

Scanning Electron Microscope Studies on Head Louse, *Pediculus humanus capitis* (Anoplura : Pediculidae)

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ABSTRACT. The external anatomy of male and female adults, egg operculum and 1st instar larva of human head louse, *Pediculus humanus capitis* De Geer, 1778, were studied with a scanning electron microscope. The morphological aspects of the antennal sense organs in adult and larva were also described. The peg organ located at the apical region of antennae possesses 10 sensory hairs in adult and 8 in larva. Two tuft organs with 4 to 6 sensory hairs and 2 or 3 pore organs were also existed on the antennal surface of the adult and larva. The egg operculum has 6 to 10 aeropyles but none was found with reticulum structure between the aeropyles.

Key words : SEM — *Pediculus humanus capitis* — antennal sense organs — Anoplura — Pediculidae

The human louse once a tremendous vogue among Japanese around World War II had almost vanished within several years by use of DDT and γ -BHC having spectacular effects. Human head louse (*Pediculus humanus capitis* De Geer, 1778) infestation however are again occurring frequently among schoolchildren in recent years, and the problem is now concerned from medical and public health points of view.

The numerous inquiries pertaining to identify the insects and effective insecticides for head louse are increasingly demanded from dermatologists. And a number of *Pediculus* specimens were collected by us in the last year or two. In this study we report the results of our study on the external anatomy of male and female adults, the eggs and the 1st stage larva of *Pediculus humanus capitis* by a scanning electron microscope.

MATERIALS AND METHODS

The study is done on male and female adults, the 1st stage larva and the

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eggs. The specimens were obtained from the patients bearing pediculosis capitis found in Okayama City,¹⁾ and kept in 70% alcohol for several days. For scanning electron microscopy (SEM), the specimens were washed in 70% alcohol several times and were dehydrated through graded alcohol series. Then they were transferred into isoamyl acetate and dried in a carbon dioxide critical point apparatus, followed by coating with platinum-palladium and studied with Hitachi HHS-2R scanning electron microscope.

RESULTS

A. Male and female adults

The body of head louse is elongated and dorsoventrally flattened in form, and has distinct 3 parts of a cylindrical head, a fused thorax with 3 pairs of legs, and a segmented abdomen (Figs. 1-3). A male body studied measured about 1.9 mm in length and 0.6 mm in width (Fig. 3).

The head segment is almost cylindrical in form, and has a pair of short 5-jointed antennae and a pair of compound eyes. The eyes are located just behind the antennae (Figs. 4-5). The mouth part at the anterior end of the clypeus is highly specialized for blood sucking and able to pierce the host skin (Fig. 6), and the structure of the mouth opening is identical to those of crab louse, *Phthirus pubis*.

The ventral surface of head segment has deep longitudinal invagination just below the prestomum, and a few number of fixing folds were situated on both sides of the longitudinal invagination (Figs. 5 and 7).

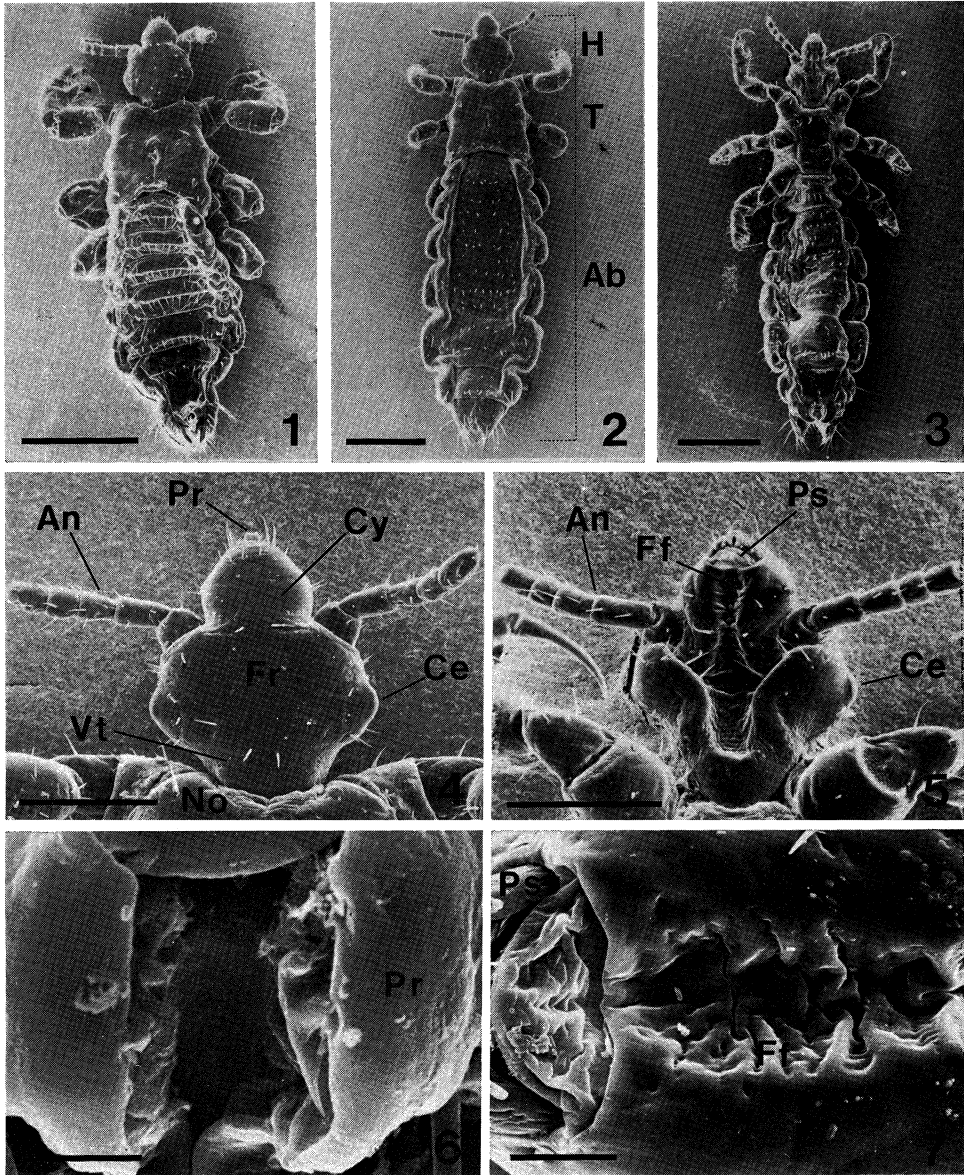
Examinations of the antennae revealed 2 tuft organs on the dorsolateral surface of the 4th and 5th segments (Fig. 8), the peg organs (sensilla basiconica) on the apical region of the 5th segment (Fig. 9) and 2 or more frequently 3 pore organs on the dorsolateral surface of the 5th segment (Fig. 11).

The tuft organs found on the 4th and 5th antennal segments are morphologically similar to each other, and the tuft hairs arising within the antenna are 4 to 6 in number; 6 on the 5th segment, 4 to 6 on the 4th segment respectively. Although the base of the tuft hairs is not seen as it descends through a tuft pit, some tuft organs the base seemed to be a curly trunk. The tuft pit is 2.2 to 3.1 μm in diameter (Fig. 10).

SEM of the apical region of antennae revealed 10 peg organs (sensilla basiconica) of which 4 were thickish hairs (Fig. 9).

Two or rarely 3 pore organs were seen on the dorsolateral surface of the 5th antennal segment (Fig. 11). The pore organs have the appearance of circularly arranged slits measuring 0.8 μm in length, surrounding a smaller central pore (Fig. 12). The outside diameter of the circle is about 3.3 μm and the central pore size is about 0.3 μm .

Three fused thoracic segments (prothorax, mesothorax and metathorax) are trapezoidal in form and each segment bears a pair of legs (Figs. 13-14). Notal pit is dorsally located on the middle of the thorax, and it measured about



Figs. 1-21. Scanning electron micrographs of male and female adults of *Pediculus humanus capitis*.

Fig. 1. Whole body of male, dorsal view. (bar=500 μ m)

Figs. 2-3. Whole body of female, dorsal (2) and ventral view (3). (bars=500 μ m)

Figs. 4-5. Head segment of male, dorsal (4) and ventral view (5). (bars=200 μ m)

Fig. 6. High-mag. micrograph of the mouthpart. (bar=5 μ m)

Fig. 7. High-mag. micrograph of the ventral surface of head segment. (bar=25 μ m)

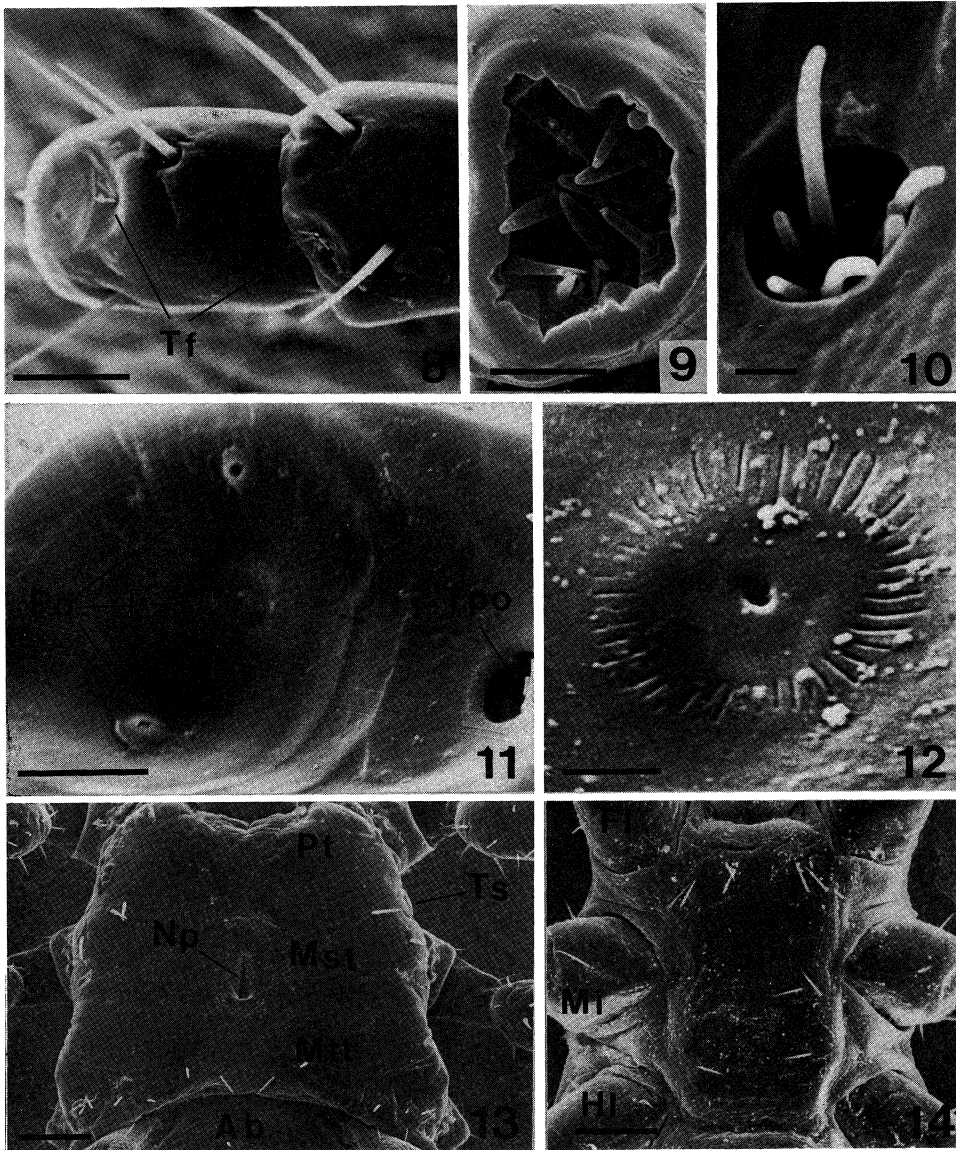
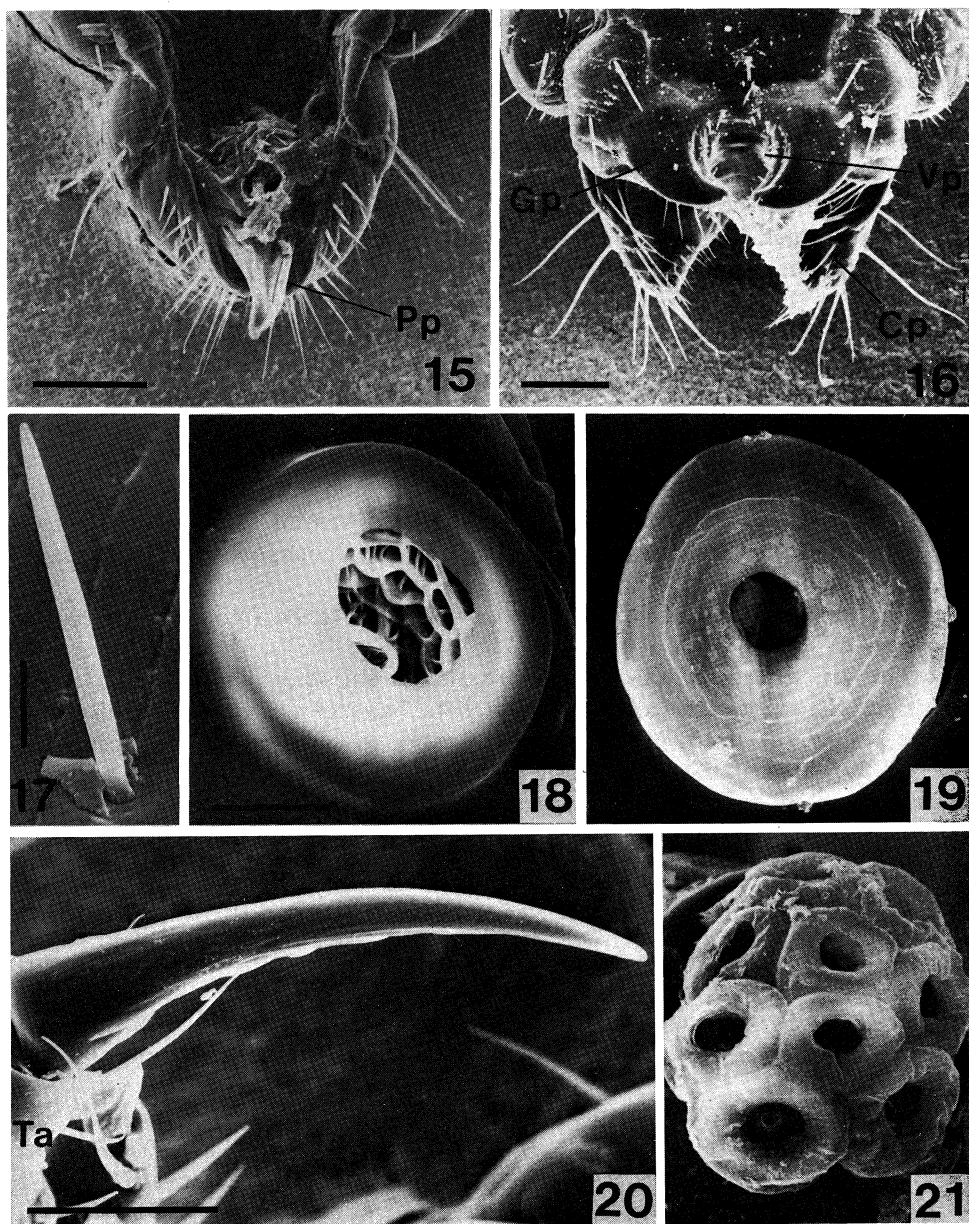


Fig. 8. 4th and 5th antennal segments with 2 tuft organs, dorsolateral view. (bar = 20 μ m)
 Fig. 9. High-mag. micrograph of apex of antenna showing peg organs. (bar = 10 μ m)
 Fig. 10. Tuft organ located on the 5th antennal segment. (bar = 1 μ m)
 Fig. 11. Pore organs located on the 5th antennal segment. (bar = 5 μ m)
 Fig. 12. High-mag. micrograph of a peg organ. (bar = 1 μ m)
 Figs. 13-14. Thoracic segment of male, dorsal (13) and ventral view (14). (bars = 100 μ m)



- Fig. 15. Posterior ventral portion of male. (bar=100 μ m)
 Fig. 16. Posterior dorsal portion of female. (bar=100 μ m)
 Fig. 17. A seta on venter of the abdomen. (bar=10 μ m)
 Fig. 18. A thoracic spiracular plate. (bar=15 μ m)
 Fig. 19. An abdominal spiracular plate. (bar=15 μ m)
 Fig. 20. First tarsal claw, dorsal view. (bar=50 μ m)
 Fig. 21. High-mag. micrograph of the egg operculum. (bar=30 μ m)

50 μm longitudinally. The thoracic spiracle is circular in form, and dorsolaterally located on both sides of the mesothorax, and it measured about 47 μm in diameter. Inside of the spiracular pit is seen a highly complexed structure with reticulum appearance for clear of gross things (Fig. 18).

The abdomen is elliptical in form and divided into 9 segments (Figs. 1-3). The dorsal setae arranged in a transverse row on the posterior edge of each segment towards the hind body (Fig. 1). The setae extending on the dorsal surface are much larger and longer than those of the ventral surface (Fig. 17). Six pairs of the abdominal spiracles are existed on dorsolateral side of the paratergal plates (Fig. 1). The structure of the abdominal spiracle differ entirely from those of the thoracic one (Fig. 19), and the abdominal spiracular plates measured about 26 μm in diameter.

The terminal segment of abdomen is a great different in male and female. As shown in Figs. 15 and 16 the terminal segment of the male appears to be roundly protruded, while that of the female appears to be branched. The male genital organ is located in dorsal side having, and the protrusion of pseudopenis (Fig. 15). The female genital organ is in ventral side and a crescent-shaped pair of gonapophyses are seen (Fig. 16). The gonapophyses play a major role in clasping of host's hairs during oviposition.

The inner surface of the 1st tarsal claw looks to be smooth (Fig. 20).

B. Eggs

The visible eggs of this species are almost ellipsoidal in form and white in color. The eggs are capable to attach to hairs of the host. The live eggs of the present specimens measured about 0.6 mm longitudinally. The operculum of eggs appears to be convex protrusion showing pore structure which approximately equal in diameter (aeropyles). The aeropyles on the operculum are 6 to 10 in number and about 15 μm in diameter. The reticulum structure is not apparent between the aeropyles (Fig. 21).

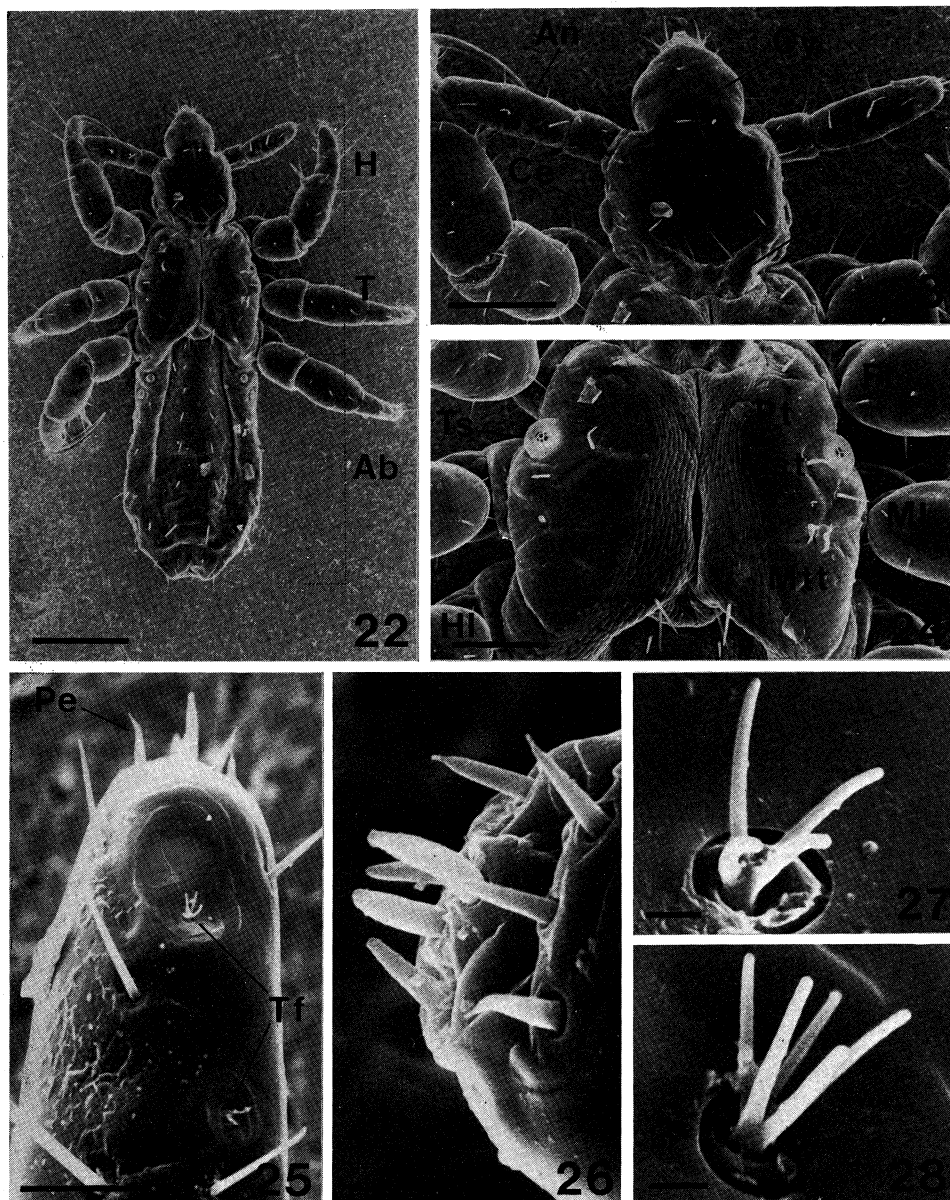
C. 1st stage larva

The whole body of the 1st instar larva is shown in Fig. 22. The antennae of the larva may be divided into 3 segments (Fig. 23), and the thoracic segments of left and right sides are not fully fused (Fig. 24). The segmentation of abdomen is not seen, and the dorsal setae are arranged in a double file, but the thoracic and abdominal spiracles attain its complete development (Figs. 22, 24 and 29).

Examinations of the antennae of the larva revealed the presence of 2 tuft organs on the dorsolateral surface of the terminal segment (Fig. 25). The tuft organs have 4 to 6 sensory hairs which arising within the antenna (Figs. 25, 27-28). The tuft pit is about 2.5 μm in diameter (Figs. 27-28). The external appearances of the tuft organs are very similar to those of adult louse.

SEM of the apical region of larval antennae showed the peg organ with 8 sensilla basiconica of which 2 were somewhat thickish hairs (Fig. 26).

The antennal pore organs are always 2 in number, and located on the dorsolateral surface of the terminal segment in front of the forward tuft organ



Figs. 22-34. Scanning electron micrographs of 1st instar larva of *Pediculus humanus capitis*.

Fig. 22. Whole body, dorsal view. (bar=200 μ m)

Fig. 23. Head segment, dorsal view. (bar=100 μ m)

Fig. 24. Thoracic segment, dorsal view. (bar=70 μ m)

Fig. 25. Terminal segment of the antenna with 2 tuft organs, dorsolateral view. (bar=20 μ m)

Fig. 26. High-mag. micrograph of apex of antenna showing peg organs. (bar=5 μ m)

Figs. 27-28. Tuft organs with 4 hairs (27) and 5 hairs (28). (bars=1 μ m)

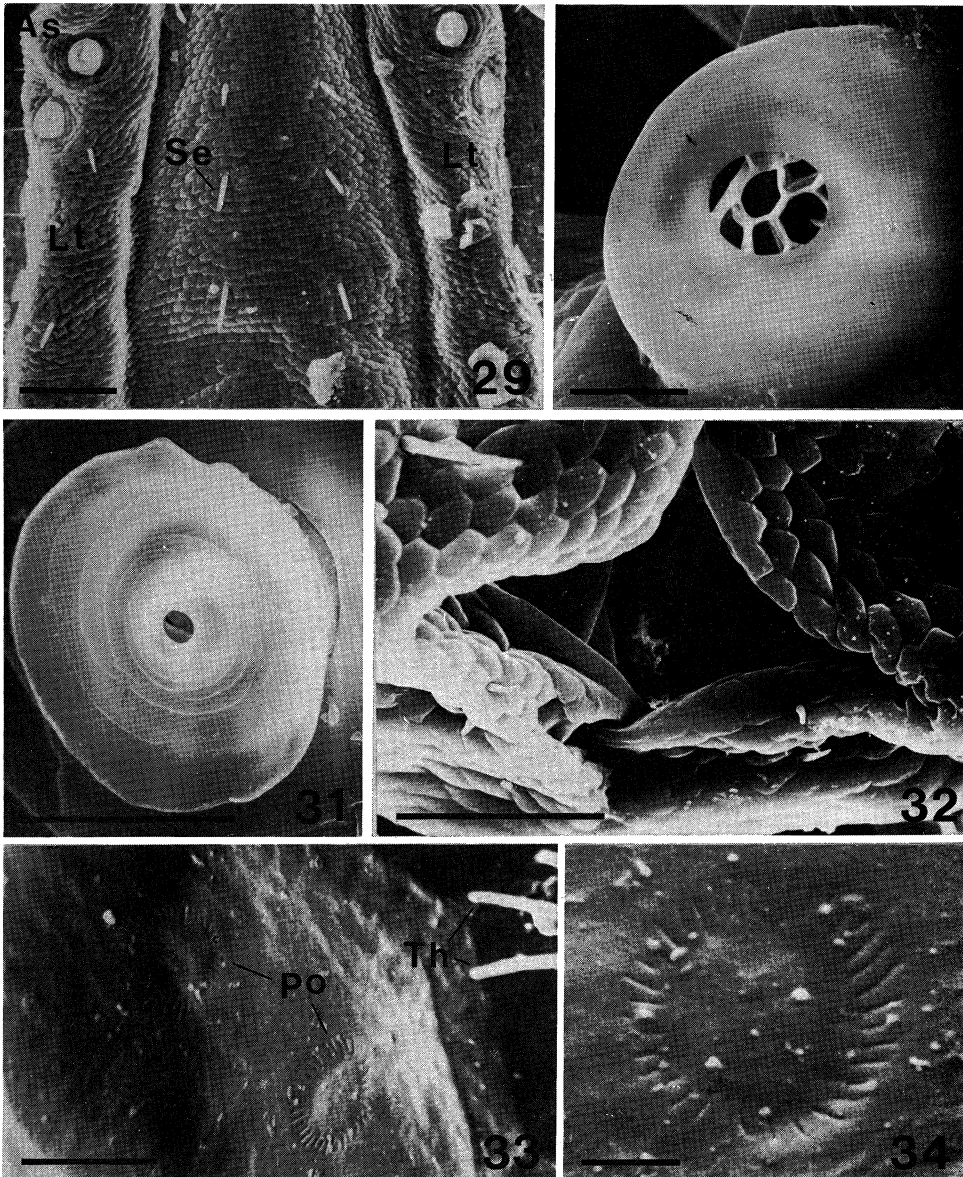


Fig. 29. Middle portion of the abdomen. (bar=50 μ m)

Fig. 30. A thoracic spiracular plate. (bar=10 μ m)

Fig. 31. An abdominal spiracular plate. (bar=10 μ m)

Fig. 32. High-mag. micrograph of the caudal region, rear view. (bar=20 μ m)

Fig. 33. Pore organs located on the 5th antennal segment. (bar=3 μ m)

Fig. 34. High-mag. micrograph of a peg organ. (bar=1 μ m)

(Fig. 33). The structure of the pore organs is substantially the same as those of adults. The circle of slits were about 3.0 μm in outside diameter (Fig. 34).

The external appearance of the thoracic and abdominal spiracles of the larva was very similar to those of adults, but difference was found in the thoracic spiracles. The reticulum structure of the thoracic spiracle were rougher than those of adult louse (Figs. 18 and 30). The size of thoracic spiracular plate of the larva is about 35 μm in diameter, and abdominal thoracic spiracular plate is about 30 μm in diameter.

The reproductive organs of the larva were still unidentifiable externally (Fig. 32).

DISCUSSION

The louse is parasitic for avians and mammals having characteristic of host specificity. The parasitic lice to man are known with 3 species, i. e., *Pediculus humanus capitis* De Geer, 1778 (head louse), *Pediculus humanus corporis* De Geer, 1778 (body louse) and *Phthirus pubis* Linnaeus, 1758 (crab louse).

Most of reports on the external anatomy of human lice have been done by light microscopy so far²⁻⁵⁾ and scanning electron microscopy have not yet well been studied.⁶⁾

The antennae of the louse play a major role for detection of odor and humidity. The tuft organs perform leading function in humidity detection. The study of antennal tuft organs of adults has been made by several workers.⁷⁻⁹⁾ Wigglesworth (1941)⁷⁾ originally described the presence of 4 sensory hairs on the 4th and 5th antennal segments of *Pediculus humanus corporis* as tuft organ. Miller (1969)⁸⁾ demonstrated 2 tuft organs on the 4th and 5th antennal segments of *Phthirus pubis*. Ubelaker et al. (1973),⁹⁾ on the other hand, reported the tuft organs with 10 sensory papillae on the 5th antennal segment of *Phthirus pubis*. The structures of antennal tuft organs of the present louse are substantially the same as other species mentioned above, but the number of tuft hairs arising from a tuft pit is much fewer than that of *Phthirus pubis*.

The antennal peg organs of human louse perform an important function in odor detection. The peg organs of adults were also described by Wigglesworth,⁷⁾ Ubelaker et al.,⁹⁾ and Kraus and Glassman.¹⁰⁾ Wigglesworth (1941)⁷⁾ reported that the peg organs with 9 or usually 10 sensory hairs were found at the apical region of the 5th antennal segment of *Pediculus humanus capitis*. Ubelaker

Ab : abdomen, An : antenna, As : Abdominal spiracular plate, Ce : compound eye, Cl : claw, Cp : clasper, Cy : clypeus, Fe : femur, Ff : fixing folds, Fl : fore-leg, Fr : frons, Gp : gonapophysis, H : head, Hl : hind-leg, Lt : laterotergites, Ml : mid-leg, Mst : Mesothorax, Mtt : metathorax, No : notum, Np : notal pit, Pe : peg organ, Po : pore organ, Pp pseudopenis, Pr : probosis, Ps : prestomum, Pt : prothorax, Se : seta, Sp : sternal plate, T : thorax, Ta : tarsus, Tf : tuft organ, Th : taft hair, Ti : tibia, Tp : tergal plate, Tpo : tuft pore, Ts : thoracic spiracular plate, Vp : vaginal plate, Vt : vertex.

et al. (1973)⁹⁾ observed the peg organs with 10 sensilla basiconica on the apical region of the 5th antennal segment in *Phthirus pubis*. Kraus and Glassman (1976)¹⁰⁾ also reported the peg organ of *Phthirus pubis* however with a photomicrograph showing only apical region of antenna. The external appearances of peg organs of the present species are exactly the same as two species of louse mentioned above.

The antennal pore organ of lice was originally reported by Miller.⁸⁾ The accurate functions of the pore organ have not yet been solved. According to Miller (1969)⁸⁾ the pore organ consists of a series of slits surrounding a smaller central opening, and the slits measured about 0.3 μm in length and the outside diameter of the circle of slits was about 3 μm . The structure of the antennal pore organs found in the present louse is very similar to those of *Pediculus humanus corporis*, but the fused number of the antennal pore organ is subtly different.

Ubelaker et al. (1973)⁹⁾ reported that the inner surface of the 1st tarsal claw of *Phthirus pubis* was distinctly serrated, but that of the 1st tarsal claw of the present louse is relatively smooth (Fig. 20).

The antennal sense organs of the larva have been studied only by two workers.^{2,8)} Keilin and Nuttall (1930)²⁾ reported a tuft organ with 4 sensory hairs in the 1st stage larva of *Pediculus humanus corporis*. Although they observed the peg organs of the same materials, the paper contained no mention on the actual number of the sensillum basiconicum. Judging from their illustration there were 9 sensilla basiconica on the apical region of the antenna. The fused number of the sensilla basiconica found in the present larva was fewer than that of *Pediculus humanus corporis* larva.

The external appearance of abdominal spiracles has a strong resemblance to those of *Phthirus pubis* by Kraus and Glassman,¹⁰⁾ and Ubelaker et al.⁹⁾ Ubelaker et al. (1973)⁹⁾ described that the spiracular plates of *Phthirus pubis* were mushroom-shaped extending above the body surface.

The aeropyles on the operculum of louse egg are important for respiratory exchange of gasses in the developing embryo, as noted by Kraus and Glassman,¹⁰⁾ and Berman and Firstenberg.¹¹⁾ The structure of aeropyles of louse eggs has been reported by various workers.⁹⁻¹²⁾ According to Ubelaker et al. (1973),⁹⁾ the aeropyles on the operculum of *Phthirus pubis* eggs are arranged on two concentric circles, and the larger aeropyles are in the center and the smaller ones at the periphery. Moreover, they demonstrated the presence of the reticulum structure between aeropyles. Berman and Firstenberg (1979)¹¹⁾ reported that the number of aeropyles of *Pediculus humanus corporis* differ from egg to egg varying from as few as 9 to as many as 21, and the reticulum structure is not existed. The operculum is not apparent reticulum structures between the aeropyles, and it looks the same as that of *Pediculus humanus corporis* eggs. The number of aeropyles on the operculum is the fewest of all species of human louse.

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