Postembryonic Development of Megathripine Species, *Bactridothrips brevitubus* TAKAHASHI (Thysanoptera)*

by
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INTRODUCTION

It is thought that the postembryonic development of Thysanoptera shows as intermediate type between insects having incomplete and complete metamorphosis. Insects of the suborder Tubulifera, which includes only the family Phlaeothripidae, have five instars of immature stages, while four instars occur in the other suborder Terebrantia.

Descriptions and illustrations of these instars have been accumulated by some taxonomists, such as PRIESNER (1926, 1928, 1964), STANNARD (1968), ANANTHAKRISHNAN (1969), etc., and the biology and life-history of the insects, especially the species which have economic importances, have been studied by BUFFA (1911) in *Heliothrips haemorrhoidalis*, by FOSTER & JONES (1915) in *Taeniothrips inconsequens*, by SMITH & NELSON (1933) in *T. gladioli*, by MELIS (1935) in *Liothrips oleae*, by BUHL (1936) in *Kakothrips robustus*, by RAHMAN & BHARDWAJ (1937) in *Rhipiphorothrips cruentatus*, by SPEYER & PARR (1941) in many species of Aeolothripidae and Thripidae, by PESSON (1951) in general remarks, by LOAN & HOLDAWAY (1955) in *Haplothrips niger*, and by FRANSSEN & MANTEL (1965) in some cereal thrips. On the other hand, morphological studies of the postembryonic development have been done by MÜLLER (1927), DAVIES (1961, 1969), and HEMING (1970a, 1970b, 1971, 1972) using as materials thrips belonging to Thripidae and Phlaeothripinae.

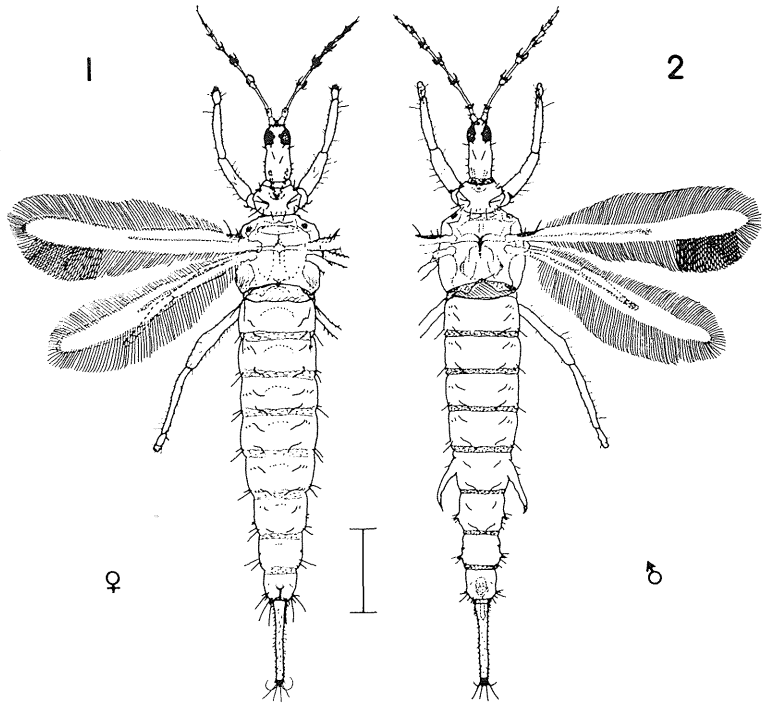
In spite of the phylogenetical interest and their large size, the postembryonic development of the insects of the subfamily Megathripinae has never been fully investigated, either biologically or morphologically, except for only a partial observation on the development and life-history of *Megathrips lativentris* reported by JOHN (1922).

This paper describes the immature stages of a Megathripine species, *Bactridothrips brevitubus*, and presents some notes on its life-history and metamorphosis, and terminology of the immature stages and the metamorphosis of Thysanoptera are discussed.

MATERIALS

A large spinose thrips, *Bactridothrips brevitubus* TAKAHASHI (figs. 1 & 2.) lives on the

* Contributions from the Sugadaira Biological Laboratory of Tokyo Kyoiku University No. 26



Figs. 1-2. *Bactridothrips brevitubus*. 1. Female, 2. Male. Scale : 1 mm.

dead leaves of evergreen trees of the following genera : *Quercus*, *Shiia*, *Cinnamonum*, *Machilus*, and *Litsea* which are distributed throughout the warm-temperate zone of the south-western Japan. The insects aggregate on the upper surface of the leaves, feeding the spores of certain imperfect fungi which spread in the tissues of leaves.

There are more than six species of the genus *Bactridothrips* in Japan including some species which have not been studied taxonomically,* but the author has used two unnamed species for a purpose of comparison. Collecting localities and host plants of these species are :

B. brevitubus	Mino-o, Osaka.	Above-mentioned plants.
B. sp. I.	Mino-o, Osaka.	*Quercus glauca.*
B. sp. II.	Sugadaira, Nagano.	*Q. crispula.*

METHOD

Thrips and a dead leaf were removed and placed in a deep petri dish with a small wet filter paper to retain moisture. The series of rearing dishes were kept at room temperature (20°−25°C). When necessary the old leaf was replaced by another dead leaf.

* The author is studying these species.

Immature thrips were fixed by A.G.A. solution or 60% ethanol for total mount, or alcoholic BOUIN's fixative for histological study. Some insects were mounted directly in the water soluble mountant *Gum-chloral* in order to retain their body colour. Other specimens were decoloured with caustic potassium, and after dehydration they were mounted in *Euparal* mountant.

All drawings were made with the Abbe camera lucida.

DESCRIPTION OF IMMATURE STAGES

First larval instar (L 1) (Figs. 4 & 5.)

Body length : 0. 90—0. 96 mm. (just hatched) ; 1. 88—2. 02 mm. (just before ecdysis).

Colour pale yellowish grey, sclerotized portions pale grey ; meso- and metathorax and abdomen with three rows of red hypodermal pigments ; eye pigments dark red.

Head capsule including mouth-cone relatively very large, square in shape anteriorly, semioval posteriorly, with smooth surface ; eyes consist of each two ommatidia and area just behind them containing dark red pigments ; dorsum of head with three pairs of prominent setae slightly curved, acute at apices, i.e. middorsal pair (SPEYFR & PARR's 1.) longest, anteocular pair (S. & P. 3.) subequal to postoculars (S. & P. 4.). Maxillary stylets very well developed, band-like, situated in deep head near eyes in V-shape ; maxillary palpi two segmented, similar in shape to those of adult ; mandibular stylet stout, orange yellow in colour while maxillary stylets yellow ; labial palpi short.

Antennae six segmented ; morphological segment VI and VII completely fused. Segment I broader than long, with short seta directed inwardly. Segment II longer than wide, with five setae, and round sensorium on dorsal anterior third. Segment III claviform, white at anterior fifth, with very long straight, sharp seta on dorsal anterior fifth ; apical outer edge with short slender sense cone. Segment IV gradually swollen forwards ; apical inner edge with stout sense cone ; surface with mere striae ; two long dorsal, and one outer lateral setae present ; apical outer edge with dark finger-like sense stick. Segment V with three setae ; apical outer edge with sense cone shorter than that of segment IV. Segment VI parallel sided at basal half ; apical half narrower than basal half ; morphological segment VI with sense cone on outer dorsal surface and long seta on inner dorsal, and two setae on ventral surface ; extreme apex with two stout, straight setae and four setae curved slightly.

Prothorax with large sclerotized plates, and with four pairs of pronotal setae well developed except for minute B_1 and B_2. Mesothorax with a pair of spiracles on its shoulder, with five pairs of setae. Metathorax similar to mesothorax, without spiracles. Fore coxa with two long and one short setae on each dorsal and ventral surface ; fore femur parallel sided, smooth ; fore tibiotarsus also parallel sided, swollen bulbously at apex ; fore pretarsus complicated, with a pair of inwardly curved terminal setae, stout straight terminal seta, paired unguis, and arolium with several radial ribs. Mid- and

hind legs same to fore legs except for lengths.

Abdomen of just hatched larva : segment I as broad as metathorax ; segments II-VIII gradually narrowed and shrunken, setose in appearance ; length of the shrunken segments II-VIII together shorter than head capsule ; segment IX sclerotized, rectangular in shape, wider than shrunken segment VIII, with three pairs of long setae, dorsal pair and lateral pair longer than ventral pair, all these setae with apices slightly dilated, spoonlike, with two pores and neighboured minute setae ; segment X gradually narrowed towards apex, width at base 2. 5 times as wide as at apex, with slight striae, and with a pair of pores, minute setae, and ventral short setae ; segment XI ring-like, very short, with four variable pairs of anal setae, i.e. straight short pair, curled pair, short lanceolate pair, and long angulated setae of which apices spoon-like.

Abdomen of LI of just before ecdysis : segments II-VIII fully expanded, about three times as long as head capsule ; segment I with two pairs of dorsal setae, lateral pair short, without ventral setae ; segment II and segment VIII with a pair of spiracles ; segment II-VIII each with three dorsal pairs and paired weak ventral setae ; segment IX, X, and XI unchangeable in the duration.

Measurements in mμ of a full-grown L I.

Head capsule with mouth-cone length 365, width across eyes 185, width across cheeks 200 ; prothorax length 140, width 255 ; mesothorax length 85, width 245 ; metathorax length 90, width 225 ; abdominal segments I-VIII together length 1100 (of just hatched larva 200), segment II length 105, width 390 (widest), segment VIII length 195, width at anterior margin 190, at posterior margin 120, segment IX length 65, width 125, segment X length 165, width at base 110, at base 110, at apex 45 ; fore femur length 140, width 70, fore tibiotarsus length 200, width 50, fore pretarsus length 45, width 30 ; midleg subequal to foreleg ; hind femur length 165, width 65, hind tibiotarsus length 210 ; setae length : middorsals of head 92, anteoculars 65, postoculars 68, prothoracic B_3 62, B_4 95, B_5 58, B_6 72, mesonotal longest setae 158, tergal three pairs of segment II 78, 95, 78, of segment VIII 110, 80, 108, longest seta of segment IX 230, anal long seta 295, long seta of antennal segment III 135.

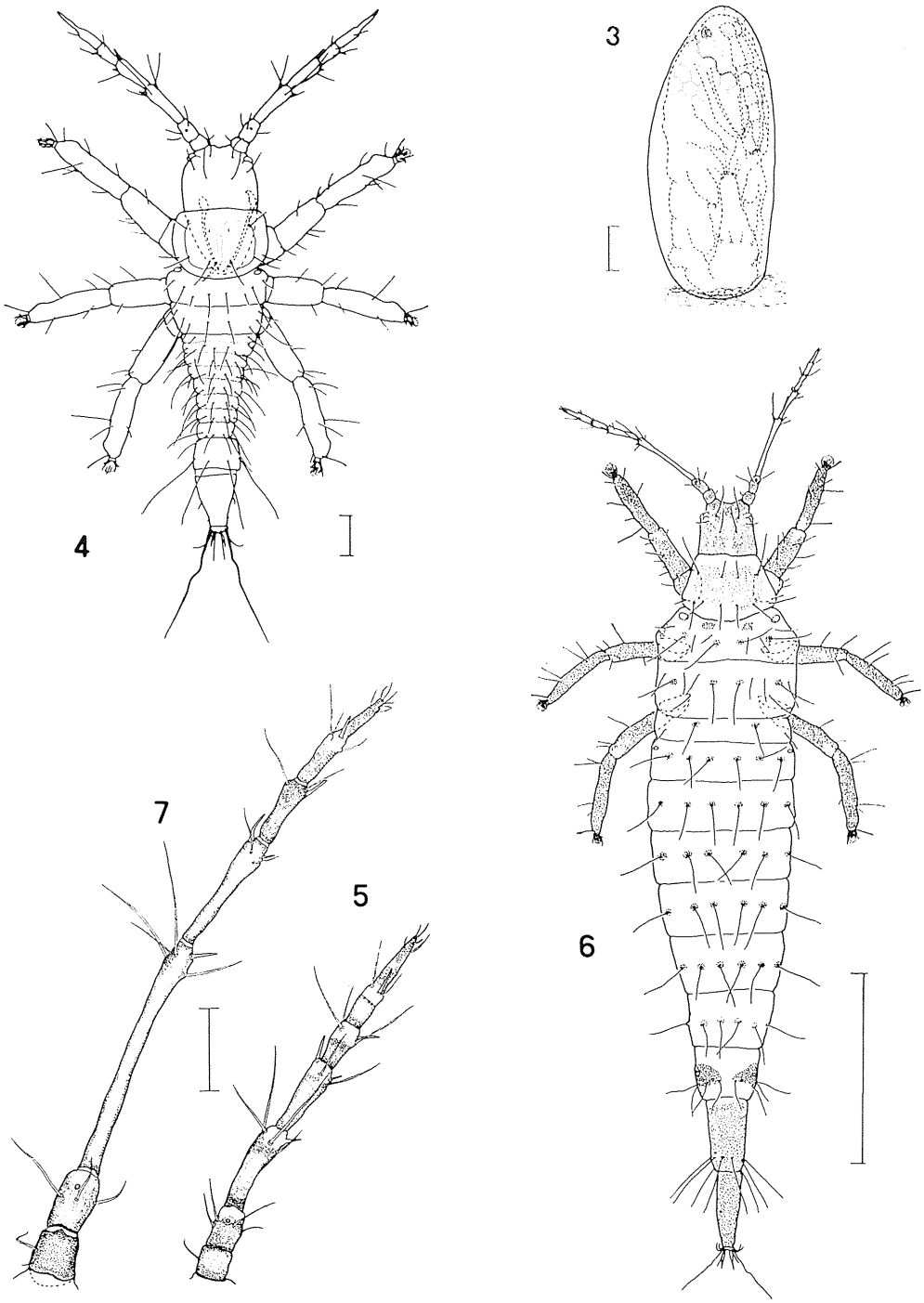
Antennal segments :

	I	II	III	IV	V	VI
Length	40	55	125	100	60	135
Width	45	40	35	37	30	25
Sense cone length			20	28	17	26

Second larval instar (L II) (Figs. 6, 7, 11, 17.)

Body length : 3. 6—3. 8 mm. (full-grown larvae).

Colour redish grey, sclerotized portions greyish brown ; meso- and metathorax and



Figs. 3–7. *Bactridothrips brevitubus.* 3. Egg, just before hatching. 4. First larva (L I), just hatched. 5. Right antenna of LI. 6. Second larva (L II). 7. Right antenna of L II. Scales : 3–5, 7. 0.1 mm., 6. 1 mm

abdomen with three rows of red hypodermal pigments, often diffuse in the whole surface.

Head trapezoid in shape, almost sclerotized, with weak striation ; cheeks smooth, without setae ; eyes consist of three ommatidia on dorsum and dark red pigment ; a pair of small oval sclerotized platelets in contact with each other on the middle between eyes ; three pairs of dorsal head setae curved, pointed or blunt at tip, mid-lateral seta (S .& P. 1) longer than postocular seta (S. & P. 4) and subequal to middorsal seta (S. & P. 3). Four pairs of ventral head setae slender, the apical pair and basal middle setae very long, sharply pointed. Maxillary stylets V- or U-shaped, mesad ; mandibular stylet stout but short ; maxillary palpi two segmented, broad ; labial palpi very short.

Antennal segment I as long as wide, slightly narrowed to the apex, with hooked inner seta and basal vestigeal seta. Segment II twice as long as wide, basal two thirds dark, with round sensorium on dorsal surface at apical fourth, and with four long setae and short curved seta. Segment III elongated, more than ten times as long as wide at widest part, pale coloured, somewhat clouded at base, with two long and two short setae, and with outer slender sense cone near apex. Segment IV gradually swollen to apex, twice as wide at apex as at base, with two short setae and inner sigmoid sense cone and outer dark sense stick. Segment V constricted at basal third, with three long setae and outer sense cone. Segment VI similar to first larval segment VI.

Prothorax with paired sclerotized plates and six pairs of setae ; additional seta present near B_6, short ; B_1 very short, B_2 far from anterior margin, B_3, B_5, B_6 subequal each other, long. Fore leg same as first larval foreleg but more sclerotized. Mesothorax three times as wide as long, with a pair of spiracles near shoulder ; and with six pairs of dorsal seta of which bases are sclerotized ; a pair of square grey plates present near anterior margin. Metathorax 2. 5 times as wide as long ; chaetotaxy subequal to mesothorax.

Abdominal segment I short, rectangular, with two pairs of dorsal setae. Segment II with a pair of small spiracles at lateral anterior third. Segment II and III parallel sided, slightly wider than width of metathorax ; abdomen gradually narrowed from segment IV to segment X. Segment II-VIII with three pairs dorsal setae which arise from grey plate. Segment VIII with a pair of spiracles and large dorsoventral triangular sclerites ; segment IX and X tubiform, elongated, sclerotized, with weak anastomosing striae ; IX with eight straight long setae around posterior fifth ; terminal setae consist of two curled pairs, short pair, lanceolate pair, and major pair slightly meandered, pointed ; ventral surface of abdomen with two pairs of weak setae.

Measurements in mμ of a full-grown L II.

Head capsule with mouth-cone length 580, dorsal head length 270, width across eyes 260, width at base 30 ; prothorax length 330, width at anterior margin 300, width at

posterior margin 500 ; mesothorax length 200, width at anterior margin 520, width at posterior margin 680 ; metathorax length 280, width 710 ; abdominal segment : length, width at anterior margin, width at posterior margin, respectively : segment I. 120, 700, 700 ; II. 210, 740, 740 ; III. 260, 730, 730 ; IV. 260, 730, 700 ; V. 280, 690, 590 ; VI. 260, 590, 460 ; VII. 290, 460, 340 ; VIII. 260, 330, 240 ; IX. 370, 210, 140 ; X. 390, 120, 50. longest seta of abdominal IX 360, of X 310. Lengths (widths) of fore-, mid-, and hind legs, respectively : femora, 250 (100), 270 (100), 320 (100) ; tibiae, 350 (70), 360 (70), 440 (70) ; tarsi, 70 (40), 70 (40), 70 (40).

Lengths of antennal segments : I, 60 ; II, 90 ; III, 340 ; IV, 170 ; V, 100 ; VI, 160.

First pupal instar (P I) (Figs, 8, 12, 18, 20.)

Body length : 3. 3-3. 6 mm.

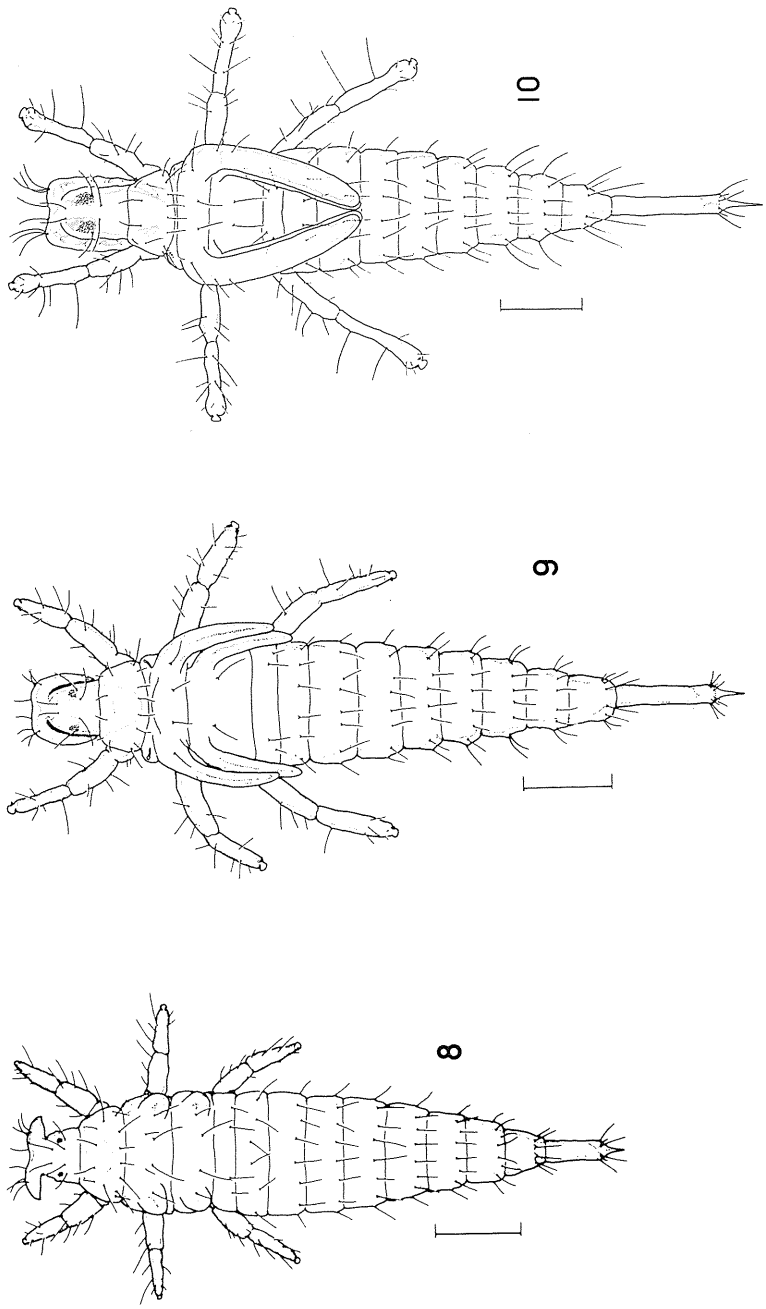
Red and bloated. Body thick, covered by thin, soft integument, only sclerotized weakly at tube.

Head semioval, narrowed to antennal base, with thick, horn-like antennae ; eyes incomplete, without lens, and with three pairs of prominent setae on dorsum and two pairs of weak setae on ventral surface. Antennal sheath not segmented, with four pairs of long curved setae directed forwards and three pairs of tiny cone-like projections. Prothorax trapezoid, with six pairs of setae. Mesothorax with a pair of spiracles, with a pair of short wing pads. Metathorax without spiracles, with a pair of short wing pads, with two pair of dorsal setae. Legs three segmented, viz. coxa, femur, and tibiotarsus ; apices of legs not segmented, with round, non-flexible bladder (pupal arolium) and a pair of fixed short tarsal claws (pupal unguis) hooked, wide apart each other.

Abdominal segment II-VIII with three pairs of dorsal setae, pointed ; segment IX with five pairs of straight setae ; tube parallel sided with wide based apical cone and with dorsal three pairs and ventral four pairs of terminal setae.

Measurements in mμ of PI.

Head length (with mouth-cone) 500, width at base 320, width at antennal bases 190 ; antenna length 230 ; prothorax length 270, width at anterior margin 330, width at posterior margin 530 ; mesothorax length 250, width at anterior margin (across spiracles) 330, width at posterior margin 770 ; metathorax length 270, width 750 ; abdominal segments : length (width) : I, 150 (700) ; II, 220 (750) ; III, 210 (780) ; IV, 240 (740) ; V, 250 (660) ; VI, 240 (560) ; VII, 220 (450) ; VIII, 230 (370) ; IX, 200 (270 at base, 140 at spex); X, 400 (120, 90) ; apical cone length 60. Length (width) of legs, fore-, mid-, and hind leg, respectively : femora, 210 (100), 220 (100), 230 (100) ; tibiotarsi, 250 (80), 280 (80), 310 (80).



Figs. 8–10. Pupae of *Bactridothrips brevitubus*. 8. First pupa (P I). 9. Second pupa (P II). 10. Third pupa (P III). Scale : 1 mm.

Second pupal instar (P II) (Figs. 9, 13, 21.)

Body length : 3. 4-3. 8 mm.

Red. Body thick, covered by thin, soft integument ; this sheath sclerotized only at tube.

Head elongated, with three pairs of prominent dorsal setae, anterior pair situated near antennal base, posterior two pairs arranged in a row behind eyes ; antennal sheaths closely contacted with lateral margins of head, with four pairs of long, curved setae and small short cone-like projection at apical fifth ; antennal sheaths not segmented. Eye portions long, developed dorsoventrally, with transverse or radial structure and small pigmental area at posterior end.

Prothorax trapezoid, with three pairs of anterior setae and four pairs of posterior setae ; mesothorax with a pair of spiracles at anterior angles ; metathorax about twice as long as mesothorax ; each meso- and metathorax with a pair of wing pads elongated along lateral margins of thorax and abdomen. Legs consist of coxa, femur, and tibiotarsus, and with apical bladder (pupal arolium) and a pair of tarsal claw (pupal unguis); all legs similar in shape and structure to each other and to those of P I.

Abdomen gradually narrowed towards apex ; segment I with two pairs of dorsal setae ; segment II-VIII with three pairs of dorsal setae ; setae of segment IX rather short ; tube parallel sided with apical cone, longer than that of P I, with six pairs of terminal setae.

Measurements in mμ of P II.

Head length (from anterior margin of antennal sheath to apex of mouth-cone) 550, dorsal head length (from anterior margin of antennal sheath to anterior margin of prothorax) 350, width at dorsal base 330, width across eyes 250, width at base of antennae 150. Prothorax length 270, width at anterior margin 350, width at posterior margin 540 ; mesothorax length 180, width at anterior margin 550 ; metathorax length 340, width at posterior margin 680 ; wing pads length 670 (fore), 560 (hind). Abdominal segments : length, width at anterior, and at posterior margins respectively : I, 150, 660, 660 ; II, 220, 680, 700 ; III, 220, 690, 680 ; IV, 230, 680, 640 ; V, 240, 625, 550 ; VI, 250, 530, 450 ; VIII, 220, 350, 300 ; IX, 220, 280, 150 ; X, 470, 130, 110 ; apical cone length 140. Legs length (width) of fore-, mid-, and hind legs : femora 255 (105), 260 (105), 290 (110); tibiotarsi, 320 (90), 340 (90), 380 (90).

Third pupal instar (P III) (Figs. 10, 14, 15, 16, 19.)

Body length : 4. 0-4. 7 mm.

Body more elongated than P II. Colour same to P II.

Head capsule twice as long as wide, slightly constricted behind eyes ; antennal sheaths elongated along cheeks and extended to mouth-cone ventrally ; head with three pairs

of prominent setae, viz. anterior pair near antennal base, posterior two pairs situated middle of dorsum, not in a row, antennal sheath with four pairs of curved long setae, same to P I and P II. Prothorax trapezoid, with three anterior pairs and four posterior pairs of setae ; mesothorax with paired spiracles ; legs more elongated than P II, apex of tibiotarsus swollen bulbous, with pupal arolium and pupal unguis as like as P II and P I. Abdomen gradually narrowed towards apex ; segment I with two pairs of setae; segment II-VIII with three pairs of dorsal setae and a pair of lateral setae, slightly curved ; segment VIII with a pair of small ruptures laterally ; segment IX with straight long setae ; tube parallel sided with long apical cone.

Measurements in mμ of P III.

Head capsule length 740, dorsal head length 480, width at base 340, width at narrowed cheeks 300, width across eyes 310 ; antennal sheath length 850, width 100 ; prothorax length 290, width at anterior margin 330, at posterior margin 540 ; mesothorax length 180, width 670 ; metathorax length 400, width 720 ; wing pads lengths 1200 (fore), 1055 (hind) ; Abdominal segments : length, width at anterior margin, and at posterior margin, respectively : I, 130, 740, 750 ; II, 220, 760, 790 ; III, 250, 800, 770 ; IV, 250, 760, 650 ; V, 260, 640, 600 ; VI, 250, 595, 495 ; VII, 260, 490, 420 ; VIII, 240, 410, 350 ; IX, 350, 340, 180 ; X, 680, 130, 130 ; apical cone length 230.

Forefemur length 355, foretibiotarsus length 515, midfemur length 395, midtibiotarsus length 530, hind femur length 500, hind tibiotarsus length 625.

METAMORPHOSIS

Bactridothrips brevitubus evidently has two different forms during the postembryonic development. In the former form the immature insect has a hard cuticular integument except for its abdominal segments which are covered with elastic membranes. Some similar features of the form are found in almost all adult insects, for example, in the mouth-parts to enable them to feed on fungal spores, and in the flexible elongated antennae with the sense cones and the second segmental round sensoria. However, in the latter form, the immature insect has a thin and non-sclerotized integument covering the body as a protective sheath. These two forms are called the larva and the pupa respectively.

Ecdyses occur five times in the postembryonic life of an immature insect, as follows :

Egg (fig. 3.)
↓ ..... (hatching)
lst larval instar (fig. 4.)
↓ ..... lst ecdysis
2nd larval instar (fig. 6.)
↓ ..... 2nd ecdysis (pupation)
lst pupal instar (fig. 8.)

↓ ..... 3rd ecdysis
2nd pupal instar (fig. 9.)
↓ ..... 4th ecdysis
3rd pupal instar (fig. 10.)
↓ ..... 5th ecdysis (emergence)
Adult (fig. 1 & 2.)

Changes in the form of the first instar larve are almost slightly through the first ecdysis, and only following differences are recognized : each antennal segment is more elongated ; most of the head surface is sclerotized ; the abdomen is more developed ; the eighth abdominal segment is partially sclerotized ; the tenth abdominal segment is elongated and in the form of a sub-parallel sided tube.

By the second ecdysis a considerable transformation has occurred which may be called the "pupation". The second instar larva eats a good deal of food and grows steadily. When it is fully grown, a pupal integument becomes clear within its body. The moulted insect or first pupa has escaped through the rupture of a non-sclerotized suture-like part of the dorsum of the head. The insect seems soft and deformed, resembles neither the first nor the second instar larvae nor the adult.

The exuvia of the second larva has distinct mouth-parts with a coloured mandibular stylet and paired maxillary stylets which have not moulted at the first ecdysis, while there is no stylet whithin the mouth-cone of the insect in the first pupal instar.

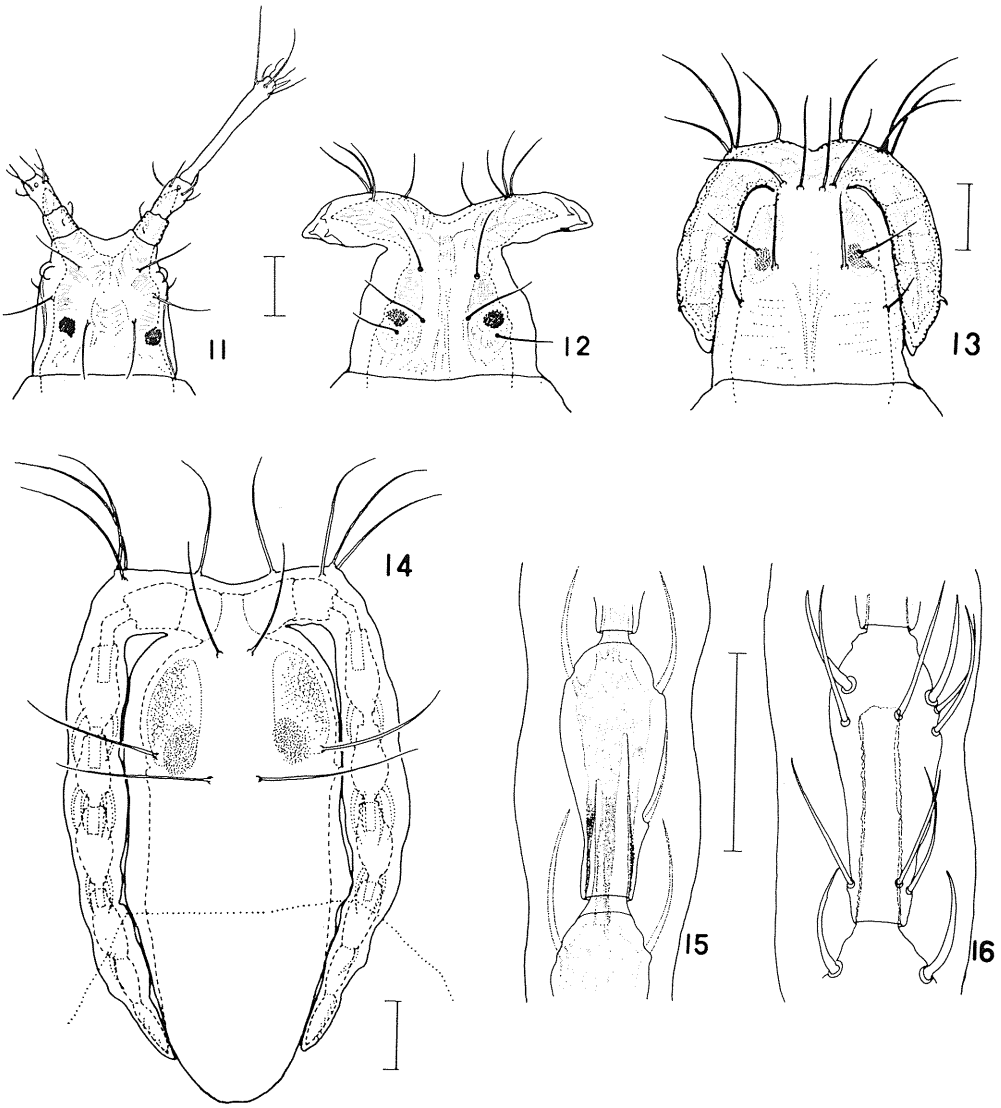
The transformations through the third ecdysis are conspicuous only in antennal sheaths and wing pads. These parts of the pupa are changed again during the fourth ecdysis.

The shed exuvia of the pupa adhering to the leaf is very thin, faintly coloured, and shrunken, except the weak sclerotized tube sheath.

The insect of the last immature stage develops steadily to the adult form. Then the adult insect appears through the fifth ecdysis, of which the exuvia of the third pupa is a little more sclerotized than that of the early pupal stages.

TRANSFORMATION OF SOME EXTERNAL ORGANS

Antennae. A pair of the first pupal antennae are prepared within each basal two antennal segments of a matured larva (fig. 11) and they are short, thick horn-like projections, and covered by a transparent sheath with a pointed apex and three tiny cone-like processes (fig. 12). On the anterior margin of the first pupal antennal sheath are three pairs of curved long setae resembling sensory hairs. In the mature first pupa one more transparent membrane is recognized and this is the second pupal antennal sheath. The internal tissue of the atennae does dot segment in the first pupal stage, but it is metamerized in the late second pupal stage (fig. 13). In the second pupal instar, the sheath elongates along the cheeks and extends almost to the anterior margin of prothorax, and it has two pairs of tiny processes near the apices and four

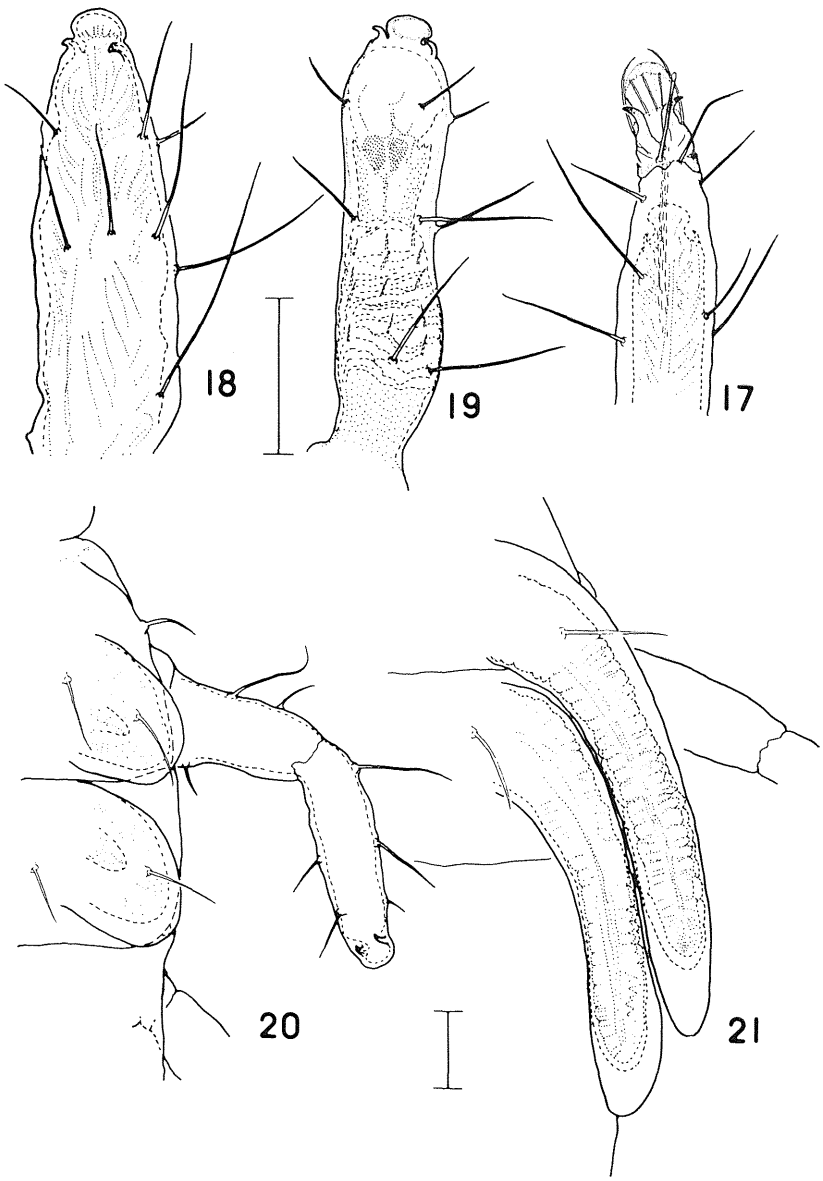


Figs. 11-16. Head with antennae of *Bactridothrips brevitubus*. 11. Mature L II. 12. P I. 13. P II. 14. Mature P III. 15. Antennal segment III of median period of P III. 16. Antennal segment III of late P III. Scales : 0. 1 mm.

pairs of long setae pointing forward. The histolysis of the antennal tissue begins after the fourth ecdysis, and about two days later the segmented blocks of the tissue appear again. These blocks are transformed into each of the antennal segments of the adult. In particular the elongated segments consisting of the swollen head, from which the sense cones project, and a long stalk are formed : the form of each block changes to oval ; the apical swollen part is clear in the oval shape (fig. 15.), and the setae and sense cones appear indistinctly and the long stalk is formed in the swollen head as a

double walled tube (fig. 16), and thus the completed antennae in the pupal sheath are similar to the beads in shape and have the tunnel-like space within them (fig. 14). The stalk is drawnout from the swollen head when the pupal sheath has been shed.

Wings. The wing pads appear early in the first pupal instar. They are two pairs of mere swellings situated on the mesothorax and metathorax (fig. 20). Both the



Figs. 18-21. Leg and wing pads of *Bactridothrips brevitubus*. 17. Apical half of foreleg of L II. 18. Tibiotarsus of P I. 19. Tibiotarsus of mature PIII. 20. Wing pads of P I. 21. Wing pads of P II. Scales : 0.1 mm.

margins and internal tissues of these swellings are rather hard to detetc, so that several workers have spoken of the absence of wing pads in PI. In the second pupal instar, the wing pads develop along the margins of the thorax (fig. 21). There is a wrinkled membrane covered with crumpled tissues in the wing sheath, and this membrane is the third pupal wing sheath. The tissue has a longitudinal tube-like line and short cross striae, and no other structures are present. The third instar pupa has long V-shaped wing pads on the dorsum of the body. It seems that the wing pads in the second pupa grew to become the third pupal wing pads. However, the histolysis of their tissues occurs immediately after the ecdysis, then the new structures are gradually reconstructed. The segment-like cross wrinkles appear distinctly at the basal half of the pad and the fringe cilia are formed densely and curved.

Eyes. The eye of the larva is composed of two or three ommatidia with dark red pigments and is located on dorsum of the head. The shape of the compound eye of the adult is transformed dorsoventrally under the sheath of the third pupal instar, and the ommatidia do not gradually increase in number but many ommatidia appear simultaneously in the late pupa.

Three ocelli are transformed finally in the third pupal stage.

Legs. The legs of larva in both stages are slightly sclerotized, and each of them consistis of the coxa, femur, tibiotarsus, and pretarsus (HEMING, 1972). The pretarsus is furnished with a protrusible, bladder-like arolium with the pretarsal scolopidia, a pair of unguis, a stout terminal seta, and a pair of curved terminal setae. These characteristic structures do not carry over into the pupal stages but are cast off with the larval integument. In the tibiotarsus of the mature larva the developing pupal leg can be seen (fig. 17). Through the pupal stages the legs are simplified and do not resemble those of the larva and adult. The pupal leg has the tibia, tarsus, and pretarsus which are united in a thick tibiotarsal part covered by a sheath having a round and non-elastic "arolium" on the apex, and a pair of small immovable "unguis" (fig. 18.) In the mature pupal instar the leg includes an adult leg consisting of the expanded pretarsus, tarsus, and wrinkled tibia (fig. 19).

BIOLOGICAL OBSERVATIONS

Oviposition. The female oviposits on the dead leaf of *Fagaceae* and *Lauraceae* which are the characteristic habitat of the insect. As a general rule, it places the eggs along a leaf vein, mostly along the median nerve of the upper surface of the leaf. It often lays the eggs on the wall of a vial, but the author has never found the eggs on the back of the leaf.

The mass of deposited eggs consists of 10—40 eggs, and they are attached to each other with an adhesive substance and fixed on the leaf at their posterior end.

The female lays a few eggs before dawn each morning for three or more days. The average number of eggs laid each of ten females was ca. 26.

Protection of egg. A male, in most cases, or a female or both sit quiescently close to the egg-mass. This seems to be in order to guard the batch, but it does not actively ward off enemies that may harm the eggs, such as the sucking mite and the red bug. The male or female occasionally touches the egg-mass with its antennae or fore tarsi.

Egg period. The period of the egg development in the laboratory at 20°—25°C was five to seven days. LOAN & HOLDAWAY (1955) reported that that of *Haplothrips niger* was 4.0—6.0 days at 25°C in the laboratory, but it was 10.0—12.0 days in the field at Ontario in early June. JOHN (1922) said that the egg of *Megathris lativentris* hatches 14 days after oviposition and the egg period is occasionally extended for a very long time in Novgorod, Russia.

Hatching. The full-grown embryo is seen through the chorion. It has a pair of red eye spots, three red abdominal hypodermal pigmentlines, and grey patterns of sclerotized parts of the larval head and prothorax near the top of the egg.

At the beginning of hatching, a slight movement of the red spots occurs and continues for two to five minutes, then the egg-shell is suddenly ruptured. This rupture runs transversely along the hexagonal reticulations at the apical third of the egg, but sometimes it runs longitudinally or irregularly. The larval head appears from the rupture of the egg-shell after only a half minute, the whole of the antennae of the new larva appear in the next minute, the thorax comes out at four and a half minutes after the start of hatching, the forelegs become free after next two minutes, and the midlegs appear one minute later. It takes nine minutes from the beginning of hatching for a new larva to emerge completely and begin walking around busily on the egg-mass. It neither eats the chorion nor drops any faeces, and them goes down on the leaf.

Duration of immature stages. As a conclusion of the periodical observations at half day intervals, at 9 a.m. and 9 p.m. in the laboratory, the duration of each immature stage is shown in the following table.

The shortest duration of the total larval stage, from hatching to pupation, is completed in 10.5 days and the longest duration is 17.0 days (mean : 12.4). The shotest duration of the total pupal stage, from pupation to emergence, is completed in 5.0 days (1.0, 1.5, and 2.5 days in the three stages respectively), and the longest duration is 7.5 days (1.5, 2.5, 3.5). The mean length of the entire pupal stage is 6.5 days. Thus the postembryonic development of *Bactridothrips brevitubus* is completed in two

Table 1. Duration of immature stages.

	Shortest duration	Longest duration	Mean
L I	3.0 days	6.5 days	3.4 days
L II	7.5 days	13.5 days	9.2 days
P I	1.0 days	1.5 days	1.2 days
P II	2.0 days	4.5 days	2.8 days
P III	2.5 days	7.0 days	4.3 days

to three weeks, and its mean is 18.2 days.

Life-history. Field observations in Mino-o of Osaka, including in the warm-temperate zone where there is little snow and frost, showed that *Bactridothrips brevitubus* has multivoltine life-history through a year. In any season of the year all stages of the insect are found on the dead leaves, the insects being particularly abundant during April, May and June. The overwinter forms of the insect are variable, and we can find the larvae, pupae and both sexes of the insect living under snow. However, while it is difficult to find the living egg-masses in the winter, the second larvae are readily found.

In the laboratory the insects reach the third generation within two months.

Ovoviviparity. *Bactridothrips brevitubus* has both forms of reproduction, viz. oviparity and ovoviviparity as reported in some members of Megathripinae. In the case of ovoviviparity the eggs remain develop in the lateral oviducts of the maternal body.

Examination of whole mounted specimens and dissected examples shows that about half the females examined had various numbers of developing embryos at various stages in their bodies as shown in the following table :

Table 2. Numbers of female having various numbers of embryos.

Number of embryos in a female	0	1	2	3	4	5	6	7	8	9	10
Whole mounted specimens	76	2	5	4	4	1	4	0	1	1	2
Dissected individuals	27	0	0	1	0	3	1	2	0	0	4

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total
1	0	3	1	1	4	3	2	0	1	0	0	1	0	0	117
4	4	2	1	3	5	0	6	2	2	3	1	1	1	1	74

The largest number of embryos in a female was twenty-five, eleven in the right and fourteen in the left of the paired oviducts.

Sometimes the hatched larvae and empty choria were found in the common oviduct

or genital tract of the adult females. However, in general, the female lays full-grown eggs on the dead leaf. These eggs are somewhat shorter, but broader than the oviparous ones in size. and have very thin white, translucent chorion.

The relationship between the ovoviviparity and the structure of the female reproductive systems will be discussed in a later report.

DISCUSSION

There are two immature phases in the species of Phlaeothripidae as previously mentioned, that is, 1. an active, well feeding phase including two instars called generally *larva* ; 2. an inactive, non-feeding phase including three instars called generally *pupa*.

Some authors hesitated to use the term *pupa* for the second phase, because the term was usually used of holometabolous insects, so that the term *nymph* or its equivalent in other languages has been used instead of *pupa* (JORDAN, 1888 ; UZEL, 1895 ; HINDS, 1903 ; MELIS. 1935 ; PESSON, 1951). But the term *nymph* was also occasionally used to refer to the active first phase (LOAN & HOLDAWAY, 1955 ; COTT, 1956). This confusions of terminology was discussed by COTT (1956) who stated that the confusion was derived from the following three sources : 1. irregularity of Thysanopterous development, 2. differences in the terminology employed by American and European workers, 3. employment of terminology interchangeable by individual workers.

In addition to the above three reasons, insufficient knowledge of the metamorphosis of the Thysanopterous insects led to obscurity about the naming of stages. Therefore only the accumulation of accurate knowledge concerning the development in the immature stages would solve these controversial problems.

The author does not hesitate to use the term *pupa* for the latter three quiescent instars of *B. brevitubus*. These pupae can walk slowly when they are stimulated, but their antennae, head, thorax and most parts of the abdomen are fixed and immovable, and are covered by the protective over-all sheath. The apices of their legs are not divided into two segments of tibiotarsus and pretarsus, and at each apex two short fixed claws and a round solid bladder are present for supporting their body. The transformation of the external organs progressesses in the three pupal stages step by step but not continually. It seems that the organs growgradually through these three stages. However, the insect of the last immature stage has a period, that is the tissues in the wing pads or antennal sheaths of the insect become clear just sfter the ecdysis and the adult organs gradually appear in its body. This manner of transformation appears similar to the histolysis and organogenesis in the holometabolous pupa.

The names of these three pupal stages are controversial, too, and the most authors used the terms *prepupa* or *propupa* for the first pupal instars (PRIESNER, 1928 ; DAVIES, 1961 ; ANANTHAKRISHNAN, 1969 ; HEMING, 1970). These usages are presumably based on the following features of the first pupal instar : 1. the duration of the instar is relatively short, as it seems only a short transitory stage ; 2. the wing pads of the

Table 3. Terminology of immature stages of suborder Tubulifera

	Active, feeding phase		Inactive, non-feeding phase		
	1st instar	2nd instar	3rd instar	4th instar	5th instar
JORDAN (1888)	L a r v a		Pronymphe	N y m p h e	
UZEL (1895)	L a r v a		Pronymfa	N y m f a	
HINDS (1903)	L a r v a e		Pronymph	Nymph or Pupa	
TAKAHASHI (1921)	Larva I	Larva II	Pupa I	Pupa II	Pupa III
PRIESNER (1928)	I Larven-stadium	II Larven-stadium	Vorpuppe	I Puppen-stadium	II Puppen-stadium
MELIS (1935)	Prima larve	Seconda larve	Proninfa	Ninfa del primo stadio	Ninfa del secondo stadio
PESSON (1951)	Larve des 1er stade	Larve des 2^{e} stade	P r o n y m p h e		Nymphe
SNODGRASS (1954)	L a r v a e		P r o p u p a e		Pupa
ROSS (1965)	L a r v a e		Propupa	P u p a	
COTT (1956)	N y m p h		(early) P s e u d o p u p a		(late)
DAVIES (1961)	lst larval instar	2nd larval instar	Prepupa	lst pupal instar	2nd pupal instar
STANNARD (1968)	Larva I	Larva II	Primipupa	Prepupa	Pupa
ANANTHAKRISHNAN (1969)	Larva I	Larva II	Prepupa	Pupa I	Pupa II
HEMING (1971)	lst stage larva	2nd stage larva	Propupa	Pupa I	Pupa II
HAGA (1973)	lst larval instar	2nd larval instar	lst pupal instar	2nd pupal instar	3rd pupal instar

instar are formed as two paris of round lateral swellings situated on the meso- and metanotum, but are so much shorter than those of the next instar that they are only observed with difficulty ; 3. the pupae of the second and the third, or the last instars are very similar to each other in appearance, and the form of the first instar pupa appears to be different from them. However, in the observations by the present author, the wing pads appear from the outset of the first pupa, and the pupa matures in its brief duration, as in the case of the second pupa. It is difficult to separate the exuviae of the first and second instar pupae, because the exuviae are very thin and non-sclerotized except the tube. The first pupal instar has no intermediate characters between the larva and the pupa. These observations show that the term *pre-* or *propupa*, or *Vorpuppe* are unsuitable to the first instar one. One the other hand, the last pupal instar was recognized as the true pupa, and the previous two instars were called *pronymphe* or *propupa* by PESSON (1951) and SNODGRASS (1954), or the last stage was called *pupa* while the former two stages were called *primipupa* and *prepupa* by STANNARD (1968). The recognition of the last pupal instar as the true pupa is appropriate for this occasion, but it would caused confusion of terms if *pre-*, *pro-*, *primi-*, *prè-*, *prae-*, or *Vor-* were prefixed to *pupa*, and the term *prepupa* has normally

been used in the case of holometabolous insects directing for the full-fed, immobable *larvae* before pupation.

In the present paper the author used the term the first, second, and third pupal instars, or abbreviations P I, P II, P III respectively to avoid any confusion in terminology.

TAKAHASHI (1921) proposed the term *Remetabola* for Thysanoptera based on the observations of the life-history of *Gynaikothrips uzeli* (ZIMMERMANN).* The term *Remetabola* has been used by PRIESNER (1928), PESSON (1951), and ANANTHAKRISHNAN (1969), but TAKAHASHI's naming of the term has not been understood correctly, for instance, ANANTHAKRISHNAN (1969) stated that "in view of the presence of the pre-pupal stage in development, the term *Remetabola* was proposed." According to TAKAHASHI's original statement on the term in Japanease, the term *Remetabola* arose from the similarity of the structures in larvae and adults which are once destructed and *re*constructed during the pupal stages.

These similarities are found in the following features : general appearance of form, slender, with six legs ; shape of antennae, short basal two segments and long, claviform sements III, IV, V ; presence of sense cones ; presence of round sensoria of segment II ; shape of head capsule with mouth-cone ; mouth-parts consisting of broad band-like maxillary palpi and short labial palpi ; slender leg with an arolium at extreme apex of leg ; shape and subequal position of spiracles ; straight long setae of abodominal segment IX ; forms of short anal setae.

The author could not find any larval external organs, having the above characteristics, remaining in the stages. These organs are entirely moulted out with the integument at pupation, and only bud tissues are present in the new pupal sheath, and the tissues develop through the first and second pupal stages, and the organs then *re-form* in the third pupal stage.

In view of the results obtained in the above-mentioned observations, the author follows TAKAHASHI in calling the metamorphosis of Thysanoptera "Remetabolous metamorphosis".

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**Cryptothrips sp.* of the original description.

SUMMARY

1. The gross postembryonic development of Megathripine species *Bactridothrips brevitubus* is described.
2. The insect has two larval and three pupal stages termed the first larval instar (L I), the second larval instar (L II), the first pupal instar (P I), the second pupal instar (P II), and the third pupal instar (P III) respectively.
3. The larvae are active and well-feeding, and have many similarities to the adults.
4. The pupae are inactive and non-feeding, covered by a thin sheath, and the most of the larval external organs are cast and adult organs are reconstructed in three stages.
5. Biological observations about the oviposision, hatching, duration of each immature stage, life-history, and ovoviviparity are added.
6. Terms used in naming the immature stages are discussed and the term nymph and pre- or allied prefixes felt to be unsuitable.
7. The term Remetabola proposed by TAKAHASHI (1921) is shown to be an appropriate term for Thysanoptera.

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