# The Instars of the Ant *Amblyopone silvestrii* (Hymenoptera: Formicidae)

by

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## ABSTRACT

Preimaginal developmental stages of the Japanese primitive ant, *Amblyopone silvestrii* (Wheeler), are described. External morphology of the larvae was investigated primarily on whole mount preparations and in specimens viewed by scanning electron microscopy. This has shown that the larval stage consists of five instars in both female and male individuals. After this examination, the instars could be easily distinguished by chaetotaxy and body length even in live specimens under a stereomicroscope. However, no external characteristics were found that enable the distinction of the larval sex, except that in statistical analyses, body hairs were more abundant in male larvae through the five instars. The prothorax of the larva, especially its ventral surface, is provided with numerous minute spinules, which possibly assist the larva in holding the anterior body region firmly in the prey. On the other hand, the hairless ventral surface of the 1st and 2nd instars may be related to their attachment to the egg pile and thus facilitate their oophagy, for they are usually attached to eggs ventrally.

## INTRODUCTION

Discrimination of the larval instars and their descriptions are often prerequisite for ecological studies of social insects, such as a study of colony development by means of age distribution analysis. For ants, although the number of larval instars has been reported for more than 20 species (see below), most studies were made on species belonging to the two advanced subfamilies, Myrmicinae and Formicinae. The primitive subfamily Ponerinae remains ignored almost completely in this aspect and no information is available for the members of the Amblyoponini. Moreover,

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even for the Myrmicinae and Formicinae, definite descriptions of each larval stage have been few. Exact determination and descriptions of larval instars in the primitive genera like *Amblyopone* could therefore be important for future comparative studies of the developmental biology of ants. I describe here the larval instars of the Japanese species *Amblyopone silvestrii* (Wheeler).

## TERMINOLOGY

The terminology applied to larval morphology of Michener (1953) and Wheeler and Wheeler (1976) is followed here. All hairs appearing on the body surface of *A. silvestrii* larvae are smooth and unbranched, and most of them are flexous apically, though the length and diameter are variable. Following Petralia and Vinson (1979a), the term "microsetae" is used below to denote protuberances 10µm or less in length occurring on the head and body trunk.

## MATERIALS AND METHODS

Colonies of *A. silvestrii* were collected in the evergreen broadleaf forest at Cape Manazuru, Kanagawa Prefecture. In the laboratory, after census of colony populations, some colonies were maintained in polystyrene observation nests (10x11x2cm or 10x19x2cm), and others were immediately fixed in Kahle's solution, followed by 80% ethanol. Presumed female larvae were collected from colonies which were producing only workers and gynes over a reasonable length of period of laboratory culture. Male specimens were taken from colony fractions containing only isolated workers, who were rearing the larvae hatched from the unfertilized eggs they laid.

To determine the larval instars, the preliminary examination was made particularly on the chaetotaxy of many live larvae of various age and size, ranging from microlarvae newly hatched from eggs to mature larvae having completed the discharge of meconium (i.e., prepupae). This examination suggested the presence of five instar stages in the larvae of both sexes. For more detailed studies, whole mount preparations were made by the procedure of Wheeler and Wheeler (1960). Permount™ (Fisher Scientific Co.) was used as the mounting medium. To prevent specimens



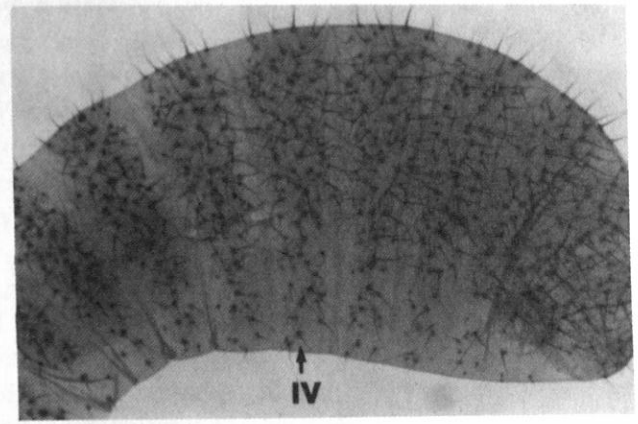



Fig. 1. Whole mount preparation of 3rd instar (female). Arrow indicates the abdominal segment IV. Stained with acid fuchsin.

## ABBREVIATIONS

| | |
|---|---|
| a | antenna |
| at | anterior tentorial pit |
| b | labium |
| c | clypeus |
| d | mandible |
| dp | cranial depression |
| f | frons |
| g | galea |
| ge | gena |
| h | hypopharynx |
| hf | hypostomal furrow |
| m | labrum |
| n | anus |
| os | opening of sericteries |
| p | labial or maxillary palp |
| s | isolated sensilla on labium or maxilla |
| v | vertex |
| x | maxilla |

Table 1. Comparison of number of hairs on the 2nd thoracic and 4th abdominal segments between female (F) and male (M) larvae of *Amblyopone silvestrii*.

| Larval instar | Sex | Thoracic segment II Mean±S.D. | Range | (N) | P* | Abdominal segment IV Mean±S.D. | Range | (N) | P* |
|---|---|---|---|---|---|---|---|---|---|
| 1st | F | 3.9±0.3 | 3-4 | (13) | <0.05 | 3.8±0.6 | 3-5 | (12) | <0.05 |
| | M | 4.4±0.6 | 4-6 | (16) | | 5.4±2.0 | 3-9 | (10) | |
| 2nd | F | 19.9±2.5 | 6-24 | (15) | <0.01 | 23.4±1.6 | 19-32 | (12) | <0.001 |
| | M | 24.7±4.4 | 21-26 | (11) | | 30.4±5.3 | 22-43 | (13) | |
| 3rd | F | 82.3±5.7 | 73- 91 | (12) | <0.05 | 95.7± 6.2 | 82-106 | (15) | <0.1 |
| | M | 90.2±7.8 | 85-106 | (10) | | 103.4±11.0 | 87-118 | (10) | |
| 4th | F | 186.0±20.3 | 155-219 | (12) | <0.05 | 217.1±29.6 | 181-272 | (12) | <0.1 |
| | M | 207.3±28.2 | 156-263 | (15) | | 237.2±26.1 | 197-291 | (17) | |
| 5th | F | 368.9±48.2 | 311-454 | (12) | <0.05 | 505.1±65.4 | 416-612 | (16) | <0.1 |
| | M | 413.5±44.9 | 318-468 | (14) | | 540.9±42.7 | 480-639 | (14) | |

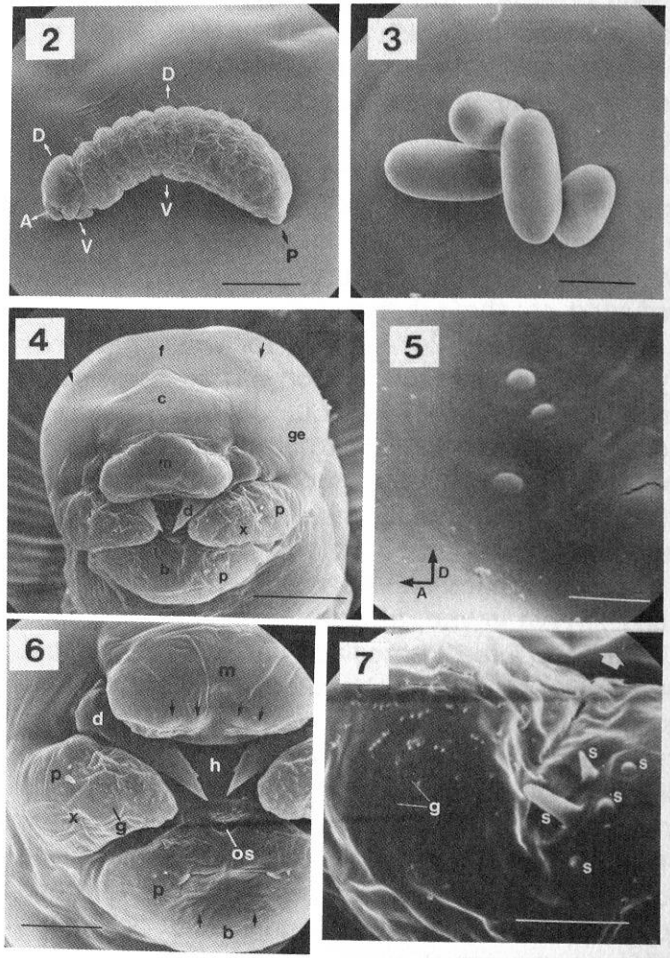
*Significance of mean differences were determined by t-test, or Cochran-Cox test when variances were not equal



from being pressed, the medium was surrounded by supports of small nylon washers which were a little thicker than the thickness of the specimens (Wheeler and Nijhout 1981).

In search of any sex related difference, numbers of hairs on the thoracic segment II (=TII) and abdominal segment IV (=AIV) were examined as indices of the density of body hairs. For this, specimens were treated with KOH, cleared with xylene, and completely pressed laterally under cover glasses. Then the preparations were photographed with a compound microscope and hairs were counted on the printing papers (Fig. 1), except for the cases of the 1st and 2nd instars, for which hairs were counted directly under the microscope. Some material was also examined with an SEM microscope (J.E.O.L. JSM-25), after being critical point dried with liquid $CO_2$ or treated with hexamethyldisilazane (Nation 1983). In the latter procedure, larvae were punctured or partially incised to facilitate penetration of hexamethyldisilazane.

Measurement was made on the head width and body length using preserved material. As representatives of each instar of male and female larvae, at least 10 larvae were chosen ranging from individuals fixed immediately after their ecdyses, to those who were ready to molt to the succeeding instar. The head width was measured with a stereomicroscope at a magnification 160X. Because the body of the *A. silvestrii* larva is strongly curled, the following method, basically the same as applied to collembolans by Tamura (1974), was used to measure the body length: Larvae were laid on their side in an alcohol filled depression of a color reaction plate. This glass plate was set on the stage of a stereomicroscope for observation at a magnification of either 50X or 80X depending on the larval size. Using a drawing tube attached to the microscope, the body length of the larva was precisely drawn as a line on a paper by tracing the central body line from the abdominal tip to the anterior surface of the head. This line drawing was then enlarged about three times with a photocopy machine (Fuji Xerox), and its length was measured with a curvimeter of the least scale of 1cm. With this method, the larval body lengths can be precisely determined to 0.1mm. Since *A. silvestrii* larvae are hypognathus, the anteroposterior and dorsoventral axes of the head are determined as indicated in Fig. 2.




Figs. 2-7. 2, Lateral view of 1st instar (female). Directions of head and body are: A, anterior; D, dorsal; P, posterior; V, ventral. Scale=0.2mm. 3, Scanning electron micrograph of eggs collected from a queenright laboratory colony of *A. silvestrii*. Metal-coated and examined alive. Scale=0.3mm. 4, Ventral view of head of 1st instar (male). Arrows point to the sites of both antennae. Scale=50µm. 5, Left antenna of 1st instar (female). It consists of three sensilla. Arrows point anteriorly (A) and dorsally (D). Scale=5µm. 6, Ventral view of mouthparts of 1st instar (female). Arrows indicate some of indistinct, encapsulated sensilla on labrum (m) and labium (b). Scale=30µm. 7, Lateral view of left maxilla of 1st instar (female). Galea (g) is recognized only as two indistinct sensilla (s). Arrow points anteriorly. Scale=10µm.

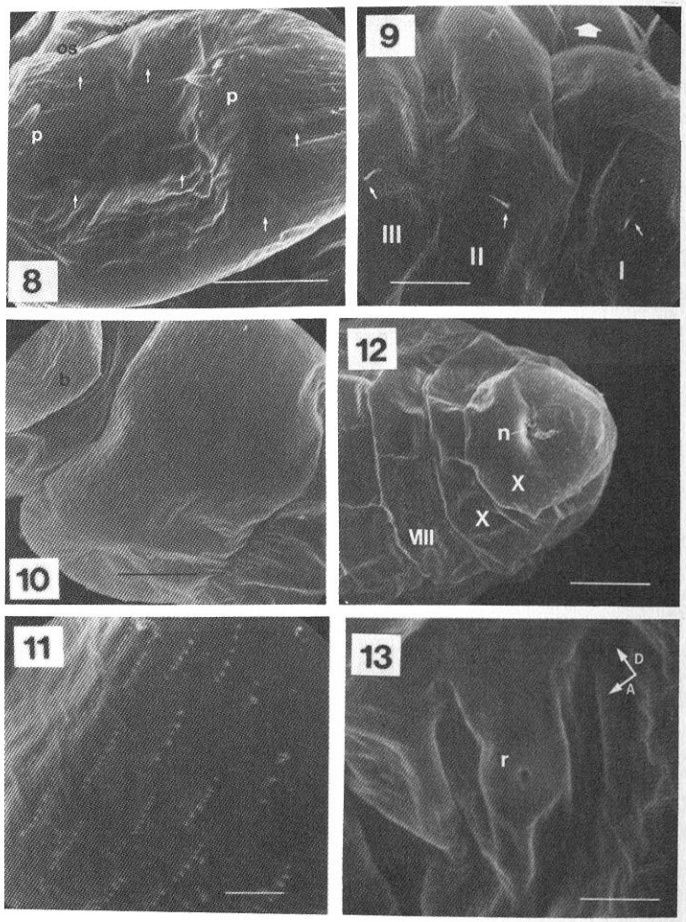


## RESULTS

General features of the chaetotaxy are identical between male and female larvae in each instar, with the exception that male larvae have a little, but statistically significant, more abundant body hairs than female larvae (Table 1). However, no other sex difference was found in the form of sclerotized body parts, e.g., mandibles, maxillae, labium, and so on. Therefore, each of the five instars is described below irrespective of sex. The results of the body measurements are summarized in Table 2.

EGG. (Fig. 3) Typical ponerine shape; elongate and rather slender. Long diameter 0.48-0.56mm ($\bar{X}$=0.51mm, n=10) in female (diploid) and 0.50-0.54mm ($\bar{X}$=0.51mm, n=10) in male (haploid), short diameter 0.18-0.23mm ($\bar{X}$=0.20mm, n=10) in female and 0.19-0.22mm ($\bar{X}$=0.20mm, n=10) in male. Color milky white and opaque. No significant difference was detected between male and female eggs.

FIRST INSTAR. (Figs. 2, 4-13) Head hairs lacking (Fig.4). All sensilla except those on genae are indistinct or only small convexities in appearance. Antenna represented by 3 indistinct smooth sensilla, arranged in a straight line or a triangle (Fig. 5). Labrum subrectangular, slightly emarginate ventrally (Figs. 4 and 6); each half bearing 5 indistinct, encapsulated sensilla (4 near ventral margin and 1 on anterior surface). The ventral surface of labrum and ventral portion of hypopharynx lack spinules (Figs. 4 and 6). Mandible narrower in distal third, which has a pointed apical tooth and two denticles (Figs. 4 and 6). Maxillary lobe conoidal, with minute spinules on surface of lacinia (Fig. 6). Maxillary palp slightly projecting, with 5 sensilla (Fig. 7, s), the medial one protruding. Galea represented by two less prominent sensilla (Fig. 7, g). Labium with minute spinules on anterior to lateral surfaces; palp like maxillary palp, consisting of 5 sensilla (Figs. 6 and 8). In addition, 4 and 8 isolated sensilla on the surfaces of maxillary lobe and labium, respectively. All of these sensilla are indistinct low convexities. Opening of sericteries present on anteromedial surface of labium; small, not prominent (Figs. 6 and 8, os). Each thoracic and abdominal segment with a single row of hairs in a group of usually 4 or 5 (longest c. 85µm) on dorsal to




Figs. 8-13. 8, Lateroventral view of labium of 1st instar (female). Six of a total of 8 isolated sensilla are visible (arrows). Scale=20μm. 9, Right lateral view of thoracic segments I, II and III of 1st instar (male). Thick arrow points dorsally. Small arrows indicate microsetae which are much shorter than the body hairs positioned on the dorsum. Each microseta is accompanied dorsally with an encapsulated sensillum (campaniform sensillum?). Scale=30μm. 10, Ventral surface of thoracic segment I of 1st instar (female). Note that numerous short rows of minute spinules are present on the anterior half of the surface. Labium (b) is seen at upper left. Scale=30μm. 11, Same view as Fig. 10, enlarged to show the ventral thoracic spinules. Scale=5μm. 12, Ventral view of posterior body region of 1st instar (female), showing anus (n) on the last abdominal segment (X). Scale=40μ. 13, Spiracle (r) of thoracic segment III of 1st instar (male). Arrows point anteriorly (A) and dorsally (D). Scale=5μm.

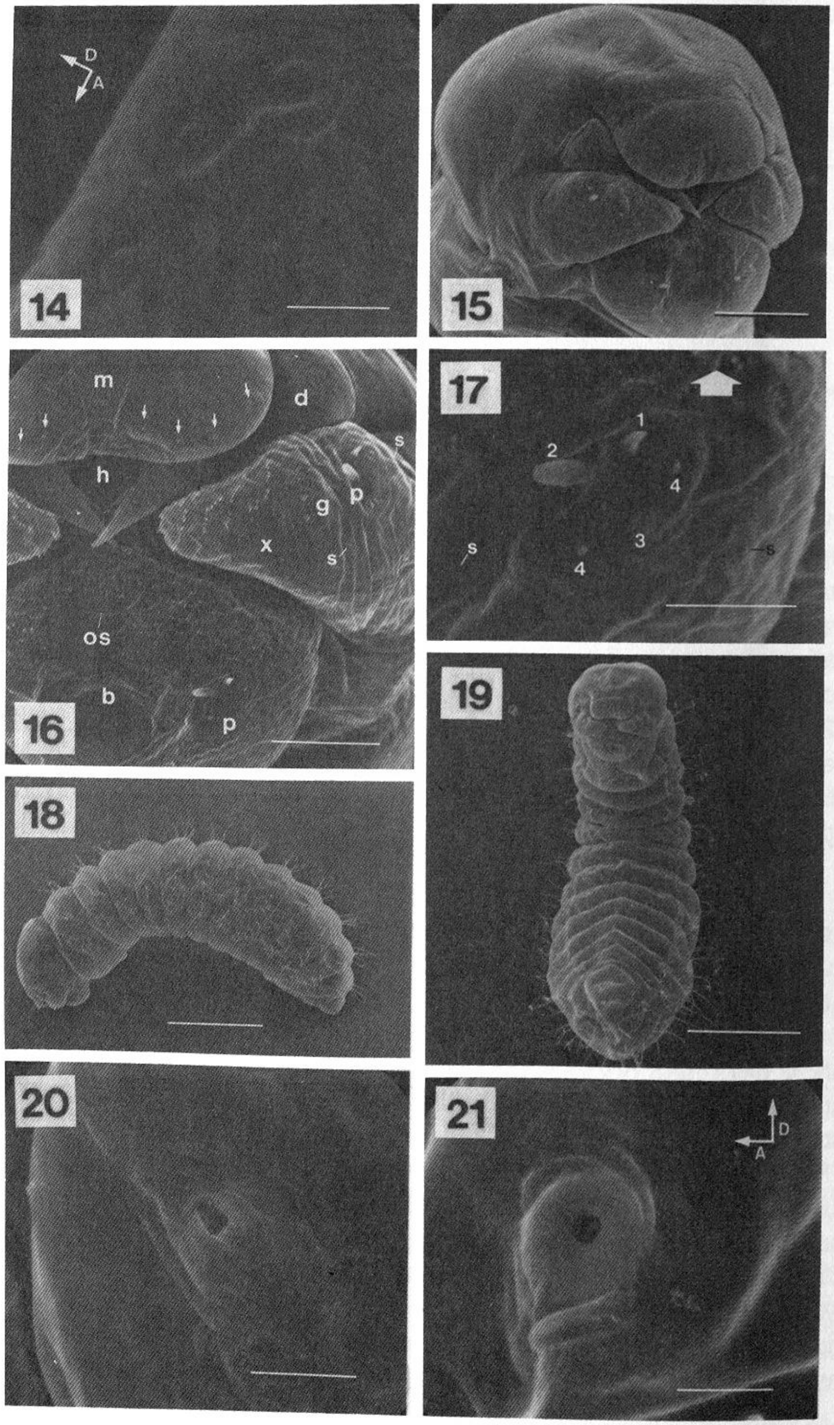


Table 2. Head widths and body lengths of *A. silvestrii* larvae.

| Larval sex | Instar | Head width range (mm) | Body length range (mm) | N |
|---|---|---|---|---|
| Female | 1st | 0.16 - 0.18 | 0.6 - 0.9 | 18 |
| | 2nd | 0.16 - 0.18 | 0.7 - 1.1 | 23 |
| | 3rd | 0.17 - 0.19 | 1.0 - 1.5 | 24 |
| | 4th | 0.18 - 0.20 | 1.2 - 2.5 | 23 |
| | 5th | 0.19 - 0.23 | 2.2 - 5.0 | 24 |
| Male | 1st | 0.15 - 0.17 | 0.6 - 0.9 | 15 |
| | 2nd | 0.16 - 0.18 | 0.9 - 1.3 | 14 |
| | 3rd | 0.16 - 0.20 | 1.2 - 1.8 | 10 |
| | 4th | 0.18 - 0.21 | 1.5 - 2.4 | 10 |
| | 5th | 0.20 - 0.25 | 2.1 - 5.5 | 20 |

lateral surfaces (Fig. 2); hairs positioned laterally often much shorter or microsetae (Fig. 9, small arrows); no hairs on ventral surface (Figs. 2 and 10). Short spinules arranged in many short traverse rows on the ventral to lateral surfaces of the anterior half of TI (Figs. 10 and 11). AVIII, AIX and AX with 1 or 2 hairs (or none), but surface of the last 2 segments spinulose (Fig. 12). Spiracles ten pairs from TII to AVIII, no collar process developed on body surface (Fig. 13); shape of atrial opening circular or oval. Anus small, present ventrally near abdominal tip (Fig. 12, n).

SECOND INSTAR. (Figs. 14-21) Similar to first instar except as follows. All head microsetae spinose or subconic (0.5-0.7μm in length); their positions are: 3 pairs on clypeus, of which 2 pairs near ventral border and 1 pair near anterior tentorial pits; 2 pairs in lower regions of genae, 1 pair dorsomedial to antennae, and 2 pairs near occipital border. Microsetae, especially on genae, are variable in number and position. Antennal sensilla more distinct and faintly papillose (Fig. 14). Labrum like that of 1st instar (Fig. 15); 5 sensilla on each lobe, ventral 4 more distinct (Fig. 16, arrows); spinules nearly invisible on ventral surface of labrum, but somewhat developed on ventral portion of hypopharynx. Mandible more sclerotized, with all 3 teeth more distinct (Fig. 16). Maxillary lobe more conoidal (Figs. 15 and 16); palp poorly developed but medial sensilla spinose (Fig. 16). Galea as high as maxillary palp, and its sensilla more evident (Fig. 16). Labial






palp like maxillary palp (Fig. 17); the isolated sensilla on the surfaces of maxillae and labium smooth low convexities (Figs. 16 and 17, s). Opening of sericteries small, only 1/15 width of whole labium (Fig. 16). Body segments TI–AVIII bearing about 20–40 hairs each (longest c. 90µm) arranged in a row extending from dorsal to ventrolateral surfaces (Fig. 18); medial ventral region hairless (Figs. 18 and 19); hairs sparser on AIX and few or absent in AX. Spinules on TI, AIX and AX longer. Spiracles without collar processes, but abdominal ones with peritremes distinct (Figs. 20 and 21). Anus a small slit on venter of AX.

THIRD INSTAR. (Figs. 22–32) Similar to second instar except as follows. Microsetae on head all spinose or rarely conic (1.0–2.0µm in length) (Fig. 22, arrows). Antennal sensilla papillose (Fig. 23). Labrum notched medially, with spinules developed on ventral surface (Fig. 24). Distal part of mandible more curved medially and posteriorly (Fig. 25). Maxillary palp a well defined round but low elevation and galea a frustum; the latter exceeds the former in height (Fig. 26). Each maxillary lobe with 4 isolated sensilla, 1 close to galea, 1 close to palp, 1 on dorsoposterior surface, and 1 dorsally on hypostomal furrow; the former 2 are smoothly convex and the latter 2 are usually conic in shape (Fig. 26, s). Each half of labium with 4 isolated dome shaped or subconic sensilla, of which 1 is medial to and 1 dorsoposterior to palp, respectively, and 2 on ventroposterior surface (Fig. 27, s). Labial palp not distinctly elevated. Opening of sericteries a short transverse slit, about 1/10 width of whole labium (Figs. 22 and 24).

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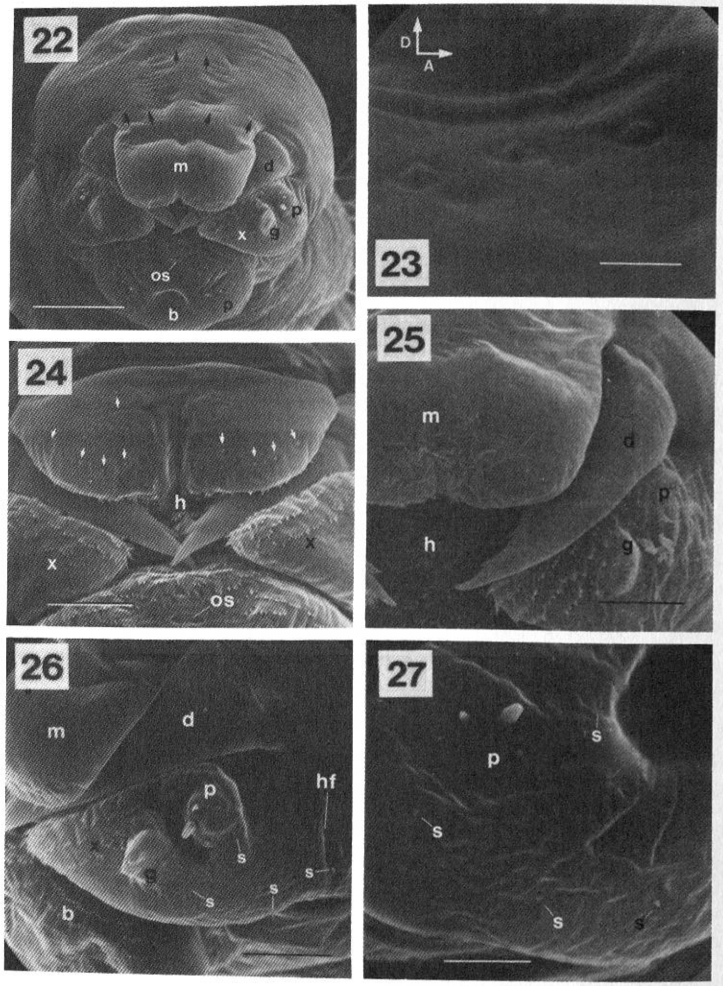
Figs. 14-21. 14, Left antenna of 2nd instar (female) with 3 sensilla. Arrows point anteriorly (A) and dorsally (D). Scale=3µm. 15, Lateroventral view of head of 2nd instar (female). Scale=50µm. 16, Ventral view of mouthparts of 2nd instar (female). Arrows point to sensilla on the labrum (m). Scale=20µm. 17, Left labial palp of 2nd instar (female), bearing 5 sensilla of apparently 4 types (numbered 1 to 4). Isolated sensilla (s) are indistinct in this instar. Arrow points anteriorly. Scale=10µm. 18, Lateral view of 2nd instar (female). Scale=0.2mm. 19, Ventral view of 2nd instar (female). Scale=0.2mm. 20, Left spiracle of thoracic segment II of 2nd instar (female). Lateral view. Orientation same as Fig. 21. Scale=5µm. 21, Left spiracle of abdominal segment I of 2nd instar. Same specimen as Fig. 20. Arrows point anteriorly (A) and dorsally (D). Scale=5µm.

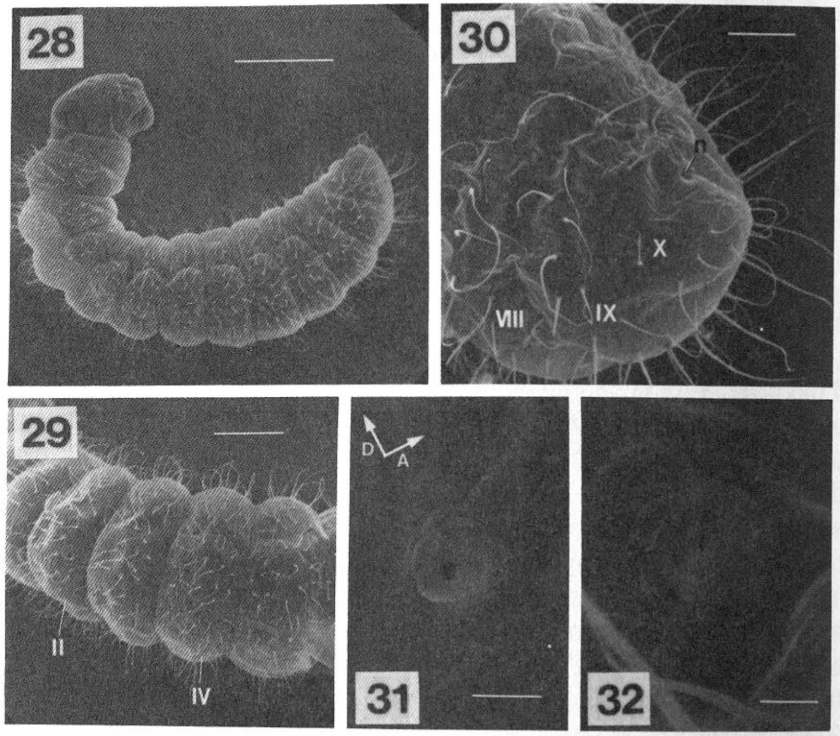



Figs. 22-27. 22, Ventral view of head of 3rd instar (female). Arrows indicate 3 pairs of spinose sensilla on the clypeus. Scale=50µm. 23, Lateral view of right antenna of 3rd instar (female). Arrows point anteriorly (A) and dorsally (D). Scale=3µm. 24, Labrum of 3rd instar (female), bearing 5 pairs of sensilla (arrows). Only 4 sensilla are visible on the left lobe in this specimen. Scale=20µm. 25, Left mandible (d) of 3rd instar (male). Scale=20µm. 26, Lateral view of left maxilla (x) of 3rd instar (female). Each maxillary lobe has 4 isolated sensilla (s), of which the dorsoposterior two are more spinose. Scale=20µ. 27, Lateroventral view of labium of 3rd instar (female), showing the right palp (p) and 4 isolated sensilla (s). Scale=10µm.



Body hairs (longest c. 95µm) numerous, distributed evenly around each segment except sparse on ventromedial surfaces (Fig. 28). TI densely spinulose on the ventral region of the anterior half. Spinules in short rows also on the last 2 abdominal segments (Fig. 30). Spiracular peritremes on abdominal segments with outer collar processes, but those on thoracic segments smaller and irregularly shaped (Figs. 31 and 32).

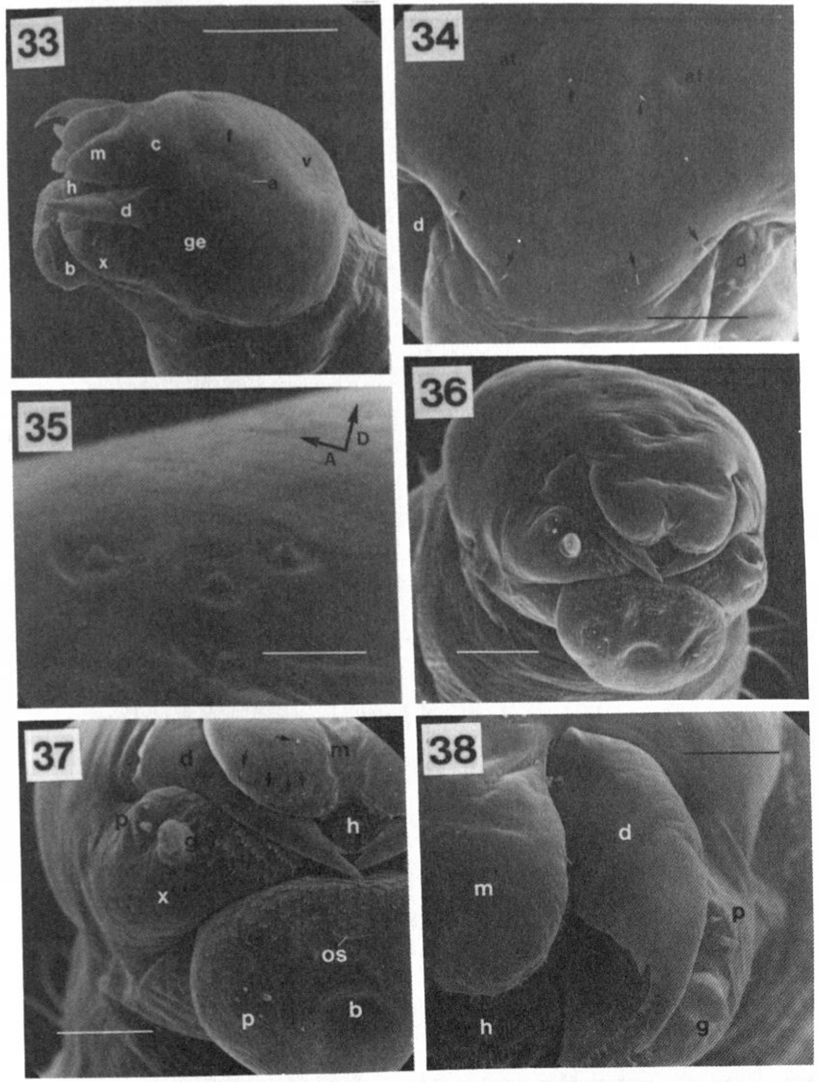
FOURTH INSTAR. (Figs. 33-44) Similar to third instar except as follows. Head longer than wide; microsetae mostly spinose (1.0-2.3µm in length), 3 pairs on clypeus (Fig. 34, arrows) and 5 pairs on cranial region except clypeus. Antenna with 3 distinctly papillose sensilla, each in a shallow depression (Fig. 35). Labrum bilobed, each lobe with 5 round or subconic sensilla; spinules well developed on ventral surface (Figs. 36 and 37). Mandible well sclerotized, with 3 stout, subequal teeth; distal third more strongly curved (Fig. 38). Maxillary apex coarsely spinulose (Figs. 37 and 39); with 4 isolated sensilla, 1 near palp and 1 near galea, shorter and conic, and 2 dorsoposterior longer and spinose. Maxillary palp a boss, wider than tall; with 2 small papillose, a long finger like, a spinose, and a large disk like sensilla (Fig. 39). Galea digitiform, about twice as high as maxillary palp, bearing 2 papillose sensilla (Fig. 39). Labium with coarse spinules on anterior surface; palp a low round elevation with 5 sensilla similar to those on maxillary palp (Fig. 40). The 4 pairs of isolated sensilla on labial surface, 2 pairs near labial palps conic and 2 pairs on ventroposterior surface spinose (Fig. 40, s); sensilla in more exposed position are longer. Opening of sericteries a transverse slit, about 1/8-1/7 width of labium (Fig. 37). Body hairs (longest c. 120µm) much denser (See Table 1); uniformly distributed over body surface except ventral region of TI (Figs. 41 and 42). A different type of body hair appears on AIX (Fig. 43, small arrows); 14-16 in number, 85-110µm in length, distinctively thick (c. 5µm in diameter at base), and arranged around the segment; always pointing posteriorly. Spinules on TI (Fig. 44), AIX, and AX more pointed (Fig. 43). Thoracic spiracles obviously smaller than abdominal in diameter. Anus opens ventrally near the abdominal tip.



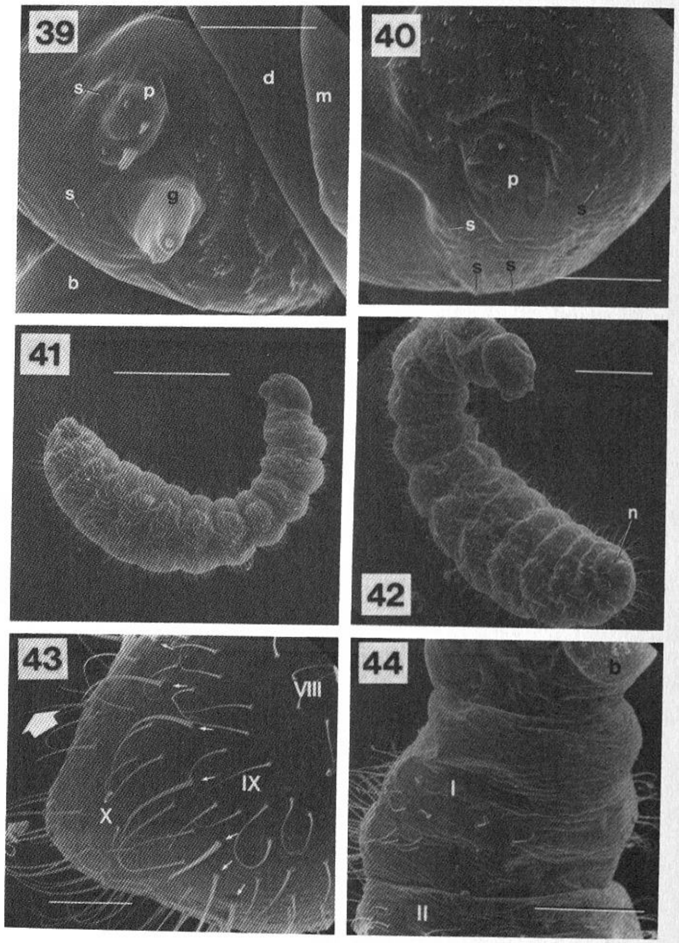

Figs. 28-32. 28, Lateral view of 3rd instar (female). Scale=0.2mm. 29, Body hairs of 3rd instar (female). Dorsal view. Abdominal segments II and IV are marked. Scale=0.1mm. 30, Posterior body region of 3rd instar (male). Scale=50μm. 31, Right spiracle of thoracic segment II of 3rd instar (male). Arrows point anteriorly (A) and dorsally (D). Scale=5μm. 32, Right spiracle of abdominal segment I of the same specimen, with the same orientation, as Fig. 31. Scale=5μm.

FIFTH INSTAR. (Figs. 45-54) Head stout, longer than wide; microsetae spinose (1.2-4.4μm in length) (Fig. 45). A groove between the right and left antennae distinct (Fig. 45, dp). [It is probably the depression in cranial wall at the origin of the frontal muscles, although the head musculature was not investigated in the present study. This structure is broadly known in larvae of other Hymenoptera (Short 1952; Yamane 1976), but has not been described for ant larvae.] Antenna with 3 papillose sensilla (Fig. 46) (rarely 4 or 5 in male larvae), which are mounted on a low circular convexity (see Fig. 45; this antennal base, however,






Figs. 33-38. 33, Anterolateral view of head of 4th instar showing cranial regions and appendages. Scale=0.1mm. 34, Anterior view of clypeus of 4th instar (male), on which 3 pairs of spinose sensilla (arrows) are distributed. Scale=30μm. 35, Dorsolateral view of right antenna of 4th instar (female). Arrows point anteriorly (A) and dorsally (D). Scale=5μm. 36, Ventral view of head of 4th instar (female). Scale=50μm. 37, Ventral view of mouthparts of 4th instar (female). Five sensilla (arrows) are seen on the right lobe of the labrum (m). Scale=30μm. 38, Anteroventral view of left mandible (d) of 4th instar (female). Scale=20μm.




Figs. 39-44. 39, Lateral view of right maxilla of 4th instar (male). Two of the isolated sensilla (s) are visible in this photograph. Scale=20µm. 40, Lateroventral view of left half of labium of 4th instar (male), showing palp (p) and 4 isolated sensilla (s). Scale=20µm. 41, Lateral view of 4th instar (female). Scale=0.5mm. 42, Lateroventral view of 4th instar (male). Scale=0.3mm. 43, Lateral view of posterior end of 4th instar (female), showing abdominal segments VIII, IX and X. Markedly thick hairs are distributed around on the abdominal segment IX (small arrows). Thick arrow points ventrally. Scale=50µm. 44, Lateroventral view of thoracic segment I of 4th instar (female). Note that the surface of the segment is differentiated anteroposteriorly into two regions, and the anterior region is in particular provided with spinules on its ventral surface. Head with labium (b) and thoracic segment II are also seen. Scale=0.1mm.



Table 3. Number of larval instars in ants. F, female; M, male; S, soldier; W, worker.

| Species | Caste | No. of instars | Reference[1] |
|---|---|---|---|
| Ponerinae | | | |
| *Amblyopone silvestrii* | FMW | 5 | The present study |
| *Brachyponera chinensis* | W | 4 | Kôriba 1963 |
| Myrmicinae | | | |
| *Myrmica rubra (=ruginodis)* | W | 3 | Weir 1959 |
| *M. ruginodis* | ? | 3 | Mizutani & Yamane 1978 |
| *M. schrencki* | W | 4?[2] | Staercke 1949 |
| *Aphaenogaster rudis* | ? | 6?[2] | Wheeler & Wheeler 1976* |
| *Messor aciculatus* | W | 3 | Onoyama* |
| *Pheidole pallidula* | SW | 3 | Passera 1974 |
| *P. fervida* | FSW | 3 | Ono 1982 |
| *P. bicarinata* | SW | 4 | Wheeler & Nijhout 1983 |
| *Tetramorium caespitum* | W | 3 | Poldi 1965; Bruder & Gupta 1972 |
| *Monomorium pharaonis* | FMW | 3 | Berndt & Kremer 1986 |
| *Solenopsis invicta* | FMW | 4 | O'Neal & Markin 1975; Petralia & Vinson 1979a* |
| *Crematogaster stadelmanni* | FMW | 3 | Delage-Darchen 1972* |
| *C. striatula* | FW | 3 | Delage-Darchen 1978 |
| *C. scutellaris* | FMW | 3 | Casevitz-Weulersse 1983 |
| *Acromyrmex octospinosus* | FM | 5 | Torre-Grossa *et al.* 1982 |
| | W | 4 | |
| Formicinae | | | |
| *Plagiolepis pygmaea* | W | 5 | Passera 1968 |
| *Acantholepis frauenfeldi* | W | 5 | Tohmé & Tohmé 1975 |
| *A. syriaca* | ? | 5 | Tohmé & Tohmé 1980 |
| *Cataglyphis cursor* | FMW | 3 | Cagniant 1980 |
| *Formica japonica* | M | 3 | Imai 1965 |
| *F. polyctena* | FMW | 4 | Schmidt 1974 |
| *Camponotus aethiops* | F | 6 | Dartigue & Passera 1979 |
| | W | 5 | |
| *Polyrhachis lamellidens* | W | 4 | Kôriba 1963 |

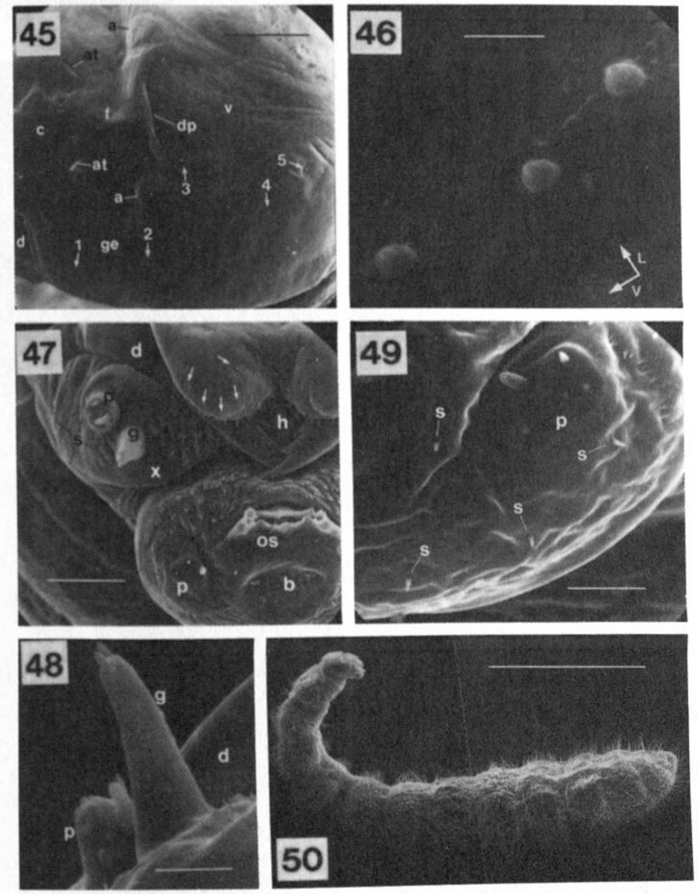
[1] Of the references in this column, only those cited in the text (marked with an asterisk) are included in Literature Cited
[2] Suggested but not confirmed by the authors

is indistinct in younger instars when observed with an SEM microscope). Labrum clearly bilobed, each lobe semicircular with 5 slightly papillose sensilla (Fig. 47, arrows); spinules on ventral surface well developed. Mandible long (Fig. 47); distal third slender, curved medioposteriorly, bearing 3 stout teeth (one apical and two subapical), of which apices positioned at almost equal intervals. Maxillary apex conoidal, with 1 spinose sensilla near palp and 1 near galea, and with 2 longer sensilla each on hypostomal furrow and on dorsoposterior surface (Fig. 47, s). Maxillary palp more slender, taller than wide; the top skewed with lateral half more protruding (Fig. 48). Galea greatly projecting, digitiform, about twice as long as maxillary palp, with 2 apical bullet like sensilla (Fig. 48). Labium with 4 pairs of spinose isolated sensilla on surface, ventral pairs clearly shorter than dorsal 2 pairs (Fig. 49); palp very short, bearing 5 sensilla similar to those on maxillary palp. Opening of sericteries well developed, about ⅓ as wide as labium, with an undulatory integumental short nozzle (Fig. 47). Body hairs (longest c. 150μm), about twice as numerous as those of 4th instar (see Table 1); uniformly distributed except sparse on ventral surface of TI but with numerous rows of posteriorly pointing spinules (Figs. 50-52). Markedly thick hairs (7.5-10.0μm in diameter at base) present on AIX (Fig. 53, arrows); their numbers 18-20 in female and 21-25 in male, arranged around the segment, all pointing posteriorly; occasionally a few additional ones on the preceding segment. Surfaces of AIX and AX with minute spinules in short rows. Collar processes of peritremes present on all thoracic and abdominal spiracles; diameter nearly uniform, ranging 11-15μm (Fig. 54). Anus opening ventrally near abdominal tip (Fig. 53, n).

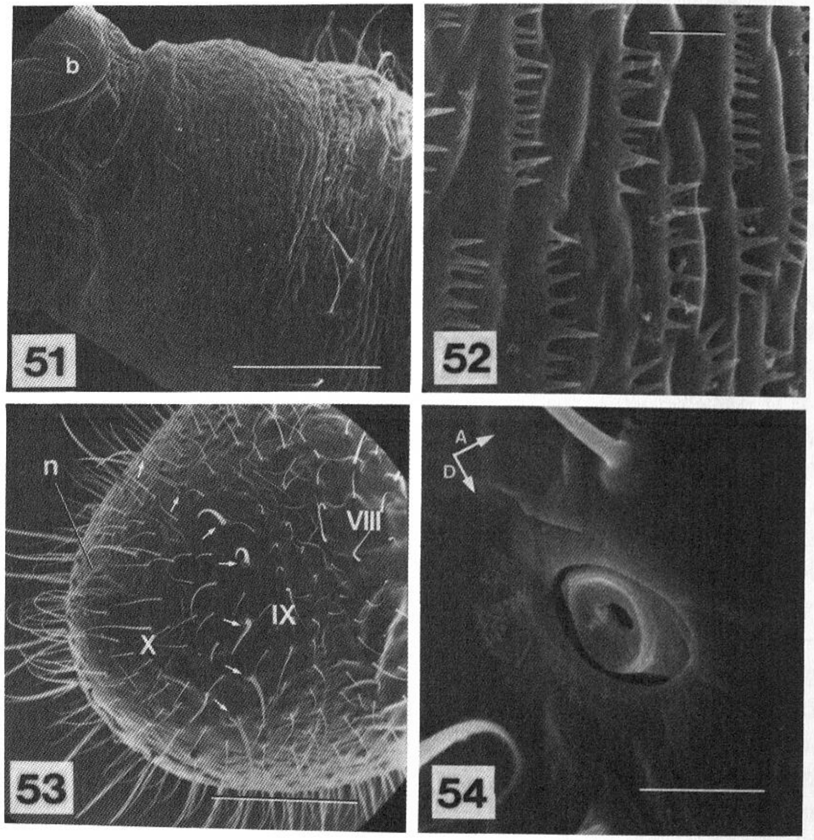
## DISCUSSION

For the genus *Amblyopone*, "very young" and "mature" larvae have been described for *australis*, *longidens*, and *pallipes* (Wheeler and Wheeler 1952b, 1964, 1971). The results of the present study on *A. silvestrii* are consistent with the description on these species. Morphology of ant larvae has been extensively examined and described by Wheeler and Wheeler (for summary see their monograph in 1976), and, based on these results, they have made several suggestions regarding ant taxonomy (Wheeler






Figs. 45-50. 45, Anterior view of head of 5th instar (female), showing conic or spinose sensilla (arrows) on its surface. Cranial regions except clypeus (c) bear 5 pairs of sensilla, of which those of the left half are numbered 1 to 5 in this photograph. A distinct groove (dp) exists between frons and vertex, which is probably the depression at the origin of frontal muscles (see text). Scale=50μm. 46, Right antenna of 5th instar (female). Anteromedial view. Arrows point laterally (L) and ventrally (V). Scale=3μm. 47, Ventral view of mouthparts of 5th instar (female). Arrows indicate 5 sensilla on the right half of the labrum. Note rows of spinules and opening of sericteries (os). Scale=30μm. 48, Maxillary palp (p) and galea (g) on right maxilla of 5th instar (male). Posterior view. Right mandible (d) is seen behind. Scale=10μm. 49, Labial palp (p) and 4 isolated sensilla (s) on left half of labium of 5th instar (female). Scale=10μm. 50, Entire body of half- grown 5th instar (male). Scale=1mm.




Figs. 51-54. 51, Lateroventral view of thoracic segment I of 5th instar (female). Ventral surface of the anterior half of the segment is covered with numerous rows of spinules. Scale=0.1mm. 52, High magnification of posteriorly pointing, ventral spinules on thoracic segment I of 5th instar (female). Scale=5µm. 53, Lateroposterior view of the last three abdominal segments of 5th instar (female). The segment IX has distinctively thick hairs (arrows). Scale=0.2mm. 54, Left lateral view of spiracle of thoracic segment II. Arrows point anteriorly (A) and dorsally (D). Scale=10µm.



and Wheeler 1985). Although most of their descriptions were based on mature larvae, the exact number of instars has been determined for few species. On the other hand, several authors described the instars of ant larvae under the necessity of instar discrimination in their research on caste determination or ecology of the interested species. As far as I know, the larval instars have been determined for 24 species of ants, including the result of the present study (Table 3). Onoyama (1982) also reviewed the number of larval instars for 12 species, and Wheeler and Wheeler (1986) has listed known numbers of instars for 18 species, principally based on Onoyama's review. The instar determination was generally based on chaetotaxy, form of hairs and body, morphological characteristics of mouthparts, or a combination of these. Although the determination by some authors remains inconclusive, it can be seen in Table 3 that the instar number reported for ant larvae mostly ranges 3 to 5, irrespective of castes. The relatively large number of larval instars (five) in *Amblyopone* may be an indication of more ancestral state of this genus in this aspect.

In general there is no sexual difference in the number of larval instars in ants (Table 3). However, some morphological differences between male and female have been found in larvae of several advanced genera (Trabert 1957; Delage-Darchen 1972; Wheeler and Wheeler 1952a, 1970a, 1976). The present study has shown that the number of body hairs differs between male and female larvae, though distinction remains to be made between queen and worker larvae. The larvae of *A. silvestrii*, even when they mature, do not have integumental structures related to internal imaginal discs of gonopods, such as known in the larvae of vespine wasps (Zander 1907; Yamane 1976). Hence, the caste discrimination is difficult in *A. silvestrii* until the larvae become prepupae, in which stage it becomes possible to examine the preconditions of internally developing imaginal discs (i.e., the presence or absence of the wing buds and the form of the gonopods). These organs are visible through the cuticle in preserved specimens *in toto*, and this enables distinction among male, queen, and worker (Masuko, unpubl. obs.).

*A. silvestrii* larvae are usually positioned by workers on whole paralyzed prey (chiefly, geophilomorph centipedes), where they insert the anterior body segments into the prey body by themselves and consume its interior (Masuko 1987). This insertion is so firm that a feeding larva often moves the posterior end of the body actively in the air. As described, the ventral surface, especially the anterior portion of the prothorax, is hairless. In contrast, in this region there are numerous rows of posteriorly pointing spinules, which are developed especially in the larvae of later stages. This spinulose prothoracic part surrounds the base of the head like a collar (see Fig. 44). Such spinules are also known from other amblyoponine genera, such as *Mystrium* and *Onychomyrmex* (Wheeler and Wheeler 1952b, 1952c), but apparently absent in *Apomyrma* (Wheeler and Wheeler 1970b). The feeding behavior of *A. silvestrii* larvae suggests that these thoracic spinules serve as minute hooks for their firm attachment to prey.

Moreover, hairs appear on the ventral surface of the body first in the 3rd instar. Hairless venters of the 1st and 2nd instars may be related to their oophagy. In this feeding, reproductive eggs laid by the colony queens are consumed as ordinary food for these young larvae (Masuko 1987). Laboratory observations have shown that each larva normally feeds on a total of 2 or 3 of such eggs before molting to the 3rd instar and thereafter it begins prey feeding (Masuko, unpubl. obs.). When in an egg pile, the 1st or 2nd instars usually adhere to eggs with their hairless ventral area. This suggests that this naked surface provides them with suitable placement for their oophagy.

Since Wheeler's (1918) classical work, there have been few studies on ant larvae from the viewpoint of functional morphology, except recent ones by Petralia and Vinson (1978 and 1979b). Probably, one reason for this is that ant larvae are apodous and totally, or for most parts, dependent on adults for nutrition and other activities. Consequently, morphological specialization of ant larvae is apparently less striking and thus more prone to be overlooked compared with specialization in adults. However, just a glimpse of the monograph by Wheeler and Wheeler (1976) convinces me that external structures of ant larvae vary considerably among taxa. Many of these differences must be closely connected with their feeding habits. Ant larvae thus deserve future study of functional morphology. To understand the functions and



adaptations of structures of ant larvae, however, information on feeding ecology of the concerned species will be necessary in most cases.

## ACKNOWLEDGEMENTS

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**Note added in proof: After the original submission of this manuscript, an additional publication has come to my notice, which described the larval instars of the formicine ant *Paratrechina flavipes* (Smith) (Ichinose, K. 1987, Kontyu 55:9–20). According to this, the larval stage of *P. flavipes* consists of four instars in all gynes, males and workers.**