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research article

First report of mass captacula autotomy behavior in Scaphopoda

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Abstract

Behavioral studies on scaphopods are scarce and predominantly focused on feeding and burrowing strategies. Available evidence indicates physiological traits relevant to stress responses, including captacula autotomy during feeding and rapid retraction of captacula and foot into the mantle cavity upon disturbance. Herein, we report a novel behavior in *Paradentalium disparile* (d'Orbigny, 1847), based on observations of living individuals from the southwestern Atlantic coast of Brazil. Upon light tactile stimulation, unburied individuals autotomized a tangled mass of captacula, which showed residual movement while the animals simultaneously retracted the remaining tissues. Similar masses of detached captacula were also observed in preserved specimens during dissection, suggesting that this probably physiological stress response may be more common than previously recognized.

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1. Introduction

Scaphopods are marine mollusks found from shallow waters to depths exceeding 6,000 meters, comprising approximately 800 species worldwide (MolluscaBase 2025), of which 42 occur in Brazil (Absalão 2006, Souza et al. 2013, Machado et al. 2023, Caetano et al. 2026). They live infaunally, buried in soft seafloor sediments, interacting with the environment through the dorsal aperture for gas exchange and excretion, and through the ventral aperture via the foot and captacula (Reynolds 2002, Sigwart et al. 2017). They capture prey, frequently foraminifera, using numerous feeding tentacles called captacula (Bilyard 1974, Shimek 1988, Langer et al. 1995). These structures represent an autapomorphy of scaphopods and are associated with both feeding and sensory functions (Reynolds 2002, Simone 2009).

Captacula are thin, tentacle-like appendages that originate anterior to the oral tube and extend through the wider shell and ventral mantle aperture alongside the foot (Reynolds 2002). Although individuals may possess up to hundreds of captacula, which are continually discarded and regenerated (Shimek 1988), no accurate estimate of their average number is available. Each captaculum consists of a main stalk connected at its base by circular muscle fibers and a terminal bulb containing ganglia and a set of glands that secrete an adhesive substance, which assists with prey capture and attachment to the substrate (Morton 1959, Shimek 1988, Byrum & Ruppert 1994). Both the stalk and bulb can be covered with cilia, which aid in movement and food capture and are also coated with the adhesive secretion (Byrum & Ruppert 1994).

The captacula vary in function depending on the environment and prey preference, and can be easily detached, when necessary, though only in small quantities during foraging (Morton 1959, Shimek 1988). However, scaphopod behavior remains poorly studied beyond feeding, largely due to the difficulty of maintaining live specimens for observation. Still, available reports indicate that under stress, captacula are rapidly withdrawn into the mantle cavity along with the foot (Davis 1968, Shimek 1988). Herein, given the limited knowledge of both captacula biology and scaphopod behavior as a whole, we report the first observations of extensive autotomy of the captacula in the shallow-water scaphopod *Paradentalium disparile* (d'Orbigny, 1847) and discuss its potential biological significance.

2. Material and Methods

The present report of a distinct behavior is based on observations of eight living individuals of *Paradentalium disparile* (d'Orbigny, 1847) (five adults and tree juveniles) together with examination of preserved museum specimens of the same species (Table 1). Living specimens were obtained from bottom samples (10–20 m depth) dredged in Araçá Bay (23°49′20.1″S, 45°24′10.3″W), on the northern coast of São Paulo State, Brazil, between February 2013 and March 2014 as part of the BIOTA-FAPESP Program. Specimens were maintained in aquaria containing a 20 cm layer of sediment (fine sand and gravel) from the sampling site, filled with seawater. Behavioral observations were conducted over a 12-hour period. All live specimens are deposited under voucher numbers in the Museu de Diversidade Biológica da Universidade Estadual de Campinas (ZUEC-SCA 04, 06). In addition, 159 preserved specimens of *P. disparile* from three lots archived in the Museu de Zoologia da Universidade de São Paulo (MZUSP 25645, 25639, 25586), representing different localities along the southeastern coast of Brazil, were also examined.

3. Results

After stress, all live individuals of *P. disparile* showed rapid withdrawal of the captacula back into the mantle cavity. However, after the initial four hours of observation, an additional response was recorded only in adults: when lightly touched with tweezers (Fig. 1A: tw), the adult specimens, already unburied from the sediment, autotomized a mass of captacula (mc) instead of retracting them into the mantle cavity (Fig. 1B-D). No release of captacula masses was observed in juveniles, which consistently responded by simple captacula retraction. The detached mass resembled a small sphere, and even after release, the individual

Table 1. Summary of museum lots of *Paradentalium disparile* examined in this study.

Catalog number	Locality, coordinates, depth	Date	N[a]	Adult[b]	Juvenile	Condition	NMC[c]
ZUEC-SCA 04	São Sebastião Channel, Station 9H, 10-15m, Van Veen, off the northern coast of São Paulo State, Brazil.	20.iv.2014	3	2	1	Live individuals	2
ZUEC-SCA 06	São Sebastião Channel, Araçá Bay (23°49′20.1″S;45°24′10.3″W), Station CE34, 18-20m, Dredge, off the northern coast of São Paulo State, Brazil.	08.vi.2014	5	3	2	Live individuals	3
MZUSP 25645	Ubatuba/Boqueirão, São Paulo, Brazil.	09.v.1962	140	-	Mostly	Preserved specimens	-
MZUSP 25639	Ubatuba/Praia Sul, 16m, São Paulo, Brazil.	23.ii.1962	2	Mostly	-	Preserved specimens	1
MZUSP 25586	Angra dos Reis, Station 345, Rio de Janeiro, Brazil.	14.iii.1969	17	Mostly	-	Preserved specimens	12

[a]total number of individuals examined. [b]individuals were primarily identified as adults based on shell characteristics (e.g., size, absence of a protoconch, and external teleoconch sculpture), together with visual confirmation of gonadal development through dissection. Additional confirmation of maturity using TEM was performed only for specimens from the ZUEC-SCA lots. [c]number of adult individuals releasing a mass of captacula.

captacula continued to contract, causing the mass to move across the sediment, reminiscent of the shape and movement of a 'tumbleweed' (Fig. 1B, E). In addition to this unusual behavior, specimens also exhibited well-established defensive responses, including the retraction of the foot (ft) and the remaining attached captacula (cp) into the shell (sh) through the ventral aperture (Fig. 1B-D).

4. Discussion

Behavioral studies in scaphopods are scarce, particularly those based on in vivo observations. Notable examples include the work of Gainey (1972-73), detailing three distinct feeding mechanisms in scaphopods; Reynolds (1992), describing the process of decollation of the dorsal shell apex in dentaliids; and Steiner (1993), documenting the spawning behavior of two gadilid species and providing one of the few accounts of reproduction in the group. The most commonly reported stress response in scaphopods is the rapid withdrawal of captacula (Morton 1959, Davis 1968), a behaviour likewise observed in the present study in addition to extensive autotomy. Therefore, to better understand the occurrence and potential mechanisms of this autotomy, it is useful to consider similar responses in other mollusks. In Bivalvia, for example, the group most closely related to Scaphopoda (Chen et al. 2025), some species are also capable of autotomizing and regenerating their siphons, such as *Solen grandis* Dunker, 1862, and *Macoma balthica* (Linnaeus, 1758) (Wu et al. 2022, Hu et al. 2025). This response can be triggered by mechanical or chemical stimuli, as seen in *M. balthica* (Hu et al. 2025). Interestingly, when examining preserved material of *P. disparile*, bundles of autotomized captacula were consistently found in the ventral mantle cavity (Fig. 1E), suggesting that this autotomy may have been induced during fixation.

Solen grandis is also capable of regenerating autotomized siphons, although this process negatively affects its feeding habits (Wu et al. 2022). Similarly, although siphons and captacula are not homologous structures, it is reasonable to assume that mass autotomy of captacula may impair feeding in *P. disparile*. However, no data are currently available on the rate or extent of captacula regeneration. In rare observed cases, scaphopods may partially compensate for the loss of captacula by using the foot to scoop sediment and food particles, although this feeding mode appears to be less selective (Shimek 1988). Gainey (1972–73) also reported that in *Graptacme eborea* (Conrad,

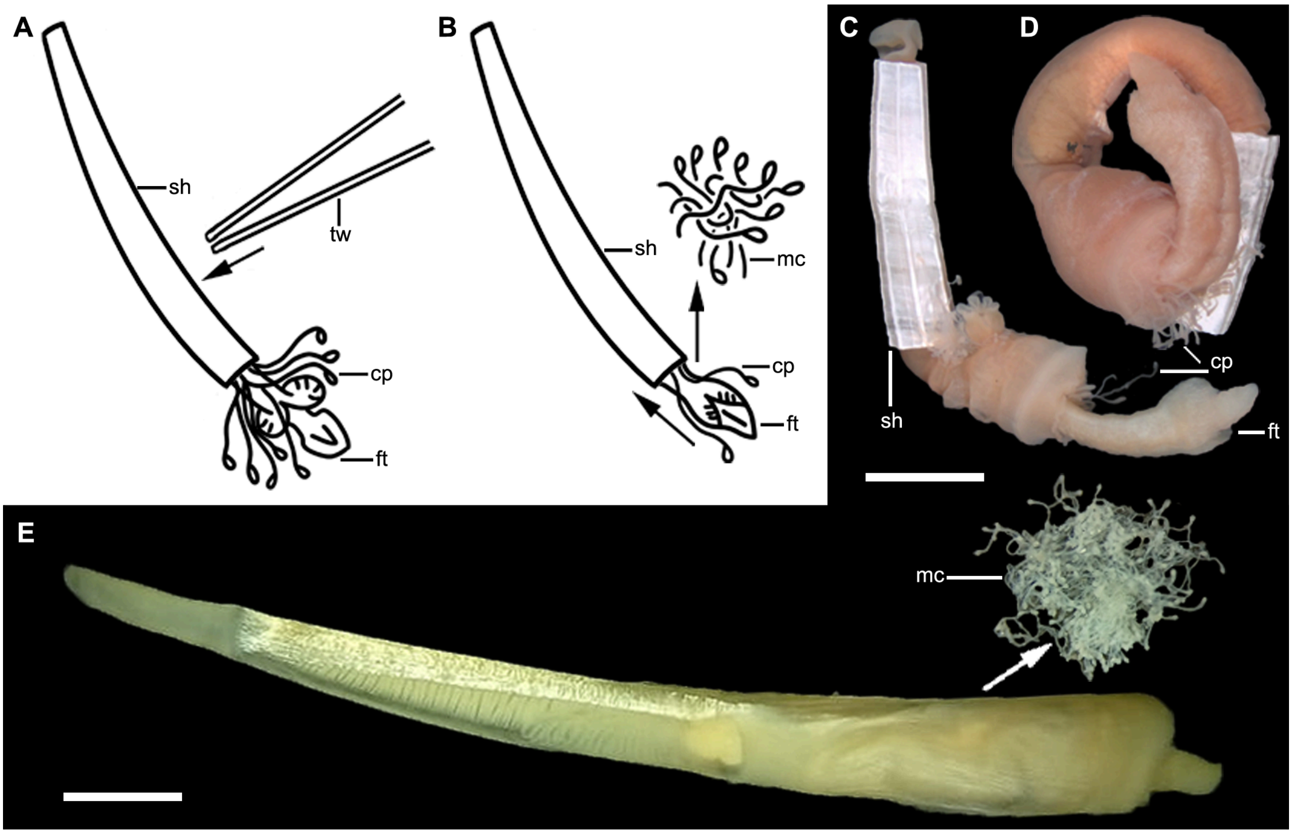

Figure 1. Schematic representation of *Paradentaluim disparile* to physical stimulation and the release of an autotomized mass of captacula. **A**, **B**. Adult individual, unburied; arrow indicates contact with tweezers; **B**. Individual after stimulation, arrows indicate retraction of the foot, remaining captacula, and release of a moving captacula mass; **C**, **D**. Two adult individuals with part of the shell removed, showing the remaining captacula after release (observed in vivo in this study); **E**. Adult individual with shell removed and mass of released captacula, probably due to fixation (preserved specimen MZUSP 25586, not observed in vivo). Scale bars: **C**-**E** = 2 mm. Abbreviations: cp, captacula; ft, foot; mc, mass of captacula; sh, shell; tw, tweezers.

1846), the burrowing activity of the foot creates a cavity within the sediment that allows the captacula to forage without dispersing through the surrounding substrate.

Although the captacula are less exposed in the water column than siphons, we hypothesized that autotomy in *P. disparile* represents a generalized response to acute stress, potentially triggered by mechanical or chemical stimuli, rather than a mechanism primarily associated with predator avoidance. Nevertheless, this process probably entails significant physiological costs, even if these have not yet been quantified. Such costs may also explain the absence of autotomy behavior in juveniles, which possess fewer captacula than adults; consequently, the loss of even a relatively small number of these structures may disproportionately affect feeding efficiency and, ultimately, growth.

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Authors' Contributions. VAF: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. FMM: Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Supervision, Validation, Visualization, Writing – review & editing. LRLS: Formal Analysis, Resources, Validation, Writing – review & editing.

Conflict of Interest. F. M. Machado serves as Managing Editor of Molluscan Horizons, and L. R. L. Simone serves as a Subject Editor of Molluscan Horizons. Neither author was involved in the peer-review process or in any editorial decisions regarding this manuscript. Editorial responsibility was delegated to an independent member of the editorial team to ensure an unbiased review process. The remaining author declares no conflicts of interest.

Use of AI. No AI tools were used in this manuscript.

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