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# A new species of Nudibranchia of the genus *Phyllidia* Cuvier (Gastropoda, Opisthobranchia) from the Maldive Islands

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A new species of the nudibranch genus *Phyllidia* Cuvier, 1797, *P. koehleri* spec. nov., is described from the Maldive Islands. It is compared with the most similar congeneric species, *P. polkadotsa* and *P. scottjohnsoni*. Its colour pattern is convergent with that of five Indo-Pacific *Phyllidiopsis* species, sharing the habitus of *Phyllidiopsis striata*.

Key words: Gastropoda, Opisthobranchia, Nudibranchia, *Phyllidia*, *Phyllidiopsis*, Indian Ocean, taxonomy.

## INTRODUCTION

The genus *Phyllidia* Cuvier, 1797, with its type species *P. varicosa* Lamarck, 1801, was described based on material from the Indian Ocean. Later on, additional *Phyllidia* species were described and named from the Indo-Pacific Ocean, the Red Sea and the Mediterranean Sea (Bergh, 1875; Pruvot-Fol, 1957; Yonow, 1986, 1988, 1996; Brunckhorst, 1993; Fahrner & Beck, 2000). Two of these, viz. *P. polkadotsa* Brunckhorst, 1993, and *P. scottjohnsoni* Brunckhorst, 1993, both described from the Hawaiian Islands, share a particular habitus and a *Phyllidiopsis*-like appearance. They have longitudinal, low, smooth ridges, simple conical or rounded tubercles and black pigment (round spots) on a yellow or white notal background. Five Indo-Pacific *Phyllidiopsis* species, viz. *P. striata* Bergh, 1888, *P. dautzenbergi* (Vayssière, 1911), *P. phiphiensis* Brunckhorst, 1993, *P. annae* Brunckhorst, 1993, and *P. sphingis* Brunckhorst, 1993, share the same habitus but have black stripes, small spots, and rays on a white or pale blue notal background (fig. 4). A *Phyllidia* species, with the yellow and black colours of *P. polkadotsa* but the pattern and habitus of *P. striata*, is part of a collection of nudibranchs from the Maldive Islands and is here described as a new species.

## METHODS

Living specimens were observed and photographed in the field, narcotized in a 1:1 mixture of sea water and 7% $MgCl_2$, fixed in 10% formalin, and preserved in 70% ETOH. The preserved material was dissected under a Leica MZ microscope and anatomical illustrations were made using a drawing tube. Anatomical preparations were stained with methylene blue or carmine.

## SYSTEMATIC PART

### **Phyllidia koehleri** spec. nov. (figs 1A-D, 2A-C, 3 A-F, 4)

*Chromodoris* sp.; Gothel, 1995: 108-109, unnumbered figure.
*Phyllidiopsis*; Debelius, 1997: 270, unnumbered figure.

Material (paratypes, anatomical slides and colour transparencies, in Perrone Coll'n, ASP 5322). — Indian Ocean, Maldive Islands: (1) Emboodhoo Out, Emboodhoo Island, South Male Atoll, 17 m depth, E. Koehler leg. 23.x.1999/1 specimen; (2) Guraidhoo Kandu, Guraidhoo Island, South Male Atoll, 23 m depth, E. Koehler leg. 24.x.1999/1 specimen; (3) Guraidhoo Kandu, 21 m depth, E. Koehler leg. 24.x.1999/2 specimens; (4) Rainbow Reef, Himmafushi Islands, North Male Atoll, 24 m depth, E. Koehler leg. 27.x.1999/holotype (Museum of Zoology, Roma).

Morphology. — The living animals are 7-11 mm long and have a body stiffened by spicules (fig. 1A-D). There are three longitudinal, low, smooth ridges on the dorsum. The central one is on the longitudinal, black, median stripe, whereas the lateral ones are in yellow areas (fig. 2A). Simple, conical tubercles are present both on the black and the yellow areas of the notum; they are smaller along the margin. The tubercles have the colour of their immediate background. The points of many, fine spicules end in these tubercles, whereas the ridges are not supported by spicules. The notum is bright yellow, with three black stripes. One of these is longitudinal and median, the two others form a submarginal ring, interrupted posteriorly (fig. 2A). The rhinophores are yellow and pointed at their apex, with 15 fine oblique lamellae. The anus lies dorsally on the posterior end of the central dorsal ridge. The underside of the mantle is yellow, with a black stripe running along its internal margin (fig. 2B). The foot is yellow and notched on its anterior edge. The oral tentacles are cone-shaped and have a lateral furrow. The triangular branchial leaves are arranged in two rows and are of two alternating sizes (fig. 3C). There are 39 leaves on the left side and 37 on the right side, where the reproductive opening interrups the branchial row. A different pattern phase (lot 1) is illustrated in fig. 1D. In that specimen the annular, black, dorsal stripe is not continuous, but prolonged into transversal, black triangles with their points on the notal margin.

Anatomy. — The alimentary and reproductive systems conform to those of the genus *Phyllidia*. The internal organs are whitish in the preserved material but the digestive gland is light brown in live specimens. Many needle-shaped spicules are present within the notum and the foot. The oral tube leads into a large conical pharyngeal bulb (fig. 3A), which has seven glandular, radially arranged protuberances with a rather irregular outline (fig. 3B). The strong retractor muscles connect the dorso-lateral surface of the pharynx to both sides of the body wall (fig. 3A). There is a small, three-pointed blood gland on the proximal oesophagus and the nerve ring. The oesophagus runs towards the left side of the body wall, bending halfway its free tract (fig. 3A). Then the oesophagus enters the digestive gland without forming a stomach. A short intestine tract is visible crossing the proximal aorta and running to the right where it reaches the anal opening in a mid-dorsal position. The ovotestis is on the anterior part of the digestive gland. The hermaphroditic duct is very short and leads into a bag-shaped ampulla of about the same size as the bursa copulatrix (fig. 3E). The ampulla and the bursa copulatrix lie on the large, rounded, nidamental gland. The receptaculum seminis is concealed by the ampulla. The proximal vas deferens is very short and leads into a convoluted prostatic gland,

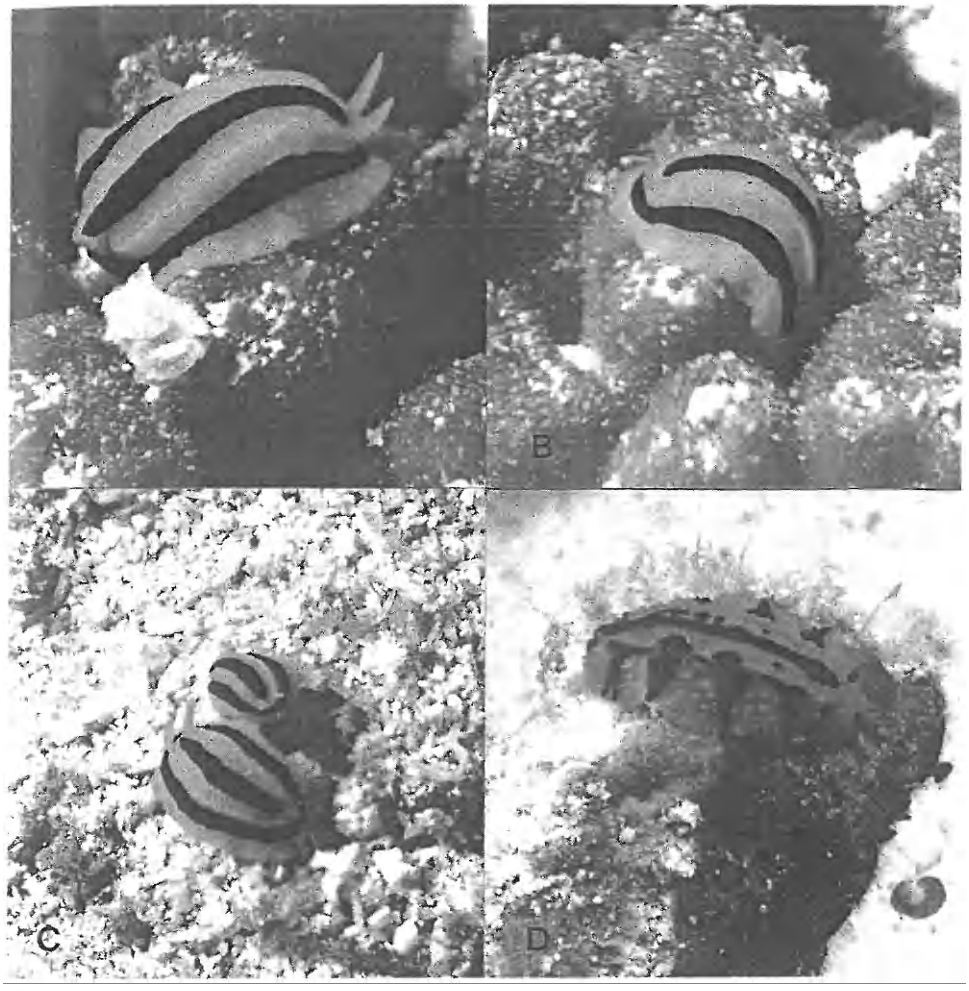


Fig. 1. *Phyllidia koehleri* spec. nov., live animals. A-B, holotype (11 mm long), Himmafushi Island, North Male Atoll; C, paratypes (7 and 9 mm long), Guraidhoo Island, South Male Atoll; D, paratype (11 m long), Emboodhoo Island, South Male Atoll. Photographs by E. Koehler.

becoming much narrower where the ejaculatory duct begins. The penis –not everted- is armed with four rows of chitinous spines at its distal tract (fig. 3F). The spines have a rounded base and a recurved tip.

Ecology. — *Phyllidia koehleri* appears to be associated with a bright orange arborescent demosponge (fig. 1A-B). The same association is depicted by Debelius (1997). Its study is in progress.

Etymology. — The epithet *koehleri* refers to the collector, Erwin Koehler.

Discussion. — Recent diagnoses of the genus *Phyllidia* were published by Brunckhorst

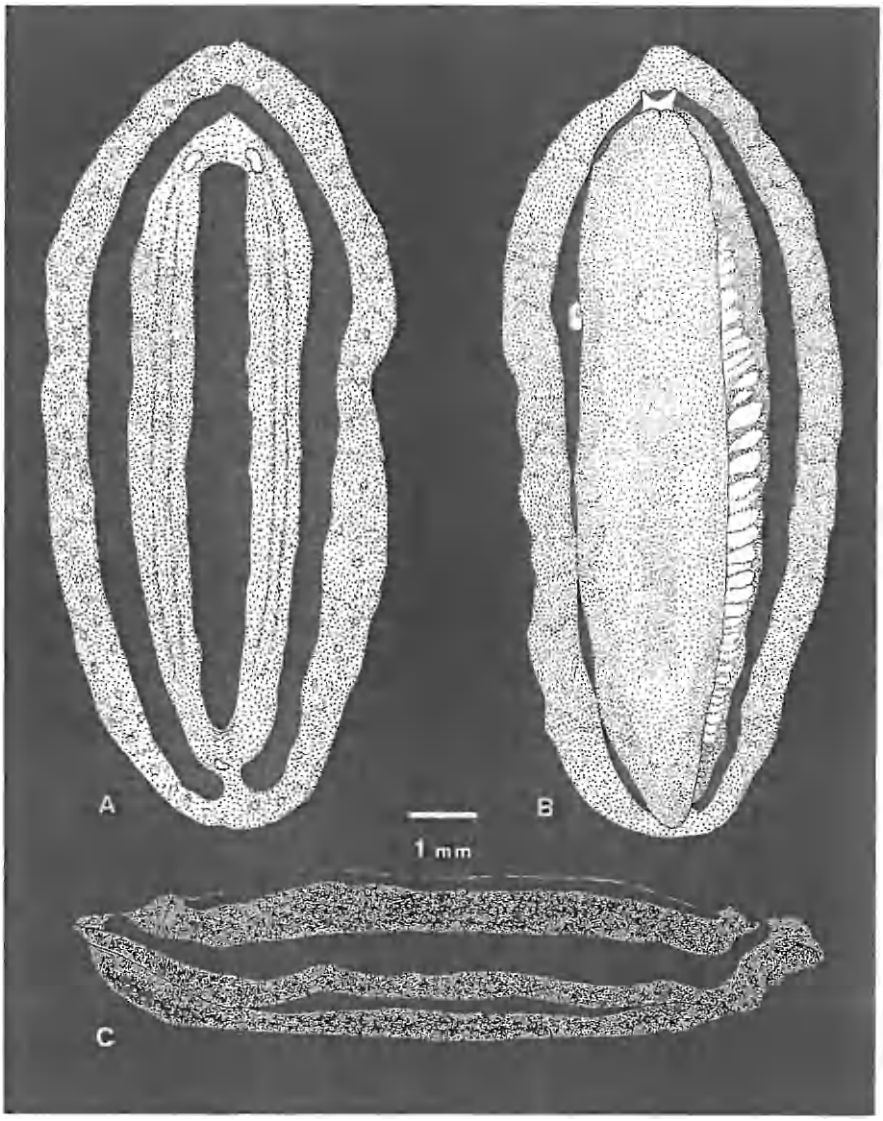


Fig. 2. *Phyllidia koehleri* spec. nov., colour pattern. A, dorsal view; B, ventral view; C, lateral view.

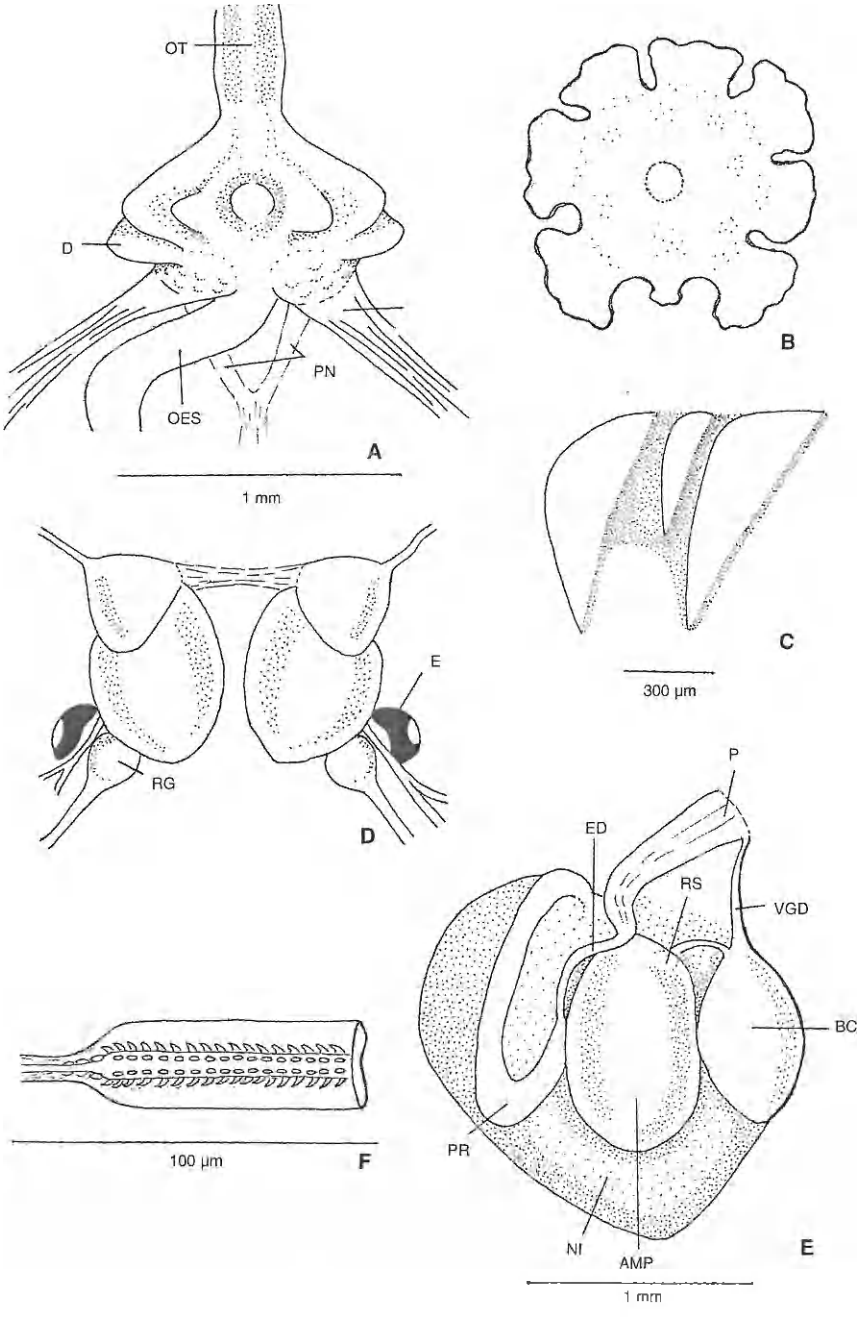


Fig. 3. *Phyllidia koehleri* spec. nov., internal anatomy. A, anterior part of the alimentary canal; B, pharyngeal bulb in frontal view; C, three branchial leaves; D, central nerve ring; E, reproductive organs; F, penis. Abbreviations: AMP, ampulla; BC, bursa copulatrix; D, pharyngeal gland; E, eye; ED, ejaculatory duct; NI, nidamental gland; OES, oesophagus; OT, oral tube; P, penis; PN, pharyngeal nerve; PR, prostatic gland; PRM, pharyngeal retractor muscle; RG, rhinophore ganglion; RS, receptaculum seminis; VGD, vaginal duct.

(1993) and Fahrner & Beck (2000). The characters of *P. koehleri* were analyzed following these generic diagnoses. The number of species to be classified in *Phyllidia* is uncertain (Yonow, 1996); 22 nominal species are listed in table 1. A phylogenetic analysis of the Phyllidiidae was reported by Brunckhorst (1993). According to his work, *Phyllidia* shares 12 characters with the other genera, viz. *Ceratophyllidia* Eliot, 1903, *Phyllidiopsis* Bergh, 1875, *Phyllidiella* Bergh, 1869, *Reticulidia* Brunckhorst, 1990, and *Fryeria* Gray, 1853 (only morphological and anatomical characters are considered here): 1, hard body stiffened by spicules; 2, presence of many calcareous and chitinous spicules; 3, ventrolateral gills; 4, lateral grooves on oral tentacles; 5, jaws absent; 6, radula absent; 7, salivary glands absent; 8, a pair of foregut retractor muscles; 9, pharyngeal bulb conical or cylindrical; 10, oviduct and prostate separate at exit from ampulla. The following characters are shared with *Phyllidiopsis*, *Phyllidiella*, *Reticulidia* and *Fryeria*: 1, notal tubercles present and stiffened by spicules; 2, ptyaline glands absent; 3, bursa copulatrix not stalked; 4, penial spines present. The following character is shared with *Phyllidiella*, *Reticulidia* and *Fryeria*: 1, pharyngeal bulb elongate or broad and conical. The following characters are shared with *Reticulidia* and *Fryeria*: 1, oral glands internal to the pharyngeal bulb; 2, posterior or posteriodorsal exit of pharynx from the bulb. The following characters are shared with *Fryeria*: 1, rhinotubercles present; 2, 'cauliflower' oral glands within the bulb. *Phyllidia* has two autapomorphies: 1, oral tentacles present, not fused; 2, penis bulbous.

In *Phyllidia koehleri* the rhinotubercles were not observed; if existing, they are very small. The penis has a relatively elongate, not a bulbous shape. These two characters appear to be synapomorphies of *P. polkadotsa* and *P. koehleri*. Among the known species

Table 1. *Phyllidia* species, with the location of their type localities.

| | |
|---|---|
| *P. alyta* Yonow, 1996 | Indian Ocean, Maldive Islands |
| *P. arabica* Ehrenberg, 1831 | Red Sea, Egypt |
| *P. babai* Brunckhorst, 1993 | Pacific Ocean, Papua New Guinea |
| *P. carlsonhoffi* Brunckhorst, 1993 | Pacific Ocean, Papua New Guinea |
| *P. coelestis* Bergh, 1905 | Indian Ocean, Indonesia |
| *P. elegans* Bergh, 1869 | Pacific Ocean, Philippines |
| *P. exquisita* Brunckhorst, 1993 | Pacific Ocean, Australia |
| *P. flava* Aradas, 1847 | Mediterranean Sea, Italy |
| *P. goslineri* Brunckhorst, 1993 | Pacific Ocean, Papua New Guinea |
| *P. japonica* Baba, 1937 | Pacific Ocean, Japan |
| *P. koehleri* spec. nov. | Indian Ocean, Maldive Islands |
| *P. madangensis* Brunckhorst, 1993 | Pacific Ocean, Papua New Guinea |
| *P. multituberculata* Boettger, 1918 | Indian Ocean, Maldive Islands |
| *P. ocellata* Cuvier, 1804 | Indian Ocean, Indonesia |
| *P. polkadotsa* Brunckhorst, 1993 | Pacific Ocean, Hawaiian Islands |
| *P. schupporum* Fahrner & Schrödl, 2000 | Red Sea, Gulf of Aqaba |
| *P. scottjohnsoni* Brunckhorst, 1993 | Pacific Ocean, Hawaiian Islands |
| *P. tula* Marcus & Marcus, 1970 | Pacific Ocean, Micronesia |
| *P. undula* Yonow, 1986 | Red Sea, Saudi Arabia |
| *P. varicosa* Lamarck, 1801 | Indian Ocean, Réunion Island |
| *P. willani* Brunckhorst, 1993 | Pacific Ocean, Papua New Guinea |
| *P. zebrina* Baba, 1976 | Pacific Ocean, Japan |

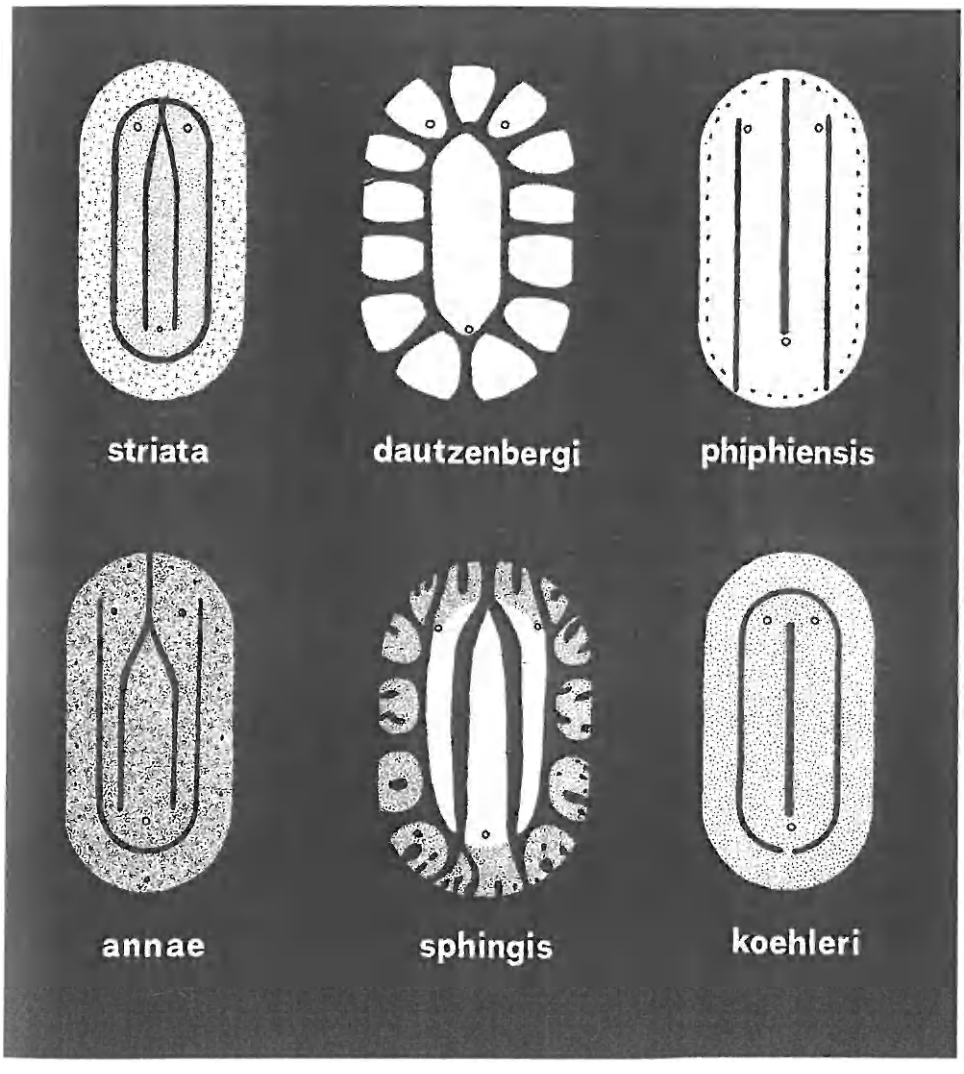


Fig. 4. Patterns in *Phyllidia koehleri* spec. nov. and the *Phyllidiopsis* species group with the *P. striata* habitus.

of Phyllidiidae, seven species have longitudinal low ridges, simple notal tubercles and black dorsal stripes or spots. These are *Phyllidia polkadotsa*, *P. scottjohnsoni*, *Phyllidiopsis striata*, *P. dautzenbergi*, *P. phiphiensis*, *P. annae*, and *P. sphingis*. *Phyllidia kochleri* shares its habitus with five *Phyllidiopsis* species. This pattern convergence is noteworthy. Externally, *Phyllidiopsis dautzenbergi* and *P. sphingis* are oval and easily distinguished from the remaining taxa with an elongate-ovate body shape and a pattern without rays. *P. phiphiensis* is white, with two longitudinal notal ridges and a pattern of three black stripes and many small

black spots. *P. annae* is bright blue, with three longitudinal notal ridges, four black stripes and black marginal spots; it has black rhinophores. Externally, *Phyllidiopsis striata* resembles *Phyllidia koehleri* in the following characters: 1, body elongate-ovate; 2, presence of three longitudinal, low, white or pale, notal ridges; 3, presence of simple, conical, notal tubercles; 4, yellow rhinophores. Marginal black pigment is only known in a phase of *Phyllidia koehleri*. The holotype of *Phyllidiopsis striata* has a large, marginal, black stripe, but that pattern is unknown in all recently recorded specimens. The two forms are distinguished by a set of external characters: 1, presence of four longitudinal, black stripes in *P. striata* and three in *Phyllidia koehleri*; 2, notum pale blue in *Phyllidiopsis striata* and bright yellow in *Phyllidia koehleri*; marginal notum white, with a granular appearance in *Phyllidiopsis striata* and bright yellow and smooth in *Phyllidia koehleri*. The anatomy of *Phyllidiopsis striata* is typical for the genus *Phyllidiopsis* (see Brunckhorst, 1990, 1993) by an elongate cylindrical pharyngeal bulb, enveloped by minute external oral glands, a muscular oesophageal segment, an oesophageal retractor muscle, and an elongate nidamental gland. *Phyllidia koehleri* can be distinguished by its anatomical characters that are characteristic for the genus *Phyllidia*.

*Phyllidia scottjohnsoni* is dorsoventrally flattened, like *P. koehleri*, but its colour pattern differs and there are 7-9 rhinophoral lamellae. *P. polkadotsa* is most similar to *P. koehleri*. Both species have the same general shape of the body, with three longitudinal, low ridges and simple, conical tubercles on the notum, a similar number of rhinophoral lamellae (11-13 in *P. polkadotsa*) and yellow and black colours. In *P. polkadotsa* there are more than ten large, round, black spots and there is no stripe. The anatomy of *P. polkadotsa* is typical for *Phyllidia*; it shares with *P. koehleri* the relatively elongate penis and possibly the absence of true rhinotubercles. *Phyllidia polkadotsa* and *P. koehleri* are allopatric (table 1) while *Phyllidiopsis striata* and *Phyllidia koehleri*, patterned similarly, occur sympatrically in the Maldive archipelago (Gothel, 1995). In both *Phyllidia* and *Phyllidiopsis* there are sesquiterpene isocyanides (Karuso, 1987) as defence chemicals and the convergent pattern may be relevant in their defensive strategy. The distribution of character states in *Phyllidia polkadotsa*, *P. scottjohnsoni* and *P. koehleri* suggests that *P. koehleri* is the sister taxon of *P. polkadotsa*. This hypothesis should be tested however, on the basis of additional data.

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