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A new species, genus and family of a hexactinellid sponge from the Bering Sea (Porifera: Hexactinellida)

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ABSTRACT: A new species, genus and family of a hexactinellid sponge from the bathyal zone of the Bering Sea are described. This representative of Hexactinosida or Sceptrulophora has an unique dictyonal (rigid) skeleton construction. *Pseudocribrospongia piserai* gen.n., sp.n. (Pseudocribrospongiidae fam.n.) has a circular row of lamellas which are longitudinally directed, nearly parallel, beneath and between the dermal and atrial surfaces. The lamellas may branch dichotomously (providing the goblet-like or triangular tong-like body forms with undulating walls in the biggest specimens) and are connected with their neighbors by rare and irregular dictyonal structures. The sponge is thick-walled. It is characterized by the development of the diplorhitic canalization in the slits between the radial oriented lamellas (which do not involve the dictyonal framework — no channelization). The canalization is formed from the loose spicules and the syncytia. The epirhyses and aporhyses have a quincuncial (staggered) type of arrangement, externally similar to that of the mainly fossil family Cribrospongiidae with so-called channelization — "development of the gaps (in thick-walled sponges) within the dictyonal skeleton".
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KEY WORDS: new family, genus and species of Hexactinellida, Bering Sea.

Новый вид, род и семейство шестилучевых губок Берингова моря (Porifera: Hexactinellida)

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РЕЗЮМЕ: Описан новый вид, род и семейство шестилучевых губок из батиальной зоны Берингова моря. Новый представитель Hexactinosida или Sceptrulophora обладает уникальной среди других семейств особенностью строения диктионального скелета. *Pseudocribrospongia piserai* gen.n., sp.n. (Pseudocribrospongiidae fam.n.) имеет кольцевой ряд пластинок, направленных продольно, почти параллельно, расположенных под и между дермальной и атриальной поверхностями. Пластинки могут дихотомически разветвляться (придавая чашевидную или треугольную форму телу губки, расширяющуюся кверху, с волнистыми стенками у крупных экземпляров) и соединяться с соседними пластинками редкими, неправильными диктиональными структурами. Губка толстостенная. Характеризуется развитием каналов диплоризов (эпиризы и апоризы) в щелях между радиально ориентированными пластинками (без участия диктионального скелета). Каналы формируется из неспаянных спикул и синцития. Эпиризы и апоризы имеют "quincuncial" (шахматный) тип расположения, сходный с

преимущественно ископаемым семейством Cribrospongiidae, у которых в отличие от нового семейства каналы расположены непосредственно в диктиональном скелете.
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КЛЮЧЕВЫЕ СЛОВА: новое семейство, род и вид шестилучевых губок, Берингово море.

Introduction

This publication continuous the descriptions of the Hexactinellida from the Bering Sea collected by a series of the USSR and Russian expeditions. The described specimen was collected by the RV *Akademik M.A. Lavrentyev* 75 cruise to the Pijpa Seamount in the Bering Sea by the ROV *Comanche–8*, several more specimens of this peculiar sponge were observed by the ROV in the adjacent locations.

Hexactinosida – Sceptrulophora wall construction and its channelization provide the main base for most family definition of these taxa. Presence of the dictyonal skeleton in the tangential plane (surface) of the sponge body was a feature of all families of Hexactinosida or Sceptrulophora except Aphrocallistidae.

A construction of the wall similar to that of the newly found hexactinellid sponge was recently predicted by Voronkina *et al.* (2023). This form explains a possible derivation of the *Aphrocallistes* wall construction, which has a specific honey-comb-like dictyonal framework called diarhyses. Diarhyses characterize the entire family Aphrocallistidae with its both genera, *Aphrocallistes* and *Heterochone*. Similar to the new representative they have no dictyonal skeleton developed in the tangential plane of the sponge body. All their dictyonal (rigid) constructions are orientated radially (in the distal-proximal direction).

Material and methods

The spicules preparations and the preparation of the framework were made using the method described by Janussen *et al.* (2004) and investigated with the light microscope.

Abbreviations: avg — average; D, d — diameter; IORAS — P.P. Shirshov Institute of Oceanology of Russian Ac. of Sc.; L, l — length; max — maximum; ROV — remotely operated vehicle; RV — research vessel; sta — station; std — standard deviation.

The described sponge is stored in the IORAS 5/2/3836.

Systematics

Pseudocribrospongiidae **fam.n.**

TYPE GENUS. *Pseudocribrospongia* gen.n. (by monotypy).

DEFINITION. Hexactinosida – Sceptrulophora with euretoid skeleton which consists of circular row of lamellas directed longitudinally, nearly parallel, sometimes dichotomously branching. Lamellas are formed from dictyonal strands; diplorhytic canalization are arranged quincuncially in the slits between the lamellas. The dictyonal framework is not involved in the construction of canals.

DIAGNOSIS. The sponge is goblet-like or triangular, tong-like with undulating walls in the biggest specimens. Walls are thick, constructed from euretoid dictyonal skeleton which consists of circular row of lamellas directed longitudinally, nearly parallel, sometimes dichotomously branching (providing the widening of the sponge upwards). The rows of lamellas are connected by irregular dictyonal structures. Dictyonal strands which form the euretoid skeleton in the lamellas are spreading equally from the center line to dermal and atrial sides. Diplorhytic canalization has a quincuncial type of arrangement. Epirhyses and aporhyses are arranged in parallel lines in the slits between the radial oriented lamellas (the dictyonal framework is not involved in the canals construction). Epirhyses are covered by the dermal membrane with dermal spicules; aporhyses open freely into the atrial cavity. Dermalia and atrialia are hexactins with short ray directed outside the body, rarely pentactins. Loose choanosoamal spicules are discoscopules (big and small) and uncinates. Microscleres are discohexasters (big and small) and oxyoidal ones (oxyhexasters, oxyhemihexasters, oxyhexactins and abnormal oxyoidal microscleres).

REMARKS. The new family definitely belongs to Hexactinosida Schrammen, 1903 and Sceptrulophora Mehl, 1992. Recent families with the euretoid skeleton (possessing the dictyonal strands) and with sceptres, which belong to Hexactinosida – Sceptrulophora, are characterized by the specific types of channelization:

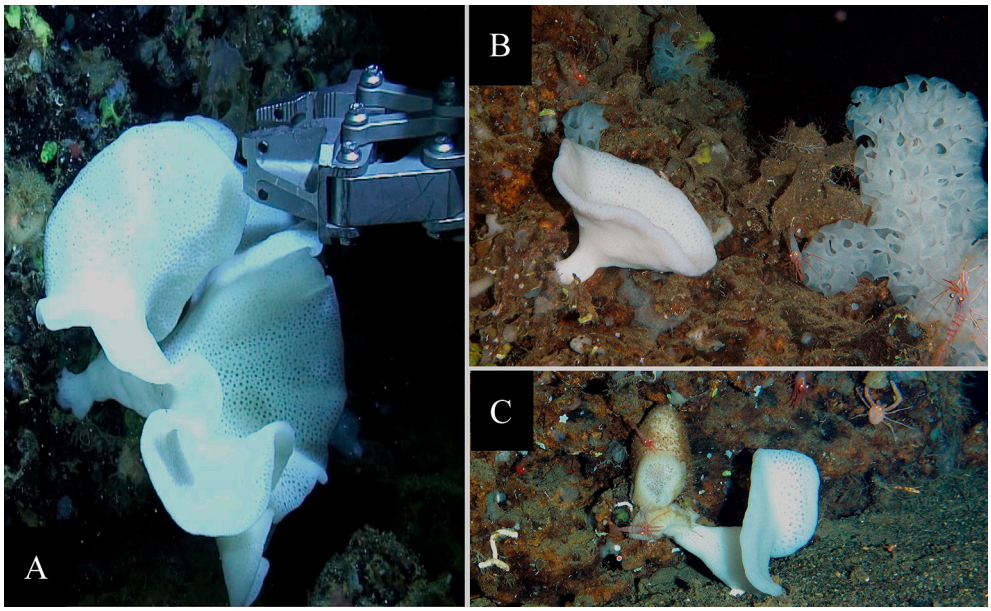


Fig. 1. *Pseudocribrospongia piserai* gen.n., sp.n., *in situ* the ROV observations. A — holotype before capturing (goblet-like with undulating walls); B — regular goblet-like specimen and large specimens of *Farrea* sp.; C — a tong-like representative with the bilateral symmetry.

1. Euretidae — no wall channelization or irregular epirhyses (i.e. "radially directed channels or continuous gaps in the dictyonal skeleton of Hexactinosida, their openings (ostica) are situated on the dermal surface" Tabachnick, Reiswig, 2002) or irregular diplorhytic structures (both epirhyses and aporhyses (the last are "channel(s) in the dictyonal framework which penetrates into the body wall from below the bounding spicules of the atrial (gastral) surface" Tabachnick, Reiswig, 2002); 2. Craticulariidae — diplorhythic structures are organized in quadrunx order ("aporhyses and epirhyses each form rows, but the two types of rows are offset" Tabachnick, Reiswig, 2002); 3. Cribrospongiidae — diplorhytic structures are organized in quincuncial order (staggered arrangement); 4. Tretodyctyidae — schizorhyses channelization (labyrinthine structures); 5. Aphrocallistidae — diarhyses (honey-comb-like construction) (Reiswig, 2002a). The other three families of Hexactinosida different notably from the listed above five families: Dactylocalycidae (Reiswig, 2002b) and Auloplacidae (Reiswig, Kelly, 2011) do not have the euretoid skeleton, the first family has also no sceptres and uncinates; the third one, Farreidae, has farreoid skeleton and clavules together with uncinates. Auloplacidae and Farreidae belong to Sceptrulophora. The peculiar and poorly known family Fieldingidae (Tabachnick, Janussen, 2004) should belong to Sceptrulophora since the presence of scopules. Meantime its position within Hexactinosida due to the very specific framework allowed to distinguish the order Fieldingida (Tabachnick, Janussen, 2004). Thus the situation with the definition of high level taxa in Hexasterophora is unstable.

The new family Pseudocribrospongiidae has definitely euretoid skeleton with both dictyonal strands and scopules. It obviously belongs to the both taxa: Hexactinosida and Sceptrulophora. Unlike the mostly fossil family Cribrospongiidae Roemer, 1864 (Krautter, 2002; Reid, 2004) the epiphyses and aporhyses in the new representative form the system of canalization — the dictyonal framework is not involved itself in the constructions of canals or their walls. In Cribrospongiidae they are called channels or the system of channelization — "development of the gaps in (thick-walled sponges with) dictyonal skeleton" (Tabachnick, Reiswig, 2002). Thus unique feature of canalization and specific framework organization which consists of series of nearly parallel, dichotomously branching lamellas give the base to suggest a new family.

The unique wall construction of Pseudocribrospongiidae was recently predicted by Voronkina *et al*. (2023). Such type of the wall construction was important for the theoretical explanation of the appearance of diarhyses type of the wall construction in *Aphrocallistes.* The initial genus used for this reconstruction was *Lefroyella* (Euretidae; Chonemasmatinae). It has both longitudinal dichotomously branching ridges of the dictyonal framework situated vertically on the atrial side. The ridges position is completely equal to the lamellas in *Pseudocribrospongia*. The genus *Lefroyella*

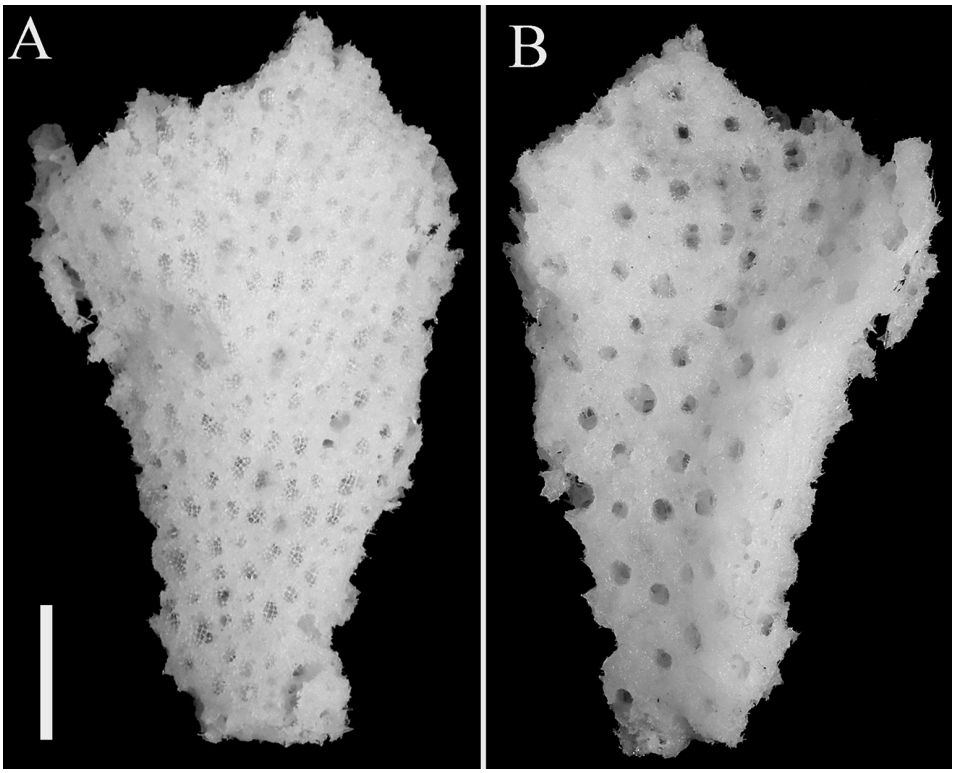


Fig. 2. *Pseudocribrospongia piserai* gen.n., sp.n., biggest captured fragment. A — view from dermal side; B — view from atrial side. Scale bar — 10 mm.

seems to be the closest relative to *Pseudocribrospongia* and looks to be the ancestral form of the new genus. However *Lefroyella* has no diplorhytic canalization arranged quincuncialy. The openings in thin-wall representatives of *Lefroyella* from the dermal surface to the spaces between the ridges are opened directly into the atrial cavity and could be rather considered as lateral oscula then epirhyses.

The new genus is very similar in appearance to several fossil Cribrospongiidae: *Cribrospongia* (goblet-like); *Hyanespongia* (leaf-like or anastomosing) and *Petalope* (ear-shaped) (Finks *et al.*, 2004). It is possible that the framework and the type of diplorhytic organization observed in *Pseudocribrospongia* represent an ancestral transitional to Cribrospongiidae form. Accordingly the skeleton construction of the new genus represents an intermediate stage between Euretidae and Cribrospongiidae. The growth of dictyonal structures around the canals (diplorhytic) can turn canalization into channelization.

Pseudocribrospongia **gen.n.**

ETYMOLOGY. The genus is named after similarities of external shapes and the organization of diplorhytic canalization in quincuncial order to the fossil hexactinellid *Cribrospongia* d'Orbigny, 1849 (fam. Cribrospongiidae).

TYPE SPECIES. *Pseudocribrospongia piserai* sp.n.

DIAGNOSIS. Same with the family diagnosis.

Pseudocribrospongia piserai **sp.n.**

Figs 1–5, Graphs 1–2.

ETYMOLOGY. The species is named in honor of my colleague and co-author of joint publications, specialist in fossil and recent sponges Dr. Andrzej Pisera.

MATERIAL. Holotype: IORAS 5/2/3836: two fragments from a single specimen. RV *Akademik M.A. Lavrentyev* – 75, ROV *Comanche*, sta. 18, specimen 7, 55.428° N 167.2701° E, depth 993 m. Several specimens of this species were observed with the ROV in adjacent locations at similar depth.

DESCRIPTION. BODY. The holotype is presented by two lamellate fragments of the wall. Its capturing was registered by the film camera. Two laser dots (seen in the film) set the scale allowing to estimate the sizes of the body *in situ*. The specimen is goblet-like, basiphytous sponge with undulating

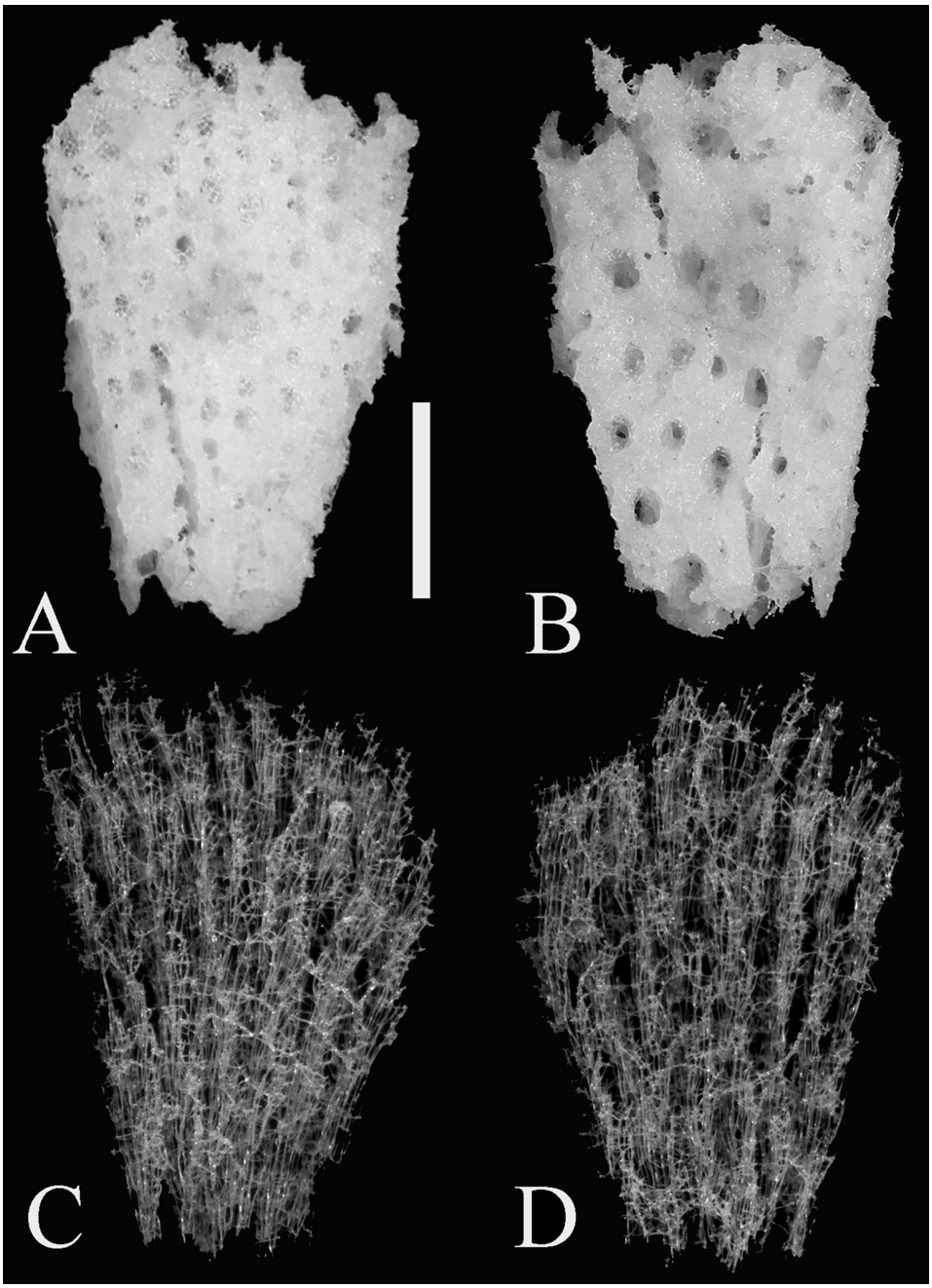


Fig. 3. *Pseudocribrospongia piserai* gen.n., sp.n., smallest captured fragment before and after the removal of loose spicules and 'tissues'. A — view from dermal side; B — view from atrial side; C — view of the framework from dermal side (after the removal of loose spicules and 'tissue'); D — view of the framework from atrial side (after the removal of loose spicules and 'tissue'). Scale bar — 10 mm.

walls. The complete specimen before the sampling was about 150 mm high and 350 mm in maximal diameter in the upper part; at the base the specimen is about 30 mm in diameter. The walls are 4–5 mm thick; the diplorhytic canalization is organized in quincuncial order; the epirhyses are rounded or ovoid 0.5–1 mm

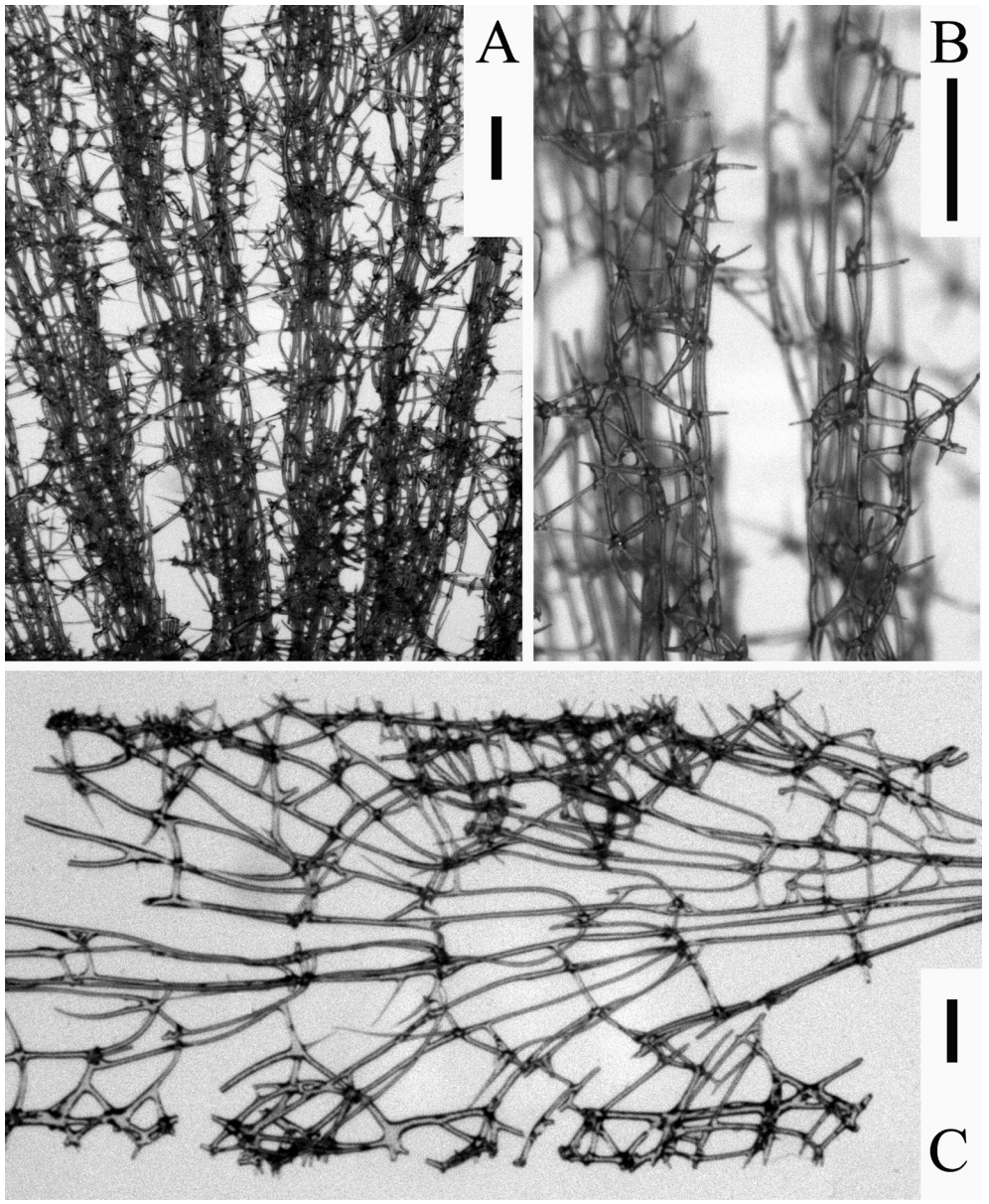


Fig. 4. *Pseudocribrospongia piserai* gen.n., sp.n. A–B — framework (lamellas) from the dermal side; C — lamella from aside. Scale bar — 1 mm.

in diameter; the aporhyses are rounded 0.7–1.5 mm in diameter. The both types of the canals openings are distributed in linear series between the lamellas of the framework which regularity is interrupted by the dichotomous branching of lamellas. Several other specimens were registered by the video and photo images by the ROV at the same station. One smaller specimen has a regular goblet-like body, whose walls do not undulate; it is about 100 mm high, 200 mm in maximal diameter of the osculum and at its base (the part of the peduncle) is about 30 mm in diameter. A tong-like representative with the bilateral symmetry corresponds in sizes to the previous specimen which has grown in a specific condition.

FRAMEWORK. The framework consists of circular row of lamellas directed longitudinally, nearly parallel. The lamellas are about 5x1 mm in section sometimes dichotomously branching (providing the

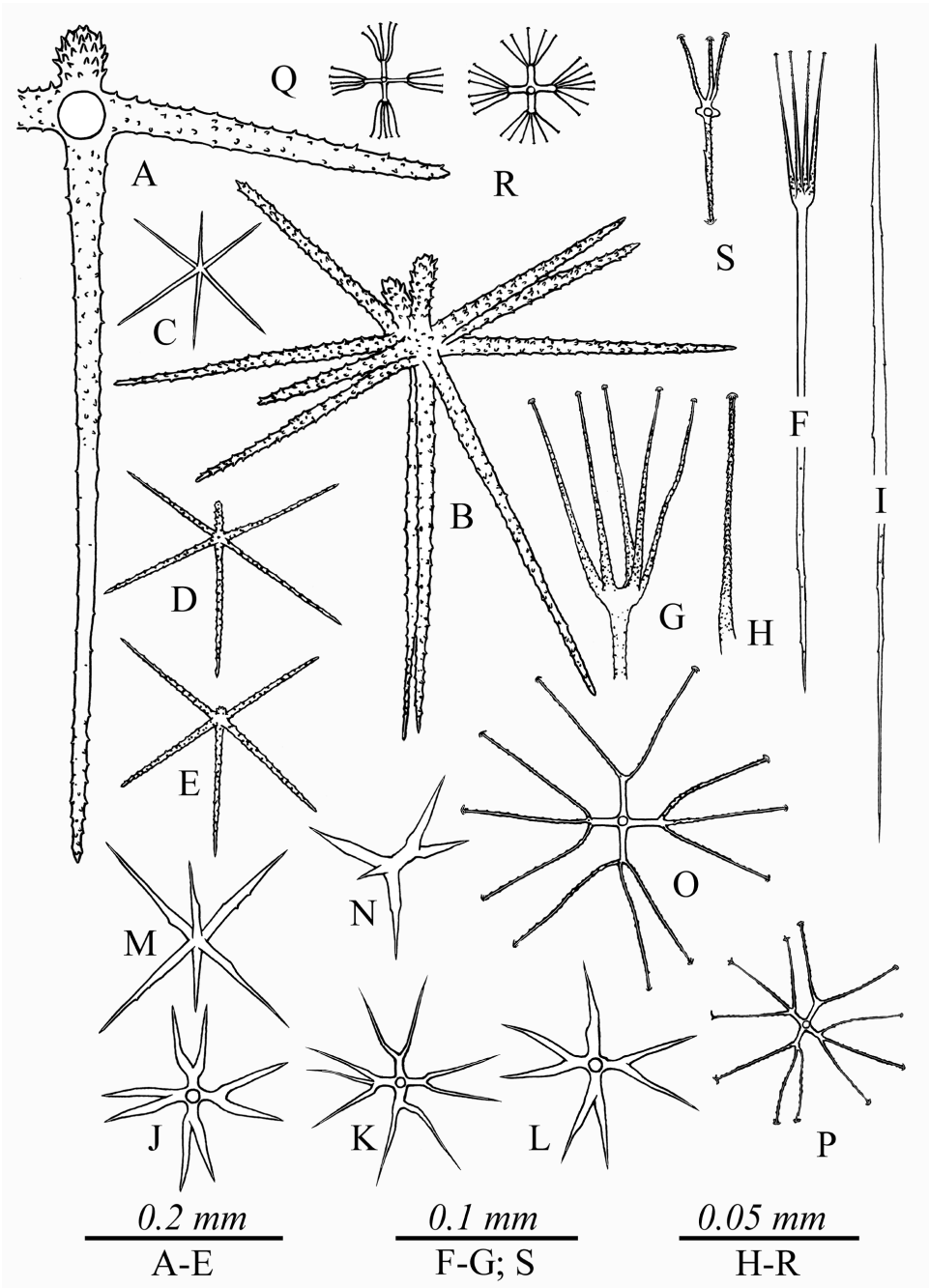
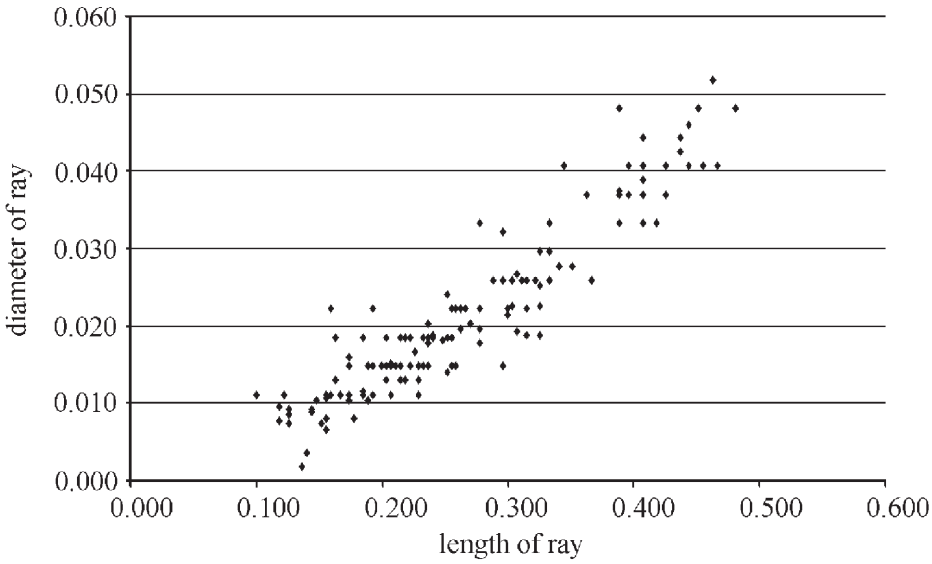
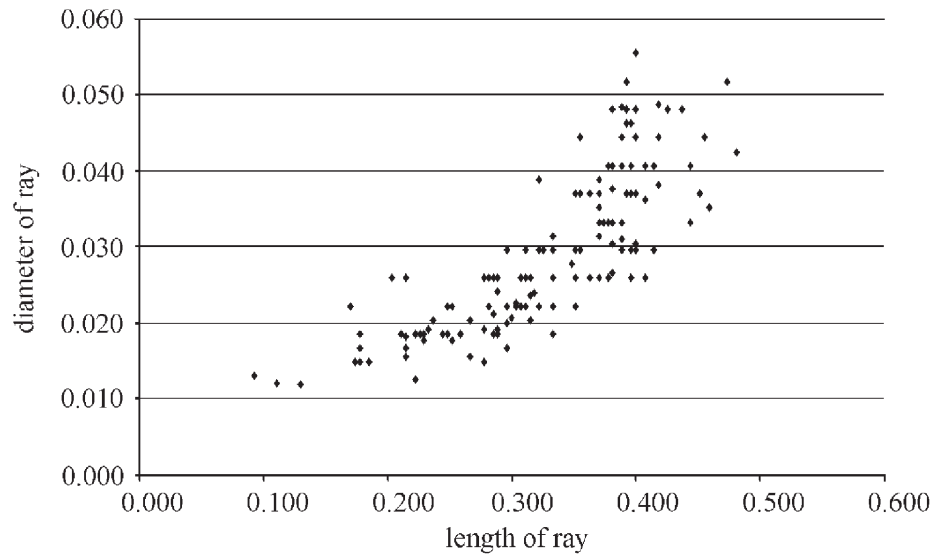


Fig. 5. Spicules of *Pseudocribrospongia piserai* gen.n., sp.n., holotype. A, C–D — dermal or atrial hexactine; B — abnormal dermal or atrial hexactins, two units were fused together at early stage of the spiculogenesis; E — dermal or atrial pentactin with a rudimental tubercle situated at place of the ray directed outside the body; F — small discoscopule; G — large discoscopule; H — tine of discoscopule; I — uncinate; J–K — oxyhexasters; L — oxyhemihexasters; M — oxyhexactin; N — abnormal oxyoidal microsclere; O — macrodiscohexaster; P — onychohexaster; Q — stellate microdiscohexaster; R — spherical microdiscohexaster; S — abnormal discoscopule or discohexaster.



Graph 1. Relationship between length and diameter of tangential rays of dermal spicules of *Pseudocribrospongia piserai* gen.n., sp.n. (in mm; n=150).



Graph 2. Relationship between length and diameter of tangential rays of atrial spicules of *Pseudocribrospongia piserai* gen.n., sp.n. (in mm; n=150).

widening of the sponge upward). Each lamella is generally formed from the primary euretoid dictyonal skeleton (approximately 2 layers). The gaps between lamellas are 1–1.5 mm in width. The lamellas are connected by irregular dictyonal structures. Dictyonal strands in the lamellas are distributed equally from the center line to dermal and atrial sides where some fine structures of the secondary euretoid skeleton may be observed. The primary euretoid skeleton is rather irregular but some more or less rectangular meshes may be found; they are extremely elongated 0.3–0.7x0.7–1.5 mm. The secondary euretoid skeleton

is very thin, located on the outer and inner surface of the lamellas with triangular and rectangular meshes with side 0.03–0.40 mm long. The beams are 0.04–0.12 mm in diameter, their surface is rough or with short-spines.

SPICULES. MACROSCLERES. Discoscopules of two types of sizes have similar external shape, the large discoscopules are less common than the smaller ones. The small discoscopules are 0.355–0.585 mm long (n=25, avg: 0.407 mm, std: 0.045 mm), they have 2–5, usually 4 tines 0.048–0.093 mm long (n=25, avg: 0.059 mm, std: 0.010 mm), the diameter of the shaft of discoscopules is about 0.004 mm. The large discoscopules are 0.796–1.092 mm long (n=2, avg: 0.944 mm, std: 0.209 mm), they have 4 tines 0.115–0.205 mm long (n=25, avg: 0.156 mm, std: 0.021 mm), the diameter of the shaft of discoscopules is about 0.011 mm. The uncinates are nearly smooth, they have small and rare hardly resolvable spines and rarely a widening of the shaft; the uncinates are 0.5–0.8/0.004 mm.

Dermalia and atrialia are hexactins and rare pentactins with a short ray or rudimental tubercle instead of the ray directed outside the body; the rays directed inside the body are often the longest or rarely they are short. The rays of dermal and atrial spicules are spiny, the ray directed outside the body may be even somehow pinnular, the outer ends of the rays are rounded or conically pointed. Dermal and atrial spicules are similar in shape and size. The ray of dermal spicules directed outside the body is 0.011–0.104 mm long (n=25, avg: 0.045 mm, std: 0.022 mm), tangential rays are 0.100–0.481 mm long (n=150, avg: 0.262 mm, std: 0.093 mm), the ray directed inside the body is 0.030–0.722 mm long (n=25, avg: 0.239 mm, std: 0.182 mm), the diameter of these rays is 0.002–0.052 mm. The ray of atrial spicules directed outside the body is 0.030–0.085 mm long (n=25, avg: 0.048 mm, std: 0.014 mm), tangential rays are 0.093–0.481 mm long (n=150, avg: 0.324 mm, std: 0.080 mm), the ray directed inside the body is 0.074–0.759 mm long (n=25, avg: 0.365 mm, std: 0.183 mm), the diameter of these rays is 0.004–0.056 mm. Since the sizes of the rays in both dermal and atrilal spicules vary from 5 to 10 times a special effort was applied to investigate if they may belong to various size categories. The length of the tangential rays and their diameter were estimated separately for the dermal and atrial spicules (Graphs 1–2). No gaps may be observed in both cases and thus neither dermal, nor atrial spicules should be divided into different size classes.

MICROSCLERES. Microscleres (hexasters, hexactins and derivatives) have three types of the outer ends: oxyoidal, onychoidal and discoidal. Oxyoidal microscleres are mainly oxyhexasters, rare oxyhemihexasters and some oxyhexactins, some of these spicules have sparsely spiny rays. The oxyhexaseters and oxyhemihexasters with 1–4 (usually 2–3) secondary rays are 0.043–0.076 mm in diameter (n=50, avg: 0.059 mm, std: 0.007 mm), their primary rosette is 0.011–0.040 mm in diameter (n=50, avg: 0.018 mm, std: 0.006 mm). The oxyhexactins are 0.047–0.090 mm in diameter (n=32, avg: 0.069 mm, std: 0.010 mm). Rare onychohexactins are 0.073–0.090 mm in diameter (n=5, avg: 0.081 mm, std: 0.008 mm). The microdiscohexasters are small with short primary rays, 2–8 (usually 5–6) secondary rays, mostly stellate with S-shaped secondary rays or sometimes spherical. The microdiscohexasters are 0.020–0.036 mm in diameter (n=25, avg: 0.026 mm, std: 0.004 mm), their primary rosette is 0.007–0.014 mm in diameter (n=25, avg: 0.010 mm, std: 0.002 mm). The macrodiscohexasters are large, spherical, with long primary rays and 2–3 secondary rays nearly. Spherical macrodiscohexasters and some onychodiscohexasters (with 1–4, usually 1–2 secondary rays) have the rays covered with short and minute spines. The macrodiscohexasters are 0.059–0.100 mm in diameter (n=25, avg: 0.072 mm, std: 0.010 mm), their primary rosette is 0.011–0.026 mm in diameter (n=25, avg: 0.016 mm, std: 0.004 mm).

DISTRIBUTION. Currently found only at the Pijpa underwater volcano (West Bering Sea) at 993 meters (and close areas according the ROV observations).

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