

Original Scientific Paper

## Sipuncula of the Adriatic Sea

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Sixteen species of Sipuncula are discussed with regard to their morphology and anatomy, distribution, ecology, biological relations, and literature quotations for the Adriatic Sea. Of them, *Golfingia (Siphonoides) mexicana* has not been previously noted in this area. The comparison of the Adriatic sipunculan fauna with that of the Mediterranean basin is made, and the importance of Sipuncula in the Adriatic benthic communities is pointed out.

### INTRODUCTION

In the Adriatic Sea, the Sipuncula have seldom been a subject of special investigation. The first who cited these worms in their papers were Grube<sup>1-3</sup>, Lorenz<sup>4</sup>, and Heller<sup>5</sup>. Later Stossich<sup>6</sup> and Carus<sup>7</sup> reviewed the Adriatic species and localities that were known up to that time. Graeffe<sup>8</sup> listed three species from the Bay of Trieste. Zimmermann<sup>9</sup> and Vatova<sup>10</sup> have reported on the Sipuncula from the surroundings of Rovinj. Only recently, Marcuzzi<sup>11</sup> listed six species which were inventoried in the old collection of the Marine Biological Station located in this town.

Vatova, also found several sipunculans while studying benthic communities in the North and Middle Adriatic<sup>12-16</sup>. Some Yugoslav hydrobiologists also cited sipunculan species from several localities in the North Adriatic Sea: Zalokar<sup>17</sup> and Zavodnik<sup>18</sup> from the Velebit channel, Gamulin-Brida<sup>19</sup>, Gamulin-Brida *et al.*<sup>20</sup> and Zavodnik<sup>21</sup> from the Rovinj area, Avčín *et al.*<sup>22</sup> and Matjašič and Štirn<sup>23</sup> from the coast of SR Slovenia, Zavodnik *et al.*<sup>24</sup> from the island of Krk, and Legac<sup>25</sup> from the Island of Rab.

Data on the Sipuncula from the Middle, and especially from the South Adriatic are on the other hand very scarce. In the offshore waters of this area, the sipunculans have been collected, other than by Vatova<sup>15</sup>, only by Soviet expeditions of the RV »Akademik Kovalevskij«. This material was assessed and reported on by Murina<sup>26,27</sup> and Kiseleva<sup>28</sup>. The sipunculan fauna along the Italian coasts remained poorly known<sup>15,16</sup>. Similarly, until now, only one finding of Sipuncula was published for the coastal waters of Albania<sup>26</sup> (RV »Akademik Kovalevskij«, station 237).

Only recently several papers have appeared which deal exclusively with the Adriatic Sipuncula: Zavodnik<sup>29</sup> and Zavodnik and Murina<sup>30,31</sup> have reported on the Sipuncula from the North, and Gamulin-Brida<sup>32</sup> from the Middle Adriatic Sea, Cukrov<sup>33</sup> studied the Sipuncula from the mid-Dalmatian archipelago

(the area of Šibenik). Regrettably, only a few notes of his study were published up to now<sup>34</sup>. Murina and Zavodnik<sup>35</sup> studied the material provided by the anniversary expedition of the RV »Vila Velebita« in 1973/74. Special contributions to the taxonomy and zoogeography on the Adriatic sipunculans were given by Murina<sup>27,36</sup>.

The present paper is a critical survey of the known literature data, and of the results of studies of rich biological material which was sampled in the past decennium on coastal trips and by the research vessels »Akademik Kovalevskij« (Sevastopol), »Bios« (Split) and »Vila Velebita« (Rovinj). The samples were taken by boat using various types of gear (biological dredges, Petersen and Van Veen grabs), or by skin and SCUBA divers of the Center for Marine Research at Rovinj. Some results were already presented in part in previous papers of the authors.

The biological material examined is deposited in collections of the Institute of Biology of Southern Seas, Sevastopol, USSR, and the Center for Marine Research Rovinj of the »Ruđer Bošković« Institute, Rovinj, Croatia, Yugoslavia.

#### SYSTEMATICAL PART

After the study of rich biological material and the critical review of bibliographical data related to the worms of the phylum Sipuncula, the following species are listed for the Adriatic Sea:

#### ASPIDOSIPHONIDAE

*Aspidosiphon (Aspidosiphon) kovalevskii* Murina 1964

*Aspidosiphon (A.) muelleri* Diesing 1851

#### PHASCOLOSOMATIDAE

*Phascolosoma (Phascolosoma) granulatum* Leuckart 1828

*Phascolosoma (Ph.) scolops* (Selenka et de Man 1883)

#### SIPUNCULIDAE

*Sipunculus nudus nudus* Linnaeus 1766

#### GOLFINGIIDAE

*Golfingia (Nephasoma) lilljeborgi* (Danielssen et Koren 1881)

*Golfingia (N.) minuta* (Keferstein 1863)

?*Golfingia (N.) eremita* (Sars 1851)

*Golfingia (Thysanocardia) catharinae* (Grube 1868)

*Golfingia (Siphonoides) mexicana* Murina 1967

*Golfingia (G.) vulgaris* (Blainville 1827)

*Golfingia (Dushana) adriatica* Murina 1975

*Golfingia (Mitosiphon) murinae* Cutler 1969

*Phascolion brotzkajae* Murina 1964

*Phascolion strombi* (Montagu 1804)

*Onchnesoma steenstrupii* Koren et Danielssen 1875

*Notice.* While the paper was in press, the following two species not previously noted in the Adriatic Sea, were collected by the RV »Vitjaz« in 1979<sup>162</sup>:

*Golfingia (Nephasoma) confusa confusa* (Sluiter, 1902). Geographical position: 41°22.5' N, 17°58.1' E, depth 1170 m, 1 specimen.

*Golfingia (Golfingia) shuettei* (Augener, 1903). Geographical position: 42°19.3' N, 16°49.5' E, depth 253 m, 1 specimen.

Regrettable, more details on these species could not be included in this paper. Some recent suggestions<sup>163-165</sup> on the systematics of the phylum Sipuncula could also not be considered.

#### Key to Families

- 1(2) Horny or calcareous shield, cone or cap present at the anterior extremity of the trunk . . . . . *Aspidosiphonidae*
- 2(1) No horny or calcareous shield, cone or cap present at the anterior extremity of the trunk . . . . . 3
- 3(4) Tentacles arranged in a horseshoe-shaped ring which does not surround the mouth but lies dorsal to it and which encloses the nuchal organ, if present; longitudinal musculature of body well grouped into bands; skin bears conical to hemispherical papilliform glands which may be very prominent at the anterior and posterior extremities of the trunk . . . . . *Phascolosomatidae*
- 4(3) Tentacles basically surround or partly surround the mouth and may be simple or branched, in groups, absent or reduced to a few lobes but never in a horseshoe-shaped ring situated dorsal to the mouth; nuchal organ, if present, lies dorsal to the tentacles and is not enclosed by them . . . . . 5
- 5(6) Longitudinal musculature of body wall thickened to form well defined bands, integumentary canals or coelomic sacs present in the body . . . . . *Sipunculidae*
- 6(5) Longitudinal musculature of body wall is continuous and never thickened into bands . . . . . *Golfingiidae*

#### Family ASPIDOSIPHONIDAE Quatrefages, 1865

Quatrefages<sup>37</sup>, p. 608 (in part), p. 604 (*Loxosiphonidae*, in part); Baird<sup>38</sup>, p. 100 (in part), p. 103 (*Loxosiphonidae*, in part)

Rather small worms in which a horny anal shield or calcareous cap is clearly marked off on the anterior part of the trunk and in which the tentacles do not surround the mouth but lie dorsale to it. A caudal shield may be present at the posterior extremity of the trunk. The introvert arises from the trunk ventrally to the anterior shield or cap in all genera except *Cloeosiphon*; in this last it arises from the middle of the cap. Longitudinal musculature of the body wall either continuous or grouped into bundles, the latter often anastomosing. Two nephridia.

Type genus: *Aspidosiphon* Diesing, 1851

#### Genus ASPIDOSIPHON Diesing, 1851

Diesing<sup>39</sup>, p. 68; Fisher<sup>40</sup>, p. 375; Stephen<sup>41</sup>, p. 460

Type species: *Aspidosiphon muelleri* Diesing, 1851

At anal and caudal parts of the body remarkable horny or calcareous shields. The introvert arises from the anal shield excentrically, somewhat nearer to

the ventral side. Hooks of the introvert with one or two teeth, sometimes both types are present. Inner muscle layer of the trunk continuous or branched into separated bundles. Usually two introvert retractors. Spindle muscle attaches the intestinal spiral at the caudal part of the body. Contractile vessel simple. worms live in mollusc shells, polychaete tubes and in cavities in lime-stone and corals.

In world oceans 52 species are known. Most of them are distributed in tropical areas, while only certain live in boreal and notal regions. More than one half of the species are limited to the littoral zone, and only one sixth of them penetrate into the sublittoral zone. Species of *Aspidosiphon* are rarely found in the bathyal and abyssal zones. Maximal depth of 3000 m was noted for *A. zinni* in the Atlantic Ocean<sup>42</sup>.

#### Key to subgenera of *Aspidosiphon*

- 1(2) Inner layer of longitudinal muscles grouped into bundles . . . . .  
 . . . . . *Paraspidosiphon* Stephen, 1965  
 2(1) Inner layer of longitudinal muscles continuous . . . . .  
 . . . . . *Aspidosiphon* s.str. Diesing, 1851

#### Subgenus *Aspidosiphon* s.str. Diesing, 1851

Stephen<sup>41</sup>, p. 460

Type species: *Aspidosiphon muelleri* Diesing, 1851

Inner layer of longitudinal muscles continuous. Two retractor muscles or one retractor with two roots.

#### Key to species of subgenus *Aspidosiphon* s.str.

- 1(2) Hooks of introvert single pointed; anal shield cone-shaped, with many knots carrying sharp spines; single retractor with two roots . . . . .  
 . . . . . *A. (Aspidosiphon) kovalevskii* Murina  
 2(1) Hooks of introvert in anterior part single pointed, in posterior one double pointed; anal shield semi-elliptical or heart-shaped, without sharp spines; two retractors . . . . .  
 . . . . . *A. (Aspidosiphon) muelleri* Diesing

#### *Aspidosiphon (Aspidosiphon) kovalevskii* Murina, 1964 (Fig. 1)

Murina<sup>26</sup>, pp. 51—56, Fig. 2—5; Murina<sup>43</sup>, p. 66

#### Quotations for the Adriatic Sea:

Murina<sup>26</sup>, p. 51; Murina<sup>44</sup>, p. 141; Stephen and Edmonds<sup>45</sup>, p. 229 (*kovaleskii*); Fredj<sup>46</sup>, p. 63; Murina & Zavodnik<sup>35</sup>, p. 245; Zavodnik<sup>18</sup>, Tab. XIII.; Zavodnik *et al.*<sup>24</sup>, Tab. I.

*Material*: 577 specimens.

*Description*: The largest animal is 17 mm long and 0.5—1.0 mm thick, with the introvert 5.6 mm long and 0.5 mm thick. The body is cylindrical or rod-like; body length and width relationship varied from 4:1 — 20:1. White thin-walled introvert is shorter than half of the body length and two times thinner. On the introvert located are small scarcely chitinized yellow hooks with slightly curved points 0.020—0.025 mm high (Fig. 1c).



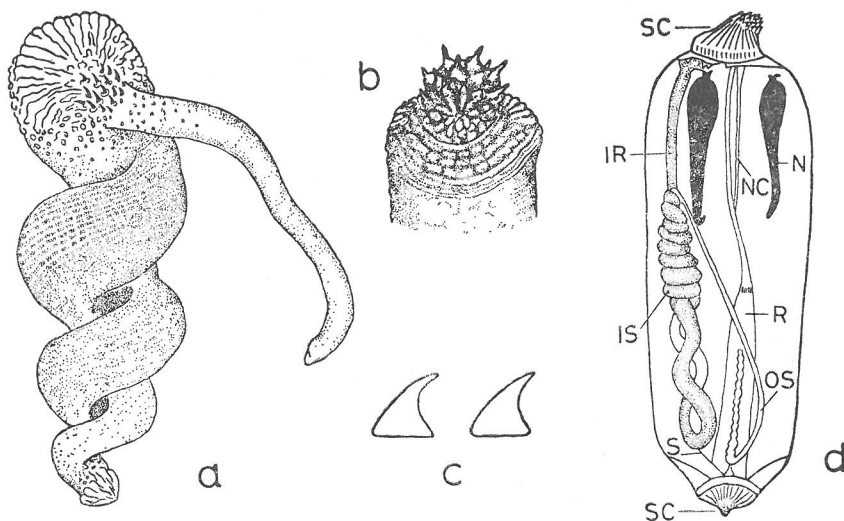


Fig. 1. *Aspidosiphon kovalevskii* Murina. a = entire specimen; b = anterior shield with hooks, the introvert is inverted; c = hooks of the introvert from its distal (left) and proximal (right) part; d = dissected specimen (a: after Murina and Zavodnik<sup>35</sup>; b, c: originals; d: after Murina<sup>29</sup>).

**Abbreviations:** A = anus; C = contractile vessel; CD = dorsal contractile vessel; CV = ventral contractile vessel; D = rectal caecum; DI = dissepiments; F = fixing muscle; G = ganglion; GO = gonads; I = introvert; IR = rectum; IS = intestine spiral or loop; IS' = accessory intestinal spiral; MS = intestinal mesentery; N = nephridium; NC = ventral nerve cord; NF = nephridiopore; OC = eye spots; OI = postoesophagal intestine; OS = oesophagus; OV = ova; R = retractor; RD = dorsal retractor; RV = ventral retractor; S = spindle muscle; SC = caudal shield; SO = oral shield; T = tentacles; W = wing muscle; Z = racemose glands.

Dependent on the condition of the animal when preserved, the shields are more or less flattened and cone shaped, or stretched and cylindrical. In worms with completely inverted introvert the anterior shield is composed of two parts: of the low cylindrical base and of irregularly contoured cone, the axis of which is at a sharp angle to the axis of the body. The upper part (cone) is furrowed with many plates which bear spines (Fig. 1b). The plates are smaller and the spines are longer at the vicinity of the introvert; on several plates the spines can be broken. On the ventral side, the plates with spines form a series of bows which encircle the introvert. Elongated furrows (12—22) are perceptible from the dorsal side; they diverge fan-like from the apex of the shield bows and prolongate to the lower cylindrical part of it.

The anterior shield is golden-yellow. The posterior shield is smaller than the anterior one with no clearly defined border. The trunk wall is white, silky, shining, thin and in the middle region of the body almost transparent. The body is covered with papillae and skin bodies, which vary in number in different individuals, or they can even be absent. Behind the anal shield, the anterior part of the trunk is covered with numerous flat skin bodies: they are most dense near the shield. The posterior half of the trunk is covered with the finger-like brown papillae 0.010—0.015 mm high and 0.005—0.015 mm thick.

The retractor muscle begins at the posterior end of the body in two roots (Fig. 1d). A long oesophagus continues into the intestinal spiral with 1—18 coils. There are 1—3 fixing muscles, which attach the anterior and posterior

parts of the intestine. The rectum with a caecum is fixed to the body wall by two wing muscles. The nephridia are white, cord- or elongated pear-shaped. The nephrostomes (*i.e.*, inner openings of nephridia) are well distinguished, the nephridiopores (*i.e.*, outer openings of nephridia) are situated posterior to the anus. All along their length the nephridia are attached to the body wall with mesenterial fibres.

*Distribution:* The Aegean Sea at 78—200 m, Gulf of Aden at 34 m. In the Adriatic Sea it is distributed in coastal and offshore areas at 1—124 m depth (Fig 2).

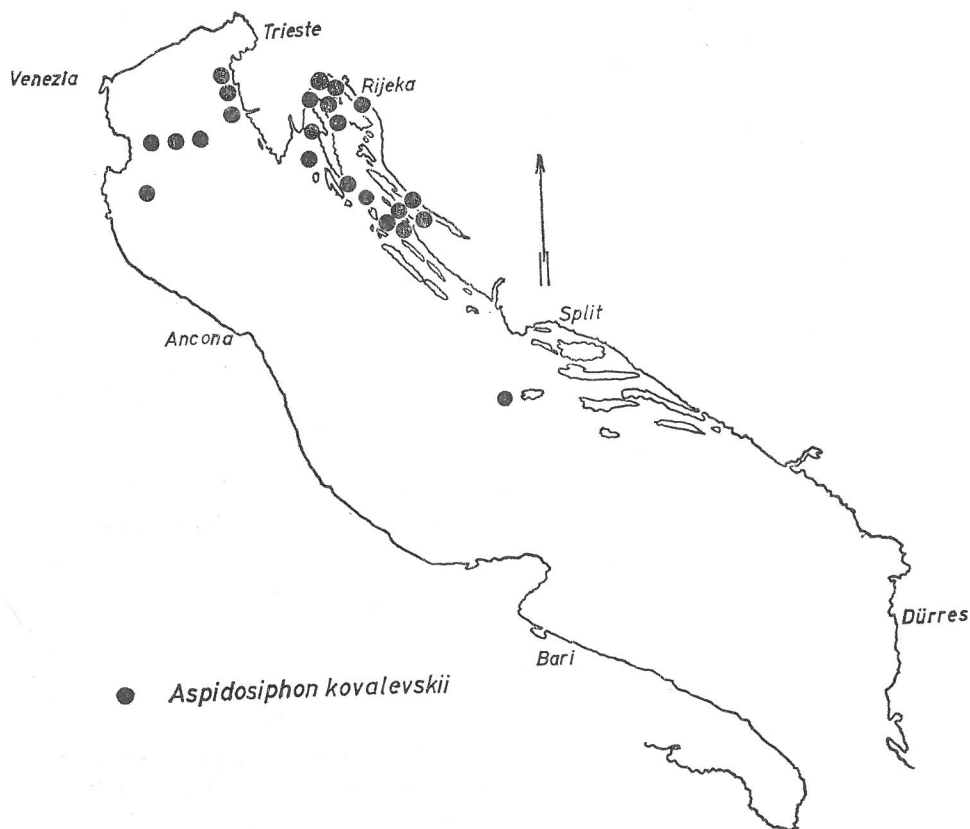


Fig. 2. Distribution of *Aspidosiphon kovalevskii* in the Adriatic Sea.

*Ecology:* This species was found on fine sand, sandy silt and clayey silt. The worms inhabit preferably the shells of *Dentalium vulgare*, *D. dentale* and *Turritella communis*, but we have found them also in *Homalopoma sanguineum*, *Cantharidus exasperatus*, *Lunatia alderi*, *Philbertia purpurea*, and in tubes of serpulid worms (*Ditrupa arietina*, *Vermiliopsis*). The temperature and salinity ranges were 10.32—14.82 °C, and 37.81—38.30 ‰ sal. respectively<sup>35</sup>.

*Biology:* Some of the animals studied by us hosted a polychaete *Syllis (Ehlersia) cornuta*, members of the loxosomatids (*e.g.*, *Loxosomella atkinsae*), and/or an unidentified bivalve of the family Montacutidae<sup>35</sup>.

*Aspidosiphon muelleri* Diesing, 1851 (Fig. 3)

Diesing<sup>39</sup>, p. 68 (*clavatus*, *muelleri*); Théel<sup>47</sup>, p. 17 (*mirabilis*); Danielssen and Koren<sup>48</sup>, p. 4—7 (*armatus*)

Quotations for the Adriatic Sea: Grube<sup>2</sup>, p. 129; Grube<sup>3</sup>, p. 93; Loren<sup>4</sup>, p. 344; Stossich<sup>6</sup>, p. 211; Carus<sup>7</sup>, p. 193; Zimmermann<sup>9</sup>, p. 312; Cuénot<sup>49</sup>, p. 13; Vatova<sup>16</sup>, p. 173; Vatova<sup>14</sup>, p. 43; Vatova<sup>16</sup>, p. 163; Gamulin-Brida *et al.*<sup>20</sup>, p. 160; Orel and Mennea<sup>50</sup>, p. 267; Zavodnik<sup>21</sup>, p. 464; Marcuzzi<sup>11</sup>, p. 180; Cukrov<sup>33</sup>, p. 10; Avčič *et al.*<sup>22</sup>, p. 188; Fredj<sup>46</sup>, p. 63; Gamulin-Brida<sup>32</sup>, p. 283; Zavodnik<sup>29</sup>, p. 99; Zavodnik and Murina<sup>30</sup>, p. 127; Zavodnik and Murina<sup>31</sup>, p. 81.

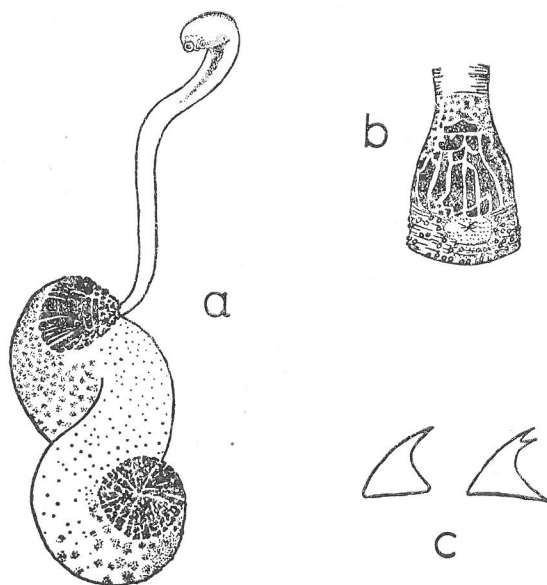


Fig. 3. *Aspidosiphon muelleri* (Diesing). a = entire specimen; b = anterior shield; c = hooks of the introvert: left single pointed hook from the proximal part of the introvert, and right a double pointed hook from its distal part (a, b: after Théel<sup>51</sup>, c: original).

**Material:** 19 specimens.

**Description:** Body length of worms 2—30 mm; the introvert is as long as the body or 2—3 times longer. Colour gray, light yellow or dark-brown. Body wall is thin, semitransparent. There are 8—12 tentacles at the end of the introvert. Hooks on the anterior part of the introvert with single point, and those on the posterior part have two points (Fig. 3c). Both shields are brown coloured and grooved. Anal shield is semielliptical or heart-shaped with some (up to 22) longitudinal grooves (Fig. 3b). Caudal shield is more brightly coloured, granulated or with radiate grooves (up to 18); the central part of the shield is higher than the border.

Longitudinal muscle layer is continuous and only at the level of anus it is split into 10—11 bands. Two retractors of the trunk arise immediately in front of the caudal shield. Intestinal spiral with 28—30 coils. The rectum has well developed wing muscles, which insert near the nephridia. The latter are free or partly attached to the trunk wall. Nephridiopores on the level of anus.

Nephrostome with small lips. The eggs are flattened, discoidal and with sharp edges; they are  $0.130 \times 0.112$  mm in diameter.

*Distribution:* The species has tropico-temperate and eurybathic distribution (1—1262 m). It is very common along the coasts of Norway and nearly approaches the Arctic. It is reported from the Atlantic Ocean, Mediterranean, Gulf of Suez, Red Sea, Gulf of Aden, Indian Ocean, East Africa and Mauritius, the water of the Malayan Archipelago, the eastern coast of Japan, in the West Indies and the Gulf of Guinea as far as the mouth of the river Congo<sup>41</sup>. In the Adriatic Sea *A. muelleri* was reported most from its northern part, at the depth of 9—85 meters (Fig. 4). It is, however, one of the deepest living species of the genus *Aspidosiphon*: it reaches the depth of 1262 metres<sup>52</sup>.



Fig. 4. Distribution of *Aspidosiphon muelleri* in the Adriatic Sea, according to literature data (o) and present material (●).

*Ecology:* This species of wide ecological distribution is reported in the Adriatic Sea from the coastal terrigenous ooze, coastal detritic bottom and the detritic bottom partly mixed with ooze.

The animals usually inhabit empty shells of molluscs. Stossich<sup>6</sup> reported them from the shells of *Vermetus gigas* and *Gourmya vulgata*, and from ser-

pulid tubes. Near Rovinj they have been found in the shells of *Turritella tricarinata*, *Muricidea blainvillei*, *Dentalium dentale* and *D. vulgare*<sup>31</sup>. The anterior shield of the worm is efficiently used as an operculum for the closing the shell or tube opening<sup>49</sup>. Larger openings of the shells are frequently cemented by fine sand or mud particles leaving only a hole wide enough for protruding the introvert, as is reported for *Phascolion strombi*. Por<sup>53</sup> reported on the boring behaviour of *A. muelleri* in the massive chalk on the Mediterranean coast of Israel.

The temperature range of the samples near Rovinj is 10.40—18.80 °C, and that of salinity is 37.09—38.33 ‰<sup>31</sup>.

*Biology*: The species is often found living symbiotically with the bivalve *Jousseaumiella concharum* (fam. *Montacutidae*) and the polychaete *Syllis cornuta* (fam. *Syllidae*)<sup>45,54</sup>.

*Notice*: In the Adriatic Sea, the distribution patterns of *Aspidosiphon muelleri* and *A. kovalevskii* have not been defined so far. In all probability the latter named species was, for various reasons, many times misidentified and recorded by the name of *A. muelleri*. Recent investigations on the variability of *A. kovalevskii* have proved that the two species are well distinct<sup>35</sup>, and that *A. kovalevskii*, in comparison with *A. muelleri*, is probably more common species in some areas of the Adriatic Sea.

#### Family PHASCOLOSOMATIDAE Stephen et Edmonds, 1972

Stephen et Edmonds<sup>45</sup>, p. 269

Worms in which the tentacles are arranged in a single crescent or near the circle which lies dorsal to the mouth and encloses the nuchal organ, if present. Longitudinal musculature of the body wall either in bands or continuous. No anal or caudal shield. Papillae usually with small platelets and generally most densely packed on the anterior and posterior extremities of the trunk. No integumentary or coelomic pouches in the body wall (except in one species).

Type genus: *Phascolosoma* Leuckart, 1828

#### Genus PHASCOLOSOMA Leuckart, 1828

Leuckart<sup>55</sup>, p. 22, Fig. 5; Selenka, de Man, Büllow<sup>56</sup>, p. 54 (*Phymosoma*); Selenka<sup>57</sup>, p. 460 (*Physcosoma*); Fisher<sup>58</sup>, p. 551; Fisher<sup>40</sup>, p. 422; Stephen<sup>41</sup>, p. 461.

Type species: *Phascolosoma granulatum* Leuckart, 1828

The tentacles are arranged in one row forming a half-circle, which is discontinuous at dorsal side and which encircles the brain and the nuchal organ. The mouth opening is not encircled by tentacles and is ventral to them. Hooks and papillae of the introvert are arranged in several alternate rings. Introvert hooks are complex: a bright canal, variously shaped, passes through the interior; in some species a bright triangle is visible at the base. The body surface is more or less uniformly covered with papillae, which bear chitinous platelets of various dimensions.

Longitudinal musculature is divided into bands. Introvert retractors are two, or more commonly four<sup>161</sup>. Intestinal spiral is attached by a spindle muscle near the anus and in several species also at the posterior part of the body. Contractile vessel is usually simple. Nephridia are usually single lobed.

The genus comprises about 60 species. They are tropical or subtropical and usually absent in cold waters in both hemispheres. The species are distributed in the littoral and sublittoral zones, and frequently live in coral reefs or in compact sandy bottoms.

#### Key to subgenera of *Phascolosoma*

- 1(2) Spindle muscle absent or, if present, not fixed posteriorly . . . . .  
 . . . *Satonus* Stephen et Edmonds, 1972, in sensu Cutler et Cutler, 1983
- 2(1) Spindle muscle fixed to the posterior body wall . . . . . 3
- 3(4) Contractile vessel with villi or tubules . . . . . *Antillesoma*  
 Stephen et Edmonds, 1972, in sensu Cutler et Cutler, 1983
- 4(3) Contractile vessel without villi or tubules . . . . .  
 . . . . . *Phascolosoma* Leuckart, 1928 s.str.

#### Key to species of subgenus *Phascolosoma* s.str.

- 1(2) Longitudinal muscles gathered into a variable number of bands, varying from 18—28, usually 24—25; at the basal part of a hook the light zone is not divided into two branches; in adults the hooks are arranged in 60—100 rings . . . . . *Ph. granulatum* Leuckart
- 2(1) Longitudinal muscles are gathered into 20—21 bands; the light zone of the hook is divided into two branches; there are no more than 50 rings of hooks . . . . . *Ph. scolops* (Selenka et de Man)

#### *Phascolosoma granulatum* F. S. Leuckart, 1928 (Fig. 5)

Leuckart<sup>55</sup>, p. 22, Fig. 5; Selenka, de Man, Bülow<sup>56</sup>, p. 79—82, Taf. X, Figs. 147—151, Taf. XI, Figs. 151—155 (*Phymosoma*)

*Quotations* for the Adriatic Sea: Grube<sup>1</sup>, p. 44; Grube<sup>2</sup>, p. 128; Grube<sup>3</sup>, p. 93; Lorenz<sup>4</sup>, p. 344; Stossich<sup>6</sup>, p. 210; Carus<sup>7</sup>, p. 191; (*granulosum*), p. 192; Cuénot<sup>49</sup>, p. 17; Gamulin-Brida *et al.*<sup>20</sup>, p. 160; Lovrić<sup>59</sup>, p. 109; Zavodnik<sup>21</sup>, p. 464; Marcuzzi<sup>11</sup>, p. 180; Fredj<sup>46</sup>, p. 63; Gamulin-Brida<sup>60</sup>, p. 14; Gamulin-Brida<sup>61</sup>, p. 79; Gamulin-Brida<sup>62</sup>, p. 283; Matjašič and Štirn<sup>23</sup>, p. 46; Zavodnik<sup>29</sup>, p. 99; Zavodnik and Murina<sup>30</sup>, p. 127; Zavodnik and Murina<sup>31</sup>, p. 83; Fedra *et al.*<sup>62</sup> p. 139; Zavodnik *et al.*<sup>24</sup>, Annex.

*Material*: 60 specimens.

*Description*: The trunk is 4.5—60 mm long and 1.5—8 mm thick. The introvert is nearly as long as the trunk. The animals are variously coloured: on the dorsal side of the trunk the irregular dark spots and bands are often present. The body is long and cylindrical, the trunk is 4—10 times as long as thick, while its posterior part is rounded. In adult animals, at the end of the introvert are located 25—26 tentacles of dark-blue colour, but in young only 12—16 tentacles can be found. There are two conspicuous eye spots. Behind the tentacles is a zone of hooks which are arranged in 10—17 rings in young

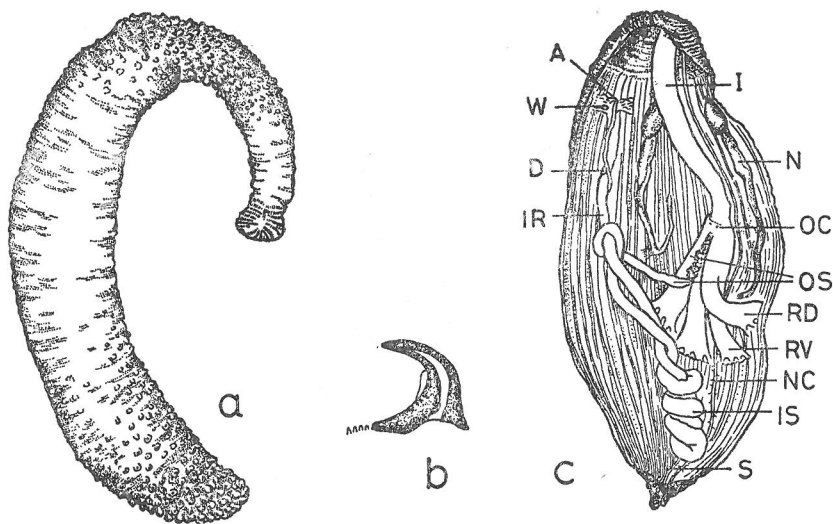


Fig. 5. *Phascolosoma granulatum* Leuckart. a = entire specimen; b = hook of the introvert; c = dissected specimen (a: original; b: after Selenka *et al.*<sup>58</sup>; c: after Wesenberg-Lund<sup>68</sup>).

animals, and even 60—100 rings in adults. The hooks are 0.050—0.094 mm high and at the base 0.06—0.08 mm thick. Their apical ends are sharply bent and a bright channel is equally wide along their whole length; in their concave side a scarcely perceptible additional tubercule is located (Fig. 5b).

The body wall is thin and not transparent. The entire body is covered with papillae, which are especially dense at the base of the introvert and at the posterior extremity where the papillae are sharply conical. In the middle part of the trunk the papillae are lower and lightly coloured. The surface of the papillae is formed by numerous multiangled normally dimensioned chitinous platelets, which are distributed irregularly around the central pore.

The longitudinal muscle sheet is divided into 18—28 bands, more commonly 24—25. Only rarely several bands are united. Four retractors are attached in the middle third of the trunk but they soon unite into one thick muscle. The intestinal spiral is composed of 6—12 double coils. A strong spindle muscle arises, near to the anus and is attached to the caudal end of the body. The fixing muscle of the intestinal coil is present or absent. The rectum has a pair of well developed wing muscles and a diverticulum. Contractile vessel is simple. The nephridia are attached to the body wall along most of their length. The eggs are flattened and elliptical. This species is hermaphroditic<sup>158</sup>.

**Distribution:** The species is tropico-temperate. The tropical and subtropical findings are Cap Verde Islands, Zanzibar, the coasts of South Africa, Mauritius, the Red Sea, New Hebrides and Caroline Islands. In the temperate area of the northern hemisphere it was reported from the Azores, coasts of Great Britain, Ireland, France. Many findings are noted from the Mediterranean, and it was found also at the coast of Korea. It is most distributed in shallow waters<sup>44</sup>. Fairly common in the Adriatic Sea (Fig. 6).

**Ecology:** The most common habitats of *Ph. granulatum* are rock crevices, fissures in coral reefs, pits in conglomerate lime-stone. In the Adriatic Sea,



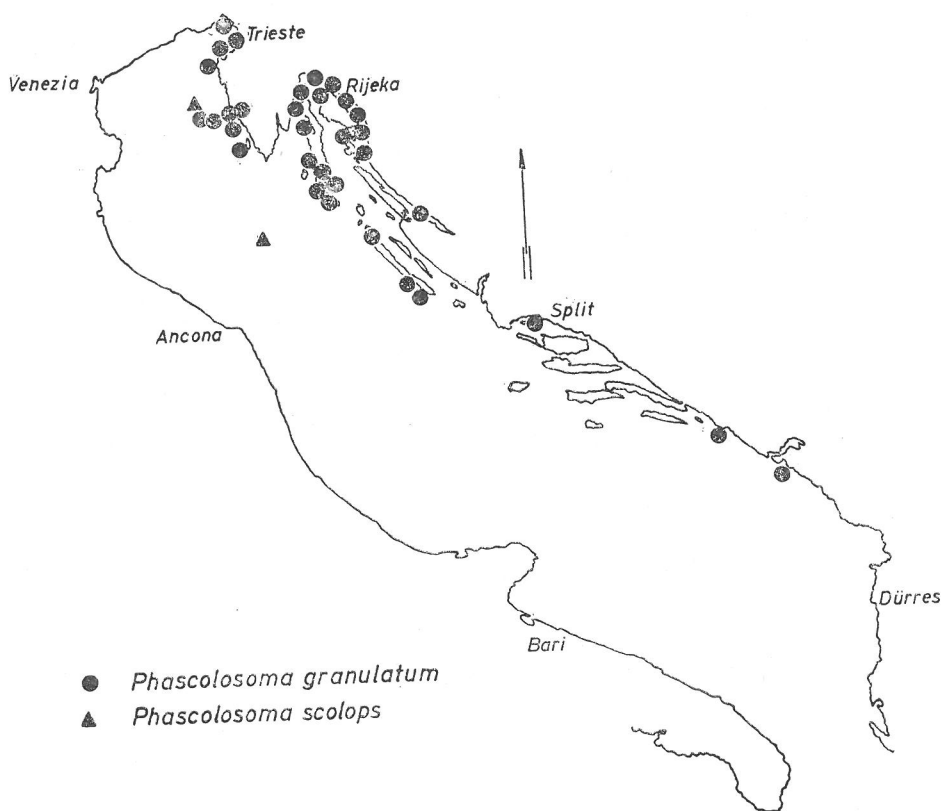


Fig. 6. Distribution of *Phascolosoma granulatum* and *Ph. scolops* in the Adriatic Sea.

it is, however, a species preferential to the biocoenosis of photophilic algae, and the only sipunculan species which is characteristic for rocky bottoms<sup>29</sup>. In the Rovinj area it was sampled also on coastal detritic bottom, where it lives in the clumps of calcareous red algae *Lithothamnion crassum*, *Lithophyllum racemus* and *Pseudolithophyllum expansum*<sup>31</sup>. Frequently we found it sheltered under stones and in the burrows of endolithic bivalves *Lithophaga lithophaga*, *Petricola lithophaga* and *Rocellaria dubia*. Several times the specimens were found hidden among the branches of the firm thalli of *Cystoseira adriatica*, and rarely also within the «hairs» of *Posidonia oceanica*. A similar ecological variability of *Ph. granulatum* was noted at Banyuls-mer<sup>64</sup>. It is a common species within the mediolittoral boulders of *Lithophyllum tortuosum*<sup>59,64-66</sup>, within incrustations of colonial Serpulidae<sup>67,68</sup>, and in the coastal boulders of *Vermetus cristatus*<sup>69</sup>. Molinier<sup>69</sup>. noted it also in the settlements of *Cystoseira crinita*. Bellan-Santini<sup>70</sup> sampled it in the fouling community which has developed on the floating tube near Marseille. Gamulin-Brida<sup>61</sup> noted this species in the biocoenosis of lower mediolittoral rocks, the biocoenosis of coastal detritic bottom, and the biocoenosis of detritic bottom of the open sea. Rarely *Ph. granulatum* was found also on oozy sediments<sup>49,71</sup>.

The population density of this species can be very high — up to 8000 specimens per square meter<sup>72</sup>. According to Riedl<sup>73</sup> the maximum population density in submarine caves exceeds 650 animals per square meter.

In the Adriatic Sea, *Ph. granulatum* was found at the temperatures of 9.40—23.60 °C and the salinities of 37.01—37.90 ‰ sal.<sup>31</sup>.

*Biology*: Wahl<sup>74</sup> noted a parasitic rhabdocoelan turbellarian *Cellastoma minutum* from the intestine of *Ph. granulatum*.

*Phascolosoma (Phascolosoma) scolops* (Selenka et de Man, 1883) (Fig. 7)

Selenka, de Man, Bülow<sup>56</sup> p. 75 (*Phymosoma*); Shipley<sup>75</sup>, p. 470 (*Physcosoma*); Wesenberg-Lund<sup>76</sup>, p. 5; Stephen and Edmonds<sup>45</sup>, p. 321; Murina<sup>44</sup>, p. 162, Fig. 110.

*Quotations for the Adriatic Sea*: Murina<sup>27</sup>, p. 36

*Material*: 2 specimens.

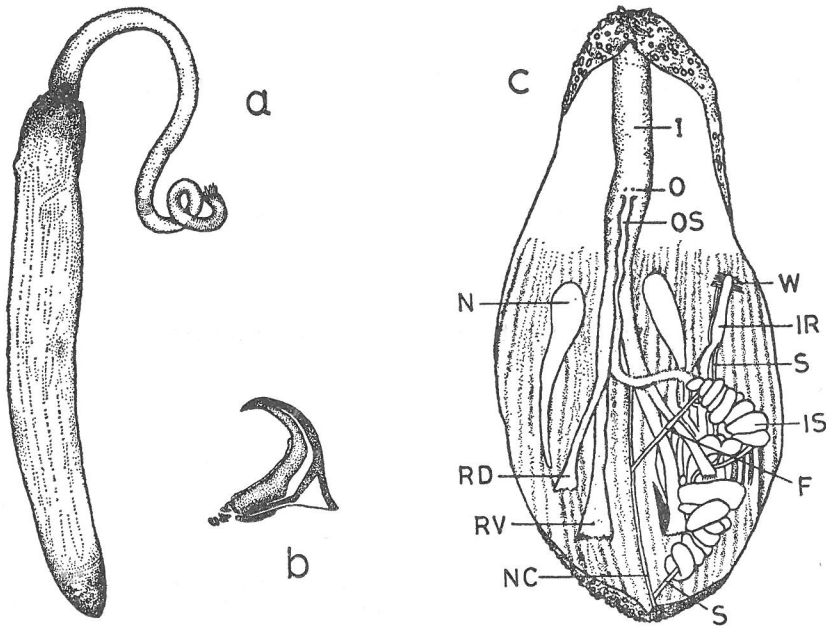


Fig. 7. *Phascolosoma scolops* Selenka et de Man. a = entire specimen; b = hook of the introvert; c = dissected specimen (a, b: after Selenka et al.<sup>56</sup>; c: after Sató<sup>77</sup>).

*Description*: Length of the trunk is 5—40 mm; the Adriatic specimens measured 12 and 14 mm respectively. The introvert is about as long as the trunk and carries 12 tentacles. The body is variously coloured: blue-gray, or red-gray, sometimes yellowish or brownish. The skin is covered with dome-shaped papillae unequally sized, which are scattered on the surface of the body. There are 15—17 rows of hooks 0.055 mm in height. Most characteristic is the shape of the light zone in hooks: it is ramified into two branches. Two eye-spots are present.

The longitudinal musculature is divided into 20—21 bands; four retractors. The intestine spiral is composed of 12—14 coils and a fairly long rectum. The contractile vessel is simple.

*Distribution:* The species is tropico-temperate and eurybathic (0—5220 m)<sup>44</sup>. It is reported from the west Indies, Red Sea, West Africa, South Africa, Zanzibar, Madagascar, Mozambique, Malay Archipelago and Indonesia, Indian Ocean, Philippines, Japan, China, Great Barrier Reef, Mediterranean. In the Adriatic Sea *Ph. scolops* was sampled in the North Adriatic at the depths of 35 and 65 meters<sup>27</sup> (Fig. 6).

*Ecology:* *Ph. scolops* lives among ascidian colonies and sandstone debris<sup>78</sup>, in the sand between gravel stones<sup>79</sup>, among stones in intertidal pools, among shells, in abandoned tubes of the polychaete *Gunnaria capensis*, and in the corridors among loose gravels or in the heaps of dead corals<sup>80</sup>.

*Biology:* No data available.

*Remark:* The Adriatic findings were the first in the Mediteranean area.

#### Family SIPUNCULIDAE Quatrefages, 1865

Quatrefages<sup>37</sup>, p. 611 (in part); Baird<sup>38</sup>, p. 77 (in part); Sedgwick<sup>81</sup>, p. 539 (in part); Stephen and Edmonds<sup>45</sup>, p. 19

Species usually large. Body wall of trunk contains either longitudinally arranged integumentary canals or independent coelomic sacs or diverticula. Numerous tentacles or tentacular fold always surround the mouth; tentacles may form clusters or be arranged in meridional rows (but never in a horse-shoe-shape ring dorsal to the mouth). Longitudinal muscles always separated into prominent bands. Anterior region of trunk not modified to form a cap or shield. Retractor muscles four (in *Siphonomecus* there are two); nephridia two.

Type genus: *Sipunculus* Linnaeus, 1766

#### Genus SIPUNCULUS Linnaeus, 1766

Linnaeus<sup>82</sup>, p. 1078; Selenka, de Man, Bülow<sup>56</sup>, p. 88; Fisher<sup>40</sup>, p. 375

Type species: *Sipunculus nudus* Linnaeus, 1766

Usually large animals, which are characterized by a long cylindrical trunk (30—500 mm) and sharply separated introvert. A part of the introvert is covered with flat triangular scale-like papillae. The mouth opening is encircled by a tentacle membrane, which is continuous or divided into lobes. There are neither hocks nor spines on the introvert. The brain is globular, oval convex. The skin surface of the trunk is divided with more or less sharpened longitudinal and circular furrows into regular rectangular or square fields. Coelomic canals are present in the trunk skin, under the longitudinal ridges and communicate with the coelom. The caudal end of the body forms a distinct glans usually smooth, globular, somewhat turgid.

The inner muscle layer is divided into longitudinal bundles (8—60). The introvert is inverted by four short retractors, two ventral and two dorsal. The spiral of the intestine has in some species a long post-oesophageal loop, which

is sometimes wound into an additional coil. The oesophagus and the intestine are attached in the body cavity with numerous fine fixing muscles. In most *Sipunculus* species there are racemose organs — the paired rectal glands. There are two contractile vessels, the dorsal and the ventral one. Nephridia are usually single-lobed, without additional branches. The ventral nerve cord at the base of the introvert set apart from the body wall and is bounded by two paraneural muscles.

The genus *Sipunculus* is comprised of 25 species and 2 subspecies which live in tropical, temperate and boreal areas. Approximately fifty percent of the species are limited to the littoral zone, while others live in the sublittoral, bathyal and even in the abyssal zone. The maximal depth of the sampling was 4400 m (*Sipunculus nitidus*) in the Atlantic Ocean<sup>83</sup>.

*Sipunculus nudus nudus* Linnaeus, 1766 (Fig. 8)

Linnaeus<sup>82</sup>, p. 1078; Selenka, de Man, Bülow<sup>56</sup>, p. 92; Ward<sup>84</sup>, p. 143—183; Metalnikoff<sup>85</sup>, p. 261—322; Fisher<sup>40</sup>, p. 376, Pl. XVIII.

Quotations for the Adriatic Sea: Grube<sup>1</sup>, p. 43; Lorenz<sup>4</sup>, p. 344; Stossich<sup>6</sup>, p. 209; Carus<sup>7</sup>, p. 192; Zimmermann<sup>9</sup>, p. 312; Issel<sup>86</sup>, p. 11; Vatova<sup>10</sup>, p. 174; Vatova<sup>12</sup>, p. 14; Vatova<sup>14</sup>, p. 43; Vatova<sup>16</sup>, p. 163; Zavodnik<sup>21</sup>, p. 464; Marcuzzi<sup>11</sup>, p. 180; Fredj<sup>46</sup>, p. 63; Legac<sup>25</sup>, p. 82; Gamulin-Brida<sup>32</sup>, p. 282; Matjašič and Štirn<sup>23</sup>, p. 46; Zavodnik<sup>29</sup>, p. 99; Murina<sup>27</sup>, p. 37; Zavodnik and Murina<sup>31</sup>, p. 83; Zavodnik *et al.*<sup>24</sup>, Tab. I.

Material: 19 specimens.

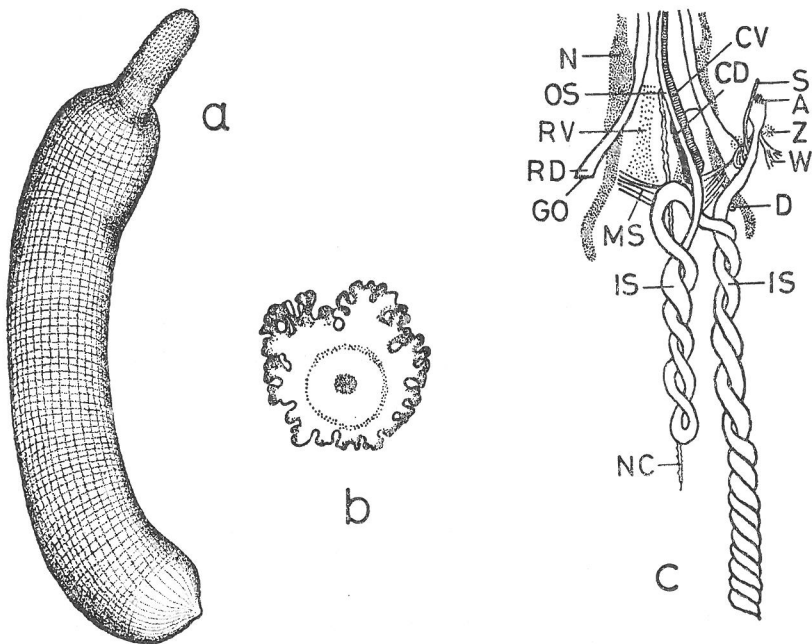


Fig. 8. *Sipunculus nudus* Linnaeus. a = entire specimen; b = ring of tentacles, seen from above; c = a part of dissected specimen (a: original; b: after Baird<sup>38</sup>; c: after Fisher<sup>40</sup>).

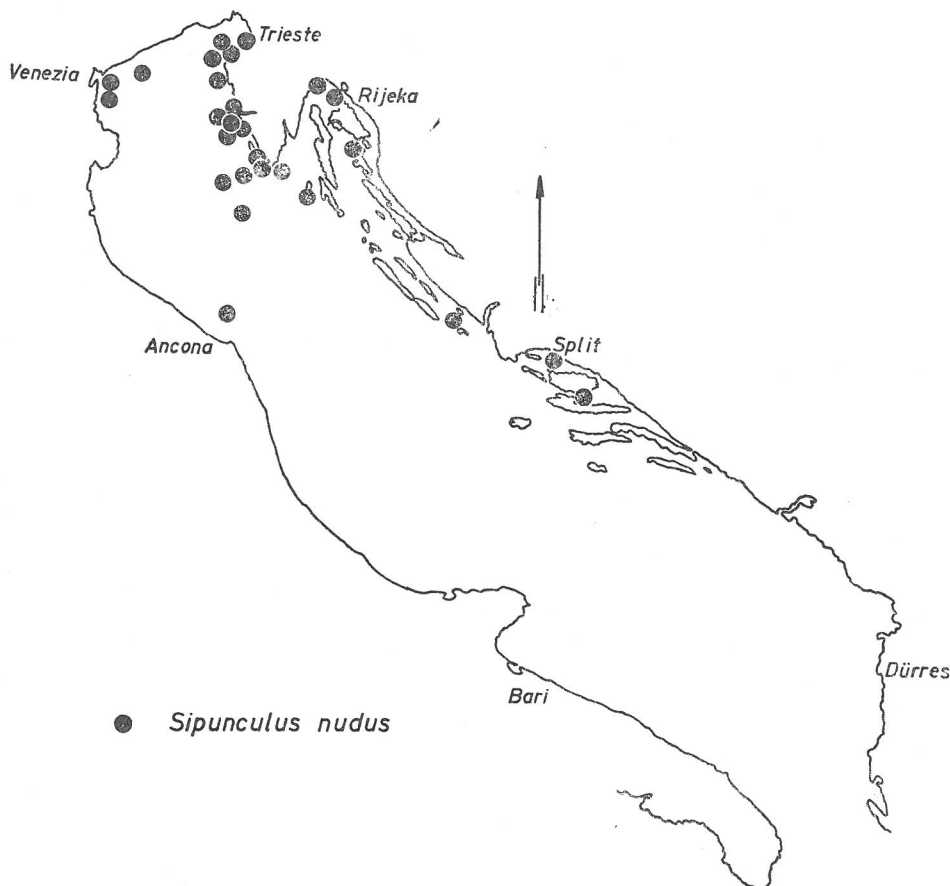


Fig. 9. Distribution of *Sipunculus nudus* in the Adriatic Sea.

*Description:* The maximal length of the trunk is 320 mm, the width 20 mm. The introvert is equal to 1/4 or 1/8 of the trunk length, while the glans is as long as 1/5—1/6 of the trunk.

The glans is sometimes swollen. The colour of the worm is gray, pink, bright yellow to brown. The scale-like triangular papillae beset one sixth part of the introvert. The tentacle membrane is formed from several split lobes, of which two dorsal are larger. The brain is composed of two lobes and located near (4—5 mm) the ring of tentacles. Digitate processes of the brain attain the length of 1 mm in largest animals.

The body wall is thin and transparent or thick and opaque. The transversal and longitudinal ridges are sharp, due to which the body surface seems as to be divided into rectangles. Longitudinal musculature contains 28—34 longitudinal bundles, usually 30—32. The muscle bands do not form anastomoses, except in the anterior part of the trunk. Four introvert retractors originate from 3—6 bundles at the proximal 16—20th part of the trunk. The spiral intestine is composed of 10—20 doubled coils. In large specimens is present a spirally formed additional coil, which is located between the end of the oesophagus and the beginning of the basal coil. The rectum has a globular

caecum and well developed rectal racemose organs. Wings muscles are strong. Nephridia stretch to the roots of retractors and are attached to the body wall for  $1/4$ — $1/5$  of their length.

*Distribution:* Tropico-temperate and eurybathic species (0—2275 m)<sup>44</sup>. In the Atlantic Ocean it is reported from the Ireland coast to the Island Gough (40 °C). It was frequently found in the Mediterranean, Red Sea and Indian Ocean. In the Pacific it is distributed from the Island Honshoe to Adelaide in Australia. It is common in Korean and Japanese waters. Usually it has been sampled in the littoral zone. In the Adriatic Sea it is distributed elsewhere at the depths of 8—37 meters (Fig. 9).

*Ecology:* In the Adriatic Sea, *S. nudus* lives mostly on sandy bottoms. It can, however, tolerate some quantities of oozy particles and was found also in communities of coastal detritic botom and coastal terrigenous muds. It was found also in the seawater pipes of the Rovinj aquarium<sup>87</sup>. The swimming habits of the worms have been observed by several authors<sup>88</sup>.

The temperature range near Rovinj was found to be 9.40—21.25 °C, and the salinity was 34.92—38.08 ‰<sup>31</sup>.

*Biology:* Reproduction period near Rovinj: VI—IX<sup>10</sup>. Issel<sup>86</sup> found the larvae of *Sipunculus* in July and August. According to Hatchek<sup>89</sup> it spawns at night. The duration of pelagic stage (trochophora and pelagosphaera) is about one month<sup>90</sup>. The intestinal contents of *S. nudus* were studied by Edmons<sup>91</sup>. The worm was frequently reported to be host of numerous parasites and commensals<sup>45,49,92</sup>.

*Notice:* In the Adriatic Sea, *S. nudus* is used sometimes as a fish bait. In Japan and China it is used as human food<sup>88</sup>.

#### Family GOLFINGIIDAE Stephen et Edmons, 1972

Quatrefages<sup>37</sup>, p. 611 (Sipunculidae, in part); Baird<sup>88</sup>, p. 77 (Sipunculidae, in part); Stephen et Edmonds<sup>45</sup>, p. 77

Tentacles basically surround the mouth; they may be digitiform, filiform, leaf-like, dichotomously branched or dentritic. The tentacles may also be reduced to a few lobes or even absent. Ring of tentacles usually interrupted on the middorsal side by the nuchal organ. Integumentary or coelomic sacs absent. Longitudinal musculature of body wall continuous. Anterior cap or shield usually absent.

Type genus: *Golfingia* Lankester, 1885

#### Key to genera

- 1(2) Nephridia two . . . . . *Golfingia* Lankester, 1885  
 2(1) Nephridium single . . . . . 3  
 3(4) Anal aperture lies on the introvert near the mouth and not on the trunk; tentacles few or absent; retractor single . . . . .  
 . . . . . *Onchiesoma* Koren et Danielssen, 1875  
 4(3) Anal aperture lies on the trunk and not on the introvert; tentacles present; 1—3 retractors . . . . . *Phascolion* Théel, 1875

## Genus PHASCOLION Théel, 1875

Montagu<sup>93</sup>, p. 74, Pl. V, Fig. 2 (*Sipunculus*); Théel<sup>47</sup>, p. 3—5Type species: *Sipunculus strombus* Montagu, 1804

Small or moderate sized worms, up to 45 mm long. The introvert is usually swollen at distal end: it is as long or shorter than the trunk. The tentacles encircle the mouth in a single ring. The cerebral ganglion (brain) resembles the heart-like or the oval pillow. The hooks of the introvert are simple, present or absent. The introvert and the trunk are covered by papillae and skin bodies. Most species possess firm chitinous horseshoe-shaped or triangular papillae; they are gathered in a broad band which encircles the posterior half of the body.

The inner layer of muscles is continuous. There are one or two retractors of the introvert, with one or more roots. The intestine is formed in several loops or somewhat more rarely as a spiral with up to 45 coils. A single nephridium is located at the right side of the ventral nerve cord. The gonad is located asymmetrically and bent around the root of the ventral retractor. The eggs are globular, 0.10—0.25 mm in diameter. Worms inhabit the shells of gastropods or scaphopods, and sometimes the tubes of annelids or empty burrows in coral rocks.

About 30 species are described from the oceans of the world; most of them are distributed in tropical and boreal areas. The majority of *Phascolion* species live in sublittoral and bathyal zones, and some of them reach even the abyssal zone.

Key to species of genus *Phascolion*

- 1(2) Retractors are attached to the body wall at different levels; the dorsal retractor has two long roots, and the ventral retractor has only one . . . . . *Ph. brotzkajae* Murina
- 2(1) Retractors are attached to the body wall about at the same level; the dorsal retractor has one root, the ventral one has two roots . . . . . *Ph. strombi* (Montagu)

*Phascolion strombi* (Montagu, 1804) (Fig. 10)

Montagu<sup>93</sup>, p. 74—76 (*Sipunculus strombus*); Théel<sup>47</sup>, p. 13—16, Pl. I., Figs. 2, 3 (*splitsbergense*); Théel<sup>94</sup>, pp. 1—29; Théel<sup>51</sup>, p. 86—89, Pl. VI, Figs. 82—95, Pl. VII, Figs. 109, 110, Pl. XV, Figs. 207, 208; Théel<sup>95</sup>, p. 31, Pl. IV, Figs. 50, 56, Pl. V, Fig. 75; Selenka, de Man, Bülow<sup>56</sup>, p. 47 (*tubicola*), p. 48 (*coementarium*), pp. 50, 51 (var. *capitatum*), p. 52 (var. *varrucosum*); Sluiter<sup>83</sup>, p. 9, Pl. I, Figs. 1, 2, Pl. III, Figs. 1—2 (*alberti*), p. 10; Sluiter<sup>52</sup>, p. 18; Gérould<sup>96</sup>, p. 403—415 (var. *tubicola*, var. *fusca*, var. *alba*, var. *hyalina*, var. *gracilis*, var. *canadensis*, var. *laevis*); Murina<sup>97</sup>, p. 172—180 (var. *tubicola*), 182—187, Fig. 45 (var. *ochotensis*); Murina<sup>26</sup>, p. 63—65, Fig. 12 (*alberti*)

Quotations for the Adriatic Sea: Grube<sup>3</sup>, p. 93; Stossich<sup>6</sup>, p. 211; Carus<sup>7</sup>, p. 192; Cuénot<sup>49</sup>, p. 12; Vatova<sup>12</sup>, p. 14; Murina<sup>26</sup>, p. 63; Marcuzzi<sup>11</sup>, p. 180; Fredj<sup>46</sup>, p. 63; Zavodnik<sup>29</sup>, p. 94; Zavodnik and Murina<sup>30</sup>, p. 127; Murina<sup>27</sup>, p. 36; Zavodnik and Murina<sup>31</sup>, p. 84; Murina and Zavodnik<sup>35</sup>, p. 251; Zavodnik<sup>18</sup>, Tab. XIII.; Zavodnik *et al.*<sup>24</sup>, Tab. I.

Material: 49 specimens.



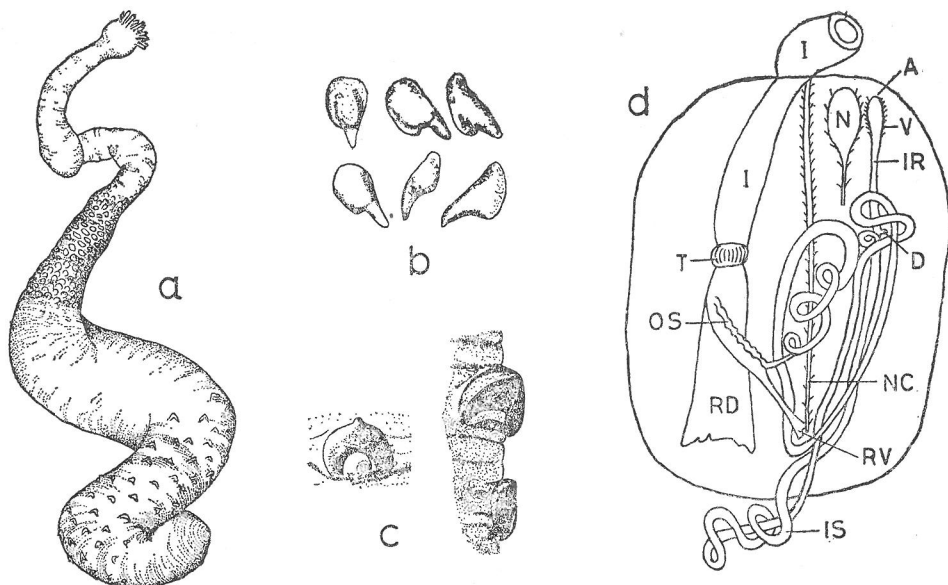


Fig. 10. *Phascolion strombi* (Montagu). a = entire specimen; b = hooks of the introvert; c = fixing papillae, seen from the side and the front; d = dissected specimen (a: original; b: after Théel<sup>95</sup>; c: after Théel<sup>95</sup>; d: after Murina<sup>44</sup>).

**Description:** The worm was found to live free or in the shells of molluscs and in dead foraminiferans, or in the tubes of polychaetes. The length of the trunk is 2—36 mm. The introvert is swollen onion-like at the anterior part: it is shorter than the trunk, of the same length or longer (maximally two times longer). The worm is extremely variously coloured: from white to dark brown; both ends of the trunk are always darker. The body is barrel-shaped or cylindrical, but when the animal is living in the gastropod shell its body is rolled as a spiral. The caudal end of the trunk is usually rounded. The introvert is sometimes separated from the trunk by a narrow circular transition. At the end of the introvert there is a simple crown of 10—26 (usually 16) tentacles. The eye spots are poorly pigmented and can be barely seen. Behind the tentacles is a belt of disarranged brown hooks, the apex of which is slightly bent (Fig. 10b). The hooks are 0.06—0.07 mm high and at the basis 0.04—0.05 mm wide.

The body wall varies from thin and transparent to robust, thick and coarse. Usually the body wall is thinner in the middle part of the body than it is at both ends. The body of the worm is densely covered with cutaneous papillae and skin bodies. High bladder-like papillae at the base of the introvert form a dense brush. Behind it there is a belt of mosaically disposed oval and flat skin bodies. Approximately at the middle of the body begin the fixing papillae horseshoe, half-moon or triangular shaped (Fig. 10c).

There are two retractors of the introvert; the dorsal one is more stout than the thin ventral retractor with two short roots, which are attached to the body wall at both sides of ventral nerve cord. The both retractors sent apart at the caudal end of the body nearly at the same level. The intestine is formed of several loops, which are sometimes rolled and form a spiral; they are attached to the body wall with numerous fixing muscles. Ventral nerve cord

is sharply disconnected between the roots of ventral retractor. The gonads are placed near the roots of ventral retractor and resemble thin curved bands. The eggs are white or yellow, spherical, 0.10—0.12 mm in diameter.

*Distribution:* Widely distributed in all seas in the northern hemisphere, especially in temperate and cold areas<sup>44</sup>. It lives usually in littoral and sublittoral zones in the depths of 5—30 m, but it was found also in the bathyal zone at 1959 meters depth<sup>96</sup>. In the Adriatic Sea, it was noted most in its northern part, at 2—78 m depth (Fig. 11).

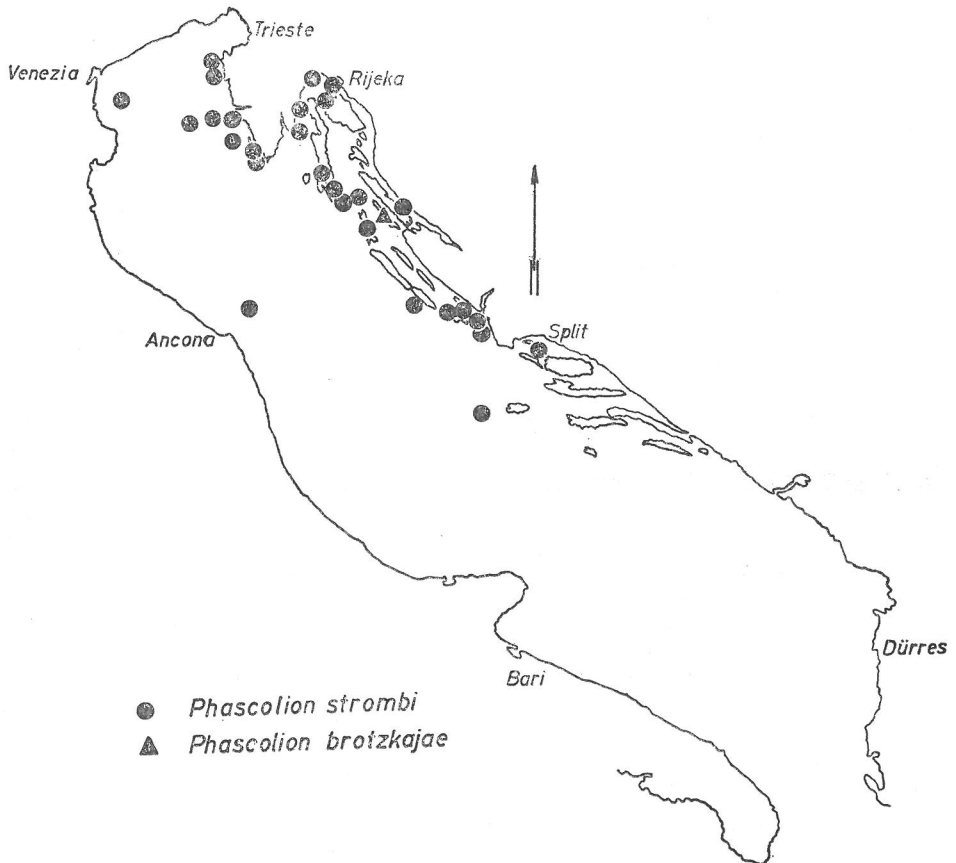


Fig. 11. Distribution of *Phascolion strombi* and *Ph. brotzkajae* in the Adriatic Sea.

*Ecology:* *Ph. strombi* lives on various kinds of bottom, and belongs to the stock of species with wide ecological distribution<sup>98</sup>. In the Adriatic Sea, it was collected mostly on coastal detritic bottom<sup>31</sup>, but also on clayey silt<sup>85</sup>. At East Groenland it prefers a bottom consisting of clay<sup>99</sup>. In the Western Mediterranean *Ph. strombi* is noted from unstable sediments<sup>66</sup>, oozy sands, detritic bottom mixed with ooze, and oozy gravels<sup>100</sup>. In the English Channel off Roscoff, Cabioch<sup>101</sup> sampled it on fine sands populated by *Corbula gibba*.

The animals usually inhabit the shells of marine molluscs or the tubes of polychaete worms. Wesenberg-Lund<sup>102</sup> noted *Ph. strombi* from the shells of

*Dentalium* (most common), *Turritella*, *Scalaria*, *Aporrhais*, *Bela*, *Sipho*, *Natica*, *Trochus*, *Clathurella*, and in serpulid- and *Pectinaria*-tubes. In the Adriatic Sea, we have noted this species in the shells of *Turritella communis*, *Archimediella triplicata*, *Gourmya vulgata*, *Fusus syracusanus*, *Dentalium dentale*, *D. vulgare*, and *D. rubescens*<sup>31,35</sup>. Among about 50 specimens studied, only one animal was collected by a diver free among the sandy particles. The temperature and salinity ranges noted by us are 10.11—19.10 °C and 37.19—38.19 ‰ Sal. respectively<sup>31,35</sup>.

**Biology:** The worms often live in symbiosis with other animals: the molluscs *Mysella cuneata*<sup>103</sup> and *Montacuta phascolionis*<sup>104,105</sup>, the polychaete *Syllis (Ehlersia) cornuta*<sup>88</sup>, the hermit crab *Eupagurus bernhardus*<sup>106</sup>, and others. Kristensen<sup>107</sup> noted that at the Swedish west coast, out of many symbiotic species, only the pyramidellid gastropod *Menestho diphana* is an obligatory parasite of *Ph. strombi*. In the Adriatic Sea, we have only rarely found this species in symbiosis by *Syllis cornuta*<sup>35</sup> and *Paguristes oculatus*<sup>108</sup>. The worms are usually infested by loxosomatids<sup>45,88</sup>; on some of our animals Emschermann<sup>109</sup> cf. *Ph. strombi*. In the Adriatic Sea, we have only rarely found this species can be present on a single worm. Out of parasites, Arvy<sup>110</sup> quoted the eugregarine *Lecudina franciana* from the rectum, and *Metchnikovella berliozii* from the intestine of the worms.

The irrigation in *Ph. strombi* was studied recently by Kristensen<sup>111</sup>. According to Rice<sup>90</sup>, the length of worm's pelagic phase (trochophore only) is 8 days.

*Phascolion brotzkajae* Murina 1964 (Fig. 12)

Murina<sup>26</sup>, p. 68; Figs. 16, 17; Stephen and Edmonds<sup>45</sup>, p. 172; Murina<sup>44</sup>, p. 261, Fig. 179.

Quotations for the Adriatic Sea: Murina and Zavodnik<sup>35</sup>, p. 251; Zavodnik<sup>18</sup>, Tab. XIII.

**Material:** 1 specimen

**Description:** The animal is slender, stick-like; its posterior end is slightly narrowed and pointed. The introvert is longer than is the trunk, it is 6 mm long and 0.2 mm thick, the dimensions of the trunk are 5 and 0.5 mm, respectively. The inner boundary between the trunk and the introvert corresponds to that from the outside of the body. The trunk is yellow, the introvert is brighter. The body wall is vigorous, thick, somewhere half transparent. The heights and diameters of the papillae in the middle of the introvert measure 0.010—0.015 mm. The basis of the introvert is covered by conical and transparent papillae which are 0.02—0.025 mm high and 0.025—0.020 mm in diameter. The upper half of the trunk is covered by flat round or oval skin bodies of 0.01—0.015 mm in diameter. On the lower half of the introvert, about 2.5 mm from the anus is a band about 1 mm broad consisting out of big holding papillae which are subcircular or horseshoe shaped; they are 0.06—0.075 mm high and 0.045—0.065 mm broad. The rounded posterior part of the body carries finger-like transparent papillae 0.02—0.025 mm high, of which diameter is 0.010 mm. At the end of the introvert there are the hooks which are not settled in rows. They are 0.02—0.04 mm high and at the basis 0.005—0.010 mm in diameter; the hooks approaching the mouth opening are bigger. Eye spots are absent.

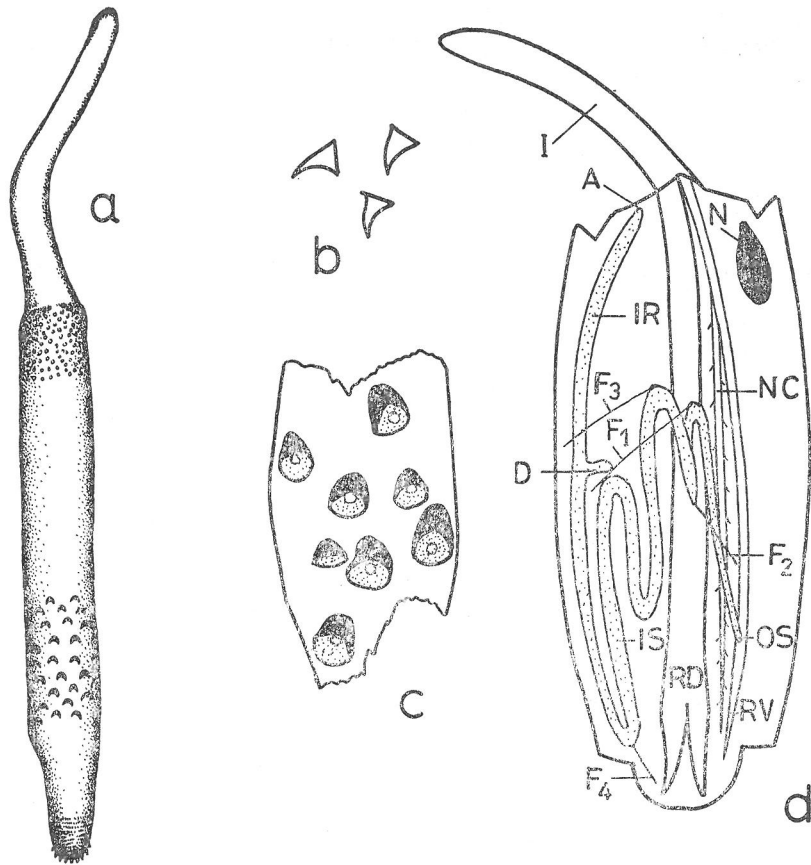


Fig. 12. *Phascolion brotzkajae* Murina. a = entire specimen; b = hooks of the introvert; c = fixing papillae; d = dissected specimen (a - d: after Murina<sup>26</sup>).

The inner musculature is continued and not divided into bands. There are two retractors. The broad dorsal retractor sets apart from the posterior end of the body with two long roots. The thin ventral retractor is attached with the narrow root between the dorsal retractor and the ventral nerve chain. The oesophagus sets apart at the lower third of the ventral retractor. There are two intestine coils, the second one is somewhat longer than is the first. The two coils and the oesophagus are fixed in the body cavity with fixing muscles. At the place where the lower intestine coil passes into the rectum located is also a thin and long fixing muscle, which according to its location corresponds to the spindle muscle. There are no wing muscles. In the middle of the rectum is a big finger-like caecum. The contractile vessel is simple.

The nephridium is small, drop-like, and has a narrow neck-nephrostome; its opening (nephridiopore) is located posterior to the anus. The nerve cord is rather thick, but suddenly becomes narrower at the posterior part and discontinues between the single root of the ventral muscle and the right root of the dorsal retractor.



- 8(7) Spindle muscle not attached posteriorly; introvert usually equal to or shorter than the trunk . . . . . 9
- 9(8) Both dorsal retractors normally developed; shields at both ends of the body absent . . . . . *Golfingia* (s. str.) Fisher, 1952
- 10(9) One dorsal retractor completely or only partly united with the ventral retractors; shields are present at both ends of the body . . . . .  
 . . . . . *Dushana* Murina, 1975

Subgenus *Nephasoma* Pergament, 1946

Pergament<sup>114</sup>, p. 189; Fisher<sup>58</sup>, p. 550; Fisher<sup>40</sup>, p. 395 (*Phascoloides*); Stephen and Edmons<sup>45</sup>, p. 131 (*Phascoloides*)

Type species: *Nephasoma marinki* Pergam. = *Golfingia lilljeborgi* (Dan. Kor.)

The introvert is not more than three times longer than the trunk; no additional comb of small teeth at the bases of hooks; two retractors; spindle muscle is not attached to body wall posteriorly; contractile vessel simple, without tubules; nephridia are single-lobed.

Key to species of the subgenus *Nephasoma*

- 1(2) The introvert is about as long as the trunk or two times longer; the skin is thin and transparent; retractors are united together at the larger part of their length . . . . . *Golfingia* (*Nephasoma*) *lilljeborgi* (Danielssen et Koren)
- 2(1) The introvert is not longer than the trunk; the skin is vigorous and not transparent; retractors are separated in major part of their length . . . . . *Golfingia* (*Nephasoma*) *minuta* (Keferstein)

*Golfingia* (*Nephasoma*) *lilljeborgi* (Danielssen et Koren, 1881) (Fig. 13)

Danielssen et Koren<sup>48</sup>, p. 3, pl. I, fig. 14 (*Phascolosoma*), p. 8, pl. 1, Fig. 15—20 (*Onchnesoma glaciale*); Théel<sup>51</sup>, p. 80 (*Phascolosoma glaciale*);

Wesenberg-Lund<sup>115</sup>, p. 30; Wesenberg-Lund<sup>116</sup>, p. 8 (*Phascolosoma glaciale*); Pergament<sup>114</sup>, p. 189 (*Nephasoma marinki*); Fisher<sup>40</sup>, p. 392 (*Golfingia/Phascoloides/glacialis*); Murina<sup>44</sup>, p. 184 (*Golfingia*); Gibbs<sup>159</sup>, p. 121.

Quotations for the Adriatic Sea: Murina<sup>26</sup>, p. 57

*Material*: 1 specimen.

*Description*: Very small thin-walled and transparent worm with a long introvert. Characteristic is the absence of tentacles, but few rounded lobes are present around the mouth. The hooks are arranged in irregular rows. Papillae of the introvert are 2—3 times higher than thick. They are shuttle like and stand on the dome-like basis. All other cutaneous corpuscles are flat. They are most densely distributed on the basis of the introvert and at the posterior part of the body. Skin corpuscles are rounded and lightly yellow coloured. One pair of retractors arises from the extreme posterior end of the trunk; they are webbed together thus giving the appearance of a single muscle. There are numerous intestinal coils but the spindle muscle is absent. Two nephridiopores are on the level of the anus.

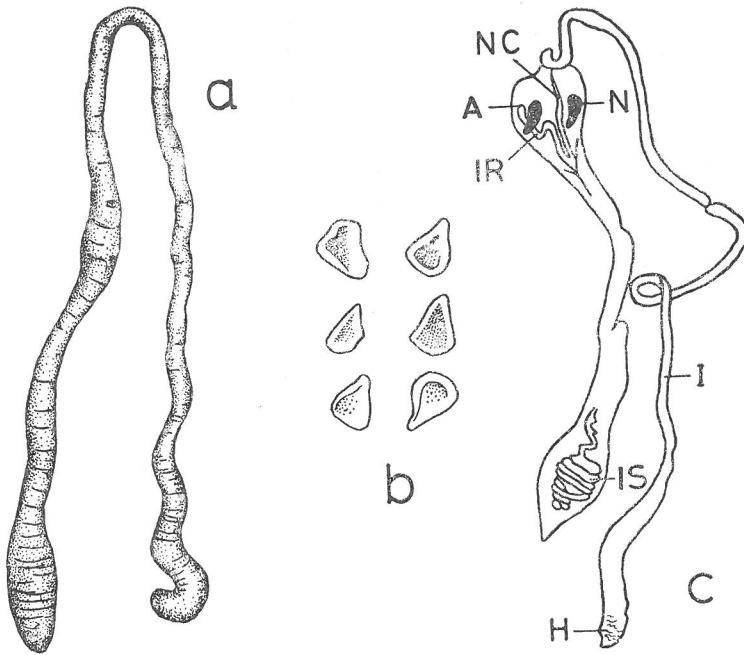


Fig. 13. *Golfingia (Nephasoma) lilljeborgi* (Danielssen et Koren), a = entire specimen; b = hooks of the introvert; c = dissected specimen (a: after Wesenberg-Lund<sup>118</sup>; b: after Danielssen et Koren<sup>45</sup>; c: after Wesenberg-Lund<sup>118</sup>).

**Distribution:** Cosmopolitan and eurybathic species. Depth distribution: 65—4800 m. This species is reported from Norway, the Buffin Bay, the Karskoe Sea, the Arctic Ocean, the eastern Siberian Sea, the Pacific and the Indian Ocean<sup>44</sup>. Most southern find areas are the Biscay Bay, the Aegean Sea, and the Adriatic Sea. In the Adriatic it was sampled near Split at 82 m depth<sup>26</sup> (Fig. 14). **Ecology:** This species prefers silty bottoms<sup>44</sup>. Our specimen was found on muddy sand which was populated by *Paralacydonia paradoxa*, *Nephtys hombergi*, *Prionospio malmgreni*, *Ampharete grubei*, *Onchnesoma steenstrupii*, numerous amphipods, tanaidaceans, decapods, *Ophiura albida*, and others<sup>28</sup>.

**Biology:** No data available.

*Golfingia (Nephasoma) minuta* (Keferstein 1863) (Fig. 15)

Forbes<sup>117</sup>, p. 254 (*Sipunculus johnstoni*); Keferstein<sup>118</sup>, p. 40, Taf. III, Figs. 7—10 (*Phascolosoma*); Kofenstein<sup>119</sup>, p. 404 (*Petalostoma*); Théel<sup>51</sup>, p. 81 (*Phascolosoma sabellariae*); p. 83 (*Ph. sarsii*), p. 84 (*Ph. anceps*); Southern<sup>108</sup>, p. 28 (*Ph. johnstoni*); Fisher<sup>40</sup>, p. 396 (*Golfingia/Phascoloides*); Murina<sup>44</sup>, p. 186, Fig. 123. Murina<sup>44</sup>, p. 186, Fig. 123.

**Quotation for the Adriatic Sea:** Salvini-Plawen<sup>34</sup>, p. 303.

**Material:** None.

**Description:** The animals are 2—15 mm long and at least 0.5 mm thick. The introvert is about the same length as the trunk. The body is rod-like or cylin-



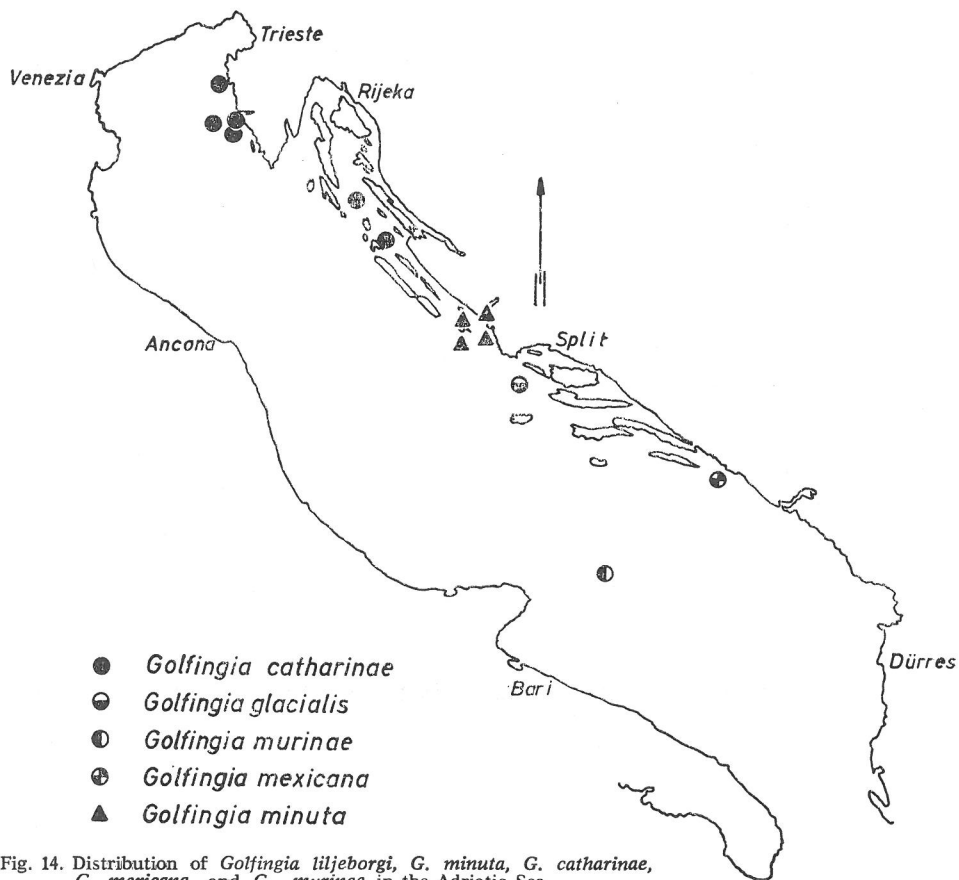


Fig. 14. Distribution of *Golfingia liljeborgi*, *G. minuta*, *G. catharinae*, *G. mexicana*, and *G. murinae* in the Adriatic Sea.

drical; it is more than 3—15 times longer than it is thick. The posterior end is usually globular. The worms are white, yellow or greyish-yellow, but the basis of the introvert and the posterior end of the body are darker. At the basis of the introvert a rosette of the anal opening is good perceptible. The tentacles are not developed: they are replaced by 4—7 short and oval lobes. Behind them there is a smooth zone and a belt of irregularly displaced hooks which are 0.02—0.05 mm high. The body wall is thin, transparent and silky. The skin is covered by flat and oval corpuscles yellow coloured, of which diameter is 0.006—0.04 mm. Eye spots are sometimes absent.

Two retractors are fastened at the middle third or the posterior half of the trunk. The retractors are joined together a lot of their length thus forming a groove in which the oesophagus is placed. The intestinal spiral is formed out of 20—50 coils and is attached near the anus by the spindle muscle. In some specimens, an intestinal fixing muscle is present. The rectum is short and has a small caecum. The wing muscles are poorly developed. Nephridia are free and short. Nephridiopores are located a bit behind the anus. In ripe animals large spherical eggs 0.14—0.16 mm in diameter can be seen in the body cavity. The hermaphroditism is reported in this species<sup>120,121</sup>.

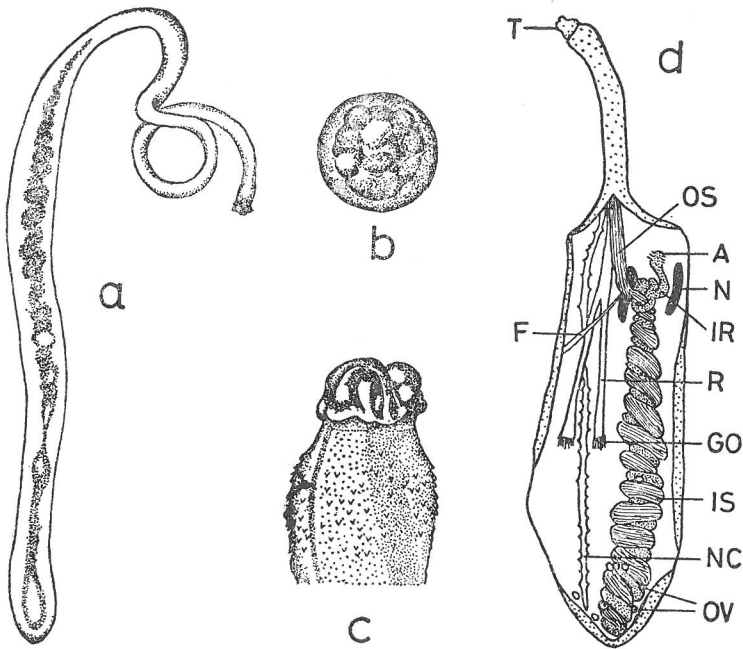


Fig. 15. *Golfingia (Nephasoma) minuta* (Keferstein). a = entire specimen; b = tentacular crown, frontal view; c = anterior part of the introvert with hooks; d = dissected specimen (a — d: after Théel<sup>98</sup>).

**Distribution:** A cold water eurybathic species which is distributed almost all around the world. It is reported from the equatorial waters to the Antarctic and the Arctic (82°N), where its distribution is circumpolar. It was found also in the central part of the Pacific and the Atlantic Oceans. The depth marks of the species<sup>44</sup> are 0—6710 m. According to Cukrov<sup>33</sup>, in the Adriatic Sea, this species is well distributed in the region of the Dalmatian littoral (Fig. 14).

**Ecology:** *G. minuta* was found frequently in eutrophic waters rich in organic materials. It lives on various kinds of bottom: clay, aleurite, calcareous, foraminiferal and sandy ooze, and similar. It was found also in oligotrophic areas on red clay mixed with concretions. In the Pacific, the worm inhabits before all the shells of molluscs, tubes of polychaetes, and tests of foraminiferans *Reophax* and *Rhabdamina*<sup>44</sup>. According to Cutler<sup>122</sup>, this species prefers the water temperatures below 10 °C.

**Biology:** Akesson<sup>120</sup> reported on primitive brood protection in this species.

#### Subgenus *Thysanocardia* Fisher, 1950

Fisher<sup>58</sup>, p. 551

Type species: *Phascolosoma procerum* Möbius, 1875

The introvert is not more than 2.5 times longer than its trunk; hooks are absent, except in one species; two retractors; spindle muscle is not attached at the posterior of the body; contractile vessel with tubules; nephridiopores anterior to the anus.

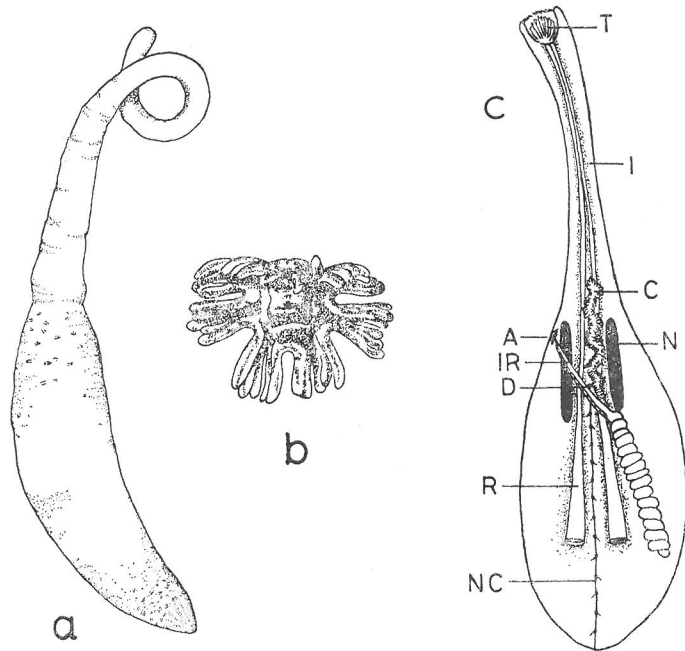


Fig. 16. *Golfingia (Thysanocardia) catharinae* (Muller). a = entire specimen; b = ring of tentacles; c = dissected specimen (a: original; b: after Théel<sup>51</sup>; c: after Murina<sup>44</sup>).

*Golfingia (Thysanocardia) catharinae* (Grube, 1868) (Fig. 16)

Grube<sup>123</sup>, p. 48 (*Phascolosoma*); Möbius<sup>124</sup>, p. 157, pl. 3, Figs. 1—5 (*Ph. procerum*); Selenka, de Man, Bülow<sup>56</sup>, p. 38, Taf. V, Figs. 56—59 (*Ph. semperi*), p. 38—40, Taf. II, Fig. 16, Taf. V, Figs. 60—63 (*Ph. procerum*); Théel<sup>51</sup>, p. 70, Pl. II, Figs. 19—26, Pl. III, Figs. 27—28, Pl. XIII, Fig. 190 (*Ph. procerum*); Ostroumov<sup>125</sup>, p. 320—324 (*Ph. pavlenkoi*); Fisher<sup>58</sup>, p. 551; Fisher<sup>40</sup>, p. 402 (*G. procerum*); Edmons<sup>126</sup>, p. 305 (*Ph. semperi*); Thorson<sup>127</sup>, p. 128—132 (*G. procera*); Cutler<sup>122</sup>, p. 146, Figs. 26, 27

Quotations for the Adriatic Sea: Cukrov<sup>33</sup>, p. 33,

Zavodnik and Murina<sup>30</sup>, p. 127; Zavodnik and Murina<sup>31</sup>, p. 84; Murina<sup>44</sup>, p. 205; Murina and Zavodnik<sup>35</sup>, p. 253; Zavodnik<sup>18</sup>, Tab. III.

*Material*: 11 specimens.

*Description*: The trunk is 4—50 mm long, 4—5 times as long as thick. The body is worm-like, slender, cylindrical or bottle-like. The colour of specimens which were freshly fixed in alcohol is whitish-gray. At the end of the introvert there are numerous finger or thread-like tentacles, which are yellow coloured with dark violet spots at the distal end. The hooks of the introvert are absent. Two eye-spots are present. The trunk wall is thin, solid and brilliant. The surface of the skin is covered with yellow or brightly-brown short finger or ball-like papillae, which are the highest (0.09 mm) at the basis of the introvert.

Two broad retractors are attached at the posterior 1/3 or 1/4 part of the trunk. They are separated at all length but unite at the introvert. The intestine spiral with 10—40 coils is attached at the anterior part of the body with one

spindle muscle, thin wing muscles and 1—2 (rarely 3) fixing muscles. The latter can be absent in some specimens. The rectal caecum is present. Contractile vessel is fluffy, beset with many short yellow or orange coloured tubules which are blind at the ends or divided. Nephridia are free and short. The nephridiopores are in front of the anus. Ripe eggs are spherical and 0.1—0.14 mm in diameter.

*Distribution:* The species is tropico-temperate and eurybathic (0—3477 m)<sup>128</sup>. It is reported from Peru (Callao) Brasil (Desterro), Chile, the West India, Azores (Pico Fayal), South Africa, Mozambique, the Japan Sea and eastern coast of Japan (Onagawa), the Western Mediterranean<sup>44</sup>. We have noted it at some stations in the north-eastern part of the Adriatic Sea, at the 16—76 m depth (Fig. 14).

*Ecology:* In the Adriatic Sea, *G. catharinae* was sampled in the community of coastal detritic bottom, on detritic bottom partly mixed with ooze, and on silty sediment which is characteristic for the complex biocoenosis of *Nephrops norvegicus* — *Thenaea muricata*. Apparently *G. catharinae* belongs to the group of species which live on muddy bottoms and are tolerant to other fractions. Picard<sup>98</sup> assigned it to exclusive mud dwellers. On the French Catalane coast, Guille<sup>129</sup> collected it on pure ooze in the community of *Nucula sulcata*. In the Adriatic the species was taken at the temperatures of 9.40—18.80 °C and at the salinity of 37.72—38.22 ‰<sup>31,35</sup>.

*Biology:* Thorson<sup>128</sup> noted a parasitic behaviour of *G. catharinae* on a polychaete *Aphrodite aculeata*, a phenomenon which was discussed by Illg<sup>157</sup>.

#### Subgenus *Siphonoides* Murina, 1967

Murina<sup>130</sup>, p. 1334

Type species: *Golfingia immuniata* (Sluiter, 1902)

Two retractors; longitudinal musculature of body not divided into separate bands; spindle muscle attached at the posterior end of the body; contractile vessel simple.

#### *Golfingia (Siphonoides) mexicana* Murina, 1967 (Fig. 17)

Murina<sup>130</sup>, p. 1334

Quotations for the Adriatic Sea: None

Material: 7 specimens.

*Description:* The trunk is spindle-like with a rounded posterior end and a long, thin introvert. The length of the trunk from the caudal end to the clearly visible bulge of the anus is 10 mm, and the thickness is 1.2 mm. The introvert is 46 mm long and 0.2 mm in diameter. At the end of the introvert there are more than 50 rings of sharp hooks with slightly curved apices; the hooks are 0.032 mm high and 0.10—0.015 mm thick at the base.

The body wall is white, robust, slightly shining. At the base of the introvert there are skin bodies of an elongated oval shape 0.07—0.10 mm in diameter. In the middle of the trunk, the bodies are flat, like rosettes, with a hole in the cen-

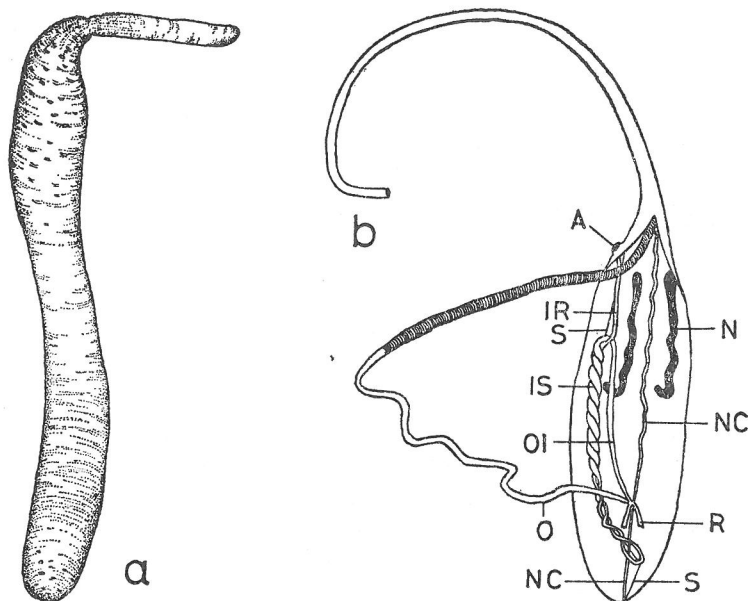


Fig. 17. *Golfingia (Siphonoides) mexicana* Murina. a = entire specimen; b = dissected specimen (a: original; b: after Murina<sup>1960</sup>).

tre and 0.020—0.025 mm in diameter. In the posterior part of the body, the bodies are 0.03—0.05 mm wide and 0.25—0.030 mm high.

The inner longitudinal muscle layer is continuous. Retractors are short (0.5 mm); they begin at the posterior fourth of the trunk and join into one muscle 14 mm long, above which lies a thin and almost imperceptible oesophagus. From the point of junction of the retractors, in the direction to the introvert, runs a long and straight postesophageal intestine, which continues in the intestinal spiral with 15 coils. The anus is clearly above the nephridopore.

The spindle muscle begins above the anus, runs along the rectum and is hidden by the intestinal spiral until its caudal part. Other muscles which would fix the intestine were not found. Caecum was not found. Contractile vessel is simple, very thin.

The nephridia are single-lobed, slightly curved and as long as one third of the trunk. Gonads are not developed. A thin ventral nerve cord is normally structured. Eye spots were not observed.

*Distribution:* Mexico Bay,<sup>130</sup> 19°26.3'N, 96°01.4'W, depth 110 m, the Adriatic Sea near Dubrovnik, 42°38.4'N, 18°04.7'E, depth 85 m, Fig. 14). The Adriatic specimens were caught on 25 June 1971.

*Ecology.* In Mexico Bay *G. mexicana* was sampled on clay, and in the Adriatic Sea on silt.

*Biology:* No data available.

*Notice:* This species was not previously reported from European seas (the Adriatic Sea and the Mediterranean included).

Subgenus *Apionsoma* Sluiter, 1902 sensu CutlerFisher<sup>38</sup>, p. 560; Murina<sup>44</sup>, p. 236; Cutler<sup>160</sup>, p. 382.Type species: *Apionsoma trichocephala* Sluiter, 1902

Two pairs of retractor muscles, spindle muscles attached to the posterior end of the trunk; nephridia single or bilobed; tentacles arranged in crescent or near circle dorsal to mouth papillae, most obvious at the posterior end of the trunk and often domelike or conical.

*Golfingia (Apionsoma) murinae* Cutler, 1969 (Fig. 18)Murina<sup>26</sup>, p. 59—63, Fig. 8—11 (*hespera*); Murina<sup>131</sup>, p. 228, Fig. 7 (*hespera*); Cutler<sup>42</sup>, p. 213, Fig 3 (*murinae*); Cutler<sup>122</sup>, p. 145 (*murinae*), Cutler<sup>160</sup>, p. 369.Quotations for the Adriatic Sea: Cukrov<sup>33</sup>, p. 43; Fredj<sup>46</sup>, p. 63.

Material: None.

*Description*: The cylindrically shaped trunk is at maximum 22 mm long and 2.5 mm thick. It transitions stepwise into the introvert which is thin and usually 4—6 times longer than the trunk. The worms are grey, yellow or brown.

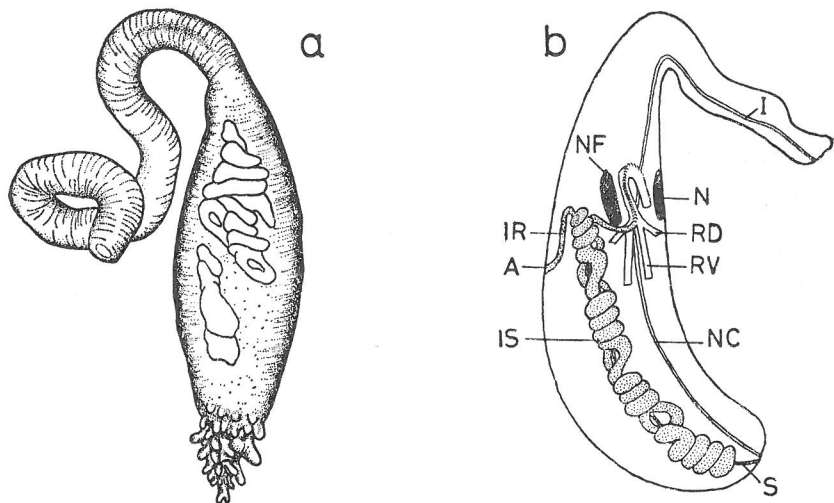


Fig. 18. *Golfingia (Apionsoma) murinae* Cutler. a = entire specimen; b = dissected specimen (a: after Cutler<sup>42</sup>; b: after Murina<sup>26</sup>).

8—10 small finger-like tentacles are gathered together at one side similarly as the genus *Phascolosoma*. The hooks are displaced in 10—50 rings. At the base of the hook there is an additional comb created of sharp teeth or spines; this comb is reduced or absent in hooks nearest to the mouth opening. The body wall can be thin and transparent, or thick, opaque and furrowed. In adults, the posterior end of the trunk is provided by large mammiform or blister-shaped papillae. Growth variations in shape of the papillae are noted: in tiny animals the papillae are globular and rosetted, in medium sized specimens papillae are dome-like, and in very large worms the papillae are transformed to flat oval skin bodies which have a small perforation in the centre.

At both ends of the trunk, the inner muscle layer is split to many small longitudinal bands. The ventral retractors are thicker in comparison to dorsal ones. The attachment places of retractors are very variable: they can be attached at the posterior third of the trunk, at its middle part, or even at the level of the anus. Both pairs of retractors are united soon thus forming a long white muscle. The intestine and the rectum are long. The intestinal spiral is formed of 10—30 coils and is attached by 1—3 fixing muscles. The wing muscles are poorly developed. The caecum is formed like a small globular protuberance. The nephridiopores are located before the anus. The nephridia are one- or two-lobed, the second lobe being much smaller than is the principal lobe. The oval eggs measure 0.085 x 0.070 mm.

*Distribution:* *G. murinae* is a tropico-boreal and eurybathic species<sup>44</sup>. It is distributed in tropical areas of the Pacific and Indian Oceans, in the shelf and bathyal regions of the Atlantic Ocean, in the Mediterranean, and in the Peruan-Chilean and Aleuthian trenches. It was noted at 56—4820 m depths. Its distribution in the Adriatic Sea is practically unknown. Cukrov<sup>33</sup> collected a small specimen in the South Adriatic pit at the 525 m depth (Fig. 14).

*Ecology:* Noted on fine silty sediments<sup>42</sup> at the temperatures 1.58—24 °C<sup>132</sup>.

*Biology:* No data available.

#### Subgenus *Golfingia* s. str. Fisher, 1952

Fisher<sup>40</sup>, p. 390

Type species: *Sipunculus vulgare* Blainville, 1827.

The introvert may be two times as long as the trunk, but usually is shorter; when present, the hooks are without the accessory comb of spinelets at the base; four retractors of the introvert: the spindle muscle is not inserted at the posterior part of the body; contractile vessel is simple, not branched; nephridia are single-lobed; nephridiopores are more or less on the level of the anus (except in *G. soyo* and *G. rugosa*).

#### Key to species of the subgenus *Golfingia* s. str.

- 1(2) The trunk 8—20 times longer than it is thick; papillae substituted by flat skin bodies . . . . . *G. elongata* (Keferstein)  
 2(1) The trunk is no more than 5—6 times longer; papillae present . . . . .  
 . . . . . *G. vulgare* (Blainville)

#### *Golfingia (Golfingia) elongata* (Keferstein, 1862) (Fig. 19)

Keferstein<sup>133</sup>, p. 39, Taf. III, Fig. 5 (*Phascolosoma*); Selenka, de Man Bülow<sup>56</sup>, p. 23—25, IV, Figs. 35—36 (*Phascolosoma*), p. 25 (*Ph. cylindrata*); Hutton<sup>134</sup>, p. 29 (*Ph. teres*); Théel<sup>151</sup>, p. 62, Pl. I, Figs. 9—13, Pl. XIII, fig. 188 (*Phascolosoma*); Hérubel<sup>135</sup>, p. 144 (*Ph. elongatum punctatum*); Gadd<sup>136</sup>, p. 102—105, Figs. 9—14 (*Ph. derjugeni*); Stephen<sup>137</sup>, 59—61, Figs. 1—2 (*Ph. cluthensis*); Stephen<sup>138</sup>, p. 132

*Quotations for the Adriatic Sea:* Vatova<sup>15</sup>, Tab. XII.; Marcuzzi<sup>11</sup>, p. 180; Zavodnik<sup>29</sup>, p. 94; Zavodnik and Murina<sup>30</sup>, p. 127; Zavodnik and Murina<sup>31</sup>, p. 85.



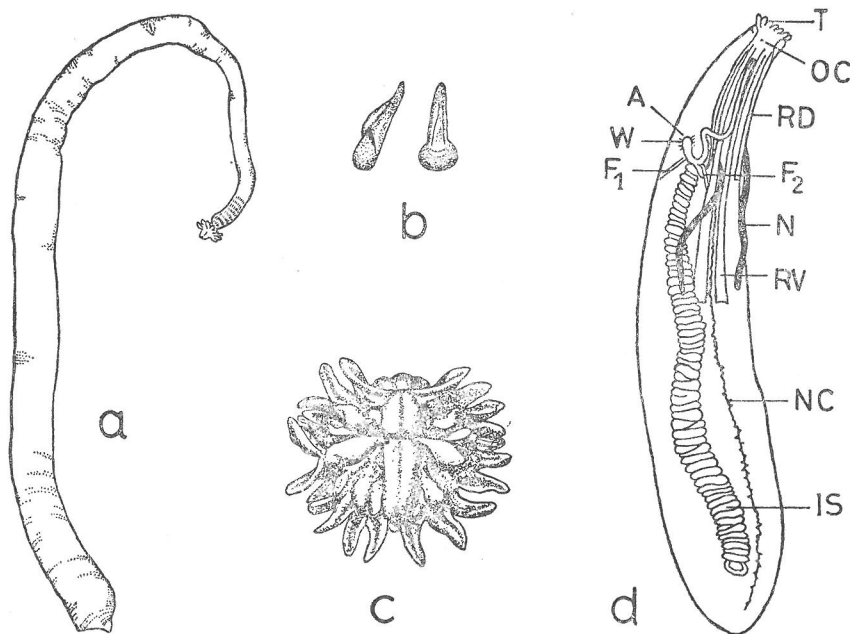


Fig. 19. *Golfingia elongata* (Keferstein). a = entire specimen; b = hooks of the introvert; c = ring of tentacles; d = dissected specimen (a: original; b, c: after Théel<sup>51</sup>; d: after Keferstein<sup>19</sup>).

**Material:** 15 specimens.

**Description:** Length of the trunk is 2—90 mm. The introvert is usually half as long as the trunk, but in several specimens it can reach its whole length. The body is elongated, cylindrical, and 4—20 times as long as thick. The colour is very variable. At the end of the introvert there are some tentacles (Fig. 19c). The nuchal organ is divided by two longitudinal grooves into three lobes. The hooks are arranged in 5—20 rings. By height the hooks vary from 0.02—0.10 mm. They are erect and somewhat pointed (Fig. 19b). On the brain there are two eye spots. The body wall is smooth, iridescent, without papillae and is covered by many flat skin bodies, which are most dense at the caudal end of the body.

Ventral retractors are attached from anterior seventh to middle third length part of the trunk. Dorsal retractors are inserted at the level of the anus. From the right and left sides the retractors unite in the vicinity of the mouth opening. The intestinal spiral is formed out of 30—60 coils. Its anterior part is attached with one or two muscles behind the root of left dorsal retractor. Caecum is present. Nephridiopores are at the level of anus or a little in front of it.

**Distribution:** Tropico-boreal. Cosmopolitan in the northern hemisphere: the North Sea, Groenland (?), northern coast of France, the English Channel, Scagerrak, Kattegatt, coastal waters of Spitzberg Islands, Island, Scotland, Sweden and Belgium, Mediterranean, coastal waters of NW part of Cuba, South China Sea. It is distributed mainly in the upper sublittoral<sup>44</sup>; maximal depth is 260 m. In the Adriatic Sea, it is distributed scatterly at 19—87 m depth (Fig. 20).

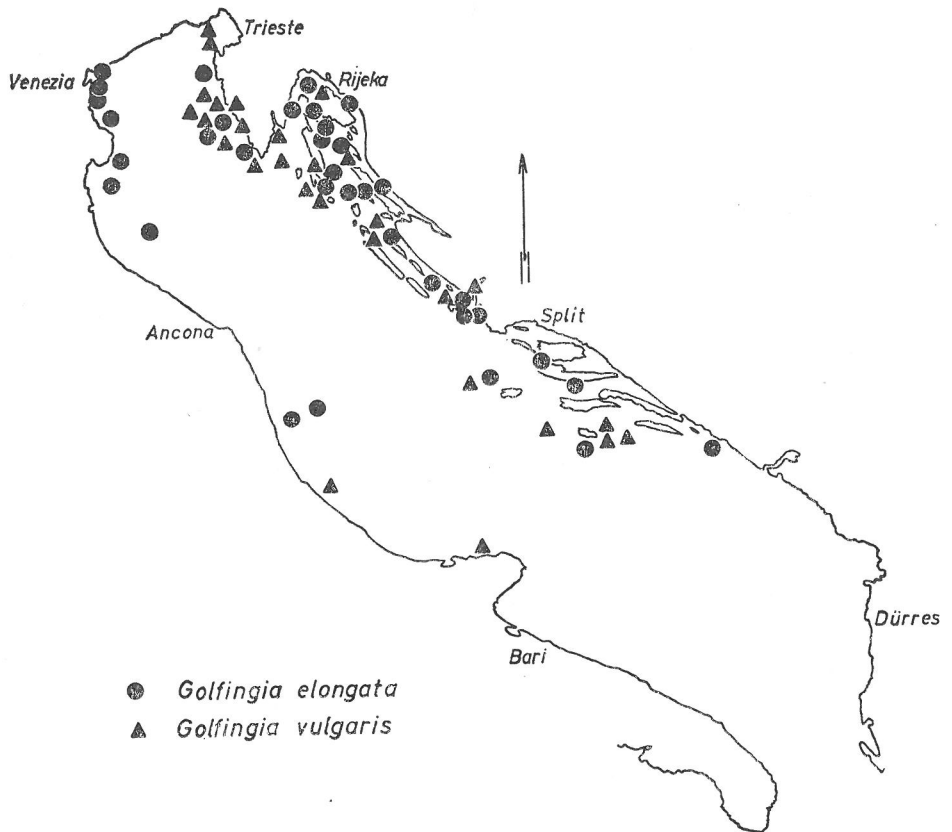


Fig. 20. Distribution of *Golfingia elongata* and *G. vulgaris* in the Adriatic Sea.

*Ecology:* The species was sampled frequently on hard bottoms: gravels sands and shells, rarely also on muddy bottoms and in gray loam<sup>71,100</sup>. In the Mediterranean, it seems to be exclusive to the community of the detritic, more or less, muddy bottom<sup>98</sup>, and in the North Adriatic it was taken also in the complex community *Nephrops novregicus* — *Nucula profunda*<sup>90</sup>. Salinity and temperature ranges noted by us are 10.31—16.53 °C and 37.40—37.62 ‰ Sal., respectively.

*Biology:* Near Plymouth<sup>139</sup> the worms reproduce in July and August, at the temperatures 16—18 °C. The developmental pattern is described by Rice<sup>90</sup> and Akesson<sup>140</sup>. *G. elongata* was seldom reported to be associated with other organisms<sup>45</sup>: an unidentified metacercaria, the bivalve *Potidoma clarkiae*, and the entoproct *Loxosomella phascolosomatum*. The importance of meiofauna in the diet of *G. elongata* was studied by Walter<sup>141</sup>.

*Golfingia (Golfingia) vulgaris* (Blainville, 1827) (Fig. 21)

Blainville<sup>142</sup>, p. 312 (*Sipunculus*); Théel<sup>51</sup>, p. 60—62, Pl. I, Figs. 1—5, Pl. II, Fig. 14, Pl. XIII, Fig. 18 (*Phascolosoma*); Selenka, de Man, Bülow<sup>56</sup>, p. 20—21,



viduals, while it is thick, wrinkled and coarse in old adult. Skin surface is covered by pear- and finger-shaped or cylindrical papillae, yellow or brown coloured. At the caudal end of the body the papillae are 8—10 times more dense than at the base of the introvert or at the middle of the trunk.

Ventral retractors are somewhat thicker than dorsal ones. They begin usually at the middle third of the trunk, closer to the ventral nerve cord. Dorsal retractors begin approximately in the middle between the ventral retractors and the anus. Both pairs of retractors are separated and join together only near the tentacles. The intestinal spiral is formed out of 6—60 coils and is attached in body cavity with 1—3 fixing muscles. The rectum is attached near the anus by two wing muscles. The caecum is present. Nephridia are pear-shaped, and nephridiopores are usually at the same level as the anus. The diameter of yellow or white spherical eggs is 0.08—0.15 mm.

*Distribution:* The species is distributed all around the world, especially in the northern hemisphere<sup>44</sup>. It is characterized by a large range of vertical distribution — from littoral to abyssal: in the Kuril-Kamchatka trench it was found at the depth of 5853 m<sup>48</sup>. In the Adriatic Sea, the species is known from its eastern part, at depths not exceeding 76 m (Fig. 20).

*Ecology:* *G. vulgaris* seems not to be closely related to a particular community. Near Rovinj (North Adriatic), it was encountered at several stations on detritic bottom, pure one or that partly mixed with ooze<sup>31</sup>. Vatova<sup>10</sup> quotes it from coastal terrigenous ooze in the Lim channel. Gamulin-Brida<sup>61</sup> reported it from silty bottoms, oozy sands, the communities of marine phanerogams, and the community of coastal terrigenous ooze. Santucci<sup>145</sup> sampled it frequently in the channel system of the sponge *Geodia cydonium*. Vatova<sup>15</sup> had found it in a shell of an *Ocinebrina*. Near Rovinj, the temperature range of the species is 9.40—18.20 °C, and that of salinity is 37.74—38.08 ‰<sup>31</sup>.

*Biology:* On sandy detritic bottom in the North Adriatic the specimens can be sampled throughout the year but no fluctuations of population could be traced.<sup>31</sup> The worms feed mostly on meiofauna (nematods, copepods, nauplia), but also on Mollusca, Bryozoa, and the like<sup>141</sup>. The breeding period on the Channel coast of France and the spawning in the laboratory were described by Gerould<sup>149</sup>. According to Rice<sup>90</sup> the developmental time is five days: three days of trochophora, and two days of benthic pelagic pelagosphaera. In the vicinity of Rovinj, the specimens are frequently infected by an unidentified species of *Loxosoma*. The infection rate can be as high as 80%<sup>31</sup>. In the Rijeka Bay, the worms were infested by *Loxosomella atkinsae*<sup>24,109</sup>. The infestation of loxosomatids and ciliates in other European seas was studied by several authors<sup>150,151</sup>. Parasites, commensals and epizootes of *G. vulgaris* were reviewed by Stephen and Edmons<sup>45</sup>.

#### Subgenus *Dushana* Murina, 1975

Murina<sup>36</sup>, p. 1085

Type species: *G. scutigera* (Roule) 1907

Anal and caudal shields present; the introvert in the centre of anal shield, somewhat nearer to the ventral side; four retractors; one of dorsal retractors completely or only partly united with the ventral one; longitudinal muscle sheet smooth; spindle muscle not attached behind; contractile vessel simple.

*Golfingia (Dushana) adriatica* Murina, 1975 (Fig. 22)Murina<sup>36</sup>, p. 1086, Fig. 1Quotations for the Adriatic Sea: Murina<sup>36</sup>, p. 1086; Zavodnik and Murina<sup>31</sup>, p. 80.

Material: 4 specimens.

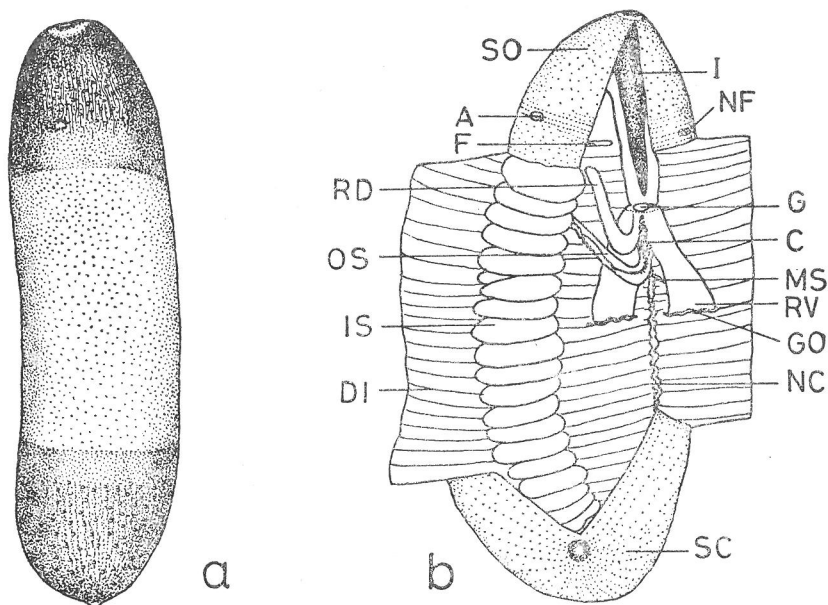


Fig. 22. *Golfingia (Dushana) adriatica* Murina. a = entire specimen; b = dissected specimen (a, b: after Murina<sup>36</sup>).

**Description:** The trunk is rod-like. 12–32 mm long and 4–9 mm thick. At the anal and caudal ends there are two dark shields, dome-like, 4 mm long. Anal shield is dark brown and more clearly divided from the trunk than the caudal shield. The introvert is about half the length of a trunk, located somewhat eccentrically nearer to the ventral side. At the end of the introvert 5–6 rings of black hooks 0.225 mm high. Pink tentacles split, 0.8 mm long and of moderate number (20–30).

The trunk wall is whitish-yellow, smooth, and densely covered with flat and very lengthened corpuscles 0.025 x 0.005 mm in diameter. On both dark shields there are transparent finger-like papillae 0.025–0.050 mm high and 0.04–0.05 mm wide. On the caudal shield there are distinct and bent pigmented bands which diverge radially from the slightly sharpened apex of the cone. The anus resembles a light rosette; it is located somewhat below the nephridiopore.

The inner surface of the body wall has conspicuous septa — short transverse sheets of muscle, 0.1 mm thick, and 0.20–0.25 mm distant one from the other. There are 26–35 septa between the anus and the caudal end of the body. The right dorsal muscle is completely united with the right ventral muscle. The ventral retractors of the introvert are attached in the first half of the trunk with wide roots. Oesophagus is short and curved. Contractile vessel

is simple, without branches. Intestine spiral with 30 coils, without attachment by spindle muscle at the caudal end. The caecum is hidden by the anterior intestinal coils. This species is characterised by a thin, narrow and glossy transparent band extending from the broad wing muscle to the right and left nephridia, crossing below the ventral neural cord. Nephridia are single-lobed, resembling short transparent funnels (not indicated in Fig. 22b). A thin band of gonads is attached to the roots of the ventral retractors. The ventral neural cord is thick and very bent.

*Distribution:* Known only from the Adriatic Sea near Dubrovnik<sup>36</sup>, Rovinj<sup>31</sup>, and Pula<sup>87</sup>, at 38—85 m depth (Fig. 23).

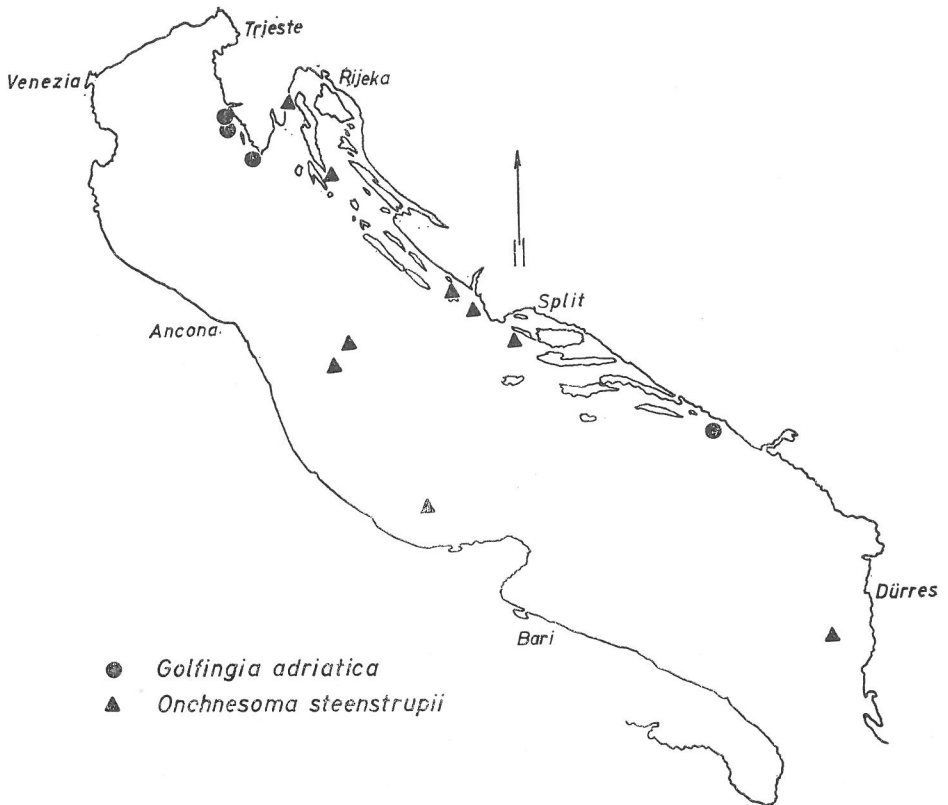


Fig. 23. Distribution of *Golfingia adriatica* and *Onchnesoma steenstrupii* in the Adriatic Sea.

*Ecology:* The specimens have been taken on ooze and on coastal detritic bottom partly mixed with ooze. Hence, the species seems to be tolerant silt dweller. In the North Adriatic, it was collected at the temperature 14.37—16.25 °C, and the salinity 37.38—37.77 ‰.

*Biology.* In June ripe eggs were found in the body wall<sup>36</sup>. A specimen taken at Pula hosted loxosomatids on caudal part of the trunk (probably, *Loxosomella phascolosomata*)<sup>109</sup>.

Genus *Onchnesoma* Koren et Danielssen, 1875

Koren and Danielssen<sup>152</sup>, p. 108; Koren and Danielssen<sup>153</sup>, p. 141; Selenka, de Man, Bülow<sup>56</sup>, p. 130; Théel<sup>51</sup>, p. 13; Fisher<sup>40</sup>, p. 374; Stephen and Edmonds<sup>45</sup>, p. 161; Murina<sup>44</sup>, p. 270.

Type species: *Onchnesoma steenstrupii* Koren et Danielssen, 1875.

The trunk is variously shaped: pear like, in the form of a barrel, or cylindrical. The introvert is as long as the trunk or up to 12 times longer. The anus is shifted to the middle or distal end of the introvert, near the mouth opening. The line between the introvert and the trunk passes the nephridiopores. At the end of the introvert there are 6—10 small finger-like tentacles, which may be absent or replaced by an oral disk. There are no hocks.

The inner layer of musculature is continuous. The single retractor is sparsely divided into joints or has two conspicuous short roots, which are attached at the caudal end of the body. The intestine is composed of several coils or forms a spiral. Spindle and wing muscles absent. The contractile vessel is simple, but is not developed in species without tentacles. A free bag-like nephridium is located at the right of the ventral nerve cord. The spherical or slightly oval eggs are 0.126—0.130 mm in diameter.

Widely distributed throughout the seas of the world, especially in the northern Atlantic Ocean and in the Mediterranean Sea. It occurs in sublittoral, bathyal and abyssal zones to 4980 m (*Onchnesoma magnibathum*)<sup>42</sup>.

*Onchnesoma steenstrupii* Koren et Danielssen, 1877 (Fig. 24)

Koren and Danielssen<sup>153</sup>, p. 142, Pl. XV, Figs. 28—36; Selenka, de Man, Bülow<sup>56</sup>, p. 130—131; Théel<sup>51</sup>, p. 93—96; Pl. X, Figs. 151—152, Pl. XI, Figs. 157—172, Pl. XIII, Fig. 185; Wesenberg-Lund<sup>115</sup>, p. 37—38, Pl. III, Fig. 43, Pl. IV, Figs. 48—49; Murina<sup>20</sup>, p. 70—71, Figs. 18—20 (*Phascolion dogieli*), p. 72—73; Murina<sup>44</sup>, p. 273, fig. 187

Quotations for the Adriatic Sea: Vatova<sup>15</sup>, Tab. XXXII, Murina<sup>20</sup>, p. 72; Kisseleva<sup>28</sup>, p. 29, 33; Fredj<sup>46</sup>, p. 63; Zavodnik<sup>20</sup>, p. 94; Zavodnik and Murina<sup>30</sup>, p. 128

Material: 23 specimens.

*Description:* Trunk 0.5—5 mm long and 0.3—5 mm wide. The introvert can attain 34 mm and is 5—12 times longer than the trunk. The shape of the body depends on the condition of the musculature: the pear shape is seen in relaxed animals with completely everted introverts, and the barrel-like shape is found in worms with an inverted introvert and contracted musculature. The caudal end of the body is slightly pointed. A surface line between the introvert and the trunk passes the level of the nephridiopore. The trunk is variously coloured: whitish-gray, yellow, green, orange, reddish-brown, sometimes with rusty spots; the introvert is lighter. The tentacular crown is reduced to an oval disk without any protuberance (Fig. 24c). Eye spots present. The skin is thin, compact, half-transparent in the middle third of the trunk, while at both ends it shows small longitudinal and ring-like folds. There are occasionally glandular cells 0.01—0.05 mm wide, with a hole in the centre.

Characteristic for this species are the cutaneous chitinous platelets, rectangular or oval, without a hole, coloured yellowish-green. Their diameter is 0.01—



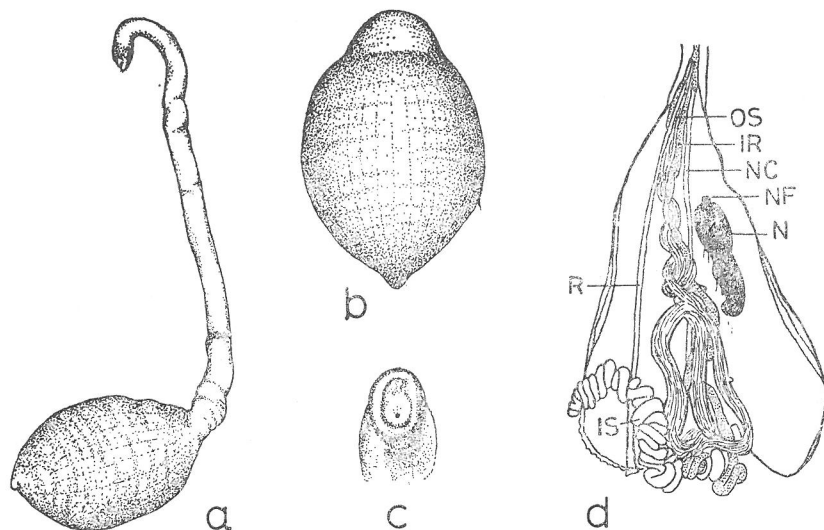


Fig. 24. *Onchnesoma steenstrupii* Koren et Danielssen. a = entire specimen with completely everted introvert; b = animal with inverted introvert; c = oral disc; d = dissected specimen (a: after Wesenberg-Lund<sup>15</sup>; b: original; c, d: after Théel<sup>21</sup>).

—0.03 mm. In the caudal part of the trunk the platelets are clearly separated, while nearer to the tail they join together and thus form 11—30 longitudinal ridges, which join together radially at the pointed apex. Among them there are chitinous granules, of various dimensions, and irregularly shaped, constituting a formation similar to the caudal shield of *Aspidosiphon*.

There is only one retractor, which is attached at the posterior part of the body and runs together with the oesophagus. No contractile vessel was found. The intestine is composed of several coils or forms a spiral. It is attached to the body with thin fixing muscles (1—2). The rectum passes through the whole introvert and opens by an anus in the vicinity of mouth opening, at 95—98% of the distance between the proximal and distal ends of the introvert. The spherical or slightly ellipsoidal eggs measure 0.13—0.15 mm.

*Distribution:* This tropico-moderate eurybathic species (0-3362 m) is mostly distributed in the northern hemisphere: in the waters of Norway, the Mediterranean, the Gulf of Suez, the Red Sea, the Indian Ocean, and near the Gold Coast. In the southern hemisphere it has been recorded along the coasts of Angola, the Congo, South Africa and the Tasmanian Sea<sup>44</sup>. In the Adriatic Sea, the specimens were taken elsewhere<sup>15,26,30</sup>, at depths of 20—199 m. According to Cukrov<sup>33</sup> this is the most common sipunculid species in silty sediments in a Mid Dalmation region of the Adriatic Sea (Fig. 23).

*Ecology:* Although *O. steenstrupii* was collected at various kinds of sea bottom<sup>44</sup>, Picard<sup>98</sup> considers it as a species exclusive to the biocoenosis of deep muddy bottoms. In the Adriatic Sea, it was taken on coastal ooze (complex community of *Nephrops norvegicus*), on deep silty bottom of the open sea, on clay sand, and on clay<sup>15,26,28,30</sup>.

*Biology:* According to the contents of the intestine, the food of this species partly consists of vegetable debris<sup>154</sup>.



## DISCUSSION AND CONCLUSIONS

Our research and the review of the published papers revealed 16\* species of the phylum Sipuncula in the Adriatic Sea, which belong to 6 genera and four families (Table I). They make up one half of the sipunculan taxa known from the Mediterranean Sea<sup>44,46,132</sup>. It seems that the sipunculan fauna in the Adriatic Sea is more diverse than in the Eastern Mediterranean or in the Black Sea. However, the species number established for the Adriatic Sea cannot be

TABLE I  
*Taxonomical composition of the worms of the phylum Sipuncula in the Mediterranean basin*

Taxon	Mediterranean	Adriatic Sea	Black Sea
Families	4	4	1
Genera	6	6	1
Species	34	16	1
Subspecies	3	1	0

\* See notice on page 24.

regarded as final. Rough mapping of the benthic stations visited previously in the Adriatic Sea clearly indicates that the benthos in the northern and the eastern part of the Adriatic is much better investigated than this is that in shallow waters along the south-western (Italian) coast, the area of the Otranto threshold, the territorial waters of Albania, and especially the southern and deepest offshore waters in the South Adriatic. Consequently, we can expect to find further sipunculan species in the Adriatic Sea not only in the bathyal zone but also in shallow waters. In fact, in his Thesis on the Sipuncula of mid Dalmatian sedimentary bottoms, Cukrov<sup>33</sup> reported the occurrence of some species which hitherto were not noted in the Adriatic Sea (*i. e.*, *Golfingia minuta*, *G. nordenskjöldi*, *G. abyssorum*, *G. procera*, *G. inhamata* n. sp., *G. murinae*, and *Phascolion tuberculosum*). Unfortunately, Cukrov's manuscript has never been published and therefore is not available to the scientific community at large; for this reason, his data mostly were not reviewed in this paper except for species which are well known, or the occurrence of which in the Adriatic Sea was checked recently. We have not considered Hérubel's<sup>135</sup> note on the finding of *Golfingia eremita* near Lussin (*i. e.*, Lošinj, 44°40'N, 14°30'E), a note which later was recited apparently only by Murina<sup>44</sup> but was never verified. The occurrence of this species in the Adriatic Sea is fully doubtful because it does not inhabit waters of which the temperature is above 10 °C.<sup>122</sup>

Ten species of sipunculan worms are common to the Mediterranean and the Adriatic Sea. If calculations are made according to Preston's<sup>155</sup> similarity index (0.45) or to Jaccard's<sup>156</sup> coefficient of commonness (26.3%), an affinity of the Adriatic sipunculid fauna to that of the Mediterranean is evident.

Some preliminary conclusions can be made from the analysis of vertical and geographical distributions of Adriatic Sipuncula. Above all, the Sipuncula were sampled in the Adriatic Sea most at depths between 0 and 100 meters (Table II). Furthermore, of the 16 species treated in this paper, 11 species were found

TABLE II

The bathymetrical and geographical distribution of worms of the phylum Sipuncula in the Adriatic Sea

Species	World Ocean (m)	Adriatic Sea (m)	Geographical distribution
<i>Aspidosiphon kovalevskii</i>	34—775	44—124	widetropical or tropico-subtropical
<i>A. muelleri</i>	0—1262	9—85 (525?)	tropico-temperate
<i>Phascolosoma granulatum</i>	0—2050	0—39	tropico-temperate
<i>Ph. scolops</i>	0—5220	35—65	tropico-temperate
<i>Sipunculus nudus nudus</i>	0—2275	8—37	tropico-temperate
<i>Golfingia lilljeborgi</i>	65—4800	82	cosmopolitan
<i>G. minuta</i>	0—6710	40—73	cosmopolitan
<i>G. catharinae</i>	0—3479	16—76	tropico-temperate
<i>G. mexicana</i>	110—340	67—85	widetropical
<i>G. elongata</i>	0—360	19—87	cosmopolitan
<i>G. vulgaris</i>	0—5853	1—73	cosmopolitan
<i>G. adriatica</i>	—	38—85	endemic
<i>G. murinae</i>	56—4820	253—1170	tropico-temperate
<i>Phascolion brotzkajae</i>	78—89	67	boreal-mediterranean
<i>Ph. strombi</i>	0—3808	2—78 (199?)	cosmopolitan
<i>Onchnesoma steenstrupii</i>	0—3362	20—199	tropico-temperate

\* See notice on page 24.

at depths less than 90 meters. It is assumed that this distributional pattern is related to the way benthic studies have been conducted in the Adriatic Sea which until now were mostly in the shallow shelf zone.

The maximum depth noted for a sipunculan species in the Mediterranean is 1900 meters (*Golfingia solitaria*)<sup>44</sup>. Of the approximately 34 species and 3 subspecies which are known for this area<sup>132</sup>, 8 species are reported from the littoral zone, 18 species live in the shelf area (sublittoral), 3 species inhabit the bathyal zone (between 730 and 1900 m), and 8 species are eurybathic, *i. e.*, they are widely distributed in the zones between the littoral and 1400 metres depth. Of the the Adriatic Sipuncula studied, 10 species (62%) are eurybathic, and the other six species belong to the stock of sublittoral (shelf) species; no one species is limited to the shallow littoral zone (Table II).

The tropico-temperate species are the most numerous sipunculan species (37.5%) in the shelf of the Adriatic Sea. Cosmopolitans are a bit less numerous (31.3%) and the wide tropical (tropico-subtropical) species are subordinated (18.7%). The endemic element is represented by the monotypical subgenus *Dushana* (*Golfingia* /*Dushana*/ *adriatica*). The only species of the boreal-mediterranean distribution is *Phascolion brotzkajae*. The comparison of zoogeographical composition of the fauna of the Adriatic and the Mediterranean revealed a greater diversity of faunal elements in the Mediterranean basin because of the presence of several arctic-boreal species. The investigations of Cukrov<sup>33</sup> pointed out the probability of finding arctic-boreal sipunculans in the Adri-

atic Sea also. The importance of cosmopolitan, wide-tropical (tropico-subtropical) and boreal species is very similar in both basins. However, the percentage of endemic elements in the Mediterranean seems to be two times that of the Adriatic Sea, while the proportion of tropico-temperate species in the faunal composition is about equal in the Mediterranean (32.4%) and in the Adriatic (37.5%)<sup>132</sup>. It is clear, however, that the final comprehension of the bathymetrical and zoogeographical structure of sipunculid fauna in the Adriatic Sea will be possible only by further study of the distribution of these animals not only in the shelf waters but also in the bathyal zone.

Biological aspects of the Sipuncula of the Adriatic Sea are not well known. No investigations on the energy flow through their food web have been carried out until recently. In addition, only few data exist on commensals and epizoots of the Adriatic Sipuncula<sup>35,109</sup>, and as far as we know, their parasites and predators have not yet been studied. On the other hand, much information has been gathered on the synecology of sipunculan worms at the community level<sup>15,29</sup>, especially with respect to their use of empty shells of various molluscs for protection<sup>35</sup>, and the importance of seaweeds and calcareous algae in providing habitats for the worms<sup>31,59</sup>. In the littoral zone, *Phascolosoma granulatum* also lives in empty burrows made by endolithic shellfish<sup>31</sup> and clionid sponges, but no active worm burrowing has been noted which would be similar to that described by Por<sup>53</sup> for *Aspidosiphon muelleri*. The preferential choice of snail shells for the sipunculan worms is possible<sup>35</sup> but it has not yet been tested experimentally in the Adriatic species.

Long-term studies on the biocoenology of benthic communities in the Adriatic Sea have provided much data on the distribution and abundance of sipunculan worms in various communities and on various kinds of bottom substrates<sup>29</sup>. However, most results refer to the relatively shallow area in the mid and North Adriatic Sea, while the bathyal Sipuncula of the South Adriatic depression remained unknown until recently. It was noted that in the North Adriatic bottom communities, the Sipuncula usually make up about 0.5—1.0% of the total animal biomass (wet weight) on oozy and detritic bottoms, *i. e.*, about 0.2—0.7 gr per square meter<sup>15,29</sup>. On coastal terrigenous ooze<sup>18,87</sup> in which *Aspidosiphon* is characteristic, the biomass of Sipuncula rarely exceeds 2 g/m<sup>2</sup>.

On soft bottoms, the population densities of Sipuncula usually are not high. In the surroundings of Rovinj, on various bottom types, the calculated average population density mostly is less than one specimen per square meter<sup>12,14,31</sup>. According to the results of the RV »Vila Velebita« cruises<sup>35</sup> in 1973—74, on clayey silt (station VV-3) populated by the Norwegian lobster (*Nephrops norvegicus*), an average of about 16 specimens of *Aspidosiphon kovalevskii* was calculated per square meter. On sandy silt (station VV-33) the population density of this species was calculated to 65 animals per square meter. On silty bottom off Ravenna as much as 250 *Aspidosiphon* per square meter were collected<sup>87</sup>. There are indications, that in the Adriatic Sea *Phascolosoma granulatum* also can reach a population density of more than 200 specimens/m<sup>2</sup> within the community of photophilic seaweeds; however, detailed studies to support this supposition have not yet been performed.

The physiology of several of the species treated in this paper, have been studied in other areas throughout the world; however, it seems that no relevant data exist concerning the Adriatic specimens. In addition, Adriatic species have

not been subject to detailed chemical analyses. Though, treatment of the material obtained from standard quantitative samples of bottom fauna has yielded some information on the water, organic matter, and residue contents of some common species (Table III).

TABLE III  
*The chemical composition of some Adriatic Sipuncula*

Species	Number of specimens	Mean weight (g)	Water (%)	Organic matter (%)	Ash (%)
<i>Aspidosiphon kovalevskii</i>	425	0.1342	84.87	11.96	3.17
<i>Phascolosoma granulatum</i>	14	0.1367	86.38	10.05	3.57
<i>Golfingia vulgaris</i>	15	0.2049	77.90	16.24	5.86
<i>Phascolion strombi</i>	38	0.0354	60.51	27.35	12.14

Considering the above, we draw the general conclusion, that in the Adriatic Sea, the shallow water sipunculan fauna is relatively rich in species and is fairly well known with regard to ecology and distribution. On the other hand, a severe lack of information on the biology, physiology and chemical composition of the majority of these species is evident. It also should be noted, that information on the bathyal Sipuncula from the Southern Adriatic depression is still lacking.

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## IZVOD

Sipuncula Jadranskog mora

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Sipunkulidi Jadranskog mora do sada su samo rijetko bili predmet posebnih studija, dok mnogo više podataka o njihovoj ekologiji i rasprostranjenju nalazimo u biocenološkoj literaturi. Na osnovu obrade bogato sakupljenog biološkog materijala, uglavnom s područja Sjevernog Jadrana, te kritičkog razmatranja literaturnih podataka, danas je u Jadranu sigurno utvrđeno 16 vrsta iz 6 rodova i četiri porodice skupine Sipuncula. Od tih vrsta samo *Golfingia (Dushana) adriatica* nije pronađena u drugim morima, a *Golfingia (Siphonoides) mexicana* ranije nije bila poznata iz evropskih mora, pa tako i Sredozemlja i Jadrana. Uz morfološki i anatomski opis svake vrste, razmatraju se i njezina ekologija, biološke osobitosti i rasprostranjenje (opće i u Jadranu), a spominju se i dosadašnji literaturni navodi koji se odnose na Jadran. Uspoređena je i jadranska fauna sipunkulida s faunom Sredozemlja. Utvrđeno je da su podaci o rasprostranjenju sipunkulida u nekim dijelovima Jadranskog mora, a naročito u dubokoj južnojadranskoj kotlini nedostatni, pa je vrlo vjerojatno da navedeni broj jadranskih vrsta nije konačan. Autori, također, ukazuju na oskudnost podataka, koji se odnose na fiziologiju, kemijski sastav interspecijske odnose i značenje sipunkulida u betonskim zajednicama Jadranskog mora.