and penultimate segments.

Spiracles: Thoracic peritreme (Fig. 25) with numerous sclerotized folds, abdominal peritreme definite (Fig. 27) with fewer folds and bordered posterodorsally by cluster of pointed projections, centered in cluster of projections is single sensillum trichodeum, atrial sclerotized projections numerous.

SPECIMENS EXAMINED: 17, recovered from stock culture in 1973.

Fourth Instar (Figs. 28–46)

Body (Fig. 28): 1.6–2.3 mm wide by 2.4–3.5 mm long, fleshy, C-shaped, width greatest at metathoracic and abdominal segments 1–4, tapering to small tenth abdominal and



Figs. 29–32. *Acanthoscelides obtectus,* fourth instar. 29, facial view showing ocellus (O) and distribution of s. trichodea on head capsule; bar = 100 μm. 30, antenna showing s. basiconicum (S); bar = 10 μm. 31, base of broken s. chaeticum showing holes through which sensory neurons likely pass; note thickened walls; bar = 1 μm. 32, antenna showing the protective effect microtrichia may have on the s. chaeticum (SC) and the two s. basiconica (darts); bar = 10 μm.

prothoracic segments, distance between appendages of a segment increasing with each succeeding segment; integument white except for lightly pigmented, yellowish prodorsum, vestiture similar to that of *Caryobruchus buscki* Bridwell (as in Fig. 1, A–C; Pfaffenberger 1974).

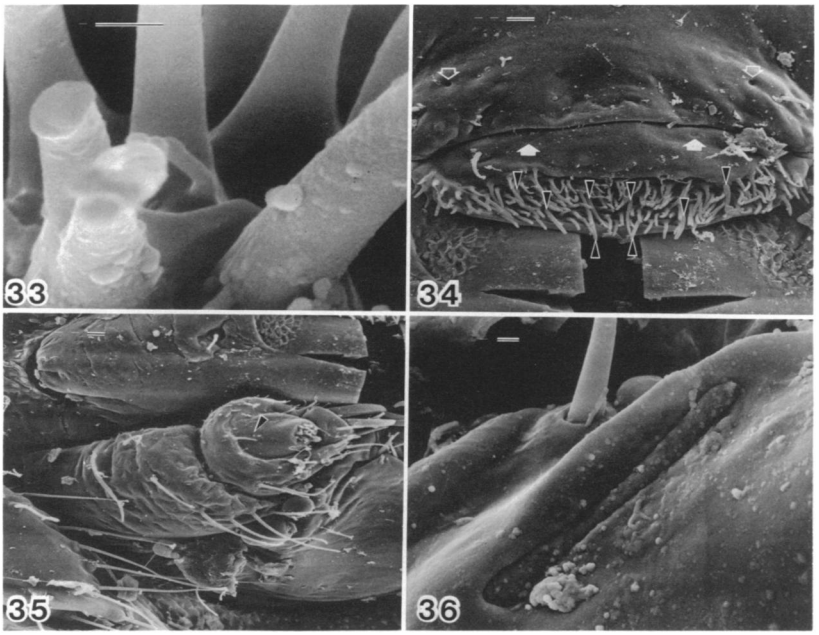
Head (cf. Fig. 29 with figs. 3 and 4 of Pfaffenberger 1977): Retractable, mostly asetiferous, with exception of three sensilla trichodea slightly dorsal and medial to each antenna and one sensillum trichodeum lateral to each mandibular base (Fig. 29); lightly pigmented except on and near mouthparts.

Ocelli (Fig. 29): Near junction of frontal suture and mandible.

Antenna (Figs. 30–33): Single telescopic segment, terminal sensilla include one enlarged medial and one smaller lateral sensilla basiconica and one elongate sensillum chaeticum (SC, Fig. 32), foregoing sensilla nearly concealed by multiple rows of elongate microtrichia (Fig. 32).

Clypeolabrum (Figs. 29, 34, 43): Labral portion with 10 blunt-tipped sensilla trichodea, eight sensilla arranged in peripheral C-shaped arc, remaining two sensilla located anteromedially within arc, all sensilla except lateral most ones (Fig. 34) nearly concealed by elongate microtrichia, single sensillum ampullaceum present (solid arrow, Fig. 34) medial to posterolateral pair of sensilla trichodea, sclerite transversely oval. Clypeal portion with convex proximal border and concave distal margin (Figs. 29, 34, 43), sclerite transversely elongate, narrow with bulbous ends, each enlarged and supporting single sensillum trichodeum and subtending sensillum ampullaceum (hollow arrows, Fig. 34).

Epipharynx (Fig. 44): Epipharyngeal groove bordered laterally by pair of strongly decurved sensilla trichodea and subtending triangular patch of sclerotized projections.



Figs. 33–36. *Acanthoscelides obtectus,* fourth instar. 33, articulating base of sensillum chaeticum (lower right) showing shortened, blunt microtrichia; bar = 1 μm. 34, facial view of clypeolabrum, showing s. ampullacea (open arrows on clypeus and solid arrows on labrum), and distribution of blunt tipped s. trichodea (darts) on labrum; bar = 10 μm. 35, lateral view of right maxilla showing s. ampullaceum (dart) near lateral base of palpus; bar = 10 μm. 36, sensillum placodeum on maxillary palpus; bar = 1 μm.

Mandible (as in Figs. 29, 35): Monocondylic, with awl-shaped chewing surface, lateral surface with two sensilla trichodea.

Maxilla (Figs. 35, 45): Cardo (C, Fig. 45) bowl-shaped; membranous stipes with five-seven sensilla trichodea with two each sensilla trichodea and sensilla ampullacea on sclerite of stipes (S, Fig. 45); palpifer (PF, Fig. 45) with twelve sensilla trichodea, two on opposite sides of elongate sensillum placodeum of palpus (PP, Fig. 45; see also Fig. 24) remaining sensilla distributed along distoventromedial to ventrolateral surface; palpus with dorsolateral, elongate sensillum placodeum (as in Fig. 24, P) sensillum ampullaceum (Fig. 38) located ventral to elongate sensillum placodeum, distal and terminating in 13 sensilla basiconica (Fig. 37); lacinia (L, Fig. 45) terminating in five truncate, blade-like setae (as in Figs. 14, 24), with mandibular surface bearing numerous, decurved microtrichia (as in Figs. 11, 14).

Labium (Figs. 39, 46): Submentum transversely elongate, narrow and lunate-shaped, flanked proximally by pair of mediolateral sensilla trichodea, latter separated by width of mentum; mentum proximally round, with pair of narrow arms separated by tear-shaped, unsclerotized cleft, converging toward narrow distal end, with single, unsclerotized islet bearing one sensillum trichodeum near base of each arm, distal end of each arm with sensillum trichodeum, subtended proximally by sensillum ampullaceum (as in Fig. 16, solid arrow) and terminating in dense cluster of microtrichia, basal half of mentum bordered laterally by pair of sensilla trichodea (one at least 1.5 times longer than other); glossae (as in Fig. 23, G) exceeding in length arms of mentum.

Leg (Fig. 40): Four clearly defined segments, ultimate segment nipple-like, with two

sensilla trichodea on opposite sides of distal end of penultimate segment and two elongate sensilla trichodea on anterolateral surface of basal segment.

Spiracles: Thoracic (Fig. 41) and abdominal (Fig. 42) peritremes with increasing numbers of integumental folds, atrial armature consisting of numerous, short rows of pointed, sclerotized projections.

Anus (Fig. 28): Transverse.

SPECIMENS EXAMINED: 25 larvae, recovered from stock culture in 1973.

Instar Differences

Marcucci (1920) was the first to suggest the existence of four instars in *A. obtectus*. His morphological characters, however, were unacceptable to Zacher (1930), who painstakingly removed old exuviae from the larval gallery to determine the number of instars; he confirmed the existence of four nearly identical instars.

Key to Instars

1. Body cyphosomatic; X- or H-shaped prothoracic plate present (Fig. 4); legs stalk-like and two-segmented (Fig. 6); 8th and 9th abdominal tergites with transversely oval sclerotized plates (Fig. 7, also see illustrations in Pfaffenberger and Johnson 1976) ..... first instar
– Body robust and C-shaped (as in Fig. 28); prothoracic plate absent; legs nipple-like and four-segmented (Fig. 26); sclerotized plates absent on 8th and 9th abdominal tergites 2

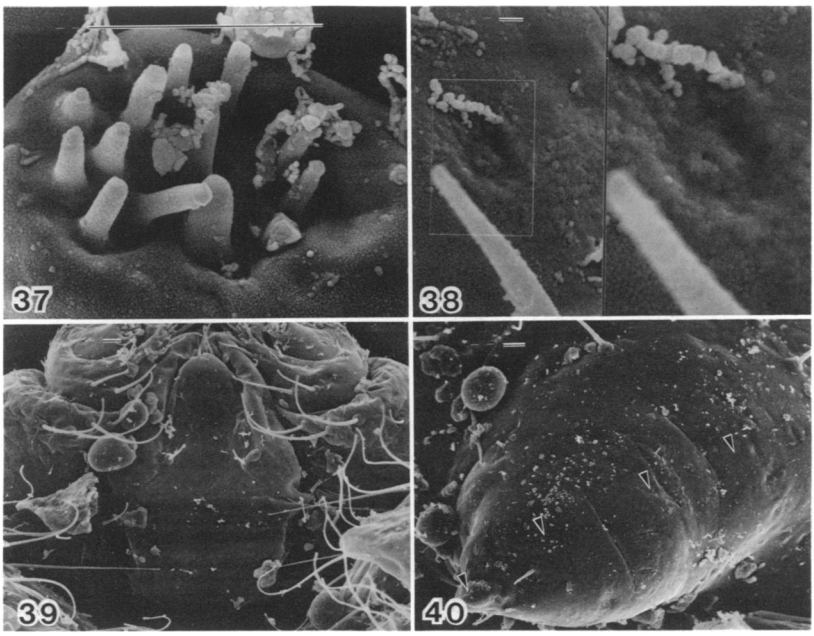
2(1). Single row of microtrichia on distodorsal antennal surface (Fig. 8); clypeolabral microtrichia absent (cf. Figs. 10, 21); leg a fleshy lobe terminating in sensillum trichodeum (Fig. 19) ..... second instar
– Combination of characters not as above 3

3(2). Multiple rows of microtrichia evident on distodorsal antennal surface (Fig. 20), but length of microtrichia not exceeding height of large sensillum basiconicum; small microtrichia evident on distolateral margins of clypeolabrum; leg vaguely four-segmented, with two sensilla trichodea (one lateral and one medial) at border of ultimate and penultimate segments (Fig. 26) ..... third instar
– Multiple rows of elongate microtrichia nearly concealing antennal sensilla (Figs. 30, 32); clypeolabral microtrichia elongate and numerous, nearly concealing sensilla trichodea (Figs. 29, 34); leg with four clearly defined segments, with two sensilla trichodea on opposite sides of distal end of penultimate segment and two elongate sensilla trichodea on anterolateral surface of basal segment ..... fourth instar

Sensillar Structures

Knowledge of bruchid sense organs comes primarily from a limited number of electrophysiological studies on adults of *A. obtectus* (Pouzat 1981). Only one species of bruchid larva has been examined (Pfaffenberger and Janzen 1984) for cuticular sensilla and no electrophysiological information exists which provides proof of sensillar function. Therefore, the following attempt to equate function with cuticular structure is merely suggestive, realizing that sensillar functions may vary within the same insect, between insects and sexes (Zacharuk 1980).

In the following list the name of the sensory receptor is followed by its proposed function, morphological description and anatomical location.



Figs. 37–40. *Acanthoscelides obtectus,* fourth instar. 37, sensilla basiconica on maxillary palpus; bar = 10 μm. 38, sensillum ampullaceum near lateral base of maxillary palpus; bar = 1 μm. 39, long, pointed s. trichodea arising from maxilla and prosternum; bar = 10 μm. 40, metathoracic leg showing four segments (marked by darts); bar = 10 μm.

Sensilla ampullacea—smell (Snodgrass 1926); appear as round, shallow depressed areas on the integument (hollow arrow in Fig. 34) and possess a small hole in the center of the depressed area (Fig. 38), in line drawings they appear as round holes (Fig. 43); clypeus (hollow arrow, Fig. 34), labrum (solid arrow, Fig. 34; circles in Fig. 43), maxilla (Figs. 24, 38, 45), and labium (solid arrow, Fig. 16) (circles in Fig. 46). They also occur on or at the base of legs (Pfaffenberger 1974; Pfaffenberger and Johnson 1976).

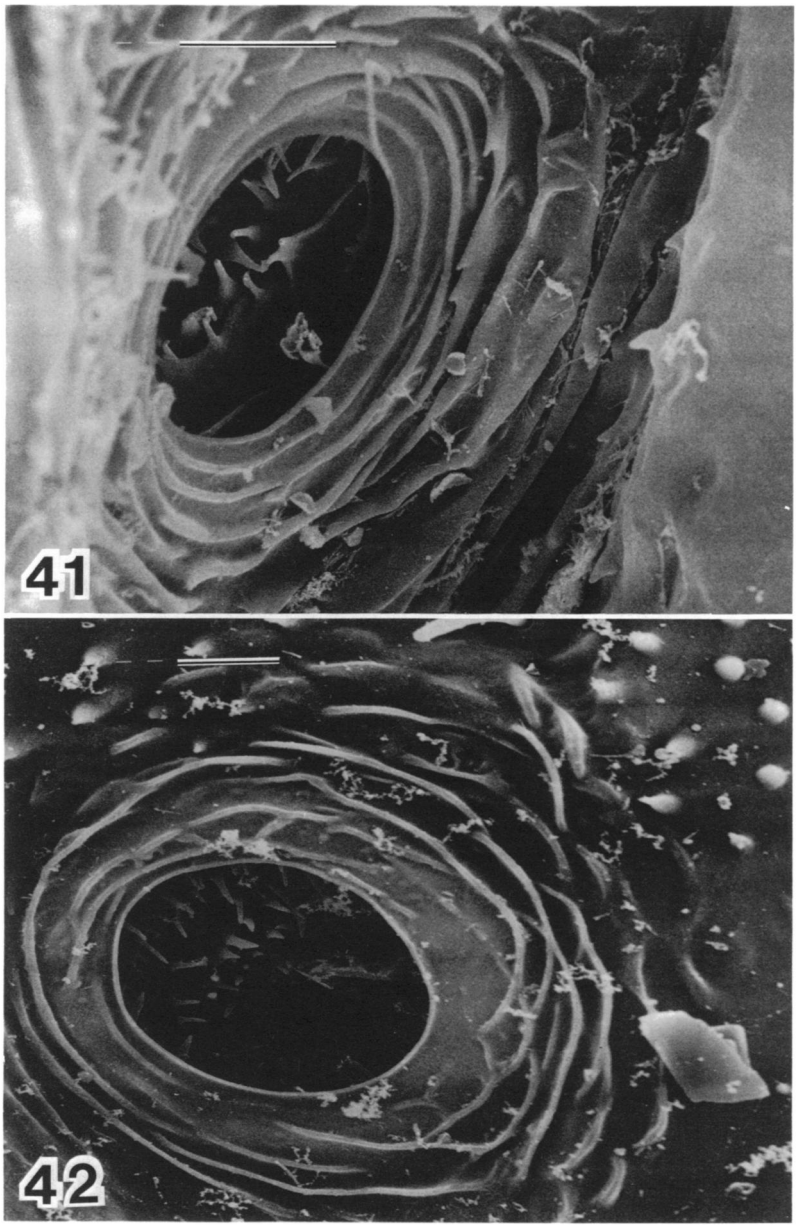
Sensilla basiconica—contact chemoreception (Pouzat 1981; Slifer 1970; Snodgrass 1926); appear as a teat on an udder which may or may not be enlarged; antenna (Figs. 30, 32), maxillary palp (Figs. 3, 13, 37, 45).

Sensilla chaetica—mechanoreception (McIver 1975; Snodgrass 1926); appear as spines or stout hair-like structures with a socket base; antenna (Figs. 1, 31, 32).

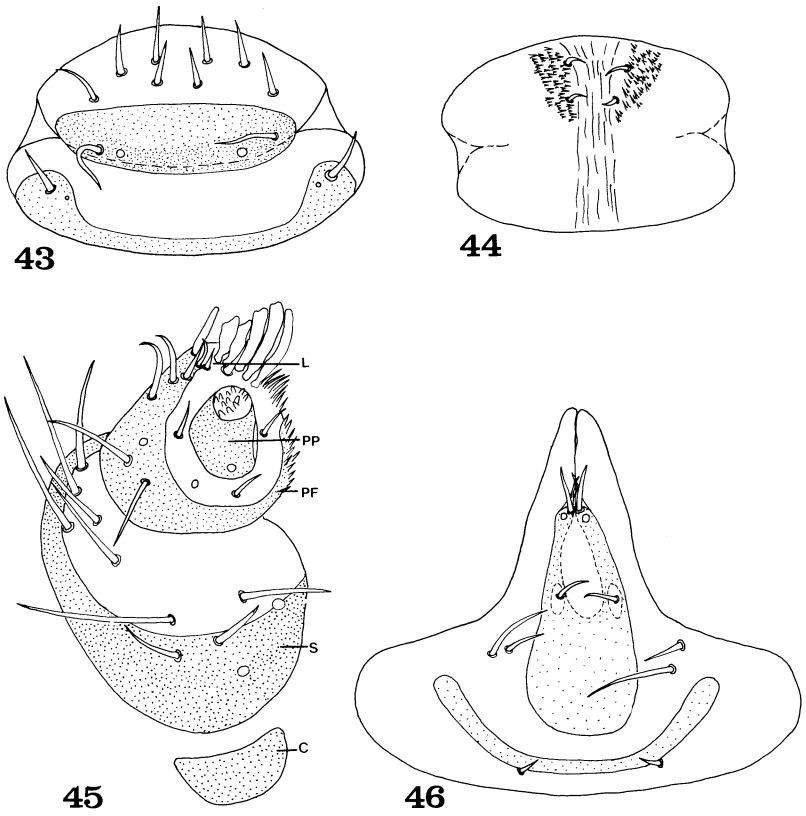
Sensilla placodea—infrared radiation sensitivity (Richerson *et al.* 1972); appear as a blunt stick pressed into a clay surface; maxillary palp (Figs. 12, 24, 36).

Sensilla trichodea—tactile hairs (Snodgrass 1926) or olfactory chemoreceptors (McIver 1982; Snodgrass 1926); all possess a socket base.

1. long or tactile hairs
   A. integument of 1st instar (Figs. 5, 7); thoracic sternites of later instars (as in Fig. 29); stipes and palpifer of later instars (Fig. 45)



Figs. 41–42. *Acanthoscelides obtectus,* fourth instar. 41, thoracic spiracle showing concentric folds in peritreme and armature of atrium; bar = 10 μm. 42, first abdominal spiracle; note increased numbers of folds in peritreme and dense atrial armature; bar = 10 μm.



Figs. 43–46. *Acanthoscelides obtectus,* fourth instar. 43, clypeolabrum showing distribution of s. trichodea minus the microtrichia. 44, epipharynx showing medially decurved s. trichodea bordering epipharyngeal groove. 45, maxilla showing cardo (C), stipes (S), palpifer (PF), palpus (PP), and lacinia (L). 46, labium showing broad, narrow submentum and nearly oval mentum.

(1) excited by fatty acids
(2) inhibited by odiferous plant oils

2. short or olfactory chemoreceptor hairs
   A. pointed tip
      (1) prothoracic plate (Fig. 4) and junction of leg segments (Fig. 6) of first instar; frons (Fig. 29) and integument (Fig. 7) of all instars
         (a) excited by higher-chain fatty acids
         (b) inhibited by lower-chain fatty acids
         (c) may be specific for chemical vapors
   B. blunt tipped type
      (1) mouthparts (as in Figs. 2, 10, 11, 14–16, 21, 22); first abdominal spiracle (Fig. 27)
         (a) excited by higher-chain fatty acids
         (b) inhibited by lower-chain fatty acids
         (c) may be specific for chemical vapors.

Other structures, which may not be innervated but are perhaps important in a discussion of functional morphology, include:

Microtrichia—serve in protecting and maintaining a clean surface on important sensory receptors (Figs. 30, 32), or perhaps are important food manipulating structures (Figs. 15, 16).

Macrotrichia—(Fig. 2) important in proprioception.

Ocelli—(Figs. 9, 29) light perception.

Spatula-like (perhaps s. chaetica) setae (Figs. 2, 14, 29) may be tactile (Richerson *et al.* 1972) or, based upon location, important in food manipulation.

Functional Morphology

Considerable resistance is normally encountered by bruchid larvae as they attempt to penetrate and feed upon one or more host seeds (Janzen 1969). At times, such resistance is compounded when oviposition occurs on host plants to which the larva is not well suited (Johnson 1981). Regardless of host plant suitability, larvae must perform certain essential tasks. Some of these include: (1) penetration of pod wall, (2) location of host seed, (3) penetration of seed, (4) avoidance of toxic compounds, (5) avoidance of other larvae feeding within the same seed, (6) recognition of suitable food source, and (7) preparation for adult emergence. Each of the foregoing activities will subsequently be addressed and indicated by a parenthetic number which corresponds to the number in the list above.

The measure of success which *A. obtectus* experiences in wild or cultivated forms of its preferred host plant (*Phaseolus vulgaris* L.) is, of course, dependent upon activities of the first instar. Since the fruit of this host is a linear, flattened pod containing several seeds and since the female oviposits a few to many eggs in chewed holes (Pouzat 1981) and cracks or cuts in pod walls (Howe and Currie 1964), it remains for the first instar to actively search out the host seed. The first instar may exit the egg through its anterodorsal end and wander before penetration (Zacher 1930) or it may exit the egg ventrally thus penetrating the pod wall directly (Pfaffenberger, in press). In either instance it must pierce the pod wall, which requires some form of leverage which the larva obtains from either the egg chorion [which may or may not be cemented in place (Zacher 1930)], or by wedging its way into cracks or crevices. Kunhi Kannan (1923) indicated that the first instar is perfectly capable of penetrating a seed without leverage [an interesting and aggressive rebuttal is presented by Lepesme (1942), as *A. obsoletus*]. Riley (1891) also stated that as many as 28 larvae have been observed to develop within a single bean. Under these circumstances it would seem that some first instars might also utilize holes drilled by other larvae (Slingerland 1893; Zacher 1930).

Is sensory discriminating ability, such as innate recognition of a "layer effect" (Pfaffenberger and Janzen 1984), necessary to penetrate the pod wall (#1)? If so, it would entail recognition of both physical and chemical differences. Chemical recognition could arise from s. ampullacea, s. basiconica and even s. trichodea, while textural changes might be perceived by s. chaetica. While chewing its way through the pod it is doubtful that any of the pod wall would be eaten because of reduced palatability (Pouzat 1981) or even the presence of potentially toxic secondary compounds (Janzen 1969).

Once inside the pod wall the first instar must then locate the host seed (#2); such a task would be greatly enhanced by the heat sensitive s. placodea. Upon locating the host seed the first instar wedges itself between pod wall and bean using s. basiconica and the long s. trichodea to determine when suitable leverage

has been achieved to penetrate the seed (#3). To position its ventral surface against the bean, rather than pod wall, its heat detecting s. placodea and ocelli seemingly would become very important as would their ability to detect response promoting chemicals through their s. ampullacea, s. basiconica and perhaps even the shorter s. trichodea.

While penetrating the seed test it again would seem unlikely, for reasons alluded to above, that the first instar would feed. Once inside the testa, however, other hazards might prevail such as (#4) presence of toxic chemicals (Nelson and Johnson 1983) or, among others (#5), presence of cannibalistic larvae. Sensilla ampullacea, basiconica, and shorter s. trichodea might function as organs for perception of toxic chemicals while chamber vibrations of neighboring larvae might be perceived by s. chaetica or even the longer s. trichodea. Arrival in the endosperm likely influences the onset of molt and may also prompt the feeding response (#6) in all subsequent instars. Such changes in behavior are likely initiated by impulses from the blunt and pointed s. trichodea, as well as from organs of olfaction (s. ampullacea) and chemoreception (s. basiconica).

Increased numbers of microtrichia around the labral margin (as in Figs. 10, 21, 34) and distal end of the antennal segment (as in Figs. 1, 8, 20, 30) seem to be associated with preventing the buildup of frass and other chamber components on the essential receptors of second through fourth instars. By comparing Figures 17–18 with 41–42, similar statements are made in conjunction with increased numbers of peritreme folds and atrial spinous projections of thoracic and abdominal spiracles.

Finally, as the larva prepares to pupate (#7) the elongate s. placodea might be utilized to detect the proximity of the exterior. Sensitivity to infrared radiation, ocellar light detection and input from other sensillar types, regarding changes in the chemical and physical nature of material close to the seed testa, enable the fourth instar to weaken a part of the seed testa substantially so that the emerging adult can escape from the seed.

Acknowledgments

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SCIENTIFIC NOTE

NEW HOST RECORD FOR *ACANTHOSCELIDES CHIRICAHUAE* (FALL) (COLEOPTERA: BRUCHIDAE)

According to Johnson (1983), *Acanthoscelides chiricahuae* has only been reared from seeds of the plant genus *Mimosa*. Recently while collecting seeds to recover larvae I reared numerous adults of *A. chiricahuae* from seeds of *Acacia greggi* Gray.

Three bruchid species have been previously reared from seeds of this host plant: *Merobruchus julianus* (Horn), *Stator limbatus* (Horn) and *Stator pruininus* (Horn) (Johnson 1981). Therefore, this report also represents a new host-genus association. Because of an ongoing effort to establish bruchid-host plant associations the following record is reported below.

Acacia greggi Gray: Sumner Lake State Park, Eastside Campground across lake to the east from the boat loading area, De Baca Co., New Mexico, VII-4-84. Most of the pods had already matured and dropped when collected.

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