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LABRAL MORPHOLOGY IN HEART URCHINS OF THE GENUS *BRISSOPSIS* (ECHINODERMATA: SPATANGOIDA), WITH AN ILLUSTRATED REVISED KEY TO WESTERN ATLANTIC SPECIES

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Abstract.—Existing keys to *Brissopsis* rely partly on the morphology of the labrum, an unpaired post-oral plate. As documented here, the unreliability of labral morphology has frequently resulted in misidentification of *B. atlantica* Mortensen, 1907 as *B. elongata* Mortensen, 1907. A revised key to western Atlantic species, using the number and shapes of plates below the periproct as substitutes for labral morphology, is provided.

The current authority on systematics of the spatangoid genus *Brissopsis* in the Atlantic Ocean is Chesher's (1968) revision based on analysis of 41 morphometric and meristic characters. His work includes a key that relies on only a few characters. The first couplet of this key separates *B. elongata* Mortensen, 1907 from other *Brissopsis* by the degree to which a post-oral plate, the labrum, extends posteriorly compared to adjoining plates. The basic format of Chesher's key was incorporated by Serafy (1979) into his key to spatangoids of the Gulf of Mexico and vicinity.

Labral extension is a convenient character to examine: a specimen need not be denuded of spines or dried, and damaged specimens often have the oral region intact. *Brissopsis* recently collected and examined by us included several specimens that were not *B. elongata* but had the labral condition of that species (Mortensen 1907). Subsequent examination of hundreds of museum specimens revealed many that were misidentified as *B. elongata*; nearly all of these had the labral condition of *B. elongata*. The purposes of this paper are to document the unreliability of labral extension as a taxonomic character in the genus and to provide for western Atlantic species a revised key that uses new characters of greater reliability.

The Labrum

The labrum is a tee-shaped, unpaired, interambulacral plate (plate 5.1, Lovén's system) located just posterior to the peristome of spatangoids (Fig. 1). Its anterior margin forms the broad posterior lip of the peristome, giving the ventrum the appearance of a carpenter's plane. Projecting posteriorly from the lip, the narrowed stem of the labrum abuts the first paired plates (sternal plates a.2 and b.2) of interambulacrum 5, which, along with the second pair (episternal plates 5.a.3 and 5.b.3), forms the broad plastron of the animal's ventrum. The labrum, plastron, and rest of interambulacrum 5 are bordered right and left by columns I.a and V.b, respectively, of the posterior paired ambulacra.

The length of the labral stem varies interspecifically. In most *Brissopsis* it is short and does not reach the suture between plates 1 and 2 of the adjoining ambulacra (viz., I.a.1 and I.a.2 or V.b.1 and V.b.2) (Mortensen 1951, Chesher 1968, Serafy 1979). In *B. elongata* and *B. obliqua* Mortensen, 1948, the labrum typically extends beyond ambulacral plates I.a.1 and V.b.1 and abuts plates I.a.2 and V.b.2. [Mortensen's (1907) statement that the labrum of *B. pacifica* (A. Agassiz, 1898) extends beyond the first ambulacral plates is in error (Mortensen 1951).]

Both Mortensen (1951:373, 377–378) and Chesher (1968:15) considered labral extension to be a stable and useful character in the genus *Brissopsis*. Variability in labral extension has been known to occur in some species, but the specimens have been considered abnormal. Mortensen (1907, 1951) found a few *B. lyrifera* (Forbes, 1841) in which the labrum extended beyond the first ambulacral plate on one (unilateral extension) or both sides (bilateral extension) or at least reached the suture between the first and second plates (Fig. 2). Mortensen (1951) pointed out that the holotype of *B. pacifica* is "abnormal" in having an extended labrum, and he included an appropriate cautionary note in his key (p. 379, footnote 3; see also p. 424 regarding a second specimen). One specimen of *B. columbaris* A. Agassiz, 1898 was reported to have an extended labrum (Mortensen 1951). Mortensen (1951:416) examined few specimens of *B. atlantica* Mortensen, 1907 and did not report any cases of abnormal labra. Chesher (1968) reported 2 of 105 *B. atlantica* with labra extended unilaterally; he also described and illustrated a case of bilateral extension in an apparent hybrid from the Caribbean coast of Colombia, where *B. atlantica* and *B. elongata* are sympatric.

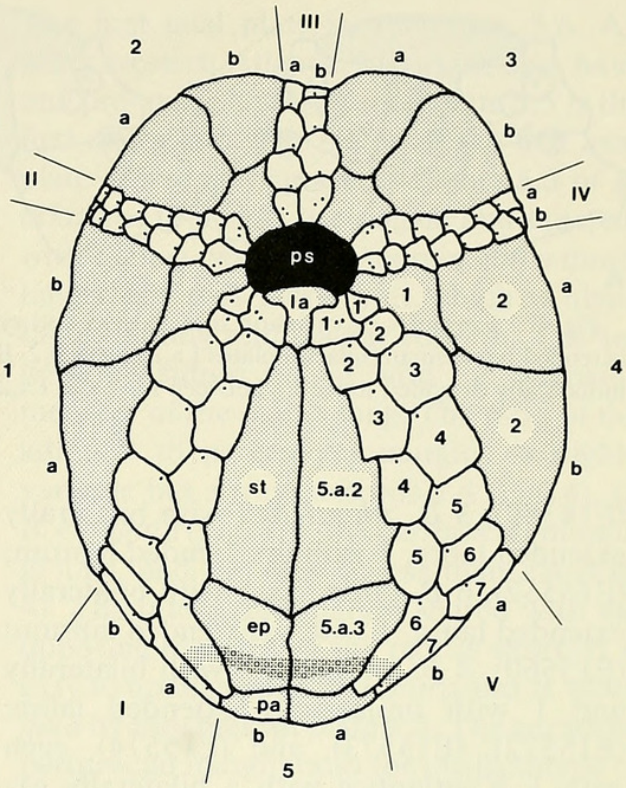

Fig. 1. Generalized ventral view of the test of a heart urchin, illustrating the alphanumeric designation of plates in the Lovénian system. Numbers of individual plates are given for interambulacrum 4 and ambulacrum V, and full designations are given for the sternal and episternal plates in column 5a. The schematic style follows David (1987). Abbreviations and conventions: ep, episternal plate; la, labrum; pa, preanal plate; ps, peristome; st, sternal plate; light stipple, interambulacra; dense stipple, subanal fasciole; ambulacra are not stippled.

Variation in *Brissopsis atlantica*

The problem of variability of labral extension in *Brissopsis atlantica* first came to the attention of one of us (RLT) in 1983 while examining uncatalogued material at the Indian River Coastal Zone Museum (IRCZM), Harbor Branch Oceanographic Institution, Florida. The material, from the east coast of Florida, was tentatively labelled *B. elongata* and consisted of 32 *B. atlantica* (IRCZM 72:346) with the labral conditions given in Table 1. Most recently, material collected specifically for this study in 1986 from the Gulf of Mexico included 24 *B. atlantica*, of which 19 had extended labra (6 lots; IRCZM 72:486–491). Thirty lots of *B. elongata* housed at the National Museum of Natural History (USNM), Smithsonian Institution, have been examined. The following misidentifications were found among them: (E10771), 2 *B. atlantica* with bilaterally extended labra; (E14283), 4 *B. atlantica*, 3 with bilaterally and 1 with unilaterally extended labra; (E14365), 1 *B. atlantica* with unilaterally extended labrum, redesignated E30961; 5 *B. elongata* remain in this lot; (E14373), 5 *B. atlantica*, 3 with bilaterally and 2 with unilaterally extended labra; (E14374), 2 *B. atlantica* with bilaterally extended labra, redesignated E30962; 56 *B. elongata* remain in this lot; (E14377), 5 *B. atlantica*, 4 with bilaterally and 1 with unilaterally extended labra, redesignated E30960; 41 *B. elongata* remain in this lot;

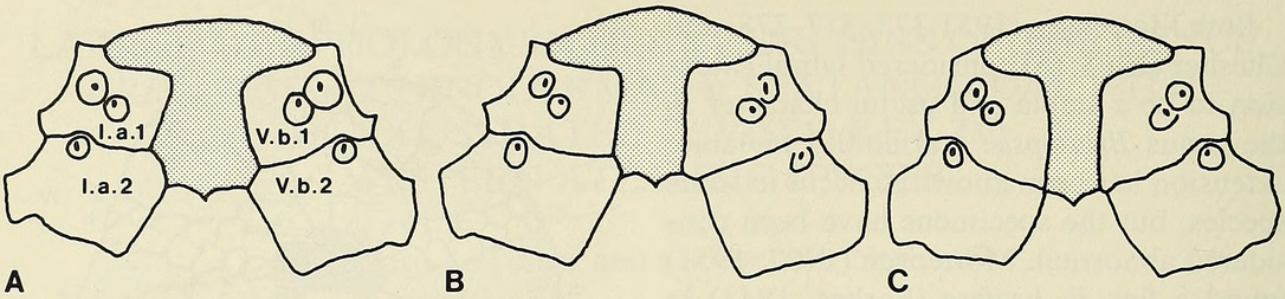

Fig. 2. Examples of variation in extension and symmetry of the labrum (stippled). A, Labrum bilaterally extended between ambulacral plates I.a.2 and V.b.2. B, Labrum unilaterally extended to plate I.a.2. C, Labrum unilaterally extended to suture between I.a.1 and I.a.2. All *B. atlantica,* IRCZM 72:346.

(E14389), 3 *B. atlantica,* 2 with bilaterally extended labra, 1 with unextended labrum; (E15552), 6 *B. atlantica,* 5 with bilaterally extended labra, 1 with unextended labrum; (E15560), 4 *B. atlantica,* 3 with bilaterally and 1 with unilaterally extended labra; (E15572), (E15573), and (E15574), each with 1 *B. atlantica* with a bilaterally extended labrum; (E15587) and (E15588), each with 2 *B. atlantica* with bilaterally extended labra; (E15589), 5 *B. atlantica,* 2 with bilaterally and 3 with unilaterally extended labra; (E15599), 1 *B. atlantica* with a bilaterally extended labrum.

The incidence of an extended labrum in some populations of *B. atlantica* is high, and misidentification of *B. atlantica* as *B. elongata* is frequent. It appears that the initial taxonomic assignment of USNM specimens was based only on the labral condition, for the course of the peripetalous fasciole over interambulacrum 3 and the ordinal number of ambulacral plates within the subanal fasciole in the specimens were typical of *B. atlantica.* Because existing keys separate *B. elongata* and *B. obliqua* from other *Brissopsis* spp. by labral morphology (Mortensen 1951, Chesher 1968, Serafy 1979), the potential exists for continued misidentification.

Pre-anal and Anal Plates

Having eliminated labral extension as a useful character for Atlantic species of *Brissopsis,* we propose two replacement characters: the number of pre-anal plates and the shape of the first anal plates. The arrangement of the labrum, sternal plates, and episternal plates of interambulacrum 5 is described above. Following these plates in columns 5a and 5b is a variable number of pre-anal and anal plates (Fig. 3). Members of the pair(s) of pre-anal plates abut each other along their interradial margins, and none touches the periproct. Beyond the pre-anal plates, the two columns of interambulacral plates diverge around the periproct; where they border the periproct, members of these columns are called anal plates, and only members of the first and last pairs are partly in contact interradially. Each anal plate has by definition a margin along the periproct.

In each column (a or b) of interambulacrum 5, *Brissopsis alta* Mortensen, 1907 has two pre-anal plates (5.4 and 5.5; Fig. 3C).

Table 1.—Labral condition of 32 atypical *Brissopsis atlantica* in IRCZM 72:346. Symmetry of extension refers to extension on one (unilateral) or both sides (bilateral) of interambulacrum 5 (see Fig. 2). Degree of extension refers to the plate number in ambulacral column I.a or V.b to which the stem of the labrum extends.

Degree of extension	Symmetry of extension: Unilateral	Symmetry of extension: Bilateral
Suture between ambulacrals 1 and 2	3	0
Beyond ambulacral plate 1	6	22
Mixed condition	—	1

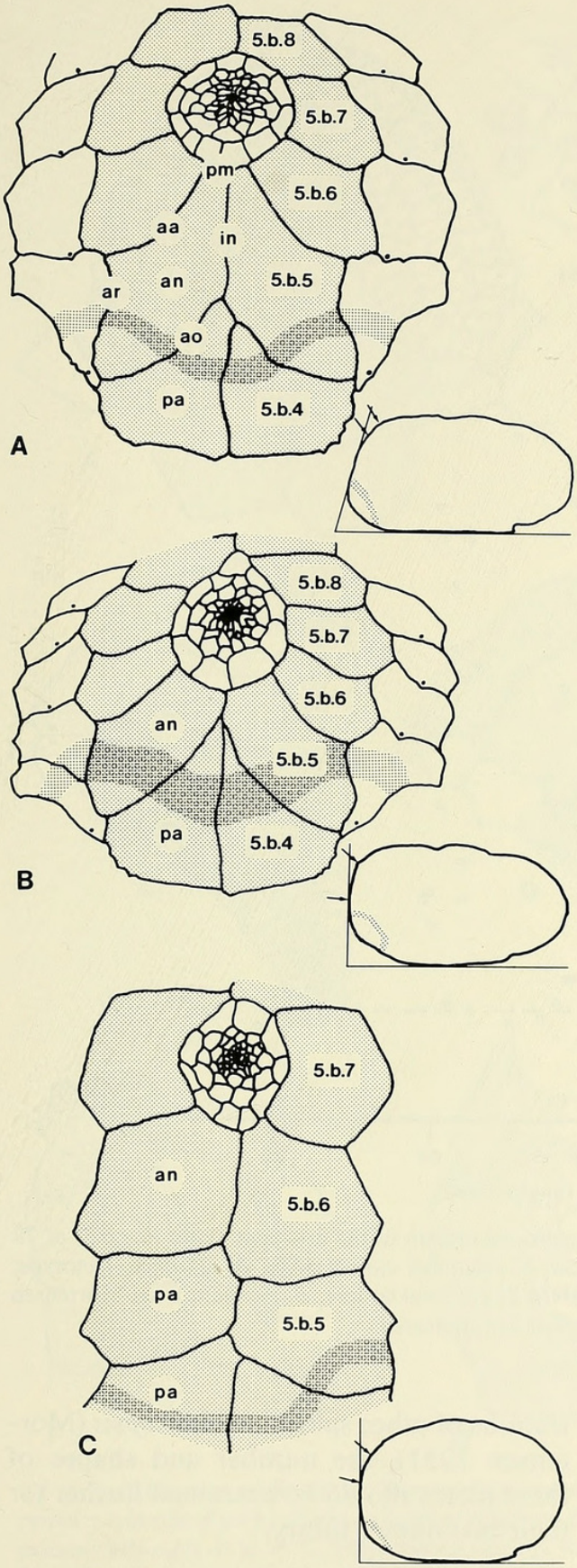

Fig. 3. Pre-anal and anal plates. A, *B. atlantica*, lectotype (USNM E10703, test length [TL] = 54 mm). B, *B. elongata*, (USNM 7117, TL = 30 mm). C, *B. alta*, lectotype (USNM E10704, TL = 67 mm). Outlined profiles give general shape of test, location of subanal fasciole, position of periproct (arrows), and angle of posterior margin of test for each species. Abbreviations and conventions: aa, adapical suture; an, first anal plate; ao, adoral suture; ar, adradial suture; in, interradial suture; pa, pre-anal plate; pm, periproctal margin; light stipple, interambulacrum 5; dense stipple, subanal fasciole; periproct and ambulacra I and V are not stippled.

The first anal plate is, therefore, 5.6. All other western Atlantic *Brissopsis* spp. have one pre-anal plate (5.4), and plate 5.5 is the first anal plate. The shape of the first anal plate differs among species. Plate 5.5 of *B. atlantica* (Fig. 3A) is elongate and tapered, with a short periproctal margin and a much longer adradial margin, at which it abuts the adjoining ambulacral column. The interradial suture shared with the opposing member of the pair is long. The ratio of the adradial to periproctal margins is highly variable but always exceeds 2.4 (Fig. 4). In *B. elongata* (Fig. 3B), the periproctal margin is long, and the ratio is less than 2.4 (Fig. 4). The interradial margin shared with the opposing member of the pair is short. It is easy to distinguish *B. atlantica* and *B. elongata* by the shape of plate 5.5. The adradial-periproctal margin ratio for the lectotype of *B. atlantica* (USNM E10703) is 5.8. A photograph of a type specimen of *B. elongata* (Mortensen 1907; pl. IV, fig. 18) gives a ratio of 1.4. Additionally, the ratio is 1.7 for a specimen of *B. elongata* (USNM 7117, *ALBATROSS* sta 2145) mentioned by Mortensen (1907:163, 426) to be conspecific with his type material, which we have not examined. The first anal plate of *B. mediterranea* Mortensen, 1913 is of variable shape in the few nominal western Atlantic specimens available to us.

The number and shapes of the pre-anal and first anal plates are partly correlated with overall body form in Atlantic *Brissopsis* (Fig. 3). In contrast to the low profile of *B. atlantica* and *B. elongata*, the presence of a second pair of pre-anal plates gives the

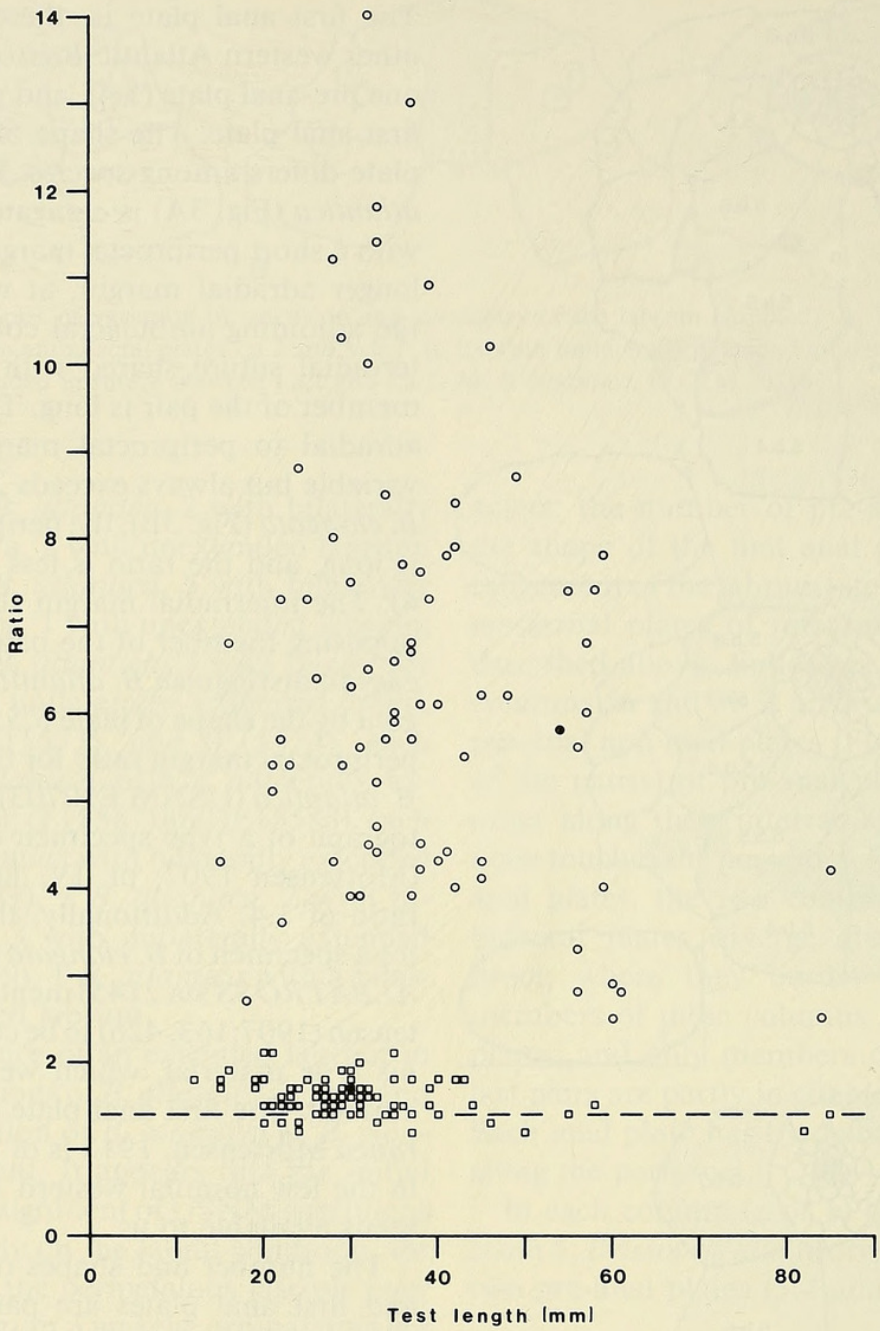

Fig. 4. Ratio of lengths of the adradial suture and periproctal margin of the first anal plates (5.a,b.5) of 78 *B. atlantica* and 94 *B. elongata*. Conventions: open circle, *B. atlantica*; closed circle, *B. atlantica*, lectotype; open square, *B. elongata*; closed square, *B. elongata* (USNM 7117); broken line, *B. elongata* from Mortensen (1907, pl. IV, fig. 18, test length unknown); overlapping plots not indicated.

posterior of *B. alta* a high profile. The inclined posterior of *B. atlantica* results from the tapered adapical extension and lengthened interradial suture of the first anal plates. On the other hand, the vertical posterior of *B. alta* is produced by the squareness of the first anal plates; and that of *B. elongata* by the strap-like first anal plates with a shortened interradial suture. Judging from illustrations of other species of *Brissopsis* (Mortensen 1951), the number and shapes of these plates should be examined further for their taxonomic utility.

Key to Western Atlantic Species of *Brissopsis*

The key presented below is a revision of keys given in Chesher (1968) and Serafy

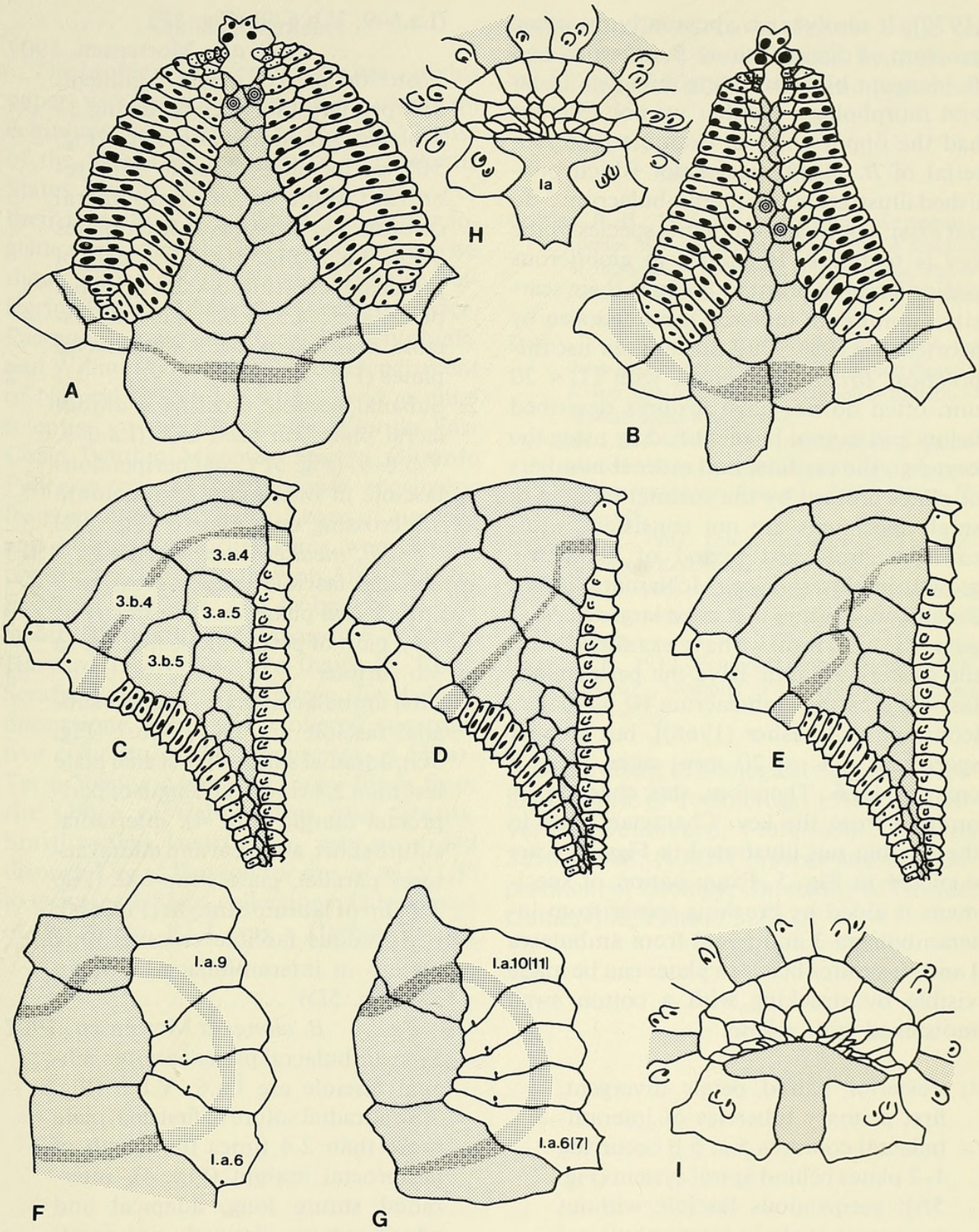

Fig. 5. Diagrams of *Brissopsis* showing features used in key. A, Divergent posterior paired petals; adapical primary tubercle of each column in interambulacrum 5 is indicated. B, Confluent posterior paired petals; adapical primary tubercles as in A. C, Peripetalous fasciole without re-entrant angle on plate 3.a.4. D, E, Peripetalous fasciole with re-entrant angle on plate 3.a.4. F, Subanal fasciole crossing 4 plates of ambulacrum I. G, Subanal fasciole crossing 5 plates of ambulacrum I. H, Lip of labrum straight. I, Lip of labrum produced. Abbreviations and conventions: la, labrum; light stipple, interambulacra; dense stipple, fascioles; ambulacra, apical system, and peristome are not stippled.

(1979). It resolves an apparently recurring problem of distinguishing *B. atlantica* and *B. elongata* by eliminating reference to labral morphology. Neither we nor Chesher had the opportunity to examine type material of *B. mediterranea,* for which published illustrations of interambulacrum 5 do not exist; our inclusion of this species in the key is tentative. Reference to globiferous pedicellariae is omitted because their scarcity on museum material [as noted also by Mortensen (1951:378)] makes their use impractical. *Brissopsis elongata* with TL < 20 mm often do not have features described below and cannot be identified by using the key; e.g., the cardinal and ordinal numbers of plates crossed by the subanal fasciole in small specimens are not consistent, indicating a prolonged period of allometric growth in this species (McNamara 1987). Finally, we caution that most larger *B. elongata* (TL > 20 mm) we have examined from the western Atlantic have the peripetalous fasciole crossing ambulacrum III on plate 7 [contrary to Chesher (1968)], but smaller specimens (TL < 20 mm) often have it crossing III.6. Therefore, this character is omitted from the key. Characters used in the key but not illustrated in Figs. 1–4 are depicted in Fig. 5. Examination of specimens is aided by brushing spines from interambulacra 3 and 5 and from ambulacra I and V; sutures between plates can be made visible by streaking with a cotton swab moistened with xylene.

1. Posterior paired petals divergent, first primary tubercles of interambulacral columns 5.a, 5.b occurring 1–2 plates behind apical system (Fig. 5A); peripetalous fasciole without re-entrant angle in interambulacral column 3.a, crossing plates 3.a.4, 3.b.4 (Fig. 5C); 2 pairs of pre-anal plates (Fig. 3C); first anal plates are 5.a.6, 5.b.6; subanal fasciole crossing 4 ambulacral plates on each side (I.a.6–9, V.b.6–9) (Fig. 5F) .... *B. alta* Mortensen, 1907

– Posterior paired petals confluent, first primary tubercles occurring 3–7 plates behind apical system (Fig. 5B); peripetalous fasciole with re-entrant angle in interambulacral column 3.a, crossing at least plates 3.a.4, 3.a.5 (Fig. 5D, E); 1 pair of pre-anal plates (Fig. 3A, B); first anal plates are 5.a.5, 5.b.5; subanal fasciole crossing 4 or 5 ambulacral plates (Fig. 5F, G) 2

2. Subanal fasciole crossing 4 ambulacral plates on each side (I.a.6–9, V.b.6–9) (Fig. 5F), *and* peripetalous fasciole in interambulacral column 3.b crossing only plate 5 (Fig. 5D) *B. mediterranea* Mortensen, 1913

– Subanal fasciole usually crossing 5 ambulacral plates on each side (Fig. 5G); path of peripetalous fasciole in 3.b various 3

3. First ambulacral plates to enter subanal fasciole are I.a.7, V.b.7 (Fig. 5G); adradial suture of first anal plate less than 2.4 times the length of periproctal margin (Fig. 4), interradial suture short, adapical and adoral sutures parallel, plate strap-like (Fig. 3B); lip of labrum straight (Fig. 5H); peripetalous fasciole crossing only plate 5 in interambulacral column 3.b (Fig. 5D) .... *B. elongata* Mortensen, 1907

– First ambulacral plates to enter subanal fasciole are I.a.6, V.b.6 (Fig. 5G); adradial suture of first anal plate more than 2.4 times the length of periproctal margin (Fig. 4), interradial suture long, adapical and adoral sutures distinctly not parallel, plate adapically elongate and tapered (Fig. 3A); lip of labrum produced (Fig. 5I); peripetalous fasciole crossing plates 3.b.4, 3.b.5 (Fig. 5E) ..... *B. atlantica* Mortensen, 1907

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Literature Cited

Chesher, R. H. 1968. The systematics of sympatric species in West Indian spatangoids: A revision of the genera *Brissopsis, Plethotaenia, Paleopneustes,* and *Saviniaster.*—Studies in Tropical Oceanography 7:1–168.

David, B. 1987. Dynamics of plate growth in the deep-sea echinoid *Pourtalesia miranda* Agassiz: A new architectural interpretation.—Bulletin of Marine Science 40:29–47.

McNamara, K. J. 1987. Plate translocation in spatangoid echinoids: Its morphological, functional and phylogenetic significance.—Paleobiology 13: 312–325.

Mortensen, T. 1907. Echinoidea (part 2).—The Danish Ingolf-Expedition 4(2):1–200.

Mortensen, T. 1951. A monograph of the Echinoidea, 5(2). Spatangoida, 2. Copenhagen, C. A. Reitzel, 593 pp.

Serafy, D. K. 1979. Echinoids (Echinodermata: Echinoidea).—Memoirs of the Hourglass Cruises 5(3):1–120.

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