Ultramorphology of Mandibles from *Dolichoderus (=Monacis) bispinosus* Males

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ABSTRACT: Mandibles of ants are usual for many activities like cut and transport of food, transport of larvae and eggs, colony defense and to dig the rolls in the soil or/and wood for next building, among other activities. In male the principal function of the mandible is to act itself to female body during the mating by other hand the female use its mandibles to cut out the end of the male body after mating. The mandible movement are be possible because the different muscle presents in its articulation- the abductor and to adductor ones. The S.E.M. makes possible to study it in details to and showed the presence of skeletal muscle. This suggests its function to be instrument to use during the mating.

KEYWORDS: Mandibles; adductor muscle; abductor muscle; mandible gland; ultramorphology.

INTRODUCTION

The morphology of mouth parts, especially the mandibles are directly related to the insect's diet.[3] It is clearly observed in ants, especially the leafcutters *Atta* and *Acromyrmex*, for instance, where the internal margin has very conspicuous teeth [9, 10, 16]. In ants other than the leafcutters, the internal margin is almost flat, which makes them able to tear or grasp the food by a mechanism called trap-jaw [6, 7]. This type of mandible can be observed among individuals from the Ponerinae sub-family (Caetano, n.p.).

Another aspect that indicates the use of the mandibles is their size. In soldiers of *Eciton,* the mandibles are long and slim and they help in larvae transport during colony migration, as well as colony defence.[8] Specimens from the Cephalotini tribe have short and thick mandibles that are used to dig chambers in tree trunks. In general, older individuals have smaller mandibles when compared to young individuals[16].

The mandibles in ants also have an important role in mating, when the male prepares to attach itself to the female body and when finished, the female uses the mandible to cut the posterior portion of the male body [18, 13, 8]. This last act serves to free the female from the male permitting other males to take their place until the sperm storage reaches its upper limit.

Because the mandible shows all these features, what is undeniably essential for the insects is the fact that the related muscles must have the strength for these activities.

According to Gillott[5] and Chapman[3] in Pterygota the mandibles movement is done by the action of two skeletal muscles: adductor (closer) and abductor (opener) which in spite of the extreme importance very little research has been done.

MATERIAL AND METHODS

Scanning Electron Microscopy (S.E.M.): The mandibles and mandilar gland were removed and fixed in Karnovsky fluid for 24hours, dehydrated in ascending alcohol series (70 to 100%), subjected to two acetone 100% baths of 15 minutes each and critical point dried (Balzers CPD 030). After dehydration the material was placed on aluminum supports attached with double-faced tape and sputter coated with gold (in sputtering Balzers SD 050). The mandibles and mandibles gland was examined with a Jeol P15 SEM and photographed on Neopan SS 120 film.

RESULTS

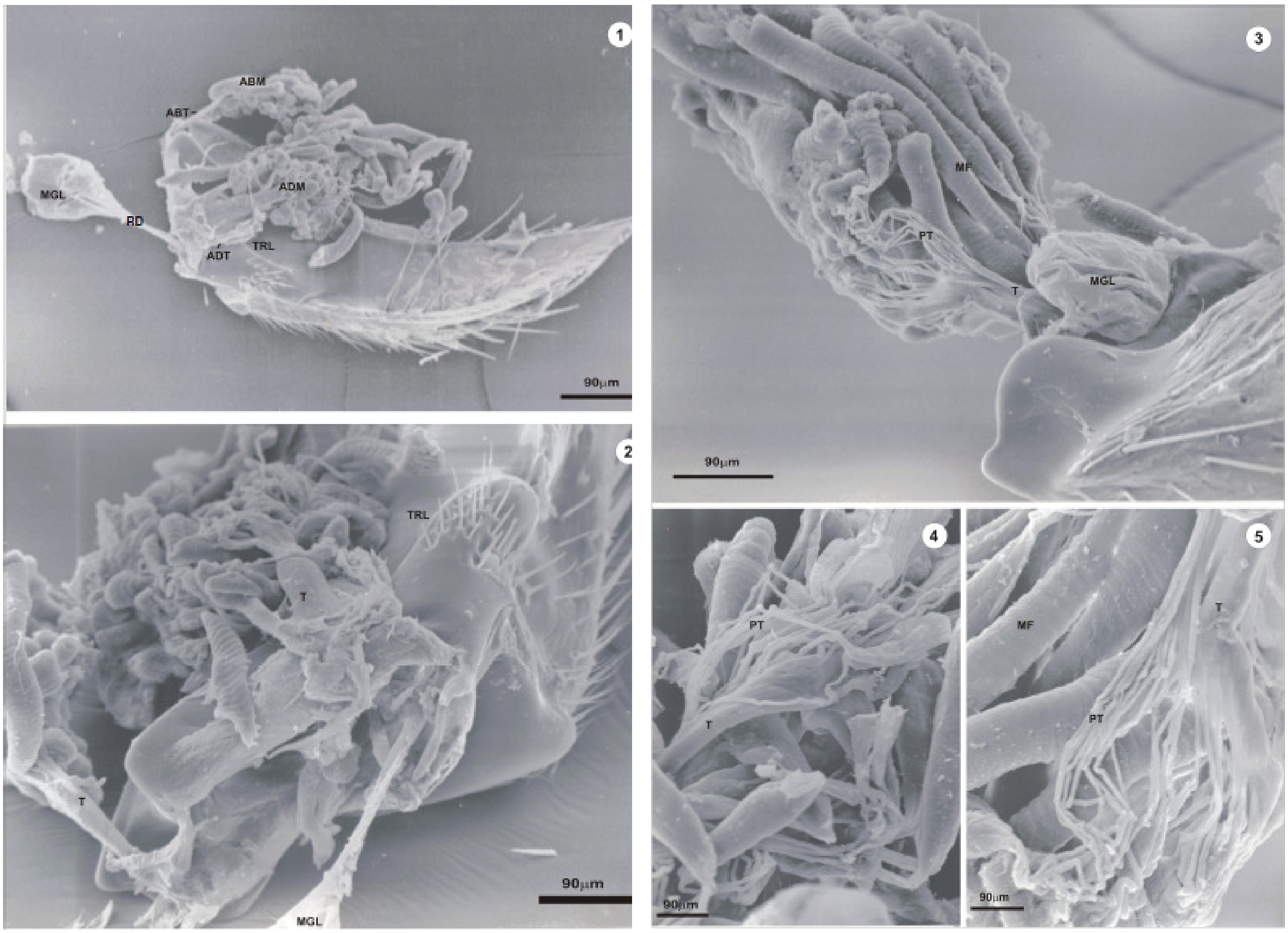
The mandible of *D.* (=*Monacis*) *bispinosus* males is a heavily sclerotized structure articulated via two points, anteriorly and posteriorly to the head capsule (dicondylic joint), allowing it to move laterally.

Two muscles open and close the mandibles and are located in the inner anterior border (adductor) and in the outer anterior (abductor) border (fig. 1 and 2).

The adductor muscle (fig.3) is well developed and consists of several muscle fibers that abruptly become thinner forming long and thin bundles (termed here as pretendons) (fig. 4 and 5). The fusion of these bundles forms a single and thick tendon that attaches to the mandible (fig. 2). These muscles consist of fibers arising from two points that can be observed as the tendon is formed in figures 1 and 2. One tendon is less developed and is formed before joining the main tendon, right above the mandible. These fibers, which are not part of the main muscle, were termed here as secondary fibers.

The inner border of the mandible is an asymmetric cutting surface compared to the external border (fig 1). In the latter, a large amount of hairs line the entire surface. Hairs are minute and thin from the proximal region to the medial portion. At this point, hairs increase in size and thickness, covering the surface from the medial region to the distal end of the mandible. They are part of the salivary system, secreting a combination of alcohols, ketones, and aldehydes. These compounds play a role in signaling alarm and defense behaviors to the colony[1,13] and also function as an attractant for mating, as suggested for *Atta laevigata* [11] and *Atta rubropilosa*[4].

In addition, Pietrobon & Caetano[19]. studying *Polistes versicolor* wasps, suggested that the amplitude of the opening of the mandible may exert different pressures on the reservoir to release more or less amounts of mandibular gland secretion, thus inducing different behaviors.



Legends
ADM= Adductor muscles; **ABM**= Abductor muscles; **ABT**= Abductor tendon; **ADT**= Adductor tendon; **MGL**= Mandible gland; **MF**= Muscular fiber; RD= Reservoir; **TRL**= Trulleum; **PT**= Pre-tendons; **T**= Tendon.

DISCUSSION

Unlike the hairs of *Odontomachus bauri* (Ponerinae) located on the inner edge of each mandible and that perceive stimuli to instantly close mandibles when hunting for preys or for defense[6,7], the hairs observed in *D.* (=*Monacis*) *bispinosus* males exhibit characteristics suggesting a role in dispersing pheromones produced by mandibular glands for communication with nestmates. This is supported by the presence of trulleum surrounded by delicate hairs and located in between the inner and outer borders in the proximal region of the mandible. The opening for the discharge of the mandibular gland secretion is located near the trulleum (fig.1).

This type of secretion discharge was also observed in arboreal ants with similar food habits, such as *Cephalotes pusillus,* in ground-foraging ants, such as *Dinoponera australis* and *Pachycondyla striata* [2] and in *Atta laevigata* [10].

The mandibular gland is located on the side of the head and connects to the inner wall of the mandible through the reservoir ducts (fig. 1). The location of the mandibular gland in the head cavity, above the trulleum suggests that its secretion discharge occurs through the opening present in the inner face of the mandible. This opening has been described by Mahyé and Caetano [16] and is maximized by the hairs and the morphology of the trulleum. Thus, when the mandible is closed, the opening is automatically closed by the internal wall of the clypeus, as also observed in *Atta laevigata* [16].

The more open the mandible, the more it pressures the gland reservoir. If that is the case, while defending themselves or attacking a predator, ants may have their mandibles as wide open as possible (as usually observed). The more mandibles and the wider they are, the more pheromone will be released, and consequently the number of individuals recruited[16].

Mayhé and Caetano[16] comparatively analyzed *Acromyrmex subterraneus* and *A. landolti* and suggested that the morphology of the trulleum may be used as a taxonomic trait for these and other genera of Attini, and demonstrated the relationship between the gland's structure and the hairs of the trulleum during pheromone dispersal.

The mixture of compounds in these secretions is extremely volatile and diffuse at different velocities in the air, inducing sequences of coordinated behaviors[2, 14, 15, 13]

Thus the hair surface near the opening of the mandible gland and trulleum might increase the surface area between these compounds and the air, maximizing the action of the sexual pheromone.

The adductor muscle (fig. 3) is well developed and composed of several muscle fibers that abruptly become thick, forming thin and long bundles.

The abductor muscle (fig.1 and 2) is not as developed as the adductor muscle and does not form pre-tendons. The general aspect of this muscle is in agreement with the described in the literature for other insects [4, 5] and ants[13].

This type of muscle might be used to close the mandible and constrain the queen during mating, similarly to the observed in different subfamilies, regardless of the type of mating. The use of the mandible by the male to constrain the queen has been observed in species with female-calling syndrome, such as in Ponerinae *Rhytidinoponera metallica* [12], male-aggregation syndrome, such as in Myrmicinae (*Pagonomyrmex)* [13] and even in species that exhibit colony fusion, such as in Ecitoninae, where the male has to win the acceptance of workers first and then have access to the queen [8, 18].

The secondary muscle fibers joining the fibers of the adductor muscle at the point where the tendon originates might play a supporting role during muscle activity, as well as allow less forceful mandible movements. Thus, forceful contractions may be performed by the joint action of both muscles, while more delicate ones, such as handling larva and eggs, by secondary fibers.

The formation of filaments, termed here as pre-tendons, could be saving space, since mandibles are very small and the attachment point is also reduced. However, this alone, does not seem to be a plausible explanation as the tendon could be formed previously, thus having the same effect. In fact, our findings suggest that this arrangement may allow distinct closing movements of the mandible regarding pressure as well as velocity. Fast movements may be a result of the contraction of fibers located more internally (facing the inner surface of the mandible); stronger and faster movements, by the group of central and innermost fibers; slow contractions, by outermost fibers, and slower and stronger actions, by the group of central fibers together with outer ones.

According to Gronemberg et al.[7], the versatility and specializations of mandibles depend directly on the plane, physiology, and components of muscle fibers. These authors correlated the velocity of closure of mandibles with two types of morphologically distinct muscle fibers: long fibers with short sarcomeres, which suggest fast muscle fibers; and short fibers with long sarcomeres, exhibiting characteristics of a slow and powerful muscle fiber.

In general, in long sarcomeres, more actin-myosin cross-bridges act in parallel, generating large forces in muscle fibers[17].

Although without an ultrastructural basis, our results indicate that the mandible of *D.* (*=Monacis*) *bispinosus* males present two types of muscle fibers. The slightly dented edge as well as muscles allow two types of movements adapted mainly to constrain the queen during mating and are not associated with feeding.

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