STRUCTURE, DEVELOPMENT AND STING MECHANISM OF THE 
LARVAL POISON HAIR OF ARTONA FUNERALIS 
BUTLER (LEPIDOPTERA : ZYGAENIDAE)*

CHISATO TSUTSUMI

Department of Medical Entomology, National Institute of Health, Tokyo

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During the summer of 1959, many cases were reported from Tokyo area of accidental dermatitis caused by contact with a kind of hairy caterpillars, which crowd on bamboo leaves growing in the garden. These caterpillars were identified as the larva of a zygaenid moth, Artona funeralis Butler, which is distributed from Hokkaido to Kyushu and is sometimes known as a pest of bamboos. It was revealed from literature and information that local outbreaks of this larva have occurred mainly in the southern part of this country. It has further been believed that the dermatitis may be caused by some sort of poisonous hair on the larva, but no attempt has ever been made even to ascertain which hair on the larva is responsible.

In the present study were described some results of morphological and histological observations on the poison hair and of a series of experiments on its possible sting mechanism.

MATERIALS AND METHODS

The larvae used in this work were bred on fresh bamboo leaves in deep Petri dishes in the laboratory. For histological observations middle instar larvae in several stages were fixed in Bouin’s picro-formol fixative and picro-chlor-acetic solution, embedded in paraffin and stained with Mallory’s triple stain. In the experiments which were designed to obtain some informations on the possible sting mechanism of a hair to the human skin, all kinds of larval hairs were carefully pressed on the previously marked soft skin surface of a right forearm under a binocular microscope. Further changes of larval hairs and succeeding cutaneous symptoms were continuously examined thereafter. Sterilized glass needles, 7 μ in diameter, and a poison hair taken from a larva, and the same from an exuvium were also used. The pH-values of the larval blood and tissue were examined by standard papers.

OBSERVATIONS

A) The Distribution and the Shape of the Poison Hair

Of the first instar larva only a single poison hair grows on each subdorsal tubercle from the mesothoracic to the eighth abdominal segment and on supraspiracular tubercle from the metathoracic to the ninth abdominal segment (Plate-Fig. 1). In the second

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instar, there appear newly formed poison hairs on each subdorsal tubercle of the ninth abdominal and supraspiracular tubercle of the mesothoracic segment. The number of the poison hairs on each tubercle increases more or less during the subsequent moultings. In the last instar larva, a few poison hairs are formed even on a lower part of each supraspiracular tubercle of mesothoracic segment. The number of the poison hairs on each subdorsal tubercle of the thoracic, the eighth and the ninth abdominal segments is about twice as many as that of other segments; on the metathoracic segment, it reaches in maximum ca. 280. The size of the poison hair naturally increases as the larval instar advances. For instance, in the first instar, it is a hollow rigid needle, 190 \( \mu \)–300 \( \mu \) in length, 7 \( \mu \)–9 \( \mu \) in diameter, dilated at the base like a flask and filled with pale yellowish liquid. The bulbed part is inserted in the socket and articulated. At the articulation, the hair is capable of being bent, instead of being detached from the larval body. The wall of the shaft of the hair is thick and brownish, and the shaft is annulated every 11 \( \mu \) interval like the nodes of bamboo stick, except the apical part. The wall of the bulbed part is thin and brownish yellow, and is provided with two slight annulations (Text-Fig. 1, A; Plate-Fig. 2). As mentioned above, the maximum length of the poison hair varies according to the larval instar. It reaches 350 \( \mu \) in the second, 490 \( \mu \) in the third, 650 \( \mu \) in the fourth, 700 \( \mu \) in the fifth, 730 \( \mu \) in the last instar larva, respectively. On the other hand, as the larval instar advances, there also appear shorter hairs, such as 160 \( \mu \) in the second, 150 \( \mu \) in the third, 120 \( \mu \) in the fourth, 115 \( \mu \) in the fifth, 110 \( \mu \) in the last instar larva. But the proportion of the bulbed part to the shaft shows approximately 1:7 in length. After the fourth instar, the poison hairs situated especially on the subdorsal tubercles of the thoracic and the first and the ninth abdominal segments showed noticeable melanization and sclerotization. The poison hairs are readily distinguishable from the ordinary hairs by the peculiar bulbed part at the base (Text-Fig. 1. A, B, C, D, E).
B) The Subcutaneous Tissue and the Development of the Poison Hair

The cuticle under poison hairs is usually twice as thick as that of the ordinary part. Here are, in contact with the endocuticle, three kinds of cells, a large one, a medium-sized one and several small ones (Text-Fig. 2, A). The large one is connected with a poison hair by a cytoplasmic process which is somewhat dilated through the endocuticle and covered with several small cells, and is found to be always associated with a medium-sized cell, which is sometimes undiscernible. In the large cell a duct-like structure is occasionally recognized. Both the large cell and the medium-sized cell are surrounded by several small cells, which are filled with reddish purple granules. The subcutaneous tissue under poison hairs as a whole shows a value of pH 9.2–9.4. Principal histological changes which occur during a poisonous hair formation are summarized as follows.

Two days before moulting, a distinct exuvial space appears immediately beneath the endocuticle due to the separation of epidermal cells from the inner part of endocuticle.
The large and medium-sized cells increase in volume (Text-Fig. 2, B), and one day before moulting a papilla-like projection of cytoplasm is produced from the large cell into the space. The large cell is filled with fibrous cytoplasmic substances, making the cytoplasmic projection, so to speak, a loose bundle of many fibrous filaments (Text-Fig. 2, C; Plate-Fig. 3). In a little later stage when the cytoplasmic projection extends a little more (one eighth of total length), it is more or less bulged at the basal part and is dwindled towards the apex. (Text-Fig. 2, D; Plate-Fig. 4). The whole projection is, thus, filled with many fibrous filaments, which stand almost parallel with one another except at the basal bulbed part, where the arrangement of filaments is more or less disordered.

When the projection is formed almost completely, surface layer of the basal part further expands and is detached from inner cytoplasmic filaments and makes a flask-shaped bulb. Although the part of the prospective shaft is still filled with fibrous filaments, the original form of the poison hair is thus completed (Text-Fig. 2, E; Plate-Fig. 5). In this stage, the large cell exceedingly reduces in size. The medium-sized cell produces prospective socket of the poison hair. The small cells secrete new surface cuticle.

Under an ordinary hair, in the subcutaneous tissue are there also three kinds of cells; a large cell is always accompanied by a medium-sized cell and surrounded by numerous small cells. These features are similar to those shown by a poison hair. However, as far as an ordinary hair is concerned, the basal part of the projection, which is similarly composed of a large number of cytoplasmic microfibers, displays neither swelling of surface layer nor irregular arrangement of the internal fibrous filaments in any stage of hair formation.

C) Experiments on the Sting Mechanism of the Poison Hair

Exp. 1: When a larva is pushed upon skin surface, the poison hairs actually stick it. But apices of almost all the poison hairs thus applied remained on the hair. Usually even a minute fragment of the poison hair did not remain in the skin, where a rash was produced.

Exp. 2: The characteristic irritation and itching, simultaneously brought about by contact with the poison hair, continued, in a case, for about thirty minutes or more, and a rash, 3 mm in diameter, was made after five minutes and increased its size, i.e. 5 mm after ten minutes, even if the hair was removed from the skin immediately after pressing. All the ordinary hairs do cause neither itching nor a rash.

Exp. 3: When a fine glass needle smeared with the liquid which is stored in the poison hairs was repeatedly (four times) stuck into the skin, weak itching and a rash resulted. A needle applied with larval blood (pH 6.8) produced a delayed, weak rash, but gave no itching. A simple sterilized glass needle, used as a control, gave neither itching nor a rash.

Exp. 4: A detached poison hair taken from an exuvium caused slight itching and a delayed rash, which were smaller than usual. The same taken from a larva, also gave a similar symptom, although that of young larvae is too flexible to enter into the skin. The reaction such as itching and a rash caused by a repeatedly applied poison hair, progressively diminished.

Exp. 5: When the bulbed part of a poison hair is pressed by fine needles, small amount of liquid as a droplet overflows from the apex of the hair and immediately coagulates into a minute ball, 8 μ-10 μ in diameter. This size is almost the same with that of the original droplet. The basal bulb exhibits wholly or partly depressed ap-
pearance according to the intensity of pressure given upon it. When partly depressed, it generally recovers again to its original shape within a few days.

Exp. 6: A drop of larval blood, 40 μ in diameter, on the apex of a fine glass needle, coagulates within five seconds. It leaves only a very small amount of yellowish solid particle.

Exp. 7: If a poison hair is pressed on solid surface, such as metal, wood, glass, etc., it is bent at the basal articulation and surprisingly the bulbed part remains perfect.

DISCUSSION

The ordinary hair on the lepidopterous larvae is as a rule a considerably flexible needle and is articulated with the socket of the hair. It is connected with the trichogen cell, which is associated with the tormogen cell.

As compared with this ordinary hair, the poison hair is dark coloured and rigid, especially at the apical part, and has a characteristic expanded portion at the base of it, where the wall is especially thin. As regards the subcutaneous tissue it is apparent from the present observation that the large cell is the trichogen cell, the medium-sized cell functions as the tormogen cell and numerous small cells are the ordinary epidermal cells.

Thus, the difference between the ordinary hair and the poison hair is in this species hardly recognizable, except that a duct-like structure was found only in the trichogen cell of the poison hair.

Our first question may be: When and how the bulbed part will be formed? It was already histologically shown that a papilla-shaped projection is recognizable in the first stage of the hair formation (Text-Fig. 2, C; Plate-Fig. 3). This suggests that some cytoplasmic product, which appears to consist mainly of soft filaments of chitinous micelles, will expand into the exuvial space through a narrow opening of trichogen cell and presumably makes a swollen basal part. But at present it remains obscure how the papilla-shaped projection is formed.

Attention should also be paid to the fact that all fibrous filaments in the projection exhibited nearly longitudinal arrangement in the prospective shaft, while it shows rather irregular arrangement in the bulbed part. These filaments are undoubtedly the basic material of future poison hair. It was also recognized that the future shaft portion is entirely filled with fibrous, deep stained filaments, whereas the basal swollen portion remains some space around the periphery (Text-Fig. 2, E; Plate-Fig. 5).

Of particular interest is that quite similar hairs have been found on the larva of an arctiid moth, Eilema yokohamae Daniel, and they cause a rash on the skin with severe pricking.

Berlese (1909) illustrated this sort of poison hair, which grew on the larva of an arctiid moth, Lithosia caniola. According to Weidner, similar hair was recorded from the larva of Lithosia griseola.

Since all these flask-shaped hairs are so far believed as the poison hair, another question will follow that: In what way does the hair of this peculiar shape cause dermatitis? My experiments will answer for it.

By Exp. 1, it became clear that the dermatitis will not be induced by pieces of a broken poison hair which remain in the skin. It would not preclude the possibility at the same time that some substance smeared on the outer surface of the hair may cause a rash. However, it is more likely from Exp. 3 that some liquid stored in the hair,
mainly in the bulbed part, will contain some poisonous substance. This is also suggested from the result of Exp. 2 and morphological observation previously mentioned. Exp. 4 and Exp. 5 were carried out in order to obtain further information on the sting mechanism of the hair. If Exp. 2 is compared with Exp. 4, it can be assumed that a poison hair with depressed bulbed part may give weaker itching and a smaller rash than does a perfect one. Furthermore, the present morphological observation presents the data that the bulbed part is readily depressed because of the extreme thinness of the wall. Exp. 6 seems to support the above assumption, showing that when the bulbed part was pressed, a drop of liquid flowed out from the top of the hair. From the experiments and observations described above, it may be concluded that liquid, which contains some poisonous substance, is injected into the skin from the apex of the poison hair, causing simultaneous itching and a succeeding rash, when the poison hair sticks the skin and especially when the bulbed part of the hair is pressed and crushed. It may also be added here that the basal bulb, which is the most characteristic feature of this hair, will play two important roles, storing and pushing out the poisonous liquid. This liquid may be secreted from the trichogen cell and seems to be extremely rich in solid component, since it remains solid substance after drying.

In view of the fact that the subcutaneous tissue of the poison hair showed the value of pH 9.2–9.4, it is assumed that the liquid will also have a value near pH 9.2–9.4. However, further investigations are expected on the chemical nature of this liquid, including the pH value of it.

Finally, it is interesting to add from the ecological point of view that the larval poison hair is bent at the basal articulation, and the bulbed part remains perfect without being crushed, if it is pressed on the solid surface, such as wood, glass, metal, etc.

**SUMMARY**

In the present paper were described some results of morphological observation on the larval poison hair of *Artona funeralis* Butler, together with a series of experiments on its sting mechanism.

1. The poison hair as a rule grows on each subdorsal and supraspiracular tubercle from the mesothoracic to the ninth abdominal segment. The number of the poison hairs increases as the larval instar advances.

2. The poison hair is a rigid hollow needle, 110 μ-730 μ in length, bulbed at the base and filled with pale yellowish liquid. The wall of the shaft is thick and brownish, whereas that of the bulbed part is extremely thin and yellowish brown.

3. The subcutaneous tissue of a single poison hair consists of a trichogen cell, a tormogen cell and numerous epidermal cells. The trichogen cell is connected with a poison hair and presumably secretes liquid into it.

4. The original bulbed part appeared to be formed from the trichogen as a papilla-like structure at the first stage of the hair formation. The extreme thinness of the wall of the formed bulbed part seemed to be due to comparatively small amount of basic material supplied during the course of its development.

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Plate-Fig. 1. The first instar larva. Magnification Ca. ×60
Plate-Fig. 2. The poison hair. Magnification Ca. ×180
Plate-Figures 3-5 represent transverse sections of the subcutaneous tissue of the poison hair with Mallory's triple stain. Magnification Ca. ×220
Plate-Fig. 3. Larva at one day before moulting. The papilla-shaped projection is being formed from the trichogen cell.

Plate-Fig. 4. Larva at a slightly later stage of Plate-Fig. 3. The basal part of the projection shows a slightly bulged appearance.

Plate-Fig. 5. Larva shortly before moulting. The projections are fully extended. The future shaft portions are filled with fibrous deep stained filaments, whereas the basal swollen portion remains some space around the periphery.
5. When the poison hair stuck the human skin and the bulbed part was pressed, the yellowish liquid stored in the poison hair was injected into the skin, and a rash with itching was caused.

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REFERENCES