

Sensillar diversity, density and distribution during post-embryonic development of *Cyrtacanthacris ranacea* Stoll and their role in feeding

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Abstract. Diversity, density and distribution of the sensilla of *Cyrtacanthacris ranacea* Stoll during post-embryonic development and their role in feeding are discussed alongside with the scanning electron microscopic studies of these sensilla.

Keywords. *Cyrtacanthacris ranacea*; sensilla; feeding.

1. Introduction

Acridids being generally polyphagous, have been known to show a selective preference for monocots, dicots or both. Since feeding preferences depend on the sensilla that aid in host selection, an understanding of the sensillar nature and distribution is all the more necessary. Blaney *et al* (1971), Blaney (1974) and Chapman and Thomas (1978) provided a basic picture on the nature and distribution of the sensilla on the mouth parts of Acridoidea in general and further studies by Ananthakrishnan *et al* (1985a) indicate that the sensilla on the antenna, maxillary and labial palps, labrum and hypopharynx play a key role in food selection aided by visual host location. Earlier studies on *Cyrtacanthacris ranacea* Stoll, an important pest of cotton relate to food preference in terms of the duration of post-embryonic development, growth rate and quantitative food utilization (Ananthakrishnan *et al* 1985b). Observations presented here relate to the diversity, density and distribution of the sensilla of *C. ranacea* during post-embryonic development and their role in feeding.

2. Material and methods

C. ranacea were collected from cotton tracts and reared in the laboratory on cotton leaves in rearing cages measuring 25 × 25 × 30 cm. Wet soil was provided in a plastic container for the purpose of oviposition. Newly hatched first instar nymphs were segregated and reared in separate cages for various biological studies. For light microscopic observations the labrum, labium, maxillae and antennae of the various stages of the grasshopper were dissected in insect ringer, washed with distilled water, incubated in 1% potassium hydroxide for 5 min, washed well in distilled water and mounted in glycerine. For scanning electron microscopic studies, the mouth parts and the antennae were washed in 30% acetone, and dehydrated in alcohol series, transferred

to amylacetate and dried using a Hitachi critical point drier with liquid carbon dioxide. The dried specimens were fixed on aluminium stubs using a double adhesive tape and coated with gold using a standard ion coater for 3 min. Photographs were taken using a Hitachi Scanning Electron Microscope under 15 KV emission current.

3. Observations

3.1 *Sensillar diversity and distribution*

The outer face of the labrum bears a large number of trichoid sensilla along with numerous much longer sensilla most abundant in the central area above the transverse sulcus. The face of the labrum bears a number of campaniform sensilla particularly dense around the edge and along the median groove immediately in front of the mandibles. The inner face of the labrum bears a large number of sensilla of which the most conspicuous are the 4 paired groups of dome shaped sensilla designated as A1, A2, A3 and A10. These 4 groups bear the campaniform sensilla (figure 1G). Light microscopic studies show the epipharyngeal surface of the clypeo-labrum to bear 3 pairs of hair tracts designated as ' α ', ' β ' and ' γ ' and a small group of hairs lateral to the A3 sensilla groups designated as ' δ '. The α -, β - and δ - tracts bear densely packed sensilla trichodea (figures 1 C, D) while the γ -tracts bears the sensilla chaetica (figure 1 E). Detailed observations using scanning electron microscope showed in addition to these 4 tracts, distinct rows of sensilla basiconica arranged in groups of 3-4 (figure 1 H), distributed along the edge of the labrum towards the α -tract, becoming intercepted with a few sensilla chaetica near the α -tract. While the α , β , γ , δ , A1, A2, A3 areas are distinct throughout the post-embryonic development, the A10 group of sensilla are best observed only in the adult stage. Another distinct zone not observed in the nymphal stages, but observed only in the adult is a row of sensilla herein designated as the ' ϕ '-tract. The ϕ -tract is represented by the sensilla basiconica and is seen distributed in the region between the α - and γ -tracts (figure 1 B). The relative positions of the right and left A2 sensilla groups are known to differ in different taxa. In *C. ranacea*, belonging to the subfamily Cyrtacanthacridinae, the two groups are approximately at the same level.

The mandibular sensilla of *C. ranacea* fall into 3 types namely, sensilla trichodea, sensilla chaetica and sensilla without specialised cuticular structures (figures 2 A, B, D). Most of the sensilla chaetica are grouped adjacent to the molar area, while a few occur along the inner edge of this area. The long trichoid sensilla are distributed along the distal inner edge of the mandible (figure 2 D).

Sensilla trichodea are the most common sensilla of the cardo and stipes of the maxilla. The most numerous sensilla of the lacinea are campaniform sensilla, forming a conspicuous group immediately proximal to the hardened apex. In addition, the inner edge is bounded by a row of stout trichoid sensilla and there are a few others scattered over the surface. On the maxillary palps, there are numerous trichoid sensilla scattered on each segment. A group of small trichoid sensilla forms a hair plate at the base of each segment. The dome at the apex of the palp bears a large number of trichoid sensilla (figure 2 E). The labium bears a few trichoid sensilla. The hypopharynx bears extensive tracts of hairs with groups of large trichoid sensilla and campaniform sensilla laterally. The labial palp bears numerous stout trichoid sensilla.

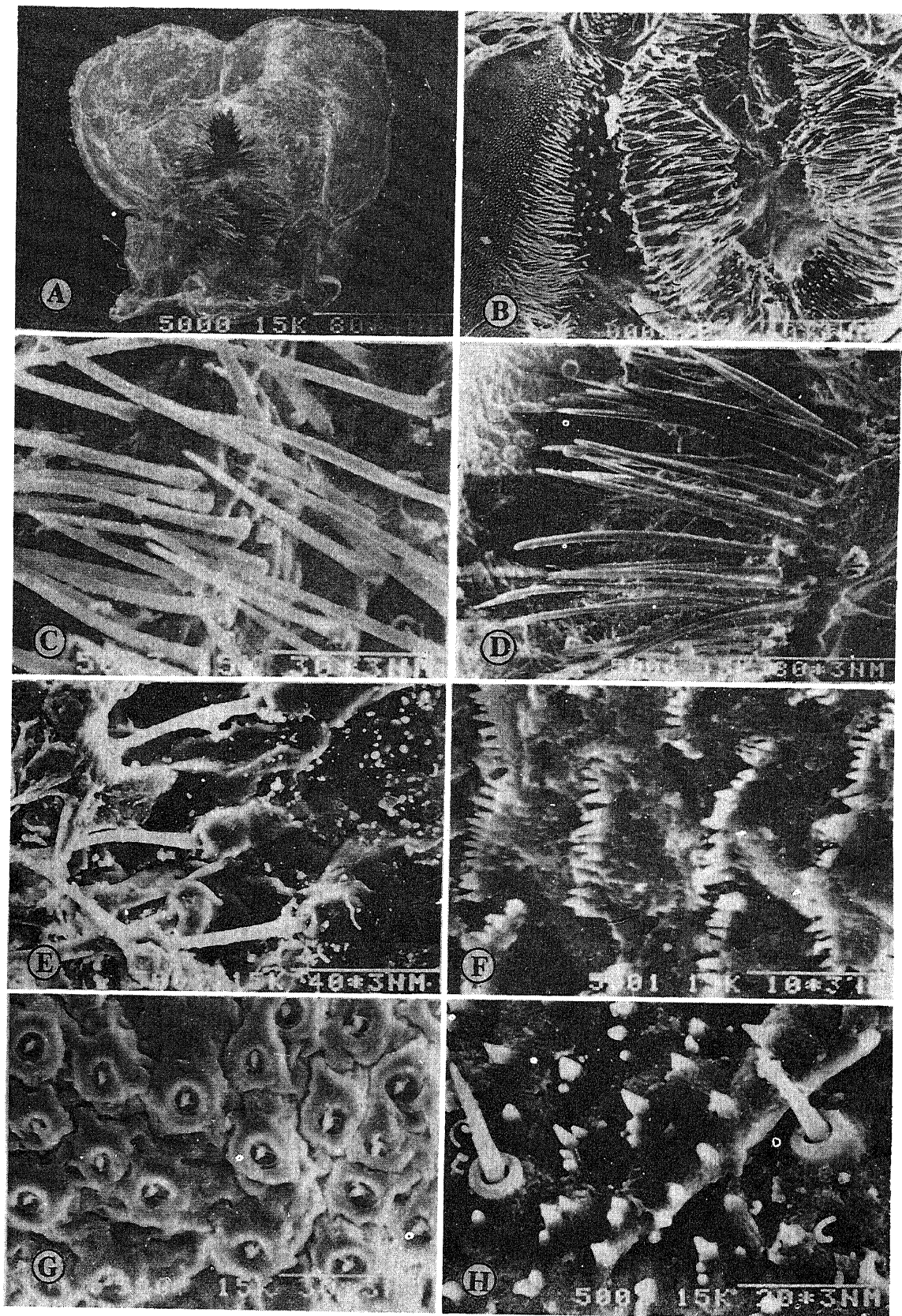


Figure 1. Scanning electron micrographs. A, B. Inner side of the labrum. C, α -Hair tract. D. β -Hair tract. E. γ -Hair tract. F. Inner edge of the labrum. G. A1, A2, A3 and A10 sensilla group. H. Between inner edge of the labrum and the α -tract.

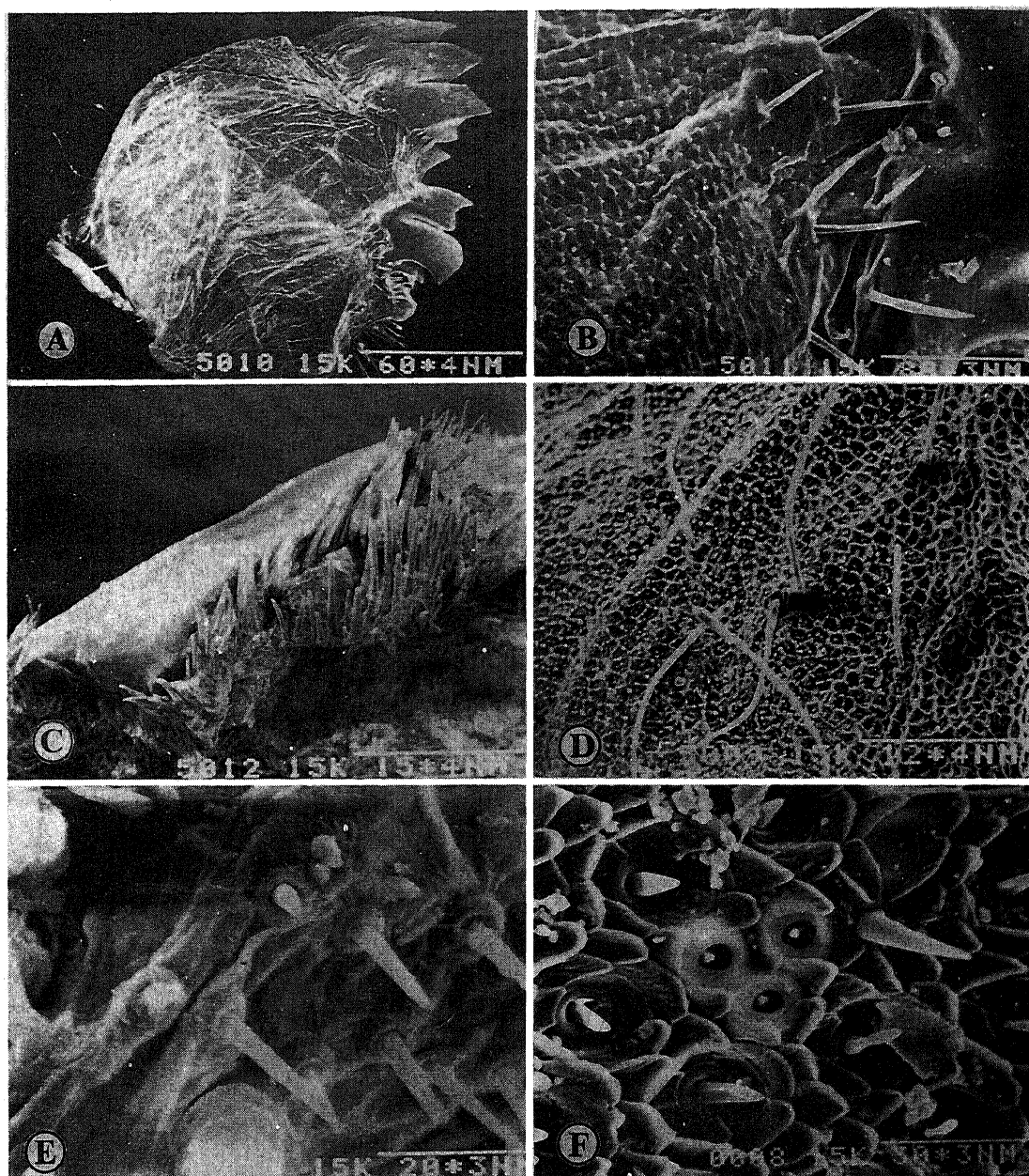


Figure 2. Scanning electron micrographs. A. Mandible entire. B. Mandible surface inner to teeth. C. Hypopharynx. D. Lateral surface of the mandible. E. Palp tip showing trichoid sensilla. F. Antennal surface.

3.2 Numerical increase in sensilla during post-embryonic development

An increase in the total number of sensilla of the labrum was evident during post-embryonic development, the rate of increase of each type of sensilla varying considerably. The maximum increase was noticed in the case of the adults, the details of which are evident from figure 3. In addition to the numerical increase in sensillar population during post-embryonic development, distinct differences were observed in the number of these sensilla in each half of the labrum at any particular stage of development. Generally the α - and β -tracts bear more sensilla on the right half than on

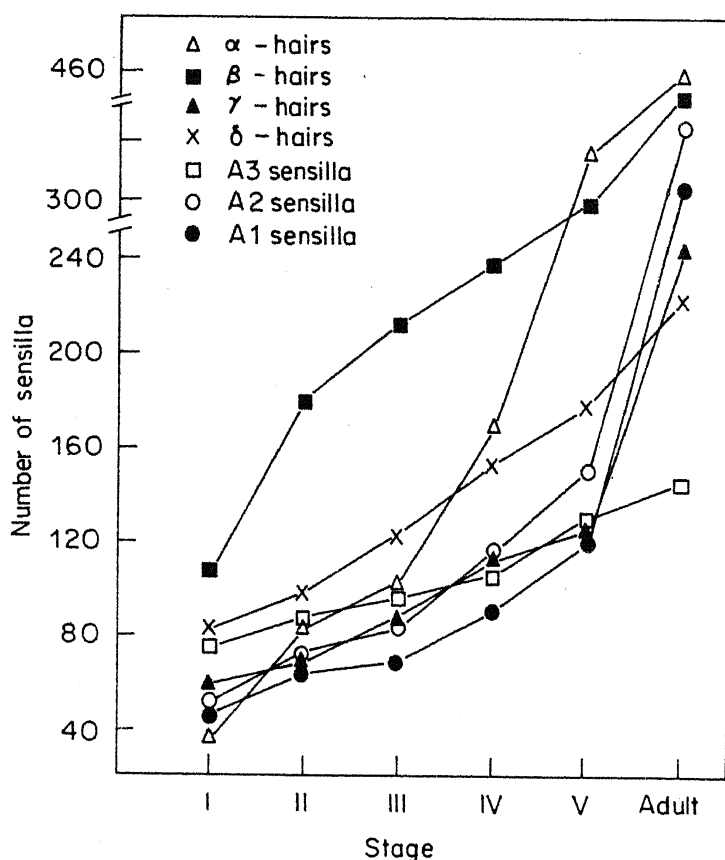


Figure 3. Numerical increase in the various sensilla of the mouthparts of *C. ranacea* during post-embryonic development.

the left while the δ -tract had the sensilla more developed on the left side. Although there were no significant differences in the sensillar count of the left and right sides of the γ -tract during the early nymphal stage, the later nymphal stages and the adult had the sensilla on the left outnumbering the right. Similarly the number of sensilla at the apices of the maxillary and labial palps also increased during post-embryonic development.

3.3 Role of sensilla in feeding

Members of the subfamily Cyrtacanthacridinae are generally considered to be mixed feeders. However, extensive field studies showed *C. ranacea* to feed mostly on such malvaceous plants as *Gossypium hirsutum*, *Abelmoschus esculentus*, *Abutilon indicum*, *Sida rhomboidea* etc. Grasses such as *Panicum maximum*, *Cynodon dactylon*, *Cyperus rotundus* did not induce feeding in *C. ranacea*. Feeding in *C. ranacea* as in other phytophagous insects involves sequential behaviour such as host finding, orientation, test bite and feeding. Host finding includes the visual as well as olfactory perception by the sensilla in the antenna. On establishing contact with the host plant, the antennal sensilla as well as the maxillary and labial palps help in food perception leading to the test bite. The movement of the labrum during feeding, facilitates the inward push of the food fragments towards the mouth and the hair tracts further guide the food towards

the central core. The densely packed, long β -hairs channelize the food particles towards the A1 and A2 group of sensilla which bear the chemoreceptive campaniform sensilla. The δ -hairs at the tip of the labrum facilitate the movement of the food fragments during test bite towards the A3 sensilla which seem to play a role in initial food selection.

The sensory systems with the different types of sensilla and their receptors, become maximally involved in arriving at suitable food preferences, sampling plants intensively, initially scanning with the sensory apparatus and nibbling, resulting in the intake of small amounts of food, mostly as a result of excitation of the peripheral receptors induced by cues from the plants. Consumption rates and duration of feeding varies with host plants, the degree of consumption being proportional to the time spent on the plant and the quantity of food ingested. Laboratory preference studies for *C. ranacea* from among the malvaceous hosts in terms of the quantity of leaf consumed per day indicate adults of *C. ranacea* to consume 1096.25 mg/day of *G. hirsutum*, 1712.75 mg/day of *A. esculentus* and 1056.25 mg/day of *A. indicum*.

4. Discussion

Studies on the distribution and abundance of diverse sensilla on labrum, maxillary and labial palps of *C. ranacea* indicated significant numerical and distributional variations besides recognition of further types of sensilla in the inner face of the labrum. In addition to the usual α -, β - and γ -tracts, additional δ - and ϕ -tracts were evident. This increase in the types of tracts may be presumed to be essential for accurate perception of various stresses. In Acridids, the number of sensilla increases with the size of the insect. The scattered sensilla have the highest rate of increase, but the number per unit area decreases as the insect get bigger, reflecting progressively wider spacing in the bigger insects (Chapman and Thomas 1978). The apical sensilla of the palps have a higher rate of increase than those elsewhere on the mouth parts. The increase in sensilla at the apices of the maxillary and labial palps of *C. ranacea* during post-embryonic development is a feature also observed by Ananthakrishnan *et al* (1985a). However, in *C. ranacea* trends for an increase in sensillar number were recognized even from the first instar nymph onwards, such an increase can be correlated with the increase in the quantitative food intake as well as the range of preference for their host plants. The relative positions of A2 sensilla between the right and left sides in *C. ranacea* is a feature also observed in *C. tatarica* (L) and *C. aeruginosa* (Stoll).

Food selection in grasshoppers is known to depend, besides a number of physical and chemical factors, on the stress conditions of the insect since an oligophagous grasshopper will eat a wider range of plants under severe conditions of stress (Bernays *et al* 1976). In general, grasshoppers are classified into those that feed on grasses or on broad-leaved plants or on a mixture of the two. The Pyrgomorphidae and Catantopinae mostly feed on broad-leaved plants, while the Hemiaceridinae, Acridinae, Oedipodinae and Gomphocerinae feed most exclusively on grasses. Some members of the subfamilies Eyprepocnemidinae, Melanoplinae, Cyrtacanthacridinae and Oxyinae are mixed feeders in the sense that they feed on either grasses or forbs. *C. ranacea* is a restricted oligophagous grasshopper feeding mainly on plants belonging to the family Malvaceae. The present study indicates that *C. ranacea* is specific to feeding on malvaceous plants. Although reports of food specificity in Acridoidea appear meagre,

Anablepia granulata has been shown to feed only on *Brachyaria* spp (Gillon 1972); *Cornops longicorne* to be associated with *Eichhornia* (Perkins 1973) and *Poecillocerus hieroglyphicus* to be associated with Asclepiadaceae (Abushama 1968). In all these insects, it was shown that the number of sensilla is comparatively less than the members of their related group. Chapman and Thomas (1978) opined insect specificity to be associated with the development of the sensilla turned to key chemicals in the normal food plant; such a development would permit a reduction in the numbers of sensilla involved in host selection. However, it does not follow that a limited host plant range will always be associated with a relatively small number of sensilla.

The sensory mechanism underlying feeding behaviour in Acridids is a complex one. Haskell and Schoonhoven (1969), Cook (1972), Chapman and Thomas (1978) and Chapman (1982) have indicated the chemosensory nature of the A1, A2 and A3 sensilla and suggested others probably as mechanoreceptors. Studies by Blaney (1974) and Haskell and Schoonhoven (1969) suggested the mechanical and chemosensory nature of the sensilla on the surface of the maxillary and labial palps, which are known to increase as they grow into adults. Although the function of the hair tracts along the inner side of the labrum is not known for certain, present observations on the movement of the food and the role of sensilla are further supported by the observations of Cook (1977) who showed that fluids spread more rapidly along these tracts than over the general surface of the epipharynx. Large amount of information on all qualities of food, both phagostimulatory and deterrent, are fed into the central nervous system of the insect and the final motor behaviour comes about as a result of filtering and integration in higher centres (Haskell and Mordue 1970), an aspect needing further investigation.

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