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Reproduction in Donatia deformis (Thiele)

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INTRODUCTION

The shoal waters about the Hawaiian Islands are well-stocked with non-commercial sponges, few of which have been determined taxonomically. One of the common forms, however, found clinging to the under surface of stones close to shore, has been recognized as *Donatia deformis* (Thiele) by de Laubenfels (5)[1] from preserved material which I sent to him. The species was described by Thiele (8) under the genus *Tethya*. This name is retained by some authors, though apparently there is uncertainty as to its preoccupation. In the following discussion, I have accepted the generic term *Donatia* as proposed by Nardo in 1833 and adopted by Dendy (3), Burton (1), Wilson (9), and others.

Living examples of *D. deformis* may be recognized by the typically hemispherical form ranging up to about one inch in diameter, pale yellow in color sometimes almost white, anchored to a support by rootlike extensions of the lower border. The exposed surface of the sponge, during what may be called a resting or inactive state, seems, on casual observation, to be quite smooth. But, on close examination, it is covered by minute rounded or conical elevations. Between the elevations are the inhalent pores which lead into a complicated system of water canals. Although a single osculum seems to be typical of the species, I have observed two in some specimens (fig. 1, *a*).

A radial section of the living sponge presents a thick medulla, greenish yellow in color, and a relatively thin, whitish, fibrous cortex. The skeletal system consists chiefly of radiating bundles of elongated

[1] Numbers in parentheses refer to Literature Cited, page 282.

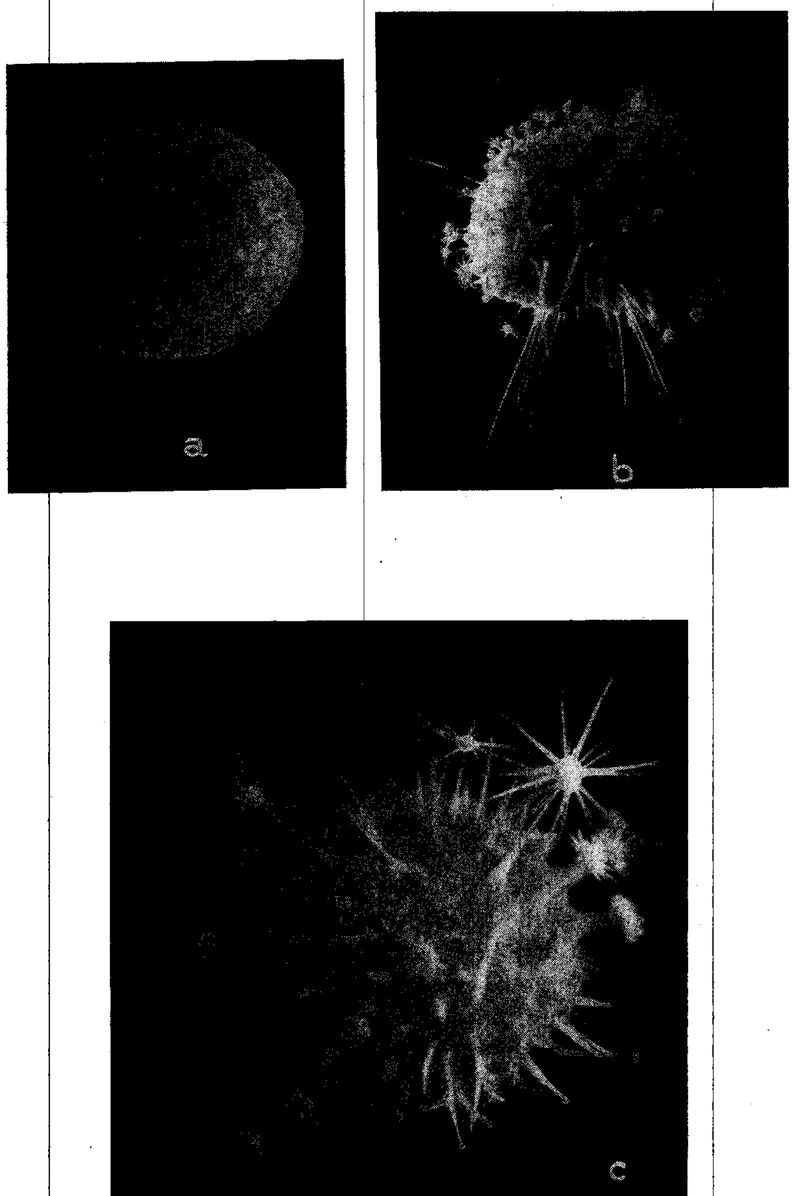

FIGURE 1.—Resting and active phases: a, resting phase; b, c, active phases showing development of gemmules and filaments (slightly enlarged).

spicules with their sharp points directed outward. Additional siliceous elements include microscopic spherasters and chiasters.

Representatives of the genus *Donatia,* or *Tethya,* range widely about shores washed by the Atlantic, Pacific, and Indian Oceans. Locality records of *D. deformis* include Japan, Christmas Island (Indian Ocean), Australia, Tasmania, New Zealand, and Hawaii. Collections in Bishop Museum from American Samoa and Washington Island include sponges which probably belong to this species. There is also reason to believe that more than one species of *Donatia* inhabit the shoal waters of the Hawaiian Islands.

SKELETAL ELEMENTS

1. Megascleres

The typical slender spicules of this species are monaxons of the stylus form, rounded at one end, acutely pointed at the other, the diameter of the middle portion being slightly greater than that at the blunt extremity (fig. 2, *b*). The monaxons are arranged in dense bundles radiating from the skeletal nucleus, the bundles increasing in thickness as the cortex is approached. They extend into the cortex almost completely filling the conical elevations of the surface (fig. 2, *a*). On the formation of buds, filaments, hold-fasts, and other processes, the monaxon spicules enter into and become a part of these surface extensions. The average length of a monaxon spicule in this species is about 1.5 mm.

The rapidity of movement of spicules noted in the formation of buds and filaments is remarkable. A shifting in position of 10 to 15 mm. in as many hours is not unusual. Dendy (4) states that cells serving as amoebocytes may envelop spicules and transport them from place to place.

2. Microscleres

Asterlike spicules, arranged in dense masses or scattered throughout the tissue, are also typical of the species. The larger of these are spherasters. A central, spherical body supports numerous broadly conical rays, the height of a ray being less than one-half the diameter of the central body (fig. 2, *c*). I find spherasters especially abundant in the deeper portions of the cortex massed around bundles of monaxon spicules. I have not observed them, however, in any of the processes extending from the surface of the sponge. The presence of these elements in sponges produced from gemmules seems to be a result of their development subsequent to the gemmule stage. Maas (6) believed that the spherasters in *Tethya* originated from a union of quadriradiate spicules. Keller, however, as recorded in the Cambridge Natural History (2) showed that in *Chondrilla* spherasters have their origin in spheres, the conical points being developed later. Sollas (7) could not find spherasters in the gemmule of *Tethya ingalli,* although spheres or globules were present. In *Donatia deformis* spherasters average about 0.05 mm. in diameter.

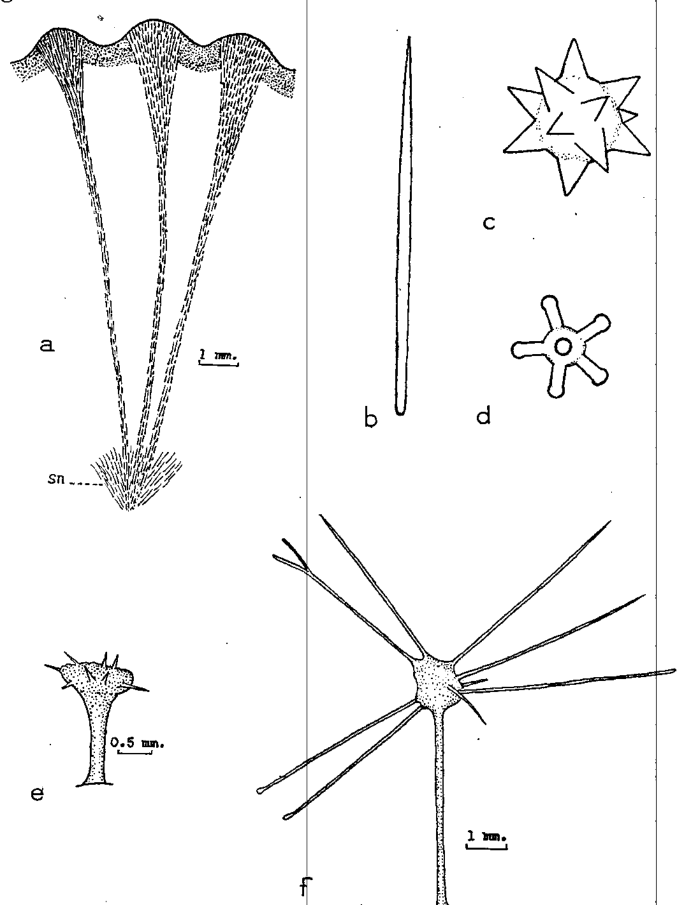

FIGURE 2.—Skeletal elements and bud formation: **a,** bundles of monaxon spicules radiating from the skeletal nucleus (*sn*) and pushing into the conical elevations of the surface; **b,** a monaxon spicule; **c,** a spheraster; **d,** a chiaster; **e,** early stage of a bud developing from the surface; **f,** *e* 24 hours later, still in contact with the sponge. (*b-d* greatly enlarged.)

Other and smaller asters, corresponding to chiasters, are also abundant in this sponge. They vary in size, the larger ones being about one-fourth that of fully developed spherasters. The rays of the chiasters are variable in number and equal or exceed in length the diameter of the central body. The clubbed ends of the rays are smooth (fig. 2, *d*). Chiasters are distributed through both medulla and cortex of the sponge but are more plentiful in the latter portion. Unlike the spherasters they are carried out in large numbers into gemmules, filaments and other processes developed from the surface of the sponge.

PROPAGATION

It has long been known that members of the genus *Donatia* or *Tethya* propagate by a rather distinctive asexual method. Maas (6) discussed the formation of buds in *Tethya* and pointed out that they represent typical gemmules arising from groups of archaeocytes in the cortex. According to him, the buds move outward along bundles of spicules and are released from the surface eventually forming new sponges.

Attention has been centered upon *D. deformis* in Hawaiian waters because of its widespread occurrence about the islands, because of its unusual fertility in the Honolulu Aquarium where myriads of specimens accumulate on the walls of the tanks, and because of its remarkable behavior as observed under controlled conditions. It has seemed worth while to record some observations on the propagation of the species.

1. Gemmules

Asterlike buds, or gemmules, the typical reproductive bodies of the species, are frequently developed from the surface of the sponge under natural conditions and, perhaps to an even greater extent, under subnormal conditions of the laboratory (fig. 1, *b, c*). The buds are pushed from the tips of the conical elevations of the surface and consist of loose bundles of monaxon spicules surrounded by masses of archaeocytes, scattered among which are many chiasters. In its early development the thick stalk of the bud expands at the end into an irregular body from which acutely pointed processes soon make their appearance (fig. 2, *e*). Within 24 hours the stalk becomes elongated and very slender while rays of variable length have been developed from the central nucleus of the gemmule (fig. 2, *f*). The rays which consist of supporting spicules surrounded by archaeocytes may number from a few to more than a dozen and, in length, range up to 10 or 15 times the diameter of the body of the gemmule.

In the laboratory, where the water is comparatively quiet, the gemmules are released from the parent sponge within one or two days of their first appearance. Under favorable conditions they may be transformed into young sponges. The changes undergone in single gemmules have frequently been followed through periods of several days. During this time the rays are retracted and a spheroidal form is assumed (fig. 3). The changes depicted should be considered representative only, as no two gemmules assume identical forms during their transformation.

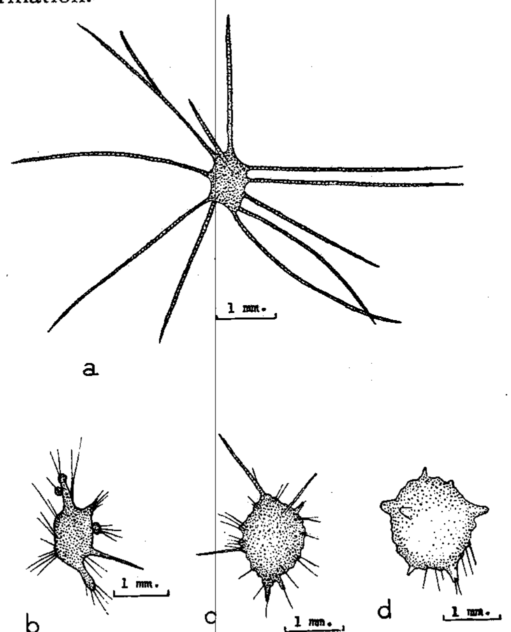

FIGURE 3.—Transformation of a gemmule into a young sponge: **a**, a gemmule after being released from the sponge; **b**, *a* after three days; **c**, *b* two days later; **d**, *c* after two more days.

When produced and released in large numbers the gemmules may come in contact with each other, the result being an aggregation which is rapidly converted into a functional sponge. Although a single gemmule may produce a young sponge, the clumping process hastens the formation. Approximately 50 free gemmules were spread out in a petrie dish of water and photographed (fig. 4, *a*). The group remained

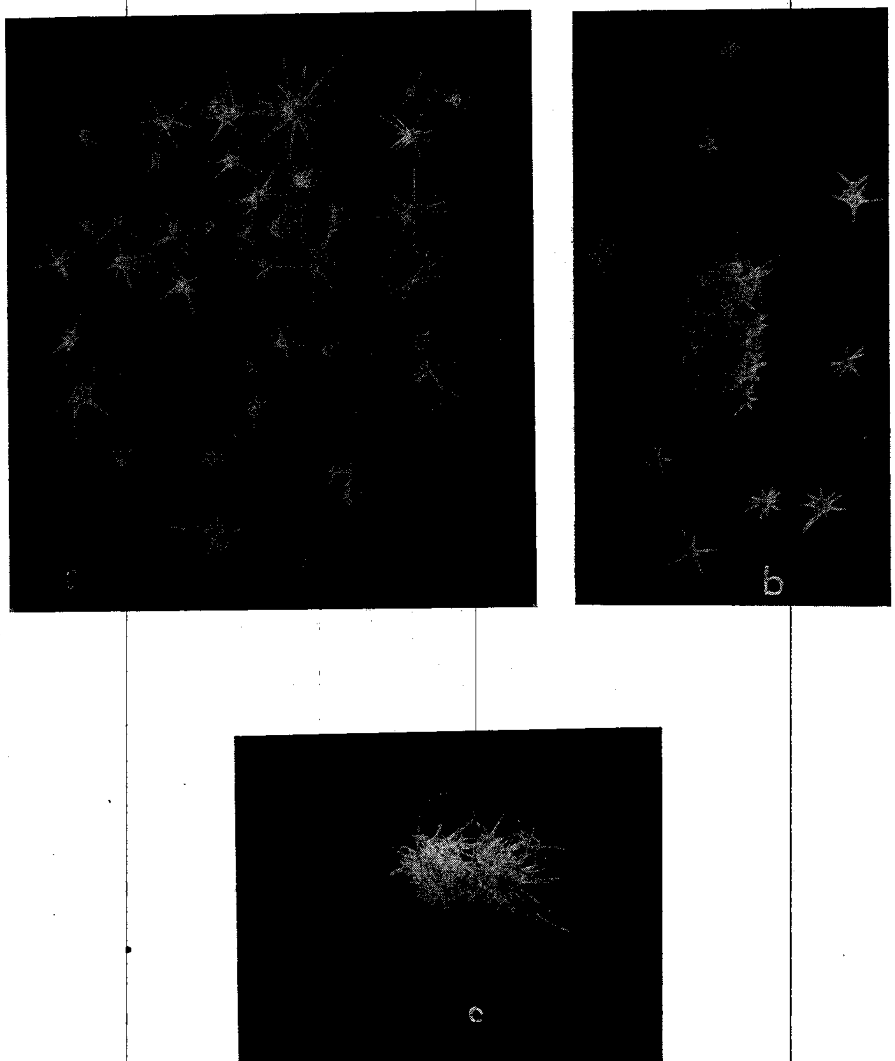

FIGURE 4.—Clumping of gemmules in forming a young sponge: **a**, a group of gemmules after being released from a sponge; **b**, *a* photographed after three days; **c**, *b* eight days later.

under the camera without agitation of the water and was photographed again two days later (fig. 4, *b*). After eight days more, the entire number had become aggregated into a single unit—potentially a young sponge (fig. 4, *c*). The flexibility of the rays of the gemmules, their capacity of extension, retraction and cohesion doubtless are factors in bringing the free buds together.

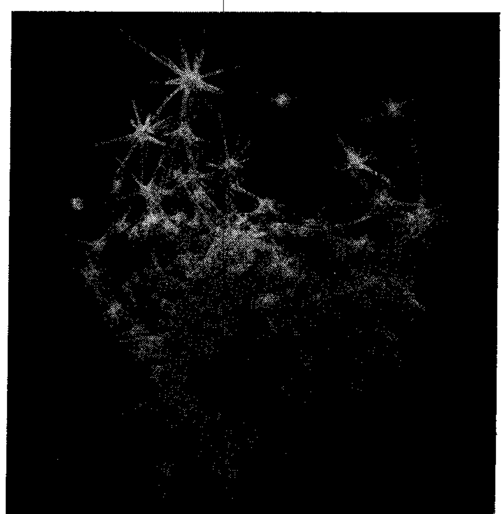

FIGURE 5.—Disintegrating tissue of a sponge rapidly producing gemmules.

In the ocean, movements of the water wash the gemmules away as they are set free, some chancing to fall in favorable situations, others settling under conditions which prevent their development. The species is plentiful in certain localities about the Hawaiian Islands and it is remarkably successful in the Honolulu Aquarium. Here under seminatural conditions the concrete walls of the tanks are at times well covered by young and old individuals. The currents of water in the tanks are sufficiently mild that many of the freed gemmules are not carried far away but make contact close to the parent sponge, a dense population resulting.

Rapid production of gemmules is occasionally brought about by unfavorable conditions. If the sea water in the laboratory surrounding the sponge becomes somewhat stagnant, portions of the tissue may disintegrate into masses of gemmules which quickly become free (fig. 5).

2. Filaments

In addition to gemmules, filaments of considerable length are often produced from the conical elevations of the surface of the sponge. They are flexible, extensile, and retractile and often fuse with each other. In length, they may exceed twice the diameter of the sponge which produces them. Both gemmules and filaments usually are developed from the sponge at the same time, but one kind of process frequently predominates over the other (fig. 6). They arise from the same source as the gemmules and are formed in the same manner and are composed of the same elements. Each filament is composed of a core of monaxon spicules surrounded by archaeocytes among which are myriads of chiasters. Filaments are simple or branched, acutely pointed or blunt at the end (fig. 7).

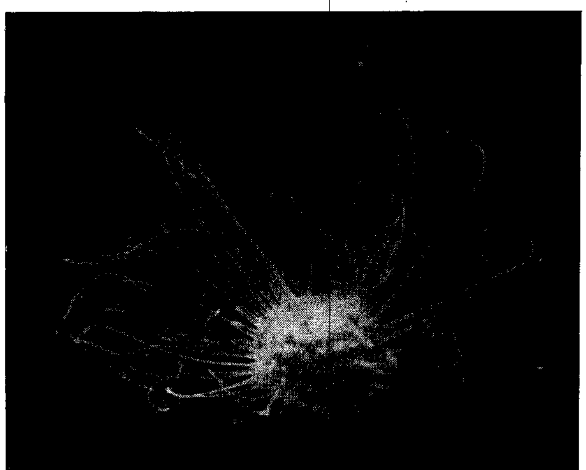

Figure 6.—Normal specimen producing many filaments and few gemmules.

Although the filamentous processes apparently have potential capacities for producing young sponges, if freed from the parent, I have not observed their natural separation at any time. They may be completely retracted into the sponge body but under normal conditions do not become released as do the gemmules. The artificial severance of filaments from the sponge, however, bears evidence of their reproductive possibilities. When cut off and kept under observation for a few days they are seen to sharply contract and take on the appearance and properties of young sponges. It may be assumed that the filamentous processes are sometimes released through accident; or, in a sponge disintegrating by reason of abnormal conditions, some might be separated while retaining their viability.

Repeated experiments indicate that a filament serves in the capacity of a gemmule and will develop into a young sponge. Usually about 48 hours are required for the transformation to take place (fig. 8, *a-c*). Clumping of severed filaments when placed in contact with each other

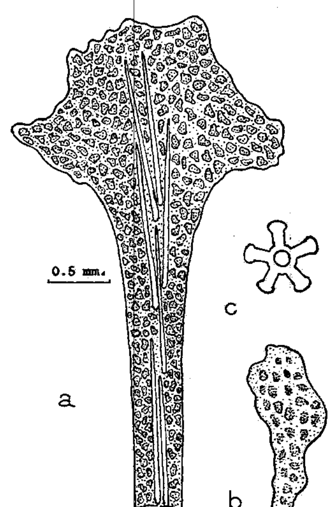

FIGURE 7.—Diagram of the tip end of a filament with its included elements: **a,** filament with core of monaxon spicules surrounded by masses of archaeocytes and chiasters; **b,** a granular archaeocyte; **c,** a chiaster, large numbers of which are scattered among the archaeocytes. (*b, c* greatly enlarged.)

hastens the building process by adding bulk to the sponge unit (fig. 8, *d-f*). Laboratory tests were also made to determine how close two severed filaments might be brought in parallel position and yet be transformed into separate sponges. When placed 10 mm. apart each filament developed into a sponge unit, and the same occurred when the filaments were separated by a distance of 5 mm. When the distance was reduced to 2 mm., however, a fusion resulted and a single unit was formed (fig. 8, *g-i*).

The asexual method of propagation in *D. deformis* by filamentous processes, while possible, probably seldom occurs in nature and is clearly secondary to that of gemmule formation.

SUMMARY

Observations are set forth on the transformation of naturally released gemmules and severed filaments of *Donatia deformis* into juvenile sponges.

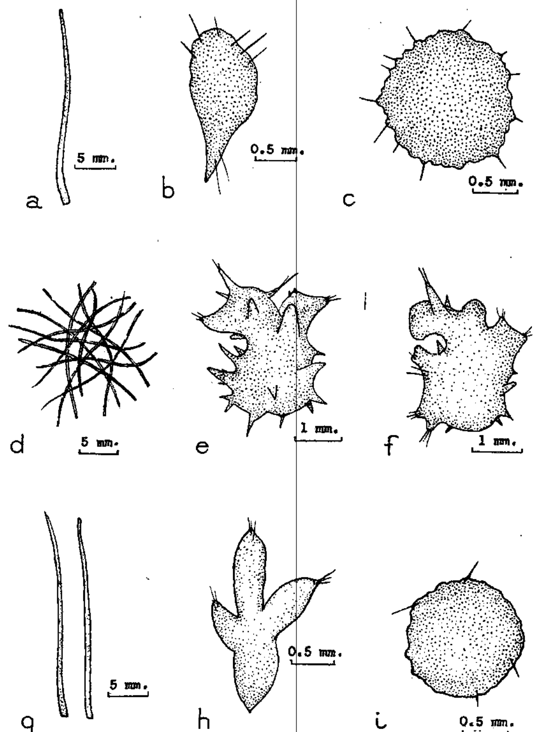

FIGURE 8.—Transformation of filaments into young sponges: **a,** severed filament; **b,** *a* after 24 hours; **c,** *b* 24 hours later; **d,** an aggregation of 12 severed filaments; **e,** *d* after 24 hours; **f,** *e* 24 hours later; **g,** severed filaments 2 mm. apart; **h,** *g* after 24 hours; **i,** *h* 48 hours later.

LITERATURE CITED

1. BURTON, MAURICE, A revision of the sponge family Donatiidae, Zool. Soc. London, Proc. 1924, 1033-1045.
2. Cambridge Natural History, Porifera 1(chapt. 9): 233-234, 1906.
3. DENDY, A., Report on the Homosclerophora and Astrotetraxonida collected by H. M. S. Sealark in the Indian Ocean, Linn. Soc. London, Trans. **17**: 225-271, 1916.
4. DENDY, A., The origin of sponge-spicules, Nature **115**: 190-191, 1925.
5. LAUBENFELS DE, M. W., Personal communication, Jan. 6, 1934.
6. MAAS, OTTO, Die Knospenentwicklung der Tethya und ihr vorleich mit der geschlechtlichen Fortplanzung der Schwamme, Zeit. für wiss. Zool. **70**: 263-288, 1901.
7. SOLLAS, I. B. J., On the sponges collected during the "Skeat Expedition" to the Malay Peninsula, 1899-1900, Zool. Soc. London, Proc. 1902 (2): 210-221.
8. THIELE, JOHANNES, Studien uber pazifische Spongien, Bibl. Zoologica **10** (24): 1-72, 1898.
9. WILSON, H. V., Siliceous and horny sponges collected by the U. S. Fisheries steamer "Albatross" during the Philippine Expedition, 1907-10, U. S. Nat. Mus., Bull. 100, 2(4): 273-532, 1925.