

Sensory Structures on the Venom Apparatus of a Primitive Ant Species^{1,2}

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ABSTRACT

Mechanoreceptors and chemoreceptors are found primarily at 8 distinct locations in the venom apparatus of *Paraponera clavata*. Receptors are in the form of

variously arranged *sensilla campaniformia*, *placodea*, *trichodea* and *basiconica* and apparently function in sting manipulation and detection of a victim.

According to Dethier (1957) and Schneider (1964), parasitic wasps can discriminate hosts accurately at 2 initial stages of parasitism: (1) when they examine the host with their antennae and (2) when they probe with their ovipositor prior to oviposition. Other observations on sensory structures in parasitic Hymenoptera and on the discriminating power of the ovipositor tip were primarily reported by McIndoo (1914), Narayanan and Chaudhuri (1954), Weseloh (1969, 1972) and Wylie (1958). After examining several species of parasitic Hymenoptera and comparing them with aculeate wasps and ants we found that the locations and types of sensory structures in both groups were much the same. However, the number and pattern of the sensory structures vary from group to group and even from species to species.

That the ovipositor and sting are well endowed with sensory structures was demonstrated by Hermann (1968a, 1968b, 1969), Hermann and Blum (1966, 1967a, 1967b, 1968), Hermann and Mullen (1974), King and Fordy (1970) and Soliman (1941). However, most investigations have been restricted to the distal tip of the 1st and 2nd valvulae (lancets and sting respectively). A more thorough examination of the venom apparatus reveals an array of different types of sensory structures at a number of locations. Here we point out specifically where these sensory structures are found and discuss their possible function in the act of stinging.

Sensory structures and their locations on the hy-

menopterous venom apparatus have been observed in the Hymenoptera by us for years prior to the initiation of this investigation. Hence, the investigation reported on here is based on some prior knowledge.

Paraponera clavata (F.), a primitive member of the ant subfamily Ponerinae, was chosen for this study because of its size and importance as a well-known stinging hymenopteran.

MATERIALS AND METHODS

Venom apparatuses were dissected to separate completely their individual parts, and all membranes and muscles were removed mechanically. Attempts to remove the muscles and other structures chemically were avoided so that no changes in structure would occur. Each part was individually mounted on specimen stubs and coated with gold in a vacuum evaporator. Structures were observed with a Cambridge Stereoscan and micrographs were taken with Polaroid 105 PN film.

RESULTS AND DISCUSSION

The locations of sensory structures in the venom apparatus are shown in Fig. 1. Basically, in *Paraponera clavata* there are at least 8 distinct sensory regions of the venom apparatus: (1) the sting, including both distal and proximal areas but primarily the distal tip; (2) the lancets, primarily the distal tip; (3) the gonostyli; (4) the basomesal region of the fulcral arms; (5) the rami of the 2nd valvifers (oblong plate); (6) the oblong plates (7) the 7th sternum; (8) the anal pad. Each group of sensory structures will be discussed individually.

Sting.—Fig. 2.—The lateral region of the distal tip

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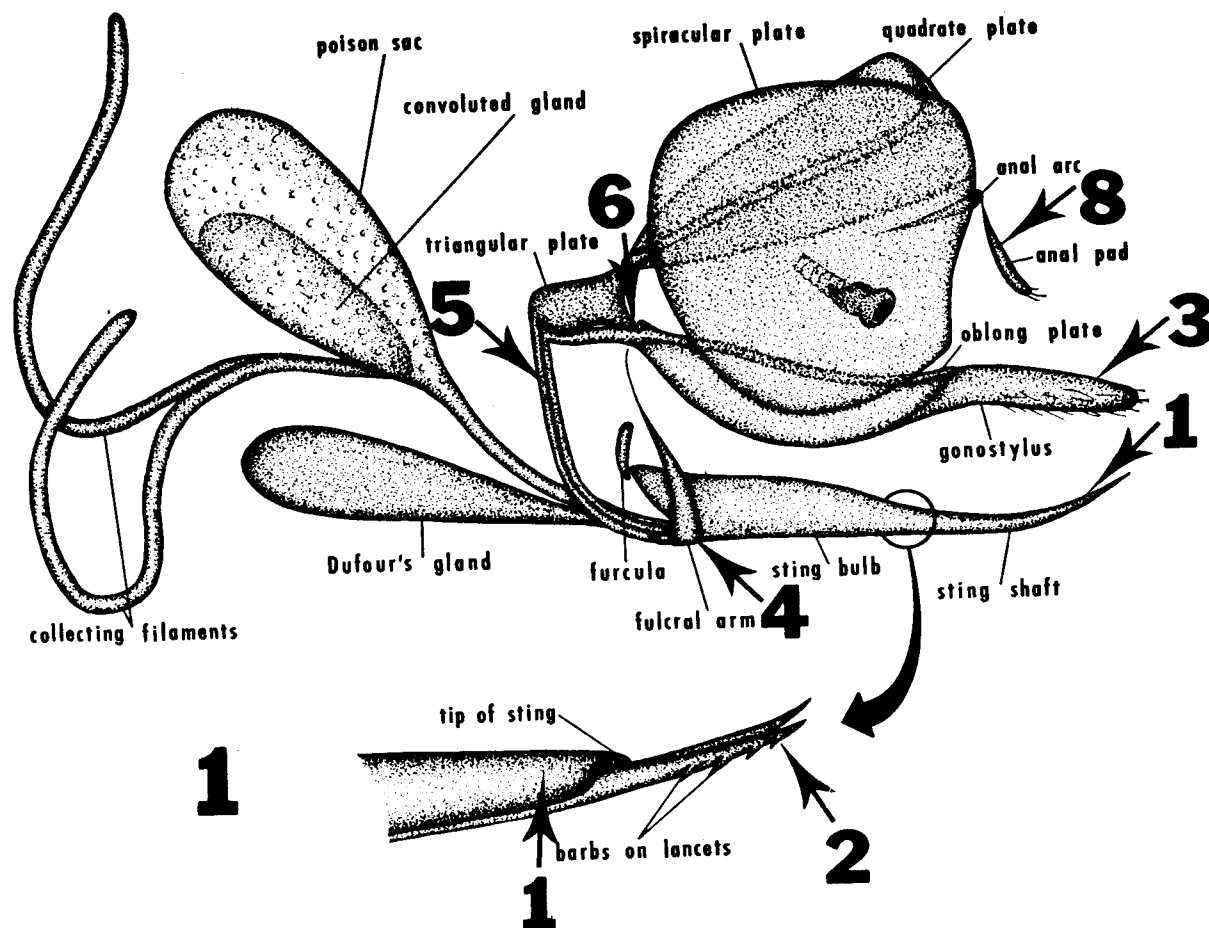


FIG. 1.—Lateral view of a generalized aculeate venom apparatus, pointing out the regions in which specific sensory structures are found. 1. Distal sting tip (SEM in Fig. 2). 2. Distal lancet tip (SEM in Fig. 2). 3. Gonostylus (SEM in Fig. 3 and 4). 4. Mesal side of fulcral arm (SEM in Fig. 5). 5. Rami of 1st and 2nd valvifers (SEM in Fig. 6 and 7). 6. Oblong plate in area where it articulates with triangular plate (SEM in Fig. 8). 7. Seventh sternum (not pictured) (SEM in Fig. 9 and 10). 8. Anal pad (SEM in Fig. 11).

of the 2nd valvulae (sting) (ST) have several *sensilla campaniformia*. King and Fordy (1970) recorded these sensory structures as pegs, modifications of pegs or simple dome-like structures set in depressions or cavities. Snodgrass (1956) reported that *sensilla campaniformia* like the ones shown here occur on the legs, sting, mouth parts, antennal bases and wing bases in honey bees. Similar sensilla have been reported on the inner surface of the sting and apparently are found scattered on the entire surface of the sting (McIndoo 1914), although in *P. clavata* they are concentrated primarily near the distal sting tip.

The presence of these structures in an aculeate hymenopteran makes one wonder about their function. Certainly the parasitic Hymenoptera employ their ovipositor tip in discriminating between acceptable and nonacceptable hosts (Narayanan and Chaudhuri 1954, Weseloh 1969, Wylie 1958). *Paraponera clavata* and most other ants employ their sting primarily

in defense and in predation. No information has been reported on the use of the sting in a discriminatory capacity. Since the sting enters the wound during the act of stinging, the sensilla may serve a function in penetration or in the detection of venom release.

Lancets.—Fig. 2.—The appearance of sensory structures on the distal lancet tip (LN) is much the same (*sensilla campaniformia*) as those on the sting tip. McIndoo (1914) reported abundant sensory structures at the base of each barb on honey bee lancets. The sensilla (PS) in *P. clavata* are ventrally located and near the base of the lancet barbs (BB).

Gonostyli.—Fig. 3 and 4.—Abundant mechanoreceptors cover the gonostyli. Most of these receptors are long and trichoid (TS) in appearance. They typically extend distally from both the proximal (PR) and distal (DR) gonostylar lobes. In addition, a few *sensilla campaniformia* (PS) may be found scattered on the gonostylar surface. These *sensilla* appear to be longer than the structures on the sting and lancets.

Fulcral Arms.—Fig. 5.—The inner surface of the fulcral arms (FA) of *P. clavata* has about 23 circular *sensilla placodea* (PO). According to Slifer (1961) plate organs apparently are pressure sensitive and may function in a similar fashion to the locust tympanum. Due to weak sclerotization a plate organ is somewhat flexible and undergoes some movement upon being touched. Considerable movement occurs

between the fulcral arms and sting (Hermann 1976) since the fulcral point for sting depression and rotation is at the basal point of attachment between these 2 structures. Since sting depression puts no particular pressure on the fulcral arms it is suggested that the plate organs function primarily during sting rotation or pivoting.

Rami.—Fig. 6 and 7.—The 2nd ramus (RA) ex-

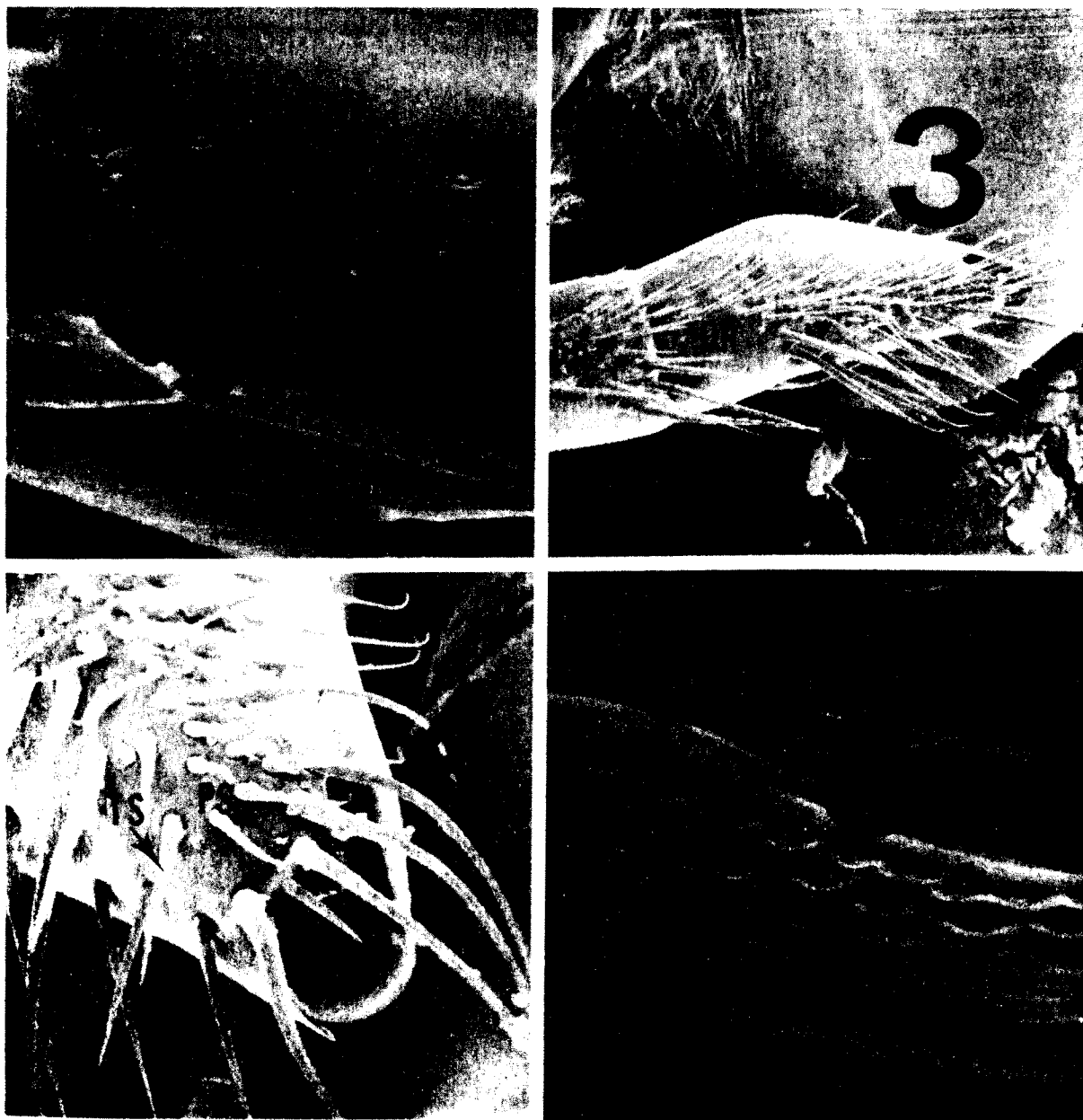


FIG. 2-5.—Scanning electron micrographs of sensory structures on the venom apparatus of *Paraponera clavata*. 2. Distal tip of sting (ST) and lancets (LN) with minute chemoreceptive pore structures (PS) (2000 \times). 3. Distal tip of one gonostylus, showing the proximal and distal lobes (PR and DR respectively) and numerous trichoid sensilla (100 \times). 4. Enlarged view of the distal gonostylar lobe, showing the long trichoid sensilla (TS) and minute pore structures (PS) (500 \times). 5. Mesal view of fulcral arm (FA), showing the two rows of pressure sensitive plate organs (PO) (2000 \times). Note: Figures reduced to 93½%.

tending from the oblong plate (2nd valvifer) to the sting (fused 2nd valvulae) has sensory pegs (SP) extending toward the closely associated 1st rami (RA 1). These sensory pegs extend from depressions in the ramal integument. We have never found sensory structures on the 1st rami. They appear to be unidirectional, their direction of bending being away from the 1st rami. The 1st rami have serrate surface extensions (TH) that rub on the mechanoreceptor pegs of the 2nd rami.

During the stinging act the lancets move alternately back and forth within the sting shaft. Hence, the 2 rami move on each other. The system of pegs and adjacent serrations appear to function at that time.

Oblong Plate.—Fig. 8.—About 15 sensory setae in the form of hair plates are found on each oblong plate (OP) in the region where it articulates with the triangular plate. The setae converge distally. Similar hair plates have been found in the joints of limbs in some insects (Pringle 1938). Pringle stated that the setae of hair plates are mechanical sense organs with a slow rate of adaptation and he suggested that they are "position" sense organs. There is considerable movement between the oblong plate and triangular plate during the act of stinging. These setae, therefore, appear also to have a vibratory or positional function during the alternating movements of the lancets.

Seventh Sternum.—Fig. 9 and 10.—The 7th sternum (7ST) of *P. clavata* has a number of trichoid structures extending both laterad and posteriad (Hermann and Blum 1966). The most obvious structures are large, nonmoveable spines (SS) that extend laterad for most of the length of the sternite. Distally they have an open end and consequently qualify as

chemoreceptors. Just how they function is not known.

Except for their size, these structures most closely resemble the thick-walled but hollow basiconic sensory pegs commonly found on insect antennae (Slifer et al. 1957, 1959).

Anal Pad.—Fig. 11.—The anal pad (AP), originating from the 10th abdominal segment, hangs over the anal opening. Distally it has 18–20 sensilla trichodea. The function of these setae is not known. However, upon examining the anal pads and associated sensory structures in doryline queens, we feel that these pads may sometimes be important in mating or egg-laying activities.

CONCLUSION

Other sensory areas associated with the ovipositor and venom apparatus, as well as those in the present report, are being investigated by us in widely divergent species of the order Hymenoptera. As a preliminary hypothesis we suspect significant differences among the major groups of the Symphyta, Parasitica and Aculeata and even greater differences in the Formicidae.

LIST OF ABBREVIATIONS USED IN FIGURES

AP: Anal pad	PS: Pore structure
BB: Barb of lancet	RA: Second ramus
DR: Distal gonostylar lobe	RA 1: First ramus
FA: Fulcral arm	SP: Sensory peg
LN: Lancet	SS: Sensory spine
OP: Oblong plate	ST: Sting
PO: Plate organ	TH: Tooth on first ramus
PR: Proximal gonostylar region	TS: Trichoid sensilla
	7 ST: Seventh sternum

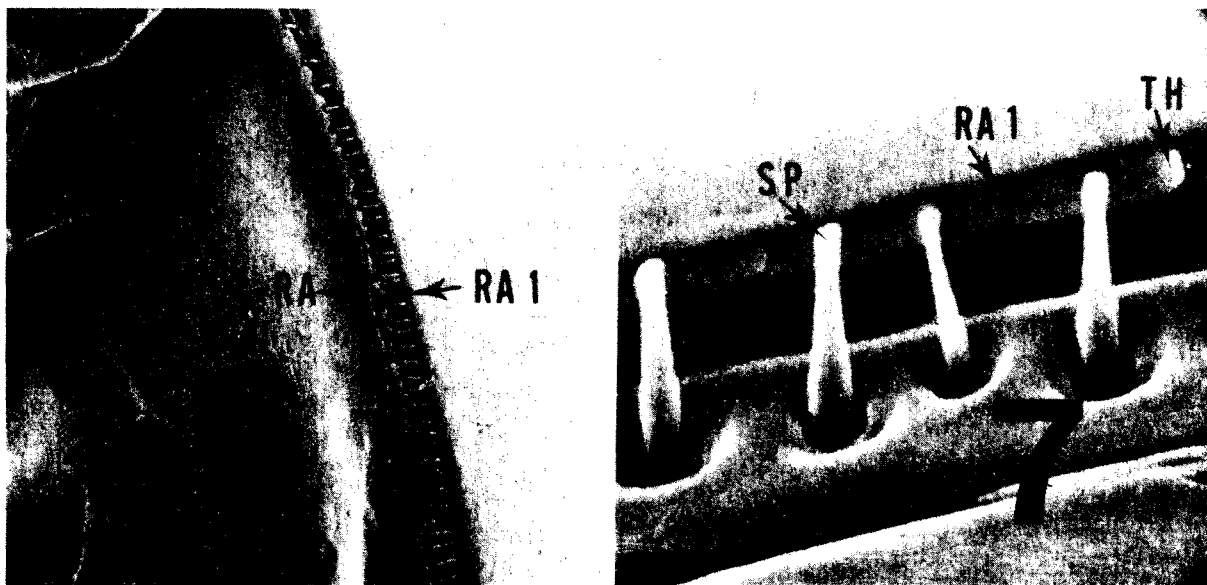


FIG. 6 and 7.—Scanning electron micrographs of the rami from the 1st and 2nd valvifers. 6. Entire rami, showing row of sensory pegs on 2nd ramus (RA) (200 \times). 7. Enlargement of rami, showing the unidirectional sensory pegs (SP) on the 2nd ramus (RA) and the serrate edge of the 1st ramus (RA 1) (2000 \times). Note: Figures reduced to 89%.

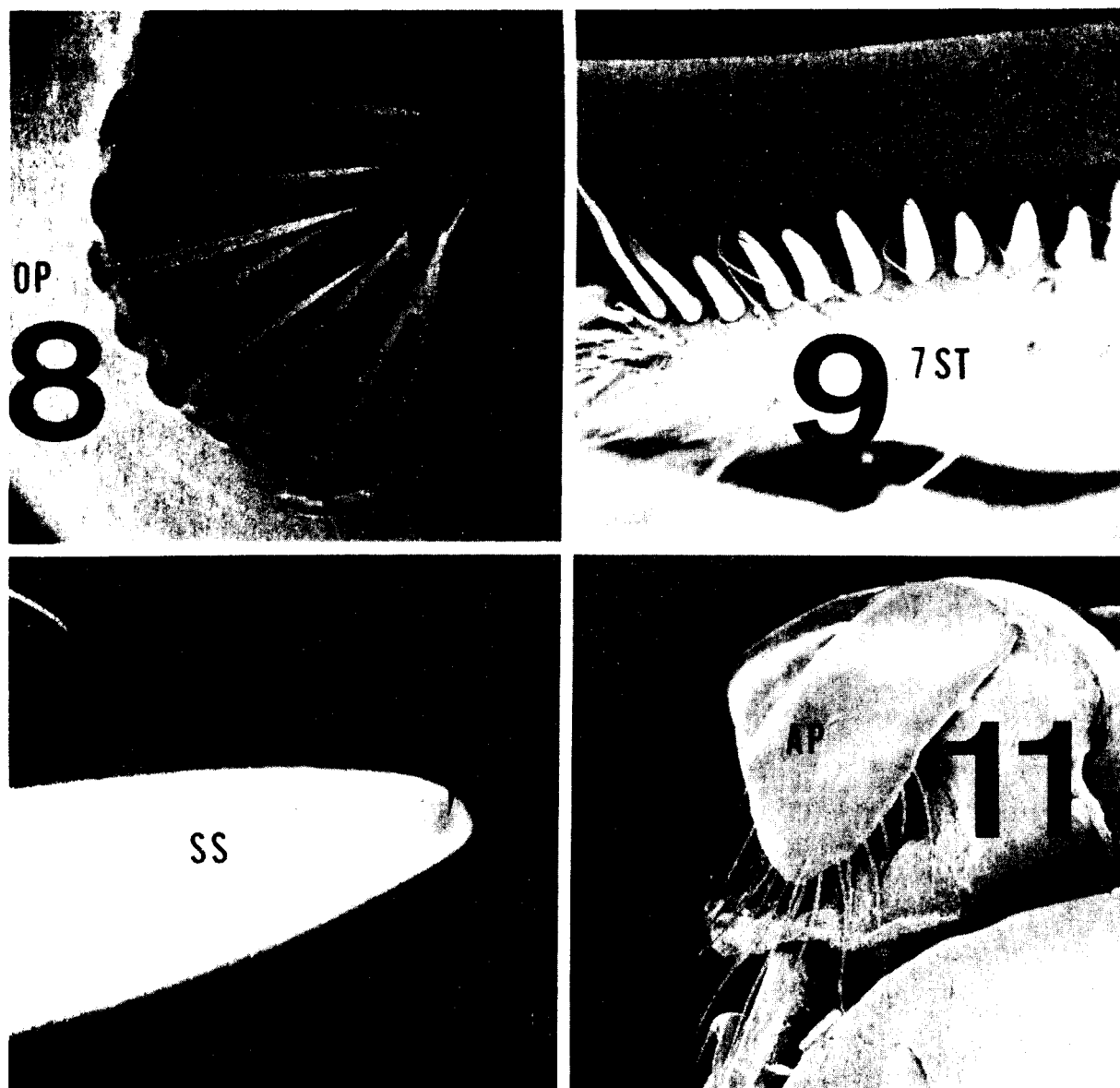


FIG. 8-11.—Scanning electron micrographs of mechanoreceptors and chemoreceptors of the venom apparatus and adjacent 7th sternum and remnant of 10th abdominal segment. 8. Hair plate on the oblong plate (OP) at its point of articulation with the triangular plate (1000 \times). 9. Seventh sternum (7 ST), showing the numerous trichoid sensilla and laterally arranged chemosensitive basiconic sensory spine (SS) (100 \times). 10. Enlargement of one sensory spine on 7th sternum, showing the pore at its distal tip (1000 \times). 11. Anal pad (AP), showing the long trichoid sensilla extending down past the anal area toward the lower venom structures (100 \times). Note: Figures reduced to 90%.

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