Ostracoda from the Late Permian of Greece (Thaumatocyprididae and Polycopidae)

I.G. SOHN
and
LOUIS S. KORNICKER

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ABSTRACT

Sohn, I.G., and Louis S. Kornicker. Ostracoda from the Late Permian of Greece (Thaumatocyprididae and Polycopidae). *Smithsonian Contributions to Paleobiology,* number 87, 34 pages, 20 figures, 2 tables, 1 map, 1998.—The ornamentation of the outer surface of the carapace of both living and fossil thaumatocyprids is compared and discussed. Seven new species of *Thaumatomma* Kornicker and Sohn, 1976, one species of *Thaumatomma* in open nomenclature, and a new species of *Polycope* from the Late Permian of the islands of Hydra and Salamis, Greece, are described and illustrated. A key to the species of *Thaumatomma* is presented.

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Contents

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Introduction

The original description of *Thaumatomma* Kornicker and Sohn (1976b:107) was based on one new species from the Late Permian of the island of Hydra, Greece. Seven new species and one species left in open nomenclature, from the Late Permian of the islands of Hydra and Salamis, Greece, are described and illustrated herein. A new species of *Polycope* from Hydra also is described and illustrated.

According to Erwin (1993:27), approximately 57 percent of all marine families disappeared at the close of the Permian. During the Permian, ostracodes were the only diverse arthropod group, but many families disappeared before the Permian-Triassic boundary (Erwin, 1993:105, 106). The Thaumatocyprididae Müller, 1906, escaped extinction, but *Thaumatomma,* the only known Permian genus, did not survive; however, it could be the ancestor of the Mesozoic genus *Pokornyopsis* Kozur, 1974. The Thaumatocyprididae (genus *Pokornyopsis*) appeared in the Triassic of Rumania, the Lower Triassic of Hungary, and the Upper Jurassic of Germany and Slovakia (Aubrecht and Kozur, 1995:3-7). Monostori (1995:155) reported *Thaumatocypris* sp. (= *Pokornyopsis* sp.) from the Lower Liassic of Hungary.

According to Aubrecht and Kozur (1995:8), "*Pokornyopsis* is clearly the ancestor of *Danielopolina* and there are extremely small changes within this stock since the Triassic." A similar phylogeny was previously proposed by Kornicker and Sohn (1976a, pl. 3). In that paper we proposed that the living genera *Thaumatoconcha* Kornicker and Sohn, 1976b, and *Thaumatocypris* Müller, 1906, had evolved from the Devonian genus *Checontonomous* Kesling, 1954, and that the living genus *Danielopolina* Kornicker and Sohn, 1976b, had evolved from *Pokornyopsis,* but all three living genera may have evolved from *Pokornyopsis.* Descendants of *Pokornyopsis* apparently survived in refugia, enabling them to repopulate present oceans.

The number of known genera of Thaumatocyprididae has increased from one in the Permian, one in the Triassic and Jurassic, to three in the Recent. Living members of the family have been collected mostly in the deep sea and in anchialine caves, whereas fossils are known from shallow-water deposits and in dikes and crevices (Aubrecht and Kozur, 1995:1). The known number of thaumatocyprid species is eight in the Permian, two in the Jurassic, and 20 in the Recent (Table 1). The explosion in the number of living species may be the result of this form having less competition in the deep sea and anchialine caves where it now lives. The survival of thaumatocyprids across the Permian-Triassic boundary may have been influenced by the broad environmental tolerances of the group. Similar wide environmental tolerances have been advanced as a cause for certain gastropods and other taxa to have survived the Permian-Triassic extinction (Erwin, 1993:100, 114).

Thaumatocyprids have not been reported from the Permian of other regions, which suggests that their presence in the Greek islands represents a restricted population, possibly a refugium, but their scarcity also could be the result of lack of preservation at available sites.

METHODS.—The field samples consisted of fairly well-rounded cobbles and boulders (blocks) containing silicified fossils (Grant, 1972:215). Ostracodes and other fossils were removed from some of the blocks by leaching with hydrochlo-

I.G Sohn, U.S. Geological Survey, Washington, D.C. 20244. Louis S. Kornicker, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

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TABLE 1.—Distribution of tubercles and nodes in the Thaumatocyprididae (+ = present; - = absent; J = Jurassic; P = Permian; R = Recent).

Taxa	Anteroventral tubercle	Anterodorsal node	Posterodorsal tubercle	Age	Reference
Thaumatoconcha					
T. pix				R	Kornicker (1992:234)
T. radiata				R	Kornicker and Sohn (1976b:26, 27)
T. punctata				R	Kornicker and Sohn (1976b:26, 27)
T. elongata				R	Kornicker and Sohn (1976b:26, 27)
T. caraionae				R	Kornicker and Sohn (1976b:26, 27)
T. polythrix				R	Kornicker and Sohn (1976b:26, 27)
T. sandersi				R	Kornicker and Sohn (1976b:26, 27)
T. hessleri				R	Kornicker and Sohn (1976b:26, 27)
T. porosa				R	Kornicker (1985:1013)
T. tuberculata			+	R	Kornicker and Sohn (1976b:26, 27)
Thaumatocypris					
T. echinata			+	R	Müller (1906:42)
Danielopolina					
D. orghidani			+	R	Danielopol (1972:1390)
D. carolineae			+	R	Kornicker and Sohn (1976b:26, 27)
D. wilkensi			+	R	Kornicker and Iliffe (1995:8, 16)
D. exuma			+	R	Kornicker and Iliffe (in press)
D. elizabethae			+	R	Kornicker and Iliffe (1992:12)
D. bahamensis				R	Kornicker and Iliffe (1989a:4, 15)
D. mexicana				R	Kornicker and Iliffe (1989a:4, 15)
D. styx				R	Kornicker and Iliffe (1989b:25)
D. phalanx				R	Kornicker and Iliffe (1995:8, 16)
Pokornyopsis					
P. bettenstaedti			+	J	Bartenstein (1949:95)
P. feifeli			+	J	Triebel (1941:376)
Thaumatomma					
T. granti, n. sp.	+	+	+	P	
T. piscifrons		+	+	P	Kornicker and Sohn (1976b:26, 27)
T. doescheri, n. sp.		+	+	P	
T. procax, n. sp.		+	+	P	
T. kozuri, n. sp.		+		P	
T. newelli, n. sp.		+		P	
T. permiana, n. sp.		+		P	
T. elongata, n. sp.		+		P	

ric acid. Because of time constraints, we did not study the ostracodes in all the residue from all the etched blocks.

Lengths of several carapaces were measured using an optical micrometer. Those measurements were compared with length measurements obtained from SEM micrographs of the same specimens using a millimeter ruler. Because both means of measuring produced almost identical results, carapace measurements given herein were obtained by the latter method.

DISPOSITION OF SPECIMENS.—The Permian specimens have been deposited in the Department of Paleobiology, National Museum of Natural History, Smithsonian Institution (under the acronym USNM for the former United States National Museum). Some specimens of *Polycope edithae* were lost after micrography; in lieu of the specimens, the micrographs have been given paratype status and have been assigned USNM catalog numbers.

SAMPLES.—The original locality data on the collection label for USNM locality 9260 are as follows: "USNM 9260 Idra Island (Hydra), Greece. Permian—about 0.25 km SW of village of Episkopi (SW side of island) on W. side of ravine below village, about 150 m elev. Collected 21 Aug 1968." Additional samples were collected in 1974, 1975, and 1977.

Specimens from USNM locality 9261 were not studied herein, but because *Thaumatomma picifrons* was reported there by Kornicker and Sohn (1976b:112), the locality data on the collection label are included here. "USNM 9261 Idhra Island (Hydra), Greece. Permian—about 0.25 km SW of village of Episkopi (SW side of island) on W. side of ravine below village, about 150 m elev., slightly lower and to N of loc. 9260 (dip makes this stratigraphically higher than 9260). Coll. R.E. Grant, Aug. 21, 1968."

The data on the collection label for USNM locality 9262 are as follows: "Idhra Island (Hydra), Greece. Permian—about 1 km nearly due E of the village of Episkopi (S side of island), down steep trail to about 25 m elev. near shrine called Aya Hohannis, relatively flat area where Permian beds make terraces. Coll. from 4 ft. bed. Coll. R.E. Grant, Aug 23, 1968." Samples considered herein were collected in 1968, but additional samples were collected in 1974, 1975, and 1977.

The ostracodes from Salamis studied herein were collected by Grant in 1968. The locality is not mentioned in his publications (Grant, 1972; Grant et al., 1991), but the collecting label for USNM locality 9264 reads, "Salamis Island, Greece, Bay of Kaki Vigla, right side (facing seaward) by resort and beach (same locality as by Nakazawa et al., 1975). Silicified brachiopods; fusulinids indicating Dzhulfian age. Collected 8/31/68." All samples from Salamis were collected in 1968.

ABBREVIATIONS.—The following abbreviations are used in legends and text.

av	anterior view	LV	left valve
dv	dorsal view	pv	posterior view
H	height	RV	right valve
iv	inside view	vv	ventral view
L	length	W	width
lv	lateral view		

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Biogeography and Stratigraphy

GEOGRAPHIC LOCATION AND PERMIAN STRATIGRAPHY OF HYDRA

Hydra is a small Greek island (area 52 sq. km (20 sq. miles), length 17.7 km (11 miles)) in the south Aegean Sea, 6.4 km (4 miles) off the east coast of Peloponnesus (Map 1). It contains exposed Permian strata that range in age from Asselian (Early Permian) to Dorashamian (Late Permian); the Late Permian Barmari Group is subdivided into the Episkopi Formation overlain by the Miras Formation (Grant et al., 1991:479). The top of the Episkopi Formation (Dorashamian) consists of silicified limestone that provided most of the ostracodes described (USNM localities 9260, 9262). Those localities are about 0.5 km south of the village of Episkopi. The precise level is given in Grant (1972:214, 215) and Grant et al. (1991:495, 496, fig. 7).

PALEOECOLOGY OF THE EPISKOPI FORMATION ON HYDRA

Grant et al. (1991) described the paleoecology of the Episkopi Formation in three separate paragraphs, and because they differ slightly, they are quoted below.

> The rich fauna, abundant in taxa and in individuals, points to a favorable environment in shallow sunny waters at a considerable distance from contaminating sediment or turbulent waves. (Grant et al., 1991:489.)

> These taxa [certain brachiopods] suggest that the depositional environment of the Episkopi Formation represented a refugium of sorts, where marine conditions favorable to Paleozoic brachiopods remained longer than in most other places. (Grant et al., 1991:491.)

> Because of the silicification present in some strata, the Episkopi Formation contains an excellent record of Late Permian life in the western Tethys. Although it contains no reefs, it is dark and abundantly algal throughout the thick section that seems to occupy a relatively brief period of Permian time, suggesting that the environment of deposition could have been behind protecting algal reefs that provided a calm, low energy environment. (Grant et al., 1991:493.)

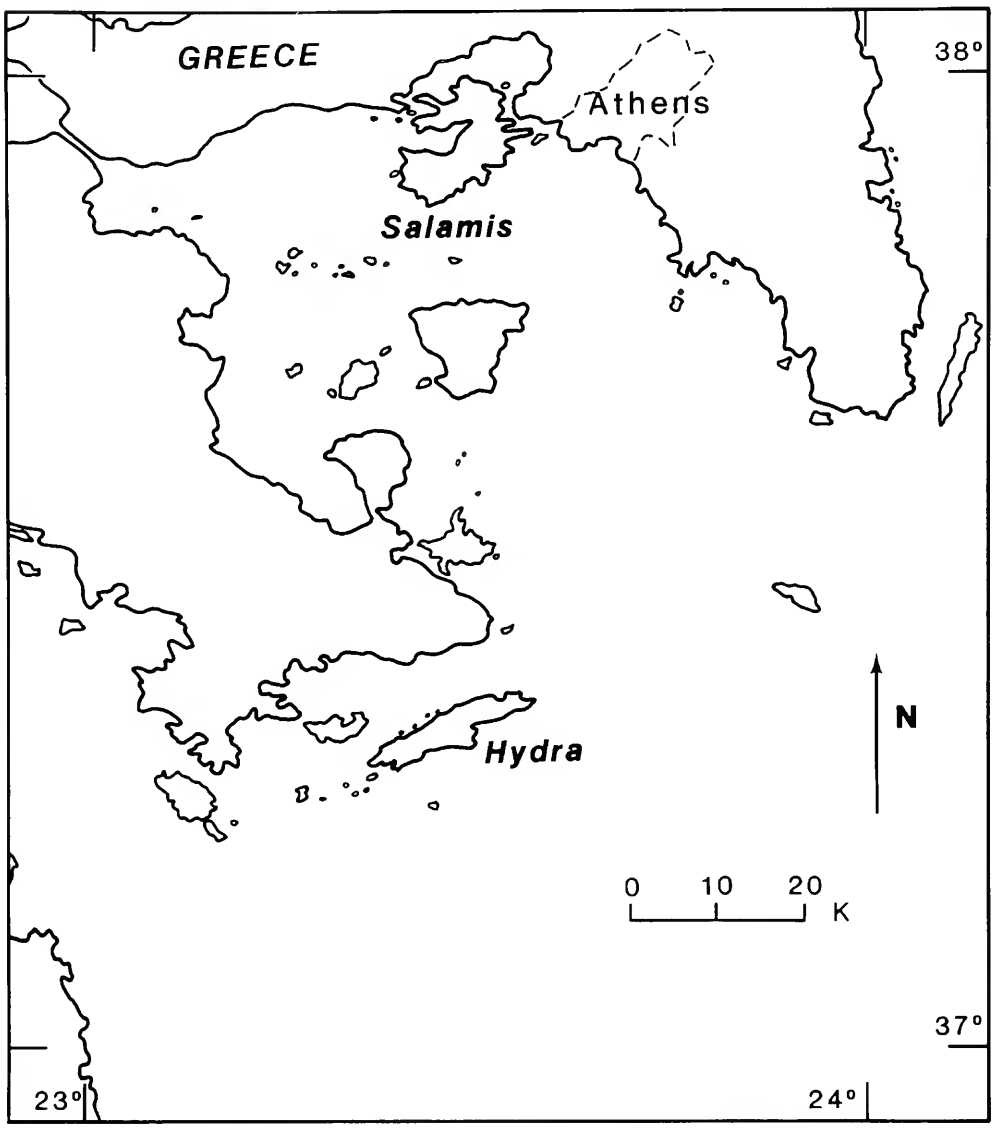
The information above was summarized in Grant (1993:59):

> The Episkopi Limestone of Hydra is a dark algal limestone, undoubtedly deposited in shallow water with fairly good penetration of light. (Grant et al., 1991.)

Kornicker and Iliffe (in press) suggested that the presence in the Episkopi Formation of thaumatocyprid ostracodes reported by Kornicker and Sohn (1976a, 1976b) might indicate that a refugium, such as that suggested by Grant et al. (1991:491), above, was an environment in which thaumatocyprids became preadapted for life in anchialine caves, such as those suggested for Jurassic thaumatocyprids by Aubrecht and Kozur (1995:1).

GEOGRAPHIC LOCATION AND PERMIAN STRATIGRAPHY OF SALAMIS

Salamis is a small Greek island (area 96 sq. km (37 sq. miles)) in the Saronic Gulf near Athens (Map 1). Nakazawa et al. (1975:23) collected fossils in 1972, "from south coast of Kaki Vigla Bay situated in the southeastern part of the island." According to Nakazawa et al. (1975:21), "The foraminiferal assemblage indicates the latest Permian Changhsingian [Changxingian] age" which is generally considered to be equivalent to the late Dzhulfian (Dorashamian), whereas the general characters of the brachiopods and corals suggest the early Dzhulfian age (Araksian). The discrepancy of the age suggests some overlapping between the Changhsingian and the early Dzhulfian."



MAP 1.—Location of the islands of Hydra and Salamis, Greece.

PALEOECOLOGY OF THE PERMIAN STRATA ON SALAMIS

According to Nakazawa et al. (1975:23, 24), "The Paleozoic fossils (foraminifers, brachiopods, corals, bryozoa and algae) were obtained from black, 10–20 cm bedded limestone alternating with black, sandy shale with a bioturbated texture."

Morphological Characteristics

PROTUBERANCES, NODES, AND TUBERCLES IN THE THAUMATOCYPRIDIDAE.—Kornicker and Sohn (1976b) used the following terminology: protuberances are at the upper and lower ends of the straight or slightly curved anteroventral margin of each valve; a node (?eye spot) is in the anterodorsal part of each valve; tubercles are either in the anteroventral or posterodorsal parts of each valve, or in both. All the processes are hollow.

Protuberances: All known thaumatocyprids have an upper and a lower protuberance. Except for *Thaumatocypris echinata* Müller, 1906, which has long slender protuberances (probably an adaptation to its planktonic lifestyle), the protuberances are short and stout. On living cave species of *Danielopolina,* the protuberances bear fragile frills that easily break off when the specimen is disturbed. Because there is no indication of frills on fossil specimens, it is not known whether frills were present on the fossils. Frills have not been reported on *Danielopolina carolynae* Kornicker and Sohn, 1976b, and on species of *Thaumatoconcha,* probably because they never were present. The lower protuberance is either larger than, or the same size as, the upper protuberance.

The upper protuberance is located very close to the contact margin, whereas the lower protuberance is farther removed from the contact margin. The lower protuberance is much longer than the upper protuberance in *T. elongata* and *T. doescheri.* On *T. doescheri* the lower protuberance bears spines.

The male *Thaumatocypris echinata* is the only known male in the Thaumatocyprididae without a sclerotized process on the endopodite of the 2nd antenna (Kornicker and Iliffe, in press). The sclerotized process probably functions as a clasper during coupling. Possibly, the long anteroventral protuberances of *T. echinata* does not allow for a normal coupling, and for this reason the endopodite of the male 2nd antenna has lost its ability to function as a clasper.

Node (?eye spot): Species of the genus *Thaumatomma,* which is known only from the Permian (eight species), have an oval node (?eye spot) on each valve. This node is absent on known Jurassic and Recent thaumatocyprid genera (Table 1). The node does not have ridges or reticulations normally present on the carapace. The node is in the correct location for an eye spot, but it seems unlikely that *Thaumatomma* had an eye because none is known in living halocyprids. Some species of *Danielopolina* have a Bellonci organ (Kornicker and Iliffe, 1992:16), and some species of the halocyprid genus *Bathyconchoecia* have dark pigment spots in the head region proximal to the base of the 1st antenna (Kornicker and Angel, 1975, fig. 5). The node, if translucent, could expose the Bellonci organ or black pigment spots to light; however, there is no evidence that either are light sensitive.

The bubble-like node (?eye spot) has a narrow trench around its periphery, and the node is indicated by a hole in many specimens in which the protuberances and tubercles on the carapace are intact. This suggests that the nodes are more fragile than the protuberances and tubercles, but whether this indicates that the node is capable of light transmission is unknown.

We associate the node herein with the term "?eye spot," more to emphasize its location than its function. If it were to be concluded that the node, because of its location, did function as an eye spot, it would follow that species of *Thaumatomma* were light sensitive.

The anterodorsal node (?eye spot) present only on *Thaumatomma* could be interpreted to be an apomorphic character state if *Pokornyopsis* and *Thaumatomma* have a common ancestor without that node, or the node could be interpreted to be a plesiomorphic character state should *Thaumatomma* be a direct ancestor of *Pokornyopsis.*

Tubercles: An anteroventral tubercle is known only on the Permian species *Thaumatomma granti.* We interpret the tubercle to be an automorphy (not useful in phylogenetic classification).

Many Permian, Jurassic, and Recent thaumatocyprid species have a posterodorsal tubercle (Table 1). The tubercle is present on four of the eight Permian species of *Thaumatomma* and on both Jurassic species of *Pokornyopsis.* A tubercle is present on the only living species of *Thaumatocypris,* on five of nine living species of *Danielopolina,* and on one of 10 living species of *Thaumatoconcha.* Baltánas and Danielopol (1995:315), in a cladistic analysis of living thaumatocyprids, interpreted the posterodorsal tubercle to be homoplasies (analogy; correspondence of structure acquired independently and not the result of common ancestry (Pennak, 1964:244)), an interpretation that we accept.

The posterodorsal tubercle varies in location and size. Except for *Thaumatocypris echinata,* which bears a tubercle only on the right valve, tubercles are present on both valves. In most species the tubercle is located in the same area on both valves; however, in *Thaumatoconcha tuberculata* Kornicker and Sohn, 1976b, the tubercle on the left valve is located anterior to the one on the right valve, and in *Danelopolina carolynae* Kornicker and Sohn, 1976b, the tubercle on the right valve is located anterior to the one on the left valve. The tubercle is farther from the contact margin in both *Thaumatomma procax* and *T. granti* than it is on other species of the genus. Some specimens of *Danielopolina bahamensis* Kornicker and Iliffe, 1989a, have a fragile serrate posterodorsal frill that we equate with a posterodorsal tubercle, but the frill may be an additional type of process unrelated to the posterodorsal tubercle of most other species. The posterodorsal tubercle of *D. wilkensi* Hartmann, 1985, also bears fragile frills. Baltanás and Danielopol (1995, table 2) interpreted both *D. bahamensis* and *D. wilkensi* to be without a posterodorsal process; however, this does not affect their cladogram.

ORNAMENTATION OF THE THAUMATOCYPRIDIDAE.—Kornicker and Iliffe (1995, table 1) divided the ornamentation of thaumatocyprids into six types listed below. Based on new species of *Thaumatomma* described herein, two additional types may be added to those categories, and they are listed as types 7 and 8 below.

Type 1, Reticulate with walls of reticulations continuous: Both species of the Jurassic *Pokornyopsis* and *Thaumatomma piscifrons* Kornicker and Sohn (1976b) were listed as having this type of ornamentation (Kornicker and Iliffe, 1995, table 1). New species of *Thaumatomma* that have this type ornamentation are *T. granti, T. newelli, T. permiana, T. kozuri, T. procax,* and a taxon left in open nomenclature as *T.* aff. *T. procax.*

Types 2 and 3, Reticulate with walls of reticulations either discontinuous or formed by papillae, respectively: Six species of *Danielopolina* were placed in these categories (Kornicker and Iliffe, 1995, table 1).

Type 4, Nonreticulate, spinous: Danielopolina mexicana Kornicker and Iliffe, 1989a, and *Thaumatocypris echinata* were placed in this category (Kornicker and Iliffe, 1995, table 1).

Type 5, Nonreticulate, smooth: Danielopolina phalanx Kornicker and Iliffe, 1995, and eight named species of *Thaumatoconcha* were referred to this category (Kornicker and Iliffe, 1995, table 1).

Type 6, Nonreticulate, punctate: Two species of *Thaumatoconcha* were referred to this category (Kornicker and Iliffe, 1995, table 1).

Type 7, Long ridges but not reticulate: Thaumatomma elongata and *T. kozuri* have this type ornamentation.

Type 8, Reticulate with spines: Thaumatomma doescheri is the only species in this category.

Kornicker and Iliffe (1995:5) hypothesized an "evolutionary" sequence based on ornamentation. This hypothesis is revised because of the two additional types of ornamentation in the new species of *Thaumatomma* described herein. The revised evolutionary sequence is as follows: (1) long continuous ridges (without reticulations); (2) reticulate with walls of continuous ridges; (3a) reticulate with walls of continuous ridges and spines at intersections; (3b) reticulate with walls of discontinuous ridges; (4) reticulate with papillate walls; (5) nonreticulate spinous; (6) nonreticulate smooth (some with reticulations along anteroventral margin); and (7) nonreticulate punctate. *Thaumatomma* has Types 1, 2, and 3a; *Pokornyopsis* has Type 2; *Thaumatoconcha* has Types 4 and 6; *Thaumatocypris* has Type 5; and *Danielopolina* has Types 3b to 6.

RIDGES, RETICULATIONS, AND SPINES ON THE CARAPACES OF *Thaumatomma*.—The carapaces of *Thaumatomma* bear ornamentation of three types: (A) nonreticulate ridges; (B) reticulations formed by short, weak cross-ridges connecting long ridges; and (C) reticulations with spines. No well-preserved specimens have smooth outer surfaces, but many eroded valves are smooth. Also, the weak cross-ridges forming reticulations are less evident on eroded specimens.

The orientation of the long ridges divides the species into two groups: *T. kozuri* and *T. doescheri,* with vertical ridges, and *T. piscifrons, T. granti, T. permiana, T. newelli, T. procax, T.* aff. *T. procax,* and *T. elongata,* with horizontal ridges.

Type A, Nonreticulate ridges: Nonreticulate ridges are present on *T. elongata* and *T. kozuri.* Viewed laterally, the ridges of *T. elongata* are straight, subparallel to the dorsal margin (Figure 13*a*). Viewed laterally, the ridges of *T. kozuri* form arcs; the chords connecting the dorsal and ventral ends of the arc are vertical. In the area posterior to the central adductor-muscle scar, the dorsal and ventral branches of the ridges become approximately horizontal at valve midheight. In anterior view, the ridges of *T. kozuri* form arcs subparallel to the outline of the outer margin of valves (Figure 3*c*). In dorsal view, each ridge of *T. kozuri* forms about a 45° angle with the dorsal contact margin (Figure 3*e*). In posterior view, the ridges of *T. kozuri* are perpendicular to the valve contact margin (Figure 3*d*). Both species are without tubercles.

Type B, Reticulate without spines: Five species of *Thaumatomma* are reticulate without spines: *T. granti, T. piscifrons, T. procax, T. newelli,* and *T. permiana.* The short cross-ridges are perpendicular to the long ridges and are in a similar location on adjacent ridges. The reticulations form squares, oblongs, and a few are irregular. The cross-ridges are well developed on *T. piscifrons,* so the orientation of the long ridges is difficult to interpret and describe (Figure 15*j*), but they appear somewhat similar to those of *T. kozuri.* In dorsal view, *T. piscifrons,* unlike *T. kozuri,* has three or four ridges parallel to the dorsal contact margin (Figure 15*g*). In lateral view, *T. granti* have slightly S-shaped ridges extending from the anterior to the posterior edge of the valve (Figure 1*a*). In dorsal view, *T. granti* bears four or five ridges with weak cross-ridges that are subparallel to the dorsal contact margin. In anterior view, the ridges of *T. granti* form a 45° angle near midheight (Figure 1*g*). The ridges are U-shaped in the immediate vicinity of the posterodorsal tubercle, with the U open to the anterior (Figure 1*a–c*). The ridges of *T. newelli* are somewhat similar to those of *T. granti* except that about seven concentric ridges are located around the periphery of each valve. A posterodorsal tubercle is absent on *T. newelli,* and the ridges are not U-shaped in the area where a posterodorsal tubercle is present in some other species (e.g., *T. granti*). The ridges are not as strongly developed on *T. newelli* as they are on other species of *Thaumatomma.* In lateral view, the ridges of *T. permiana* are similar to those of *T. granti* except for not being U-shaped in the vicinity of the posterodorsal tubercle of *T. granti. Thaumatomma permiana* is without a posterodorsal tubercle. *Thaumatomma permiana* differs from other species of *Thaumatomma* in having three broad nonreticulate ridges along the dorsal and posterodorsal margins of each valve (Figure 7*c,e*). In lateral view, the long ridges of *T. procax* are similar to those of *T. granti* (Figure 16*a*). The long ridges of *Thaumatomma* aff. *T. procax* are similar to those of *T. procax,* except that they are V-shaped rather that U-shaped in the vicinity of the posterodorsal tubercle.

Type C, Reticulate with spines: The intersections of the reticulations of *T. doescheri* bear small spines (Figure 6*c*). These spines are less developed on the holotype of *T. doescheri* (Figure 4*d,e*). The long ridges of *T. doescheri* are, in general, similar to those of *T. kozuri,* except for having U-shaped ridges surrounding the posterodorsal tubercle that are open to the posterior. *Thaumatomma kozuri* is without a posterodorsal tubercle, and the U-shaped ridges posterior to the muscle scar are located around midheight of the valve.

CONTACT MARGIN AND HINGE IN *Thaumatomma*.—Examination of the micrographs of the outsides of one complete specimen of *T. kozuri* (Figure 3) and four complete specimens of *T. permiana* (Figures 7*a–e,i–l,* 8*a–g*) in the collection reveals that the left and right valves are similar in size and do not overlap along margins. The well-preserved carapace of *T. permiana* (Figure 8*d*) is completely closed and, thus, would not have permitted either projection of appendages or passage of sea water when the specimen was living. The single complete carapace of *T. kozuri* is slightly open along the anterior and ventral margins (Figure 3*d,e*). Some gaps between the free margins of valves of complete carapaces are probably the result of damage to the edges of the valves (Figure 7*d,e,l*).

Except for the inner side of a left valve of a single specimen of *T. piscifrons,* which may have an inner short ridge at both the

TABLE 2.—Distribution of complete carapaces and separated right (RV) and left valves (LV) of species of *Thaumatomma*.

Species	Complete carapace	RV	LV
T. granti, n. sp.	0	7	3
T. kozuri, n. sp.	1	0	0
T. doescheri, n. sp.	0	2	0
T. permiana, n. sp.	4	5	2
T. newelli, n. sp.	0	7	5
T. elongata, n. sp.	0	3	2
*T. piscifrons**	0	13	9
T. procax, n. sp.	0	3	4
T. aff. *T. procax*	0	1	0
T. sp. indent.	0	19	6
Total	5	60	31

*Includes specimens reported in Kornicker and Sohn (1976b:107).

anterior and posterior ends of the dorsal margin (Figure 15*d,e*), ridges were not observed on the inner side of separated valves.

It is of interest that *T. permiana* is the only species among those examined with many complete carapaces (Table 2). This suggests that *T. permiana* may be different from other species (possibly excluding *T. kozuri*, which is known from only one complete carapace). The degree of disarticulation of carapaces could be affected by both external and internal conditions. External conditions would include those relating to the amount of movement and rapidity of burial of the complete animal after its death. Internal conditions would include both shell and soft-part properties of the ostracode that might affect ease of disarticulation after its death. Although the specific reason for *T. permiana* having many complete carapaces is unknown, the fact of its being different is of interest.

The separated valves in samples are predominantly right valves (ratio of the right to left valves 60 : 31) (Table 2), but we draw no conclusions from this. Breman (1980:135) was unable to establish selective transport by currents as a reason for significant differences in the total number of left and right valves of 11 species of Recent ostracodes in the Adriatic Sea.

Superorder MYODOCOPA Sars, 1866

Order HALOCYPRIDA Dana, 1853

Suborder HALOCYPRIDINA Dana, 1853

Superfamily THAUMATOCYPRIDACEA Müller, 1906

Family THAUMATOCYPRIDIDAE Müller, 1906

The superfamily Thaumatocypridacea and family Thaumatocyprididae were reviewed by Kornicker and Sohn (1976b:24). Until 1974 the family contained only the genus *Thaumatocypris*, with four species: *T. echinata* Müller, 1906 (living); *T. feifeli* Triebel, 1941 (Jurassic); *T. bettenstaedti* Bartenstein, 1949 (Jurassic); and *T. orghidani* Danielopol, 1972 (living). Kozur (1974:853) referred the fossil species *T. feifeli* and *T. bettenstaedti* to his new genus *Pokornyopsis* and retained *Thaumatocypris* for the living *T. echinata*. The living *T. orghidani* remained in *Thaumatocypris* because that species was not mentioned in Kozur (1974). Kornicker and Sohn (1976b:24) referred *T. orghidani* to the genus *Danielopolina* and retained the genus *Thaumatocypris* for the living *T. echinata;* the genus *Pokornyopsis* was retained for the two Jurassic species. Two additional genera in the Thaumatocyprididae were proposed by Kornicker and Sohn (1976b:35, 107): *Thaumatomma* (Permian) and *Thaumatoconcha* (living).

Aubrecht and Kozur (1995:8) stated that *Danielopolina* is surely the successor of *Pokornyopsis* and probably is even a junior synonym of that genus because it is based only on differences in strength of the reticulations, which is not a strong reason for their separation.

Is *Danielopolina* a junior synonym of *Pokornyopsis?* In an earlier paper (Kornicker and Sohn, 1976a:57), which had been in press since 1974 when Kozur (1974:853) referred the Jurassic thaumatocyprids to his new genus *Pokornyopsis,* we referred both *Thaumatocypris orghidani* and the two Jurassic species of *Pokornyopsis* to the genus *Danielopolina* (nomen nudum). This was the same relationship as that proposed by Aubrecht and Kozur (1995:8), except they included both *Danielopolina* and *Pokornyopsis* in *Pokornyopsis*.

Are there reasons for the present authors to retain *Danielopolina* for the nine living species and to retain *Pokornyopsis* for the two Jurassic species? Baltanás and Danielopol (1995:320) supported the use of the strong sculpture and ornamentation of *Pokornyopsis* to define the genus as proposed in Kornicker and Sohn (1976b:36), and we think it useful to maintain *Danielopolina* for the living species and *Pokornyopsis* for the Jurassic species, and possibly also for the Triassic species. The diversity of appendage morphology among known living species of *Danielopolina* suggests that *Danielopolina* might be divided into several genera. Whether *Danielopolina* is a synonym of *Pokornyopsis* remains unresolved, as was ascribed by Aubrecht and Kozur (1995:8).

Neale (1983:619) stated, "One would be inclined to re-assign *Polycope luxuriosa* from the Lower Maastrichtian of Rügen (Herrig, 1964) to the Thaumatocyprididae (?*Porkornyopsis*) on the grounds of general valve morphology." Neale (1983, fig. 5) oriented the specimen illustrated by Herrig (1964, fig. 4) with two long marginal spines anterior, whereas Herrig had the two long spines posterior. The posterodorsal straight hinge of Herrig's specimen, as suggested by Aubrecht and Kozur (1995:8), remains subjective and indicates that Herrig's (1964, fig. 4b) orientation is correct; therefore, we do not believe the species to be a thaumatocyprid.

Thaumatomma Kornicker and Sohn, 1976

TYPE SPECIES.—*Thaumatomma piscifrons* Kornicker and Sohn, 1976b:107.

DISCUSSION.—*Thaumatomma* is the oldest described thaumatocyprid. The diversity of species in *Thaumatomma* during the Late Permian of Greece suggested to Kornicker and Sohn (1976b:107) that the genus may have evolved during the Carboniferous or even earlier, but there is no evidence for this, and rapid speciation during the Permian is possible.

Key to the Species of *Thaumatomma*

1. Each valve with posterodorsal tubercle 2
   Each valve without posterodorsal tubercle 5
2. Each valve with anteroventral tubercle . . . . . ***T. granti,*** new species
   Each valve without anteroventral tubercle 3
3. Posterodorsal tubercle close to dorsal valve margin; ridges just ventral to posterodorsal tubercle not well developed or slightly concave ventrally . . . . . ***T. piscifrons***
   Posterodorsal tubercle about 1/4 valve height from dorsal margin; ridges just ventral to posterodorsal tubercle concave dorsally 4
4. Vertical ridges present posterior to valve midlength; concentric ridges encircle posterodorsal tubercle . . . . . ***T. doescheri,*** new species
   Oblique ridges present posterior to valve midlength; ridges curve around valve just posterior to posterodorsal tubercle, but not anterior to it . . . . . ***T. procax,*** new species
5. Ridges posterior to anterodorsal node concave posteriorly . . . . . ***T. kozuri,*** new species
   Ridges in dorsal half of valve posterior to anterodorsal node horizontal or oblique 6
6. Carapace tending to be elongate; ridges straight, sloping downward posteriorly . . . . . ***T. elongata,*** new species
   Carapace generally oval; most ridges concave dorsally 7
7. Ridges generally subdued; about 4 parallel ridges clearly visible in lateral view near dorsal margin of valve . . . . . ***T. newelli,*** new species
   Ridges generally well developed; 4 parallel ridges not clearly visible in lateral view near dorsal margin of valve . . . . . ***T. permiana,*** new species

Thaumatomma granti, new species

FIGURES 1, 2

ETYMOLOGY.—Named in honor of the collector, the late Richard E. Grant, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution.

HOLOTYPE.—USNM 488627, RV.

TYPE LOCALITY.—USNM locality 9260: Greece 2, 4 Jul 1974: uppermost brachiopod zone in Episkopi Section B, Episkopi Formation, Barmari Group, Late Permian (Dorashamian), Hydra, Greece (Grant et al., 1991:482, 495).

PARATYPES.—USNM locality 9260: Hydra, Greece 2, 4 Jul 1974: USNM 488626, LV; USNM 488628, RV; USNM 488629, LV; USNM 488630, RV. USNM locality 9262: Hydra, Greece 1, 23 Aug 1968: USNM 488631, RV; USNM 488634, RV; USNM 488635, LV. USNM locality 9264: Salamis, Greece 1, 31 Aug 1968: USNM 488632, RV; USNM 488633, RV.

DIAGNOSIS.—*Thaumatomma* with convex dorsal margin; straight anteroventral margin located at approximate midheight and trending sharply downward and backward, terminating in upper and lower protuberances equal or subequal in size; anterodorsal node (?eye spot) located slightly above and behind upper protuberance; anteroventral and posterodorsal tubercles present on each valve; surface with reticulations formed by ridges and weaker cross-ridges; orientation of ridges of anterior half varies from being horizontal to angular; ridges of posterior half of valve surface slightly concave with posterior ends joining contact margin tangentially.

DESCRIPTION.—Valves subovate, dorsal margin convex; anterodorsal margin broadly rounded, extends from approximate anterior quarter of greatest length to approximate midheight where it merges with the upper anteroventral protuberance; straight anteroventral margin trends downward and backward, length of anteroventral margin about 1/3 the greatest height, makes a distinct angle with lower anteroventral protuberance; ventral margin convex, anterior portion trends downward and backward subparallel to straight anteroventral margin to a point approximately below the junction of the dorsal and anterodorsal margins, then curves gently upward to

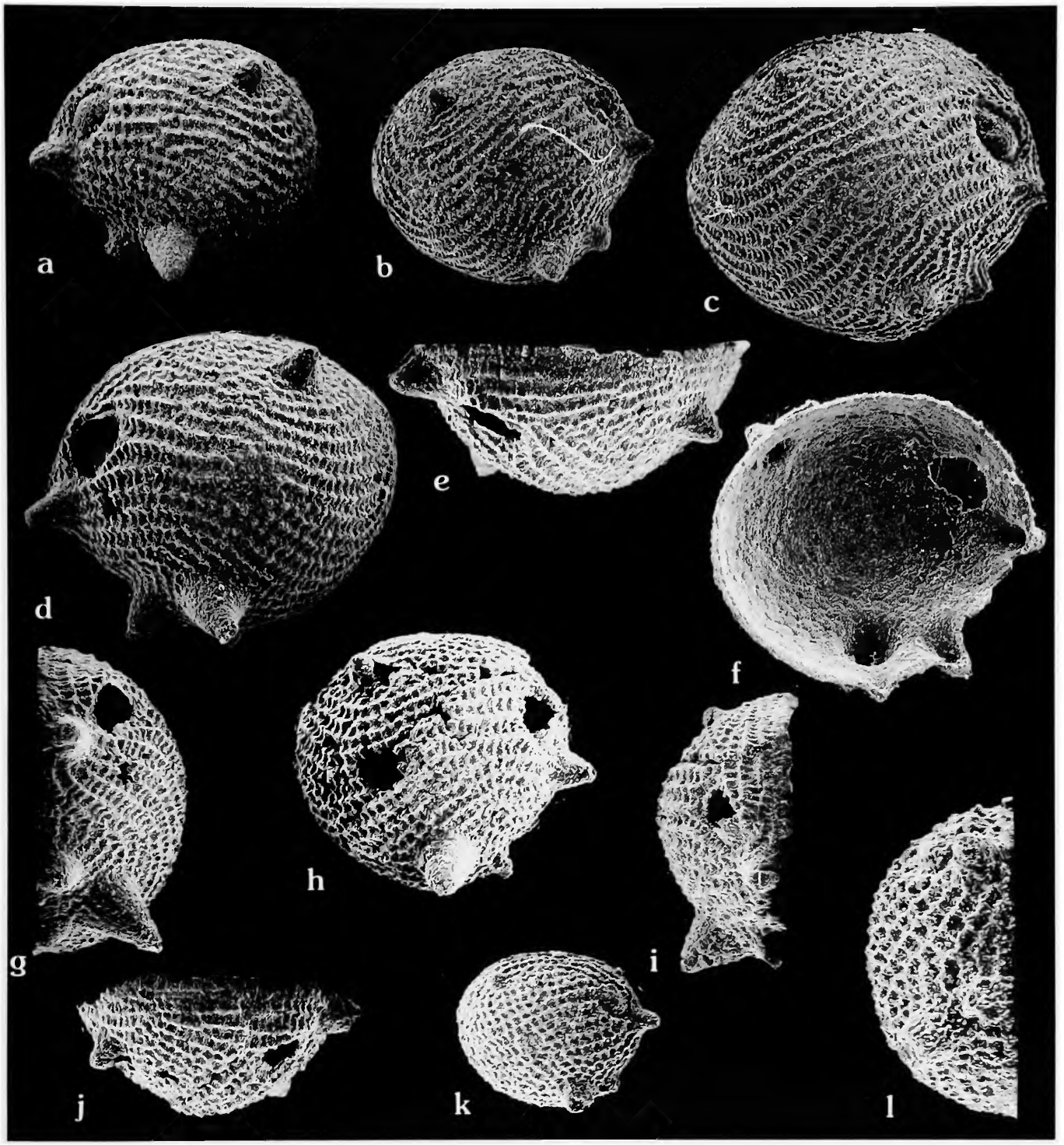


FIGURE 1.—*Thaumatomma granti,* new species: *a,* paratype, USNM 488626, LV, length 0.66 mm, lv (×100). *b,* holotype, USNM 488627, RV, length 0.97 mm, lv (×68). Paratypes: *c,* USNM 488628, RV, length 1.28 mm, lv (×68). *d–g,* USNM 488629, LV, length 0.87 mm, lv, dv, iv, and av, respectively (×100). *h–j,* USNM 488630, RV, length 0.68 mm, lv, av, and dv, respectively (×100). USNM 488631, RV, length 0.46 mm: *k,* lv (×100); *l,* av (×200). (Micrographs reduced to 71%.)

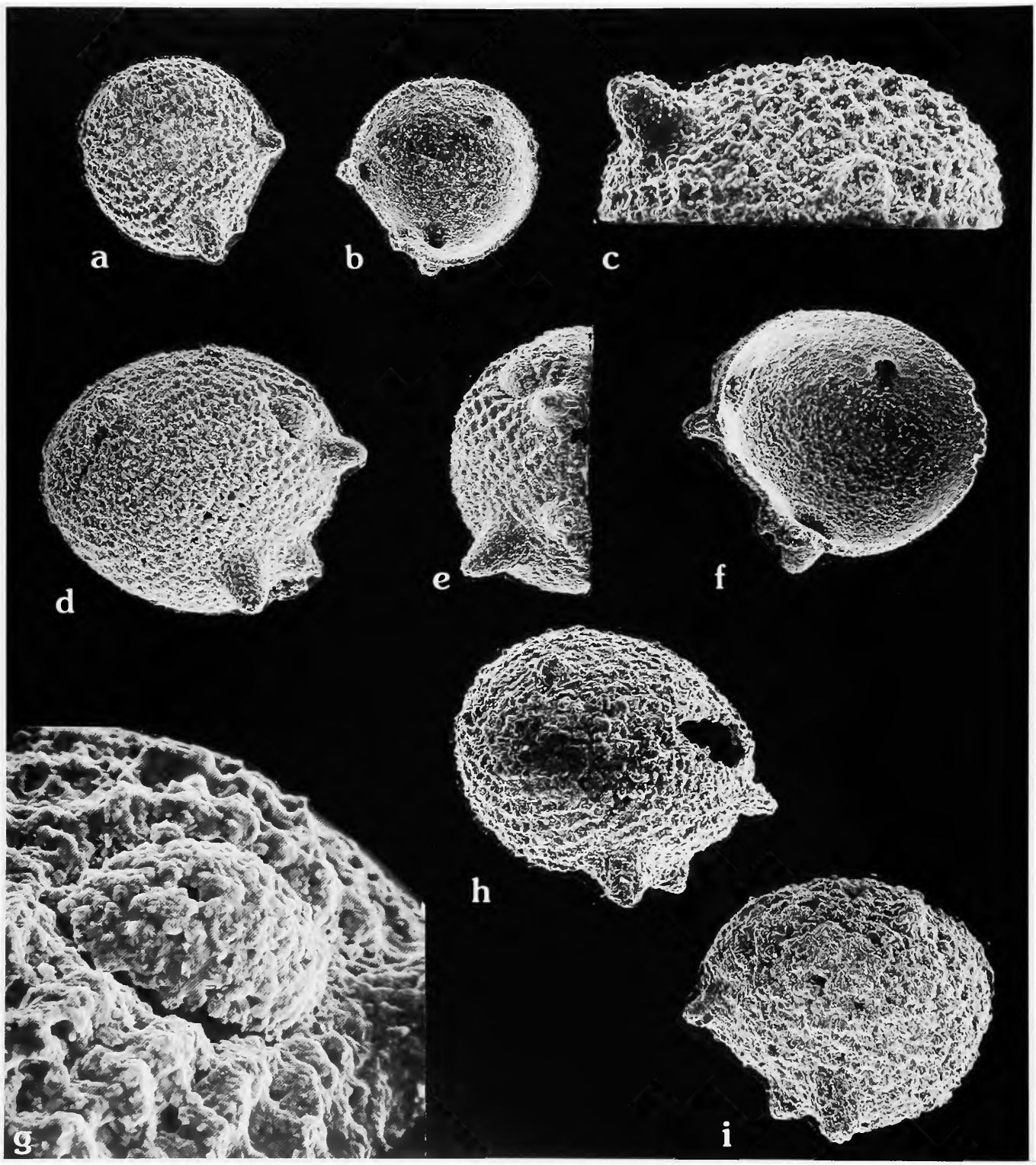


FIGURE 2.—*Thaumatomma granti*, new species, paratypes: USNM 488632, RV, length 0.42 mm: *a*, lv (×100); *b*, iv (×100); *c*, av (venter to left) (×200). USNM 488633, RV, length 0.68 mm: *d*, lv (×100); *e*, av (×100); *f*, iv (×100); *g*, detail from *d* of anterodorsal node, lv (×200). *h*, USNM 488634, RV, length 0.67 mm, lv (×100). *i*, USNM 488635, LV, length 0.65 mm, lv (×100). (Micrographs reduced to 79%.)

a point opposite lower anteroventral protuberance where it merges with the convex posterior margin; posterior margin rounded, merges with dorsal margin in vicinity of dorsoposterior tubercle; dorsal outline elliptical, greatest width subcentral; end outline subovate; greatest width central or subcentral.

Ornamentation: Surface with long, continuous, slightly S-shaped ridges extending from anterior to posterior margins; weaker short perpendicular ridges form reticules; three or four ridges subparallel to anterior and anteroventral margins extend from upper anteroventral protuberance to point just posterior to lower anteroventral protuberance; two or three ridges parallel to anterodorsal and dorsal margins of valve; parallel linear ridges of anterior half vary in orientation from subhorizontal (Figure 1*d*) to 45° to vertical (Figures 1*c*, 2*a*). These ridges continue to posterior half as concave ridges (Figures 1*a–d*, 2*a*); posterior ends of the ridges ventral to posterodorsal tubercle join posterior margin tangentially (Figures 1*a–d*, 2*a,h*). Some eroded specimens without ridges (Figure 2*h,i*). Upper and lower anteroventral protuberances located close to contact margin and similar in size on well-preserved specimens (Figure 1*g*). Posterodorsal tubercle in same position on both valves; size similar to (Figure 1*b*), or smaller than (Figure 2*d*), upper and lower anteroventral protuberances. Anteroventral tubercle set back from valve contact margin and located posterior to lower anteroventral protuberance and anterior to valve midlength; tubercle may vary in size but usually with greater diameter and length than both upper and lower anteroventral protuberances (Figures 1*a,d,h*, 2*d*). Anterodorsal round node (?eye spot) set back from contact margin and with peripheral depression (Figures 1*a–c,k,l*, 2*d–f*); in most specimens former presence of node indicated by hole (Figures 1*d–j*, 2*h*). Anteroventral protuberances and anteroventral and posterodorsal tubercles hollow (Figures 1*f*, 2*b,f*); inner surface of anterodorsal node (?eye spot) concave (Figure 2*b,f*).

Adductor Muscle Attachment Scar: Pattern unknown.

Carapace Size (mm): Holotype, USNM 488627, RV, L = 0.97, H = 0.85. Paratypes: USNM 488626, LV, L = 0.66, H = 0.56; USNM 488628, RV, L = 1.28, H = 1.12; USNM 488629, LV, L = 0.87, H = 0.73, W = 0.37; USNM 488630, RV, L = 0.68, H = 0.64, W = 0.35; USNM 488631, RV, L = 0.46, H = 0.38, W = 0.19; USNM 488632, RV, L = 0.42, H = 0.44, W = 0.18; USNM 488633, RV, L = 0.68, H = 0.60, W = 0.31; USNM 488634, RV, L = 0.67, H = 0.56; USNM 488635, LV, L = 0.65, H = 0.55. Range of length: 0.42–1.28 mm.

COMPARISONS.—*Thaumatomma granti* differs from *T. piscifrons* mainly in having a stout anteroventral tubercle. This is in addition to the upper and lower anteroventral protuberances, the posterodorsal tubercle, and the anterodorsal node (?eye spot) that also are present on *T. piscifrons*. The lower anteroventral protuberance of *T. piscifrons* is larger than the upper protuberance, whereas they are about the same size in *T. granti*. The orientation of surface ridges varies somewhat within each species, but, in general, the ridges in the anterior half of *T. piscifrons* are closer to vertical than those of *T. granti*.

Thaumatomma kozuri, new species

FIGURE 3

ETYMOLOGY.—Named in honor of H. Kozur, Budapest, Hungary.

HOLOTYPE.—USNM 488636, complete carapace.

TYPE LOCALITY.—USNM locality 9260, Hydra, Greece 3, 21 Jun 1975.

PARATYPES.—None.

DIAGNOSIS.—*Thaumatomma* with convex dorsal margin; anteroventral margin located just below approximate midheight trends sharply downward and backward and terminates at each end in an upper and a lower protuberance; surface with nonreticulate ridges; ridges in anterior half trend vertically; with anterodorsal node (?eye spot), and without anteroventral and posterodorsal tubercles.

DESCRIPTION.—Ovate, dorsal margin convex; anterodorsal margin broadly rounded, extends from approximate anterior quarter of greatest length to approximate midheight where it merges with the upper anteroventral protuberance; fairly straight anteroventral margin trends downward and backward with an upper and a lower protuberance, length of anteroventral margin less than 1/4 the greatest height; posterior margin rounded, merges smoothly with dorsal margin; dorsal outline subelliptical, posterior wider than anterior; end outline subovate; greatest width subcentral, less than greatest height.

Ornamentation: In lateral view, part of surface anterior to both midlength and central adductor muscle scar with ridges subvertical in middle part, then curving posteriorly at ventral and dorsal ends to intersect ventral and dorsal margins tangentially; concave ridges in posteroventral quarter extend from central adductor muscle scar to posteroventral and ventral half of posterior margins, joining the margins tangentially; ridges in posterodorsal quarter extend from dorsal edge of central adductor muscle scar to posterodorsal valve margin and intersects it perpendicularly. Anterodorsal node (?eye spot) with diameter about same as that of anteroventral protuberance, subhemispherical, with indented perimeter, located about equidistant from upper anterodorsal protuberance and junction of dorsal and anterodorsal margins. Dorsoposterior and anteroventral tubercles absent on both valves.

Adductor Muscle Attachment Scar: Details unknown, but centrally located at midheight and midlength.

Carapace Size (mm): Holotype (complete carapace), USNM 488636, L = 1.18, H = 1.05, W = 1.00.

COMPARISONS.—*Thaumatomma kozuri* differs from *T. piscifrons* and *T. granti* in lacking the cross-ridges that form reticules and in lacking a posterodorsal tubercle. *Thaumatomma kozuri* differs from *T. granti* in lacking an anteroventral tubercle. The ridges anterior to midlength of *T. kozuri* are more vertical than those of *T. granti*.

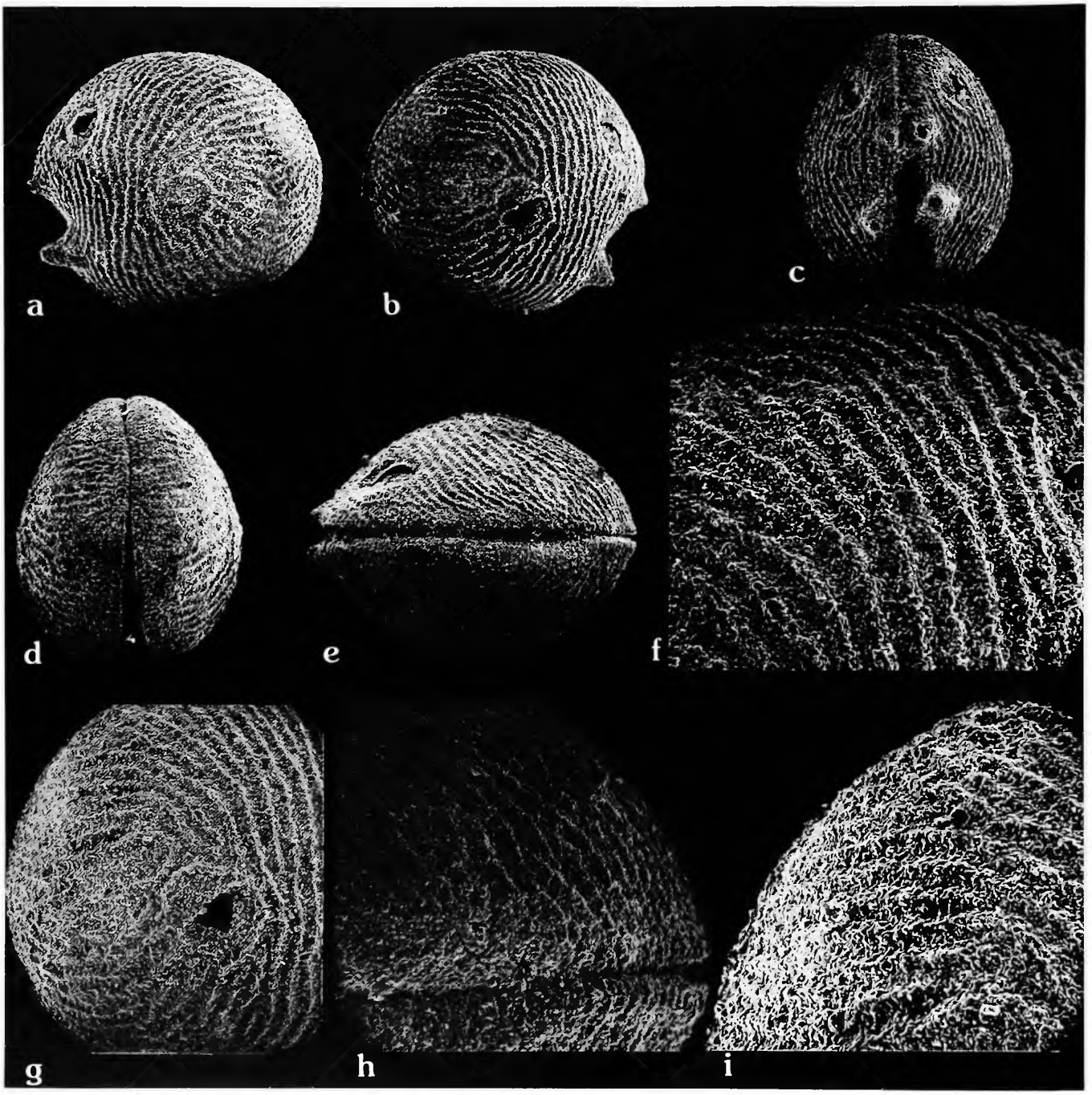


FIGURE 3.—*Thaumatomma kozuri,* new species, holotype, USNM 488636, length 1.18 mm, complete carapace: *a,* left lateral (×60); *b,* right lateral (×60); *c,* av (×60); *d,* pv (×60); *e,* dv (×60); *f,* detail from *b* of anterior half of dorsal margin (×190); *g,* detail from *b* of posterior end (×90); *h,* detail from *e* of posterior end (×200); *i,* detail from *b* of posterodorsal corner (×190). (Micrographs reduced to 70%.)

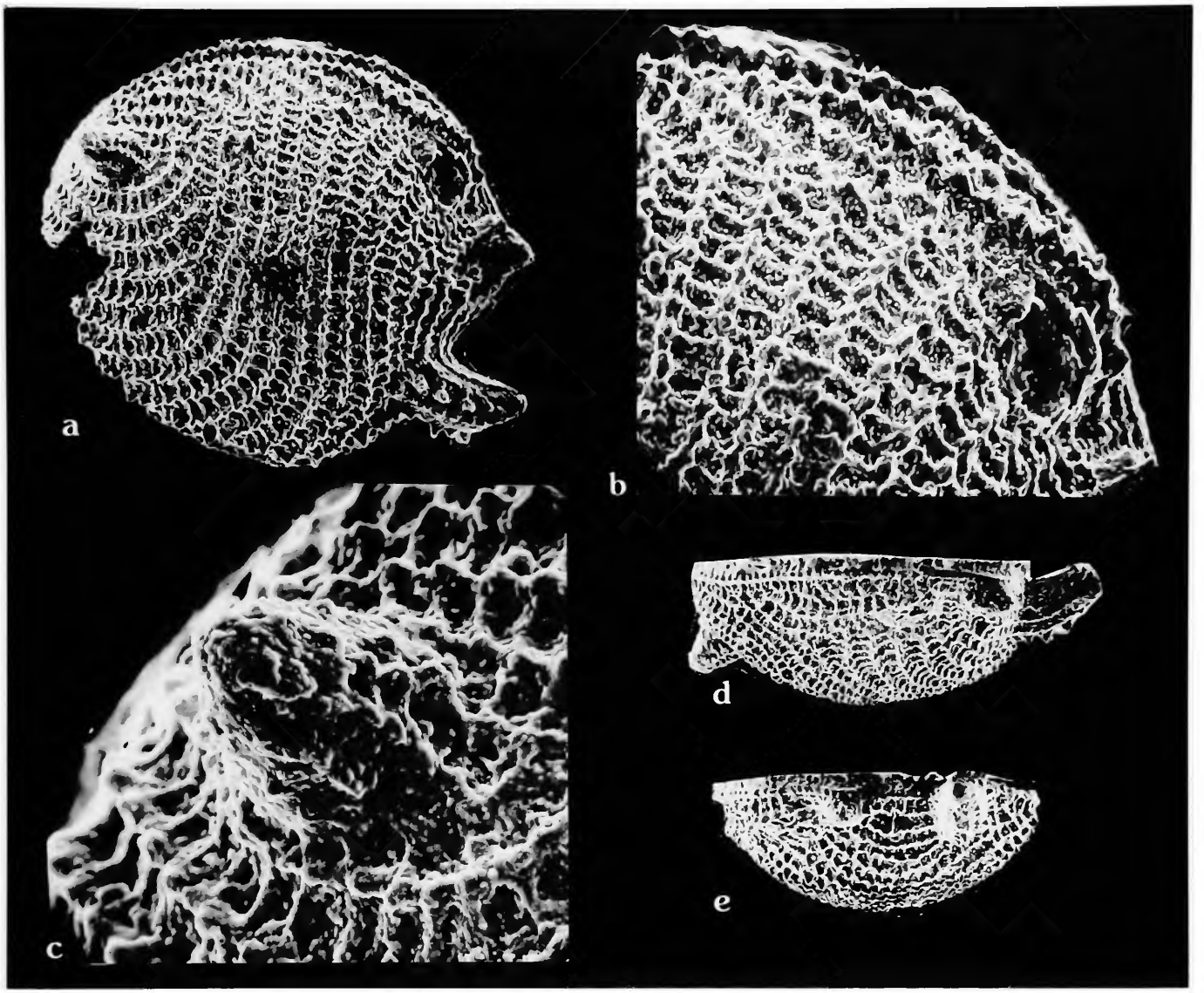


FIGURE 4.—*Thaumatomma doescheri,* new species, holotype, USNM 488638, RV, length 0.76 mm (posteroventral part missing): *a,* lv (×120); *b,* detail from *a* showing anterodorsal margin (×500); *c,* detail from *a* showing posterodorsal tubercle (×500); *d,* dv (anterior to right) (×100); *e,* av (venter to right) (×100). (Micrographs reduced to 79%.)

Thaumatomma doescheri, new species

FIGURES 4–6

ETYMOLOGY.—Named in honor of Rex A. Doescher, Department of Paleobiology, Smithsonian Institution, who processed most of ostracodes described herein.

HOLOTYPE.—USNM 488638, RV (posteroventral edge missing).

TYPE LOCALITY.—USNM locality 9260, Hydra, Greece 1, 21 Aug 1968.

PARATYPES.—USNM locality 9260, Hydra, Greece 1, 21 Aug 1968: USNM 488637, RV valve, posteroventral margin and posterodorsal part missing.

DIAGNOSIS.—*Thaumatomma* with convex dorsal margin; straight anteroventral margin located just below approximate midheight, trends sharply downward and backward and terminates in upper and lower protuberances; lower protuberance much longer than upper protuberance; anterodorsal node

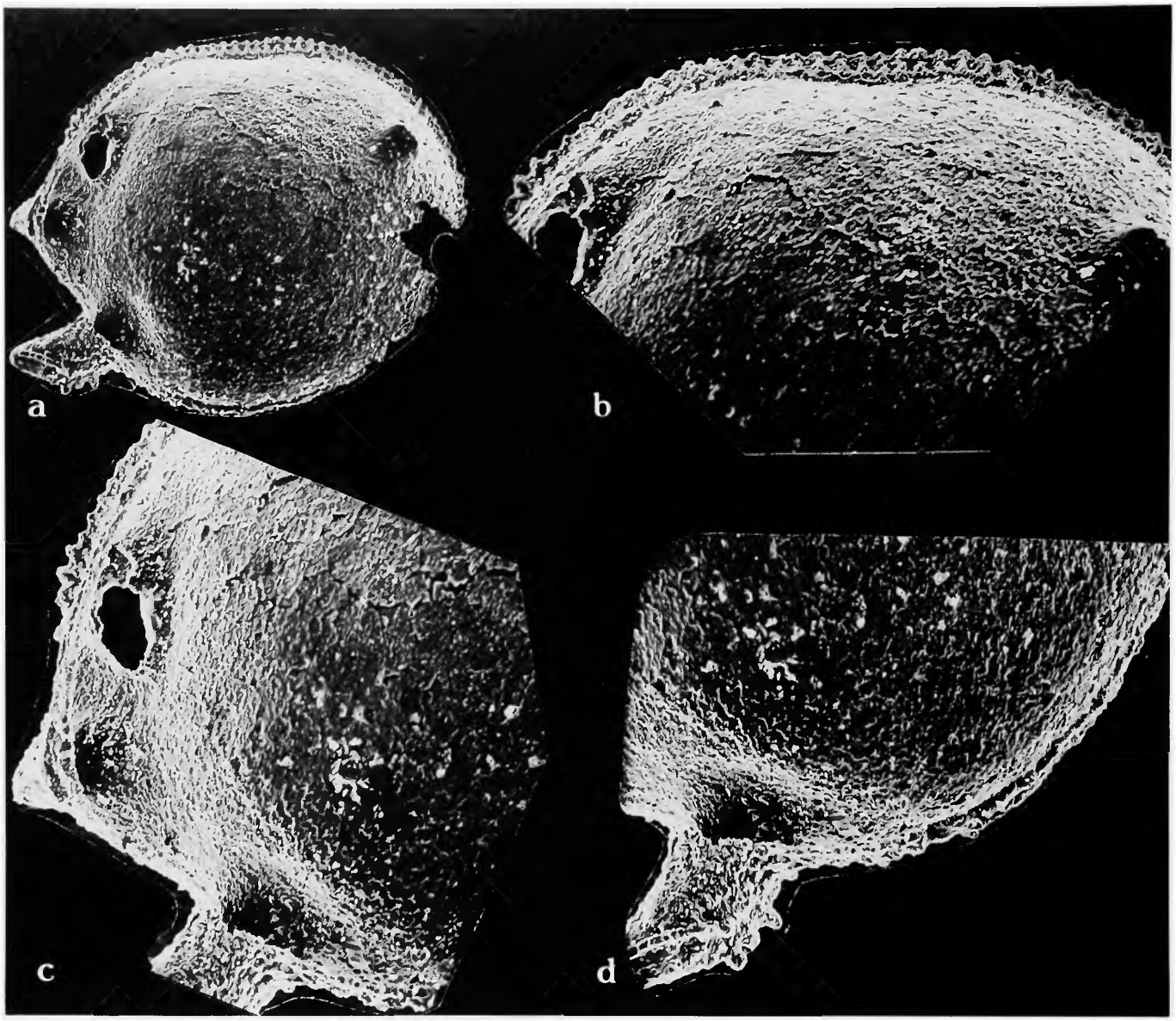


FIGURE 5.—*Thaumatomma doescheri,* new species, holotype, USNM 488638, RV, length 0.76 mm (posteroventral part missing): *a,* iv (×100); *b,* detail from *a* showing dorsal margin (×200); *c,d,* details from *a* showing parts of anterior and anteroventral margins, respectively (×200). (Micrographs reduced to 84%.)

(?eye spot) set back from contact margin. Surface strongly reticulate, with spines at intersections of ridges and cross-ridges; posterodorsal tubercle prominent (part of valve bearing tubercle missing in USNM 488637 (Figure 6)); without anteroventral tubercle. Long ridges of anterior $^{2}/_{3}$ almost vertical, except at ventral and dorsal ends where they bend towards the posterior; ridges concentric around posterodorsal tubercle; dorsal edge of valve with row of small spines; one or two short straight rows of spines located just within anterodorsal margin.

DESCRIPTION.—Subovate, dorsal margin convex; anterodorsal margin broadly rounded, extends downward from approximate anterior quarter of greatest length to approximate midheight where it merges with the upper anteroventral protuberance; straight anteroventral margin trends downward and backward, length of anteroventral margin about $^{1}/_{3}$ the

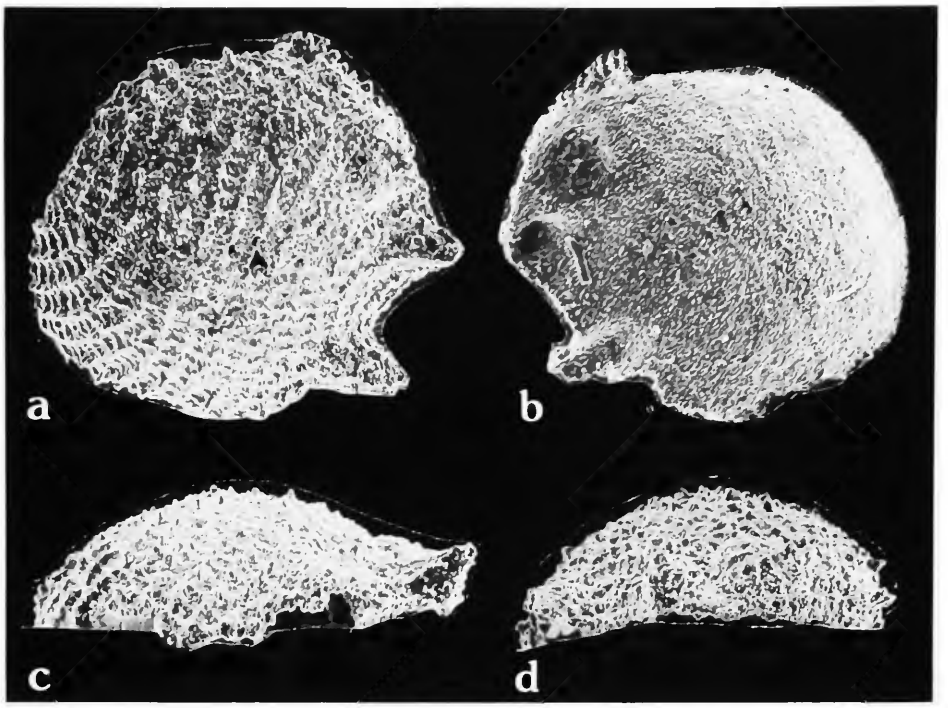


FIGURE 6.—*Thaumatomma doescheri,* new species, paratype, USNM 488637, RV, height 0.65 mm (ventral edge and posterodorsal section of valve containing tubercle missing): *a–d:* lv, iv, vv, and av (venter to left), respectively (×100). (Micrographs reduced to 78%.)

greatest height, makes a distinct angle with lower anteroventral protuberance; ventral margin convex; posterior margin rounded, merges with dorsal margin at 3/4 valve length; dorsal outline subelliptical, greatest width subcentral; end outline subovate, greatest width central.

Ornamentation: Surface with ridges; short fairly stout cross-ridges form reticules; parallel ridges of anterior 2/3 form slight angle with vertical and tend to be tangential to ventral and dorsal margins; parallel ridges of posterior 1/3 concentric around posterodorsal tubercle. Intersections of reticulations with small spines; dorsal margin with row of small spines; one or two short rows of small spines located just within anterodorsal margin. Upper and lower anteroventral protuberances close to valve contact margin, lower protuberance much longer, with spines and ridges. Posterodorsal tubercle well developed, with ridges. Anterodorsal node (?eye spot) typical for genus.

Adductor Muscle Attachment Scar: Details unknown.

Carapace Size (mm): Holotype, USNM 488638, RV, L = 0.76, H = 0.68, W = 0.27. Paratype, USNM 488637, RV, L = 0.65+ (posterior end missing), H = 0.65, W = 0.23.

COMPARISONS.—*Thaumatomma doescheri* differs from all other known species in *Thaumatomma* in having spines at the intersection of reticules and along the dorsal margin. It differs from *T. kozuri* in having a posterodorsal tubercle and differs from *T. granti* in lacking an anteroventral tubercle, as well as having surface ridges that are vertical rather than horizontal. The ridges posterior to midlength and at midheight of *T. doescheri* are not horizontal as on *T. kozuri;* also, unlike *T. kozuri, T. doescheri* is strongly reticulate.

Thaumatomma permiana, new species

FIGURES 7–9

ETYMOLOGY.—Named after Permian age.

HOLOTYPE.—USNM 488639, complete carapace.

TYPE LOCALITY.—USNM locality 9260, Hydra, Greece 2, 4 Jul 1974.

PARATYPES.—USNM locality 9260, Hydra, Greece 1, 21 Aug 1968: USNM 488640, LV; USNM 488644, RV; USNM 488646, LV; USNM 488647, RV; USNM 488648, RV; USNM 488649, RV; USNM 488650, RV. USNM locality 9260, Greece 2, 4 Jul 1974: USNM 488641, complete carapace; USNM 488642, complete carapace; USNM 488643, complete carapace; USNM 488645, RV.

DIAGNOSIS.—*Thaumatomma* with convex dorsal margin; straight anteroventral margin located just below approximate midheight, trends sharply downward and backward and

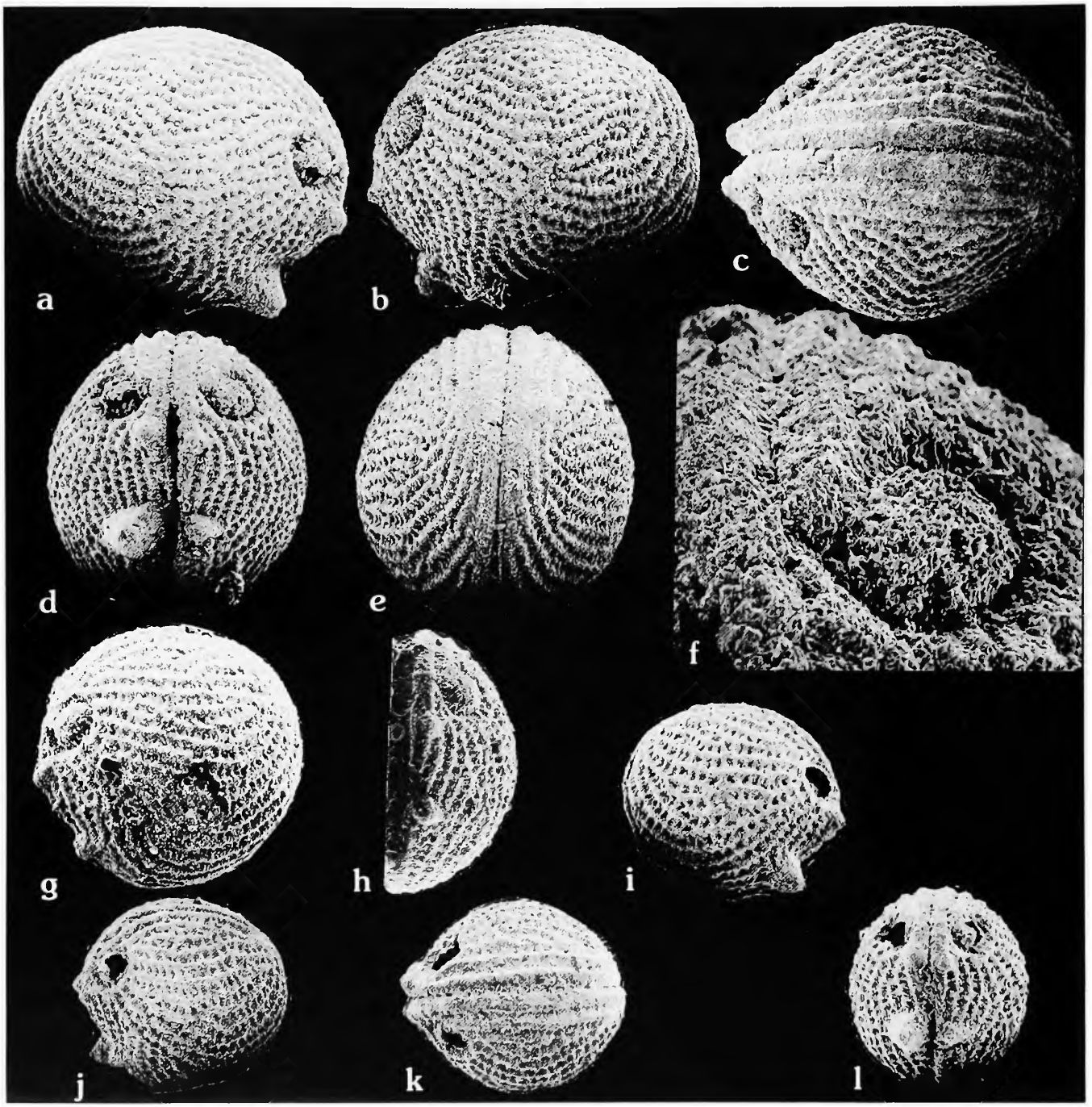


FIGURE 7.—*Thaumatomma permiana,* new species: Holotype, USNM 488639, complete carapace, length 0.79 mm: *a–e,* right lateral, left lateral, dv, av, and pv, respectively (×100); *f,* detail from *a* showing anterodorsal node (×400). Paratypes: USNM 488640, LV, length 0.63 mm: *g,h,* lv and av, respectively (×100). USNM 488641, complete carapace, length 0.53 mm: *i–l,* right lateral, left lateral, dv, and av, respectively (×100). (Micrographs reduced to 70%.)

terminates at each end in upper and lower protuberances; lower protuberance larger than upper protuberance; without posterodorsal and anteroventral tubercles; reticulations formed by ridges and weaker cross-ridges; orientation of ridges of anterior half varies from horizontal to forming a 45° angle; ridges of posterior half fairly linear in upper half and concave in ventral

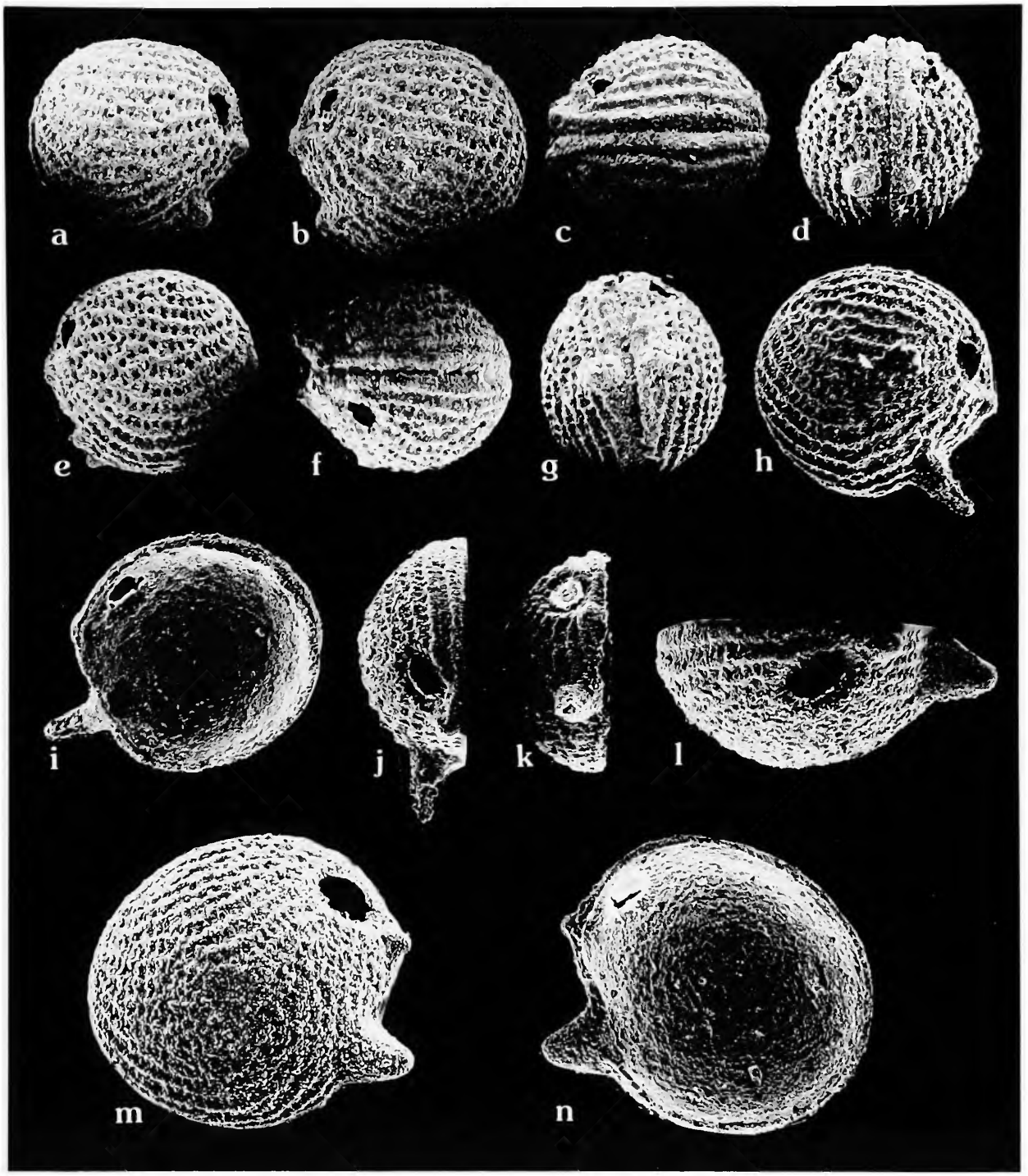


FIGURE 8.—*Thaumatomma permiana,* new species, paratypes: USNM 488642, complete carapace, length 0.45 mm: *a–d,* right lateral, left lateral, dv, and av, respectively (×100). USNM 488643, length 0.42 mm, complete carapace: *e–g,* left lateral, dv, and av, respectively (×100). USNM 488644, RV, length 0.46 mm (foreign particle is attached to tip of lower anteroventral protuberance giving it a false appearance of being longer than it is): *h–k,* lv, iv, dv, and av, respectively (×100). USNM 488645, RV, length 0.63 mm: *l–n,* dv, lv, and iv, respectively (×100). (Micrographs reduced to 83%.)

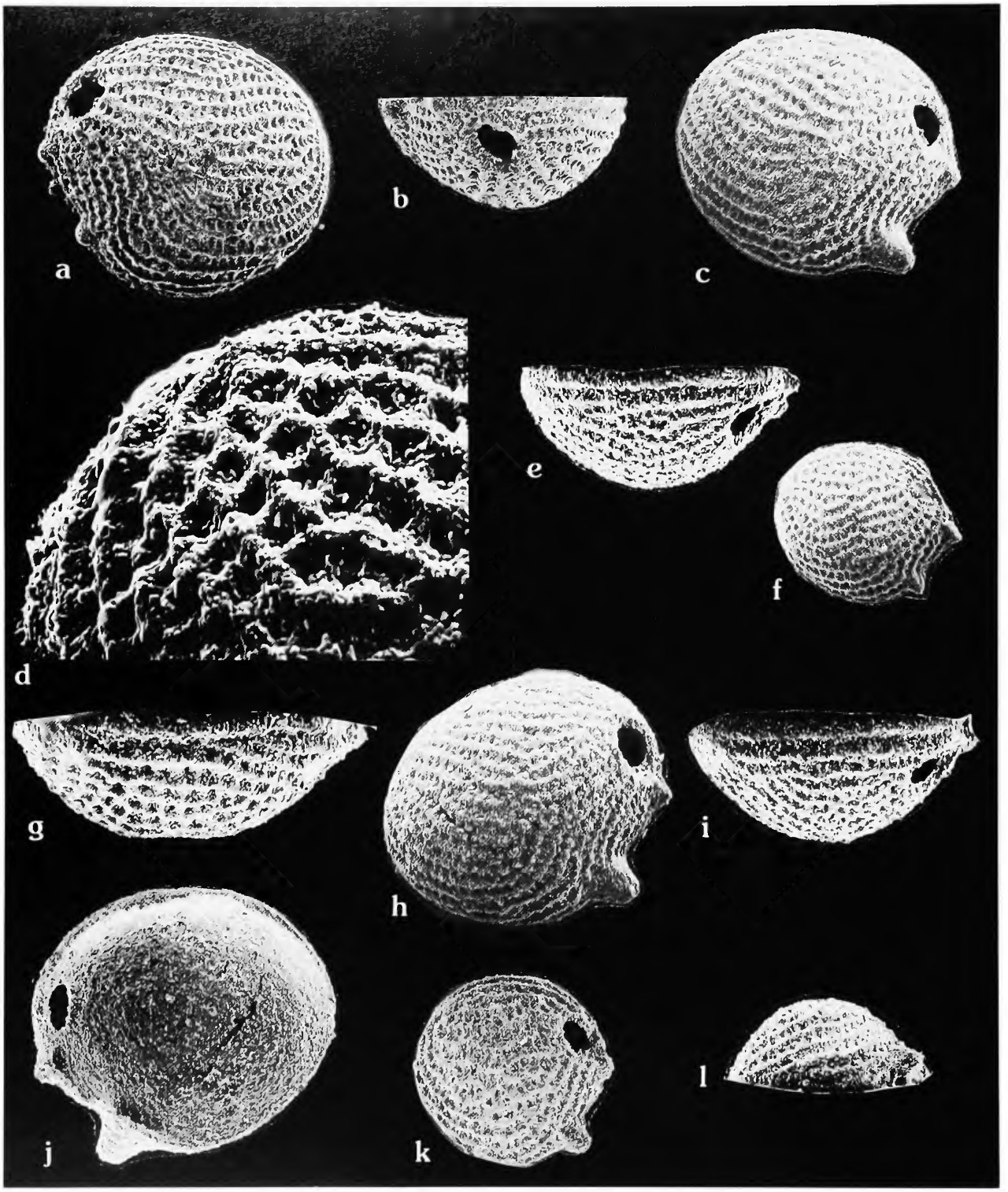


FIGURE 9.—*Thaumatomma permiana,* new species, paratypes: USNM 488646, LV, length 0.62 mm: *a,b,* lv and anterodorsal view (venter to left), respectively (×100). USNM 488647, RV, length 0.60 mm: *c,* lv (×100); *d,* detail from *c* showing posteroventral corner (venter to left) (×500); *e,* dv (×100). USNM 488648, RV, length 0.40 mm: *f,* lv (×100); *g,* dv (×200). USNM 488649, RV, length 0.67 mm: *h–j,* lv, dv, and iv, respectively (×100). USNM 488650, RV, length 0.42 mm: *k,l,* lv and vv, respectively (×100). (Micrographs reduced to 78%.)

half; several ridges just within outer margin either continue around circumference or terminate tangentially along posterior margin.

DESCRIPTION.—Valves subovate, dorsal margin convex; anterodorsal margin broadly rounded, extends from approximate anterior quarter of greatest length to approximately upper 1/3 of greatest height where it merges with the upper anteroventral protuberance; straight anteroventral margin trends downward and backward, length of anteroventral margin about 1/3 the greatest height, makes a distinct angle with lower anteroventral protuberance; ventral margin convex, anterior portion continues downward and backward to a point approximately below the junction of the dorsal and anterodorsal margins, then curves gently upward to a point opposite lower anteroventral protuberance; posterior margin rounded, smoothly merges with dorsal margin; dorsal outline elliptical, greatest width central; end outline subovate, greatest width central and either equal to or less than greatest height.

Ornamentation: Surface with ridges extending from anterior to posterior margins; weaker short perpendicular ridges form reticules; three or four ridges subparallel to anterior and ventral margins extend from upper anteroventral protuberance to point just posterior to lower anteroventral protuberance; three ridges parallel to anterodorsal and dorsal margin of valve; parallel linear ridges of anterior half vary in orientation from subhorizontal to 45° of vertical. These ridges vary from being straight, or slightly concave, in dorsal half of valve to concave in ventral half of valve; ventral ridges continue subparallel to contact margins, some outer ridges intersect posterior margin tangentially. Upper and lower anteroventral protuberances close to contact margin, lower protuberance larger. Anterodorsal ovate node (?eye spot) set back from contact margin and with depression along circumference. Without anteroventral and posterodorsal tubercles.

Adductor Muscle Attachment Scar: Pattern unknown.

Carapace Size (mm): Holotype, USNM 488639 (complete carapace), L = 0.79, H = 0.67, W = O.66. Paratypes: USNM 488640, LV, L = 0.63, H = 0.63, W = 0.25; USNM 488641 (complete carapace), L = 0.53, H = 0.46, W = 0.45; USNM 488642 (complete carapace), L = 0.45, H = 0.40, W = 0.38; USNM 488643 (complete carapace), L = 0.42, H = 0.40, W = 0.36; USNM 488644, RV, L = 0.46, H = 0.45, W = 0.21; USNM 488645, RV, L = 0.63, H = 0.57, W = 0.29; USNM 488646, LV, L = 0.62, H = 0.57, W = 0.24; USNM 488647, RV, L = 0.60, H = 0.53, W = 0.27; USNM 488648, RV, L = 0.40, H = 0.35, W = 0.14; USNM 488649, RV, L = 0.67, H = 0.57, W = 2.8; USNM 488650, RV, L = 0.42, H = 0.42, W = 0.20. Range of length: 0.40–0.79 mm.

COMPARISONS.—*Thaumatomma permiana* differs from most previously described species in lacking a posterodorsal tubercle. It is without the anteroventral tubercle present on *T. granti*. The long ridges on the anterior half are not vertical as on *T. kozuri* and *T. doescheri*.

Thaumatomma newelli, new species

FIGURES 10–12

ETYMOLOGY.—Named in honor of Professor Norman D. Newell, American Museum of Natural History, N.Y., who brought the first Permian silicified fossils from Hydra, Greece, to the Smithsonian Institution.

HOLOTYPE.—USNM 488651, RV.

TYPE LOCALITY.—USNM locality 9260, Greece 1, 21 Aug 1968.

PARATYPES.—USNM locality 9260, Greece 1, 21 Aug 1968: USNM 488652, LV; USNM 488653, LV; USNM 488654, LV; USNM 488655, RV; USNM 488656, RV; USNM 488657, RV; USNM 488658, RV (part missing); USNM 488659, LV; USNM 488660, RV; USNM 488661, RV; USNM 488662, LV.

DIAGNOSIS.—*Thaumatomma* with convex dorsal margin; straight anteroventral margin located at approximate midheight trends sharply downward and backward and terminates at each end in upper and lower protuberances equal to subequal in size; anterodorsal node (?eye spot) located below dorsal margin slightly more than 1/4 greatest height, close to anterodorsal margin; without posterodorsal and anteroventral tubercles; valve surface with reticulations formed by ridges and weaker cross-ridges; orientation of ridges in anteroventral part of valve parallel to valve margin, ridges continue concentrically within ventral, posterior, and dorsal margins and, except for concentric outer ridges, terminate near anterodorsal node; inner ridges of dorsal half of valve variable, from horizontal to slightly concave dorsally (Figure 10*a*).

DESCRIPTION.—Valves subcircular, dorsal margin convex; anterodorsal margin extends from approximate anterior quarter of greatest length to approximate midheight where it merges with the upper anteroventral protuberance; straight anteroventral margin trends downward and backward, length of anteroventral margin about 1/3 greatest height, makes a distinct angle with lower anteroventral protuberance; ventral margin convex; dorsal margin gently convex; greatest width central, less than greatest height.

Ornamentation: Surface with approximately five or six well-developed, concentric, peripheral ridges (Figure 12*a,f,g,l*); ridges within peripheral ridges in dorsal half of valve either horizontal or slightly concave dorsally; ridges subdued on most specimens, but some specimens with strongly developed ridges (Figures 11*f*, 12*g*); on some specimens concentric ridges visible on inner side (Figure 10*c*). Without posterodorsal and anteroventral tubercles. Lower protuberance larger. Anterodorsal node (?eye spot) set back from contact margin; missing node represented by hole in many specimens; interior side of anterodorsal node a shallow depression.

Adductor Muscle Attachment Scar: Pattern unknown.

Carapace Size (mm): Holotype: USNM 488651, RV, L = 1.24, H = 1.18. Paratypes: USNM 488652, LV, L = 1.24, H = 1.18, W = 0.50; USNM 488653, LV, L = 0.76, H = 0.69;

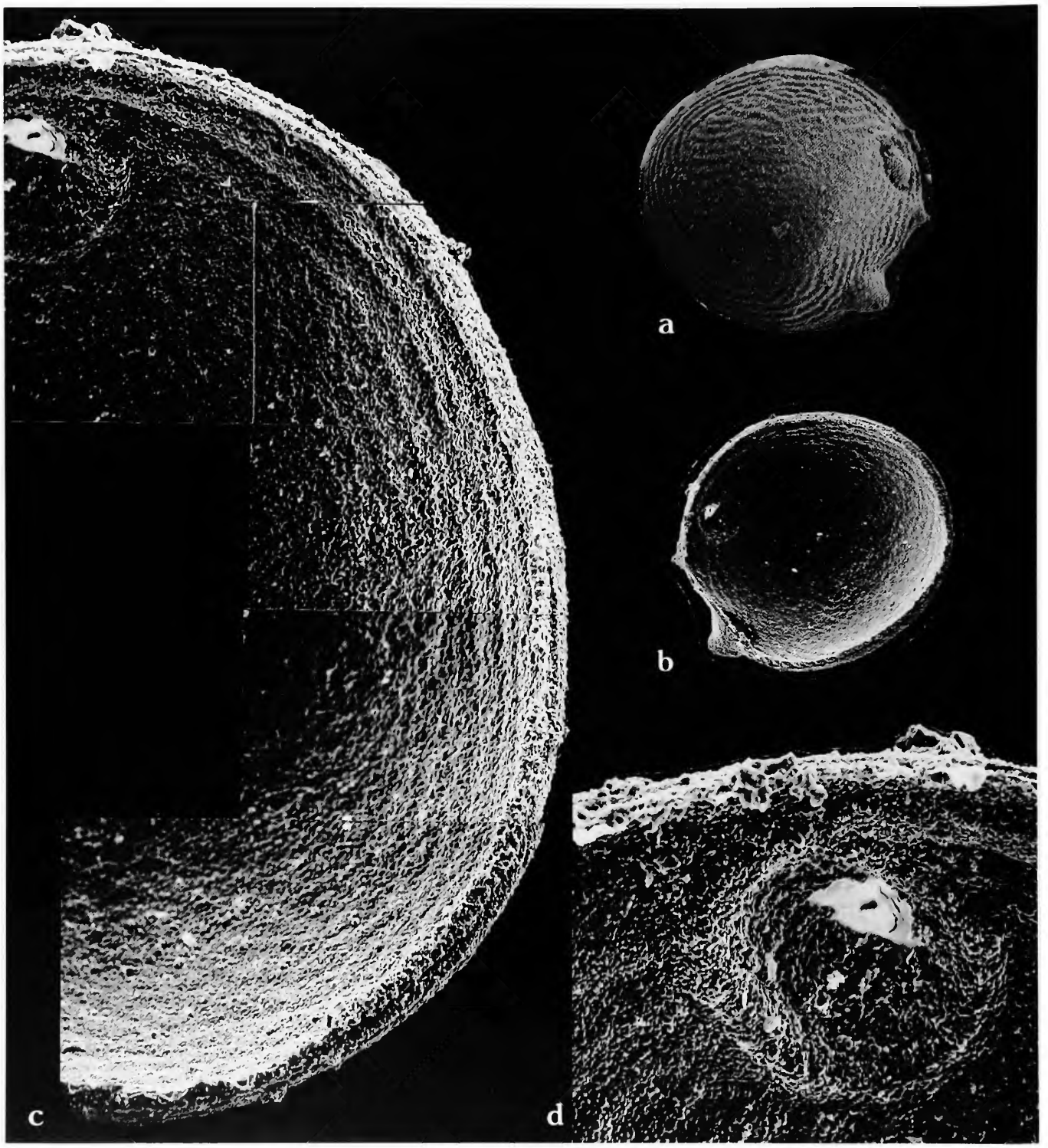


FIGURE 10.—*Thaumatomma newelli,* new species, holotype, USNM 488651, RV, length 1.24 mm: *a,b,* lv and iv, respectively (×50); *c,* detail from *b* showing composite of posterior end (×200); *d,* detail from *b* rotated to right showing interior of anterodorsal node (×300). (Micrographs reduced to 83%.)

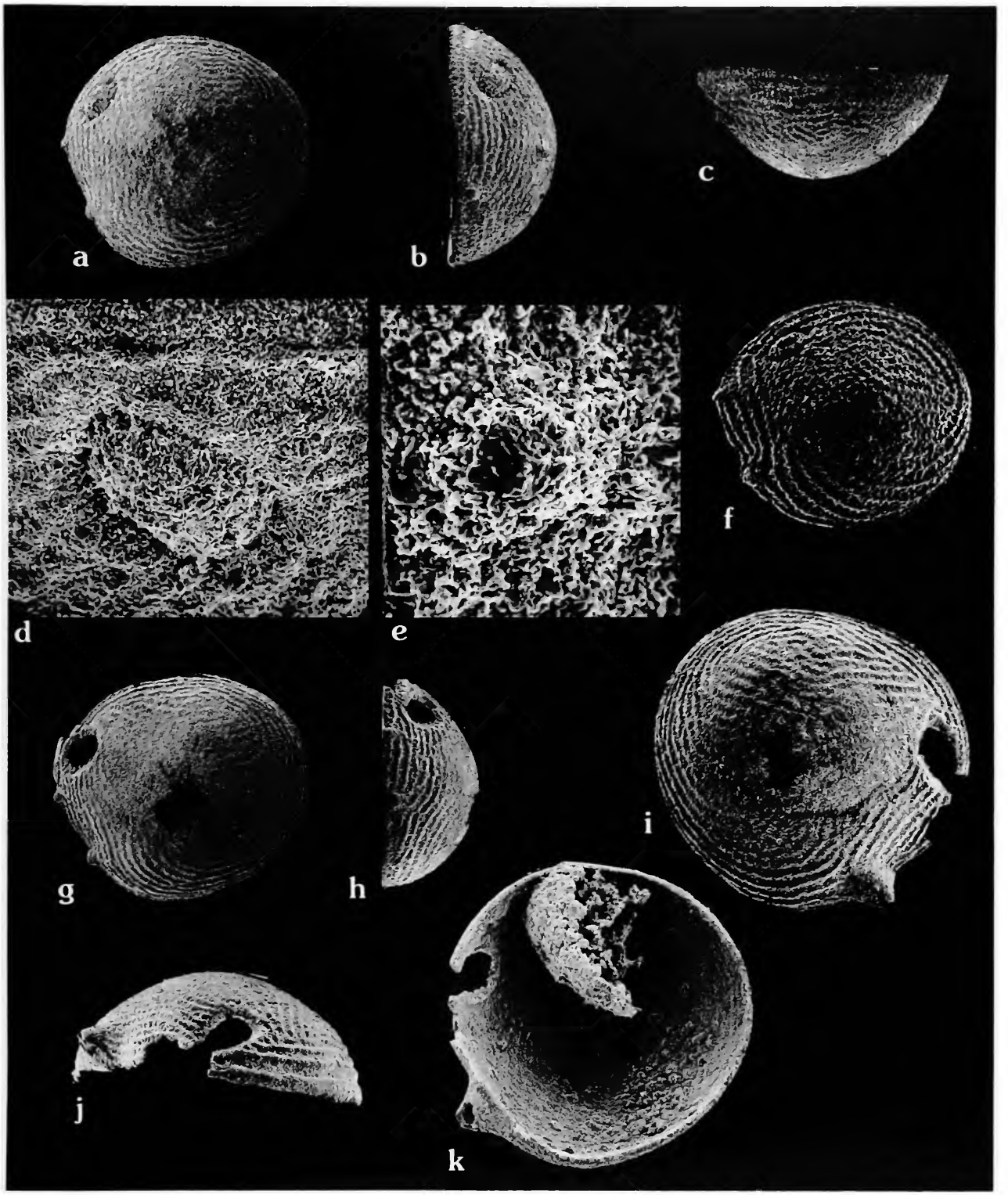


FIGURE 11.—*Thaumatomma newelli,* new species, paratypes: USNM 488652, LV, length 1.24 mm: *a–c,* lv, av, and dv, respectively (×50); *d,* detail showing anterodorsal node (from *c* slightly reoriented) (×220); *e,* detail from *b* showing lower anteroventral protuberance (×500). USNM 488653, LV, length 0.76 mm: *f,* lv (×80). USNM 488654, LV, length 1.28 mm: *g,h,* lv and av, respectively (×50). USNM 488655, RV, length 1.23 mm: *i–k,* lv, av (venter to left), and iv, respectively (×65). (Micrographs reduced to 68%.)

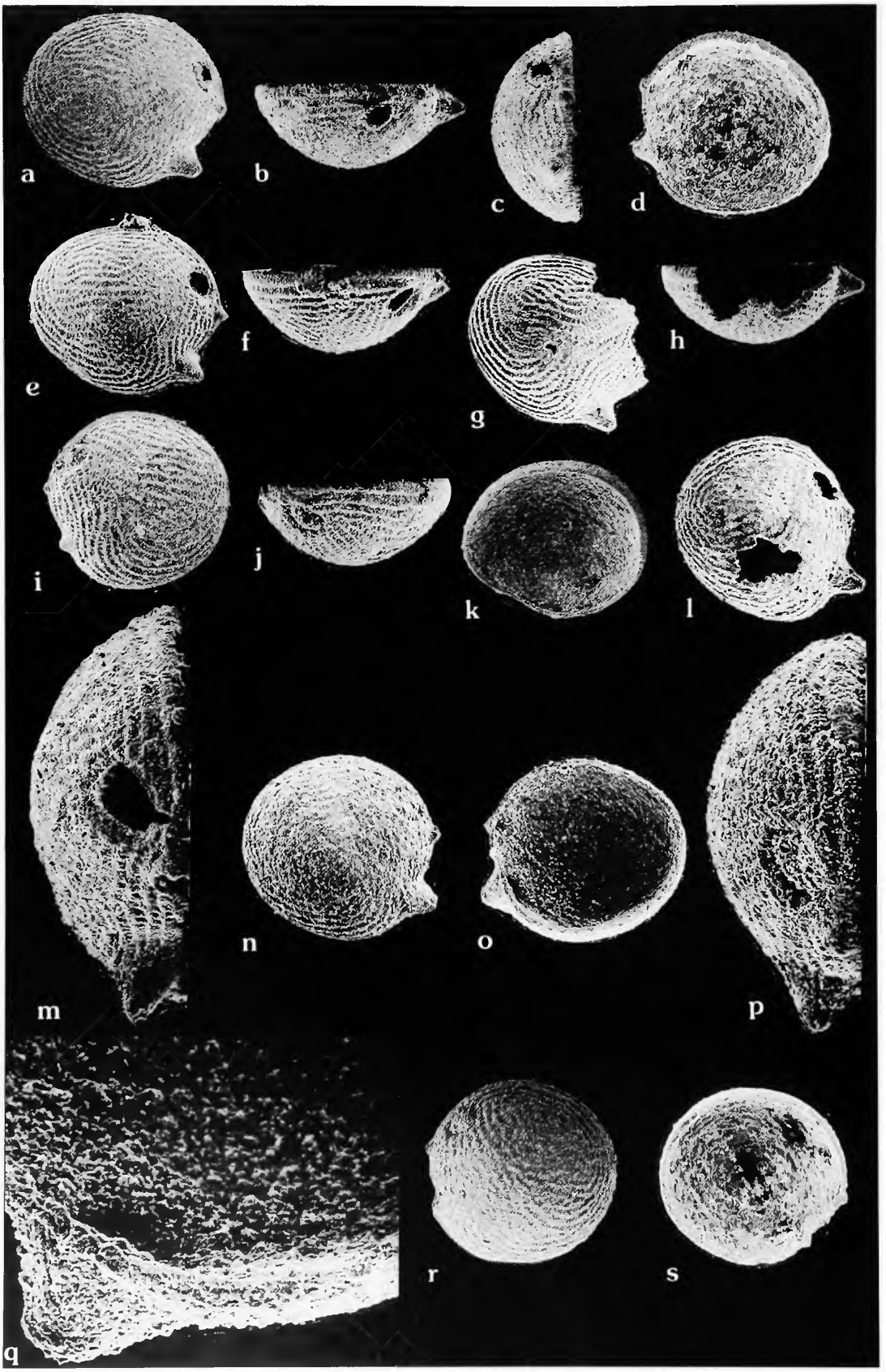

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FIGURE 12.—*Thaumatomma newelli,* new species, paratypes: USNM 488656, RV, length 0.98 mm: *a–d,* lv, dv, av, and iv, respectively (×50). USNM 488657, RV, length 0.94 mm: *e,f,* lv and dv, respectively (×50). USNM 488658, RV (anterodorsal part missing), length ~0.96 mm: *g,h,* lv and dv, respectively (×50). USNM 488659, LV, length 0.90 mm: *i–k,* lv, dv, iv, respectively (×50). USNM 488660, RV, length 0.88 mm: *l,* lv (×50); *m,* av (×100). USNM 488661, RV, length 0.47 mm: *n,o,* lv and iv, respectively (×50); *p,* dv (×100); *q,* detail from *o* showing lower anteroventral protuberance, iv (×200). USNM 488662, LV, length 0.94 mm: *r,s,* lv and iv, respectively (×50). (Micrographs reduced to 67%.)

USNM 488654, LV, L = 1.28, H = 1.14; USNM 488655, RV, L = 1.23, H = 1.17, W = 0.41; USNM 488656, RV, L = 0.98, H = 0.86, W = 0.21; USNM 488657, RV, L = 0.94, H = 0.86, W = 0.42; USNM 488658, RV (part missing), L = ~0.96, H = 0.82, W = 0.40; USNM 488659, LV, L = 0.90, H = 0.88, W = 0.42; USNM 488660, RV, L = 0.88, H = 0.94, W = 0.38; USNM 488661, RV, L = 0.47, H = 0.46, W = 0.38; USNM 488662, LV, L = 0.94, H = 0.90. Range of length: 0.47–1.28 mm.

COMPARISONS.—*Thaumatomma newelli* differs from *T. piscifrons, T. doescheri,* and *T. granti* in the absence of a posterodorsal tubercle. *Thaumatomma newelli* is close to *T. permiana,* and they could be conspecific; they differ, however, in two characters: (1) the concentric ridges are more numerous and are present within the posterodorsal and dorsal margins of *T. newelli,* and (2) the surface ridges are usually more subdued on *T. newelli.*

REMARKS.—Specimen USNM 488653, a left valve, differs from other specimens assigned to *T. newelli* in having reticulations, but it is similar in all other criteria.

Thaumatomma elongata, new species

FIGURES 13, 14

ETYMOLOGY.—From the Latin *elongatus* (prolonged), in reference to the length of the species.

HOLOTYPE.—USNM 488663, RV.

TYPE LOCALITY.—USNM locality 9260, Hydra, Greece 2, 4 Jul 1974.

PARATYPES.—USNM locality 9260, Hydra, Greece 1, 21 Aug 1968: USNM 488665, LV; USNM 488666, RV (specimen lost). USNM locality 9262, Hydra, Greece 1, 23 Aug 1968: USNM 488664, RV; USNM 488667, LV.

DIAGNOSIS.—*Thaumatomma* with straight dorsal margin; straight anteroventral margin located just below approximate dorsal 1/3 of greatest height, trends sharply downward and backward and terminates at each end in an upper and lower protuberance; lower protuberance larger than upper protuberance; anterodorsal node (?eye spot) located below dorsal margin, somewhat closer to anterodorsal margin; without anterodorsal and anteroventral tubercles; surface ridges subparallel to dorsal margin, sloping downward posteriorly.

DESCRIPTION.—Valves elongate, dorsal margin straight; anterodorsal margin broadly rounded, extends backward from anterodorsal protuberance to straight dorsal margin; straight anteroventral margin trends downward and backward, length of anteroventral margin 2/3 the greatest height, makes a distinct angle with the lower anteroventral protuberance; ventral margin convex, merges smoothly with curved posterior margin; dorsal outline with greatest width at posterior 1/3 of length; end outline subovate, greatest width subcentral, less than greatest height.

Ornamentation: Surface with long straight ridges extending from anterior to posterior margins, subparallel to straight dorsal margin of valve (Figure 13*a*). Lower anteroventral protuberance larger than upper anteroventral protuberance and set back from contact margin. Anterodorsal node (?eye spot) set back from contact margin; missing node represented by hole in many specimens; inner side of node a shallow depression. Without posterodorsal and anteroventral tubercles.

Adductor Muscle Attachment Scar: Pattern unknown.

Carapace Size (mm): Holotype, USNM 488663, RV, L = 1.32, H = 1.12, W = 0.50. Paratypes: USNM 488664, RV, L = 0.50 , H = 0.43, W = 0.19; USNM 488665, LV, L = 0.65, H = 0.48, W = 0.23; USNM 448666, RV, L = 0.62, H = 0.52, W = 0.21; USNM 488667, LV, L = 0.74, H = 0.54, W = 0.27. Range of length: 0.50–1.32 mm.

COMPARISONS.—*Thaumatomma elongata* differs from previously described species of the genus in being more elongate and in having straight ridges extending from the anterior to posterior margins. It differs from *T. piscifrons, T. granti,* and *T. doescheri* in lacking a posterodorsal tubercle, and also from *T. granti* in lacking an anteroventral tubercle.

Thaumatomma piscifrons Kornicker and Sohn, 1976

FIGURE 15

Thaumatomma piscifrons Kornicker and Sohn, 1976b:107, figs. 81–87.

HOLOTYPE.—USNM 168167, left valve of probably A–1 growth stage.

TYPE LOCALITY.—USNM locality 9261, southeastern side of Hydra, just off Argolian coast, Greece. Kornicker and Sohn (1976b:111) incorrectly listed USNM locality 9260 for the type locality, but correctly listed it as USNM locality 9261 on page 112; the two localities are adjacent (see "Samples," above).

PARATYPES.—Kornicker and Sohn (1976b:112) incorrectly listed USNM 168169 as being from USNM locality 9261, it should have been 9260.

MATERIAL.—USNM locality 9260, Hydra, Greece 1, 21 Aug 1968: USNM 488668, LV; USNM 488669, RV; USNM 488670, RV; USNM 488671, RV; USNM 488672, RV.

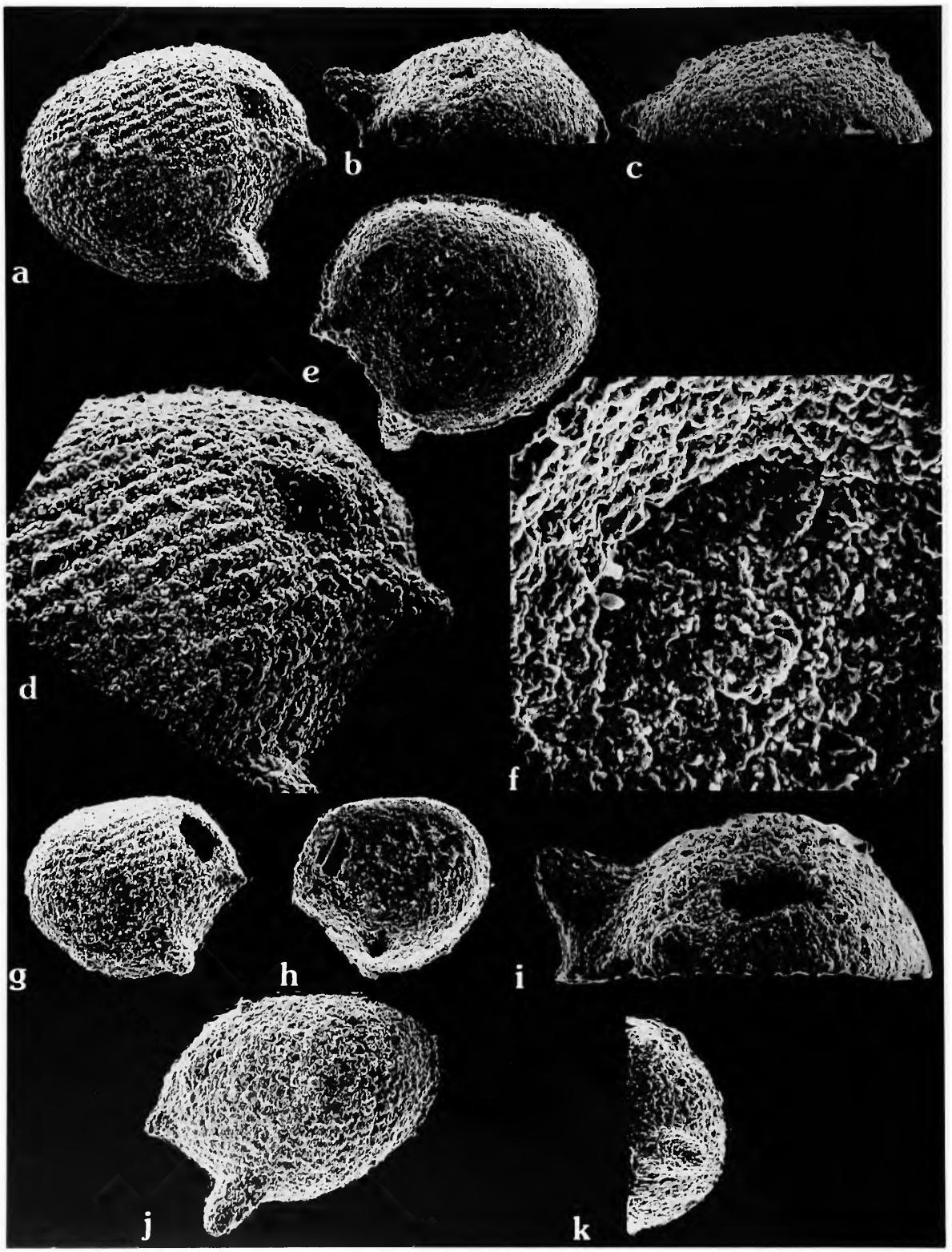

FIGURE 13.—*Thaumatomma elongata,* new species: Holotype, USNM 488663, RV, length 1.32 mm: *a–c,* lv, av, and dv, respectively (×50); *d,* detail from *a* (×200); *e,* iv (×100); *f,* detail from *e* showing interior of anterodorsal node (×500). Paratypes: USNM 488664, RV, length 0.50 mm: *g,h,* lv and iv, respectively (×100); *i,* av (×200). USNM 488665, LV, length 0.65 mm: *j,k,* lv and av, respectively (×100). (Micrographs reduced to 72%.)

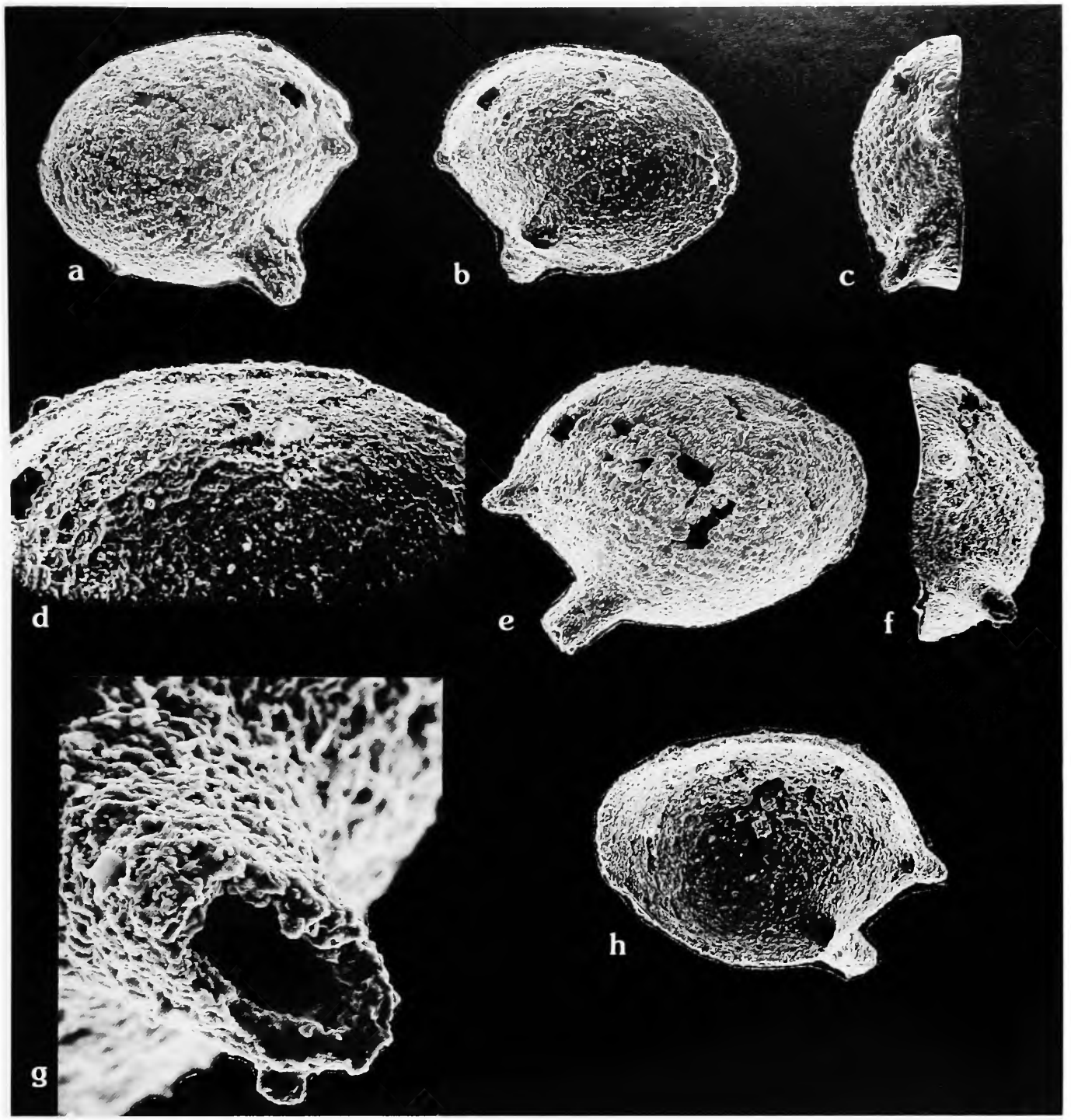

FIGURE 14.—*Thaumatomma elongata,* new species, paratypes: USNM 488666, RV, length 0.62 mm: *a–c,* lv, iv, and av, respectively (×100); *d,* detail from *b* showing dorsal part (×200). USNM 488667, LV, length 0.74 mm: *e, f,* lv and av, respectively (×100); *g,* detail from *f* showing lower anteroventral protuberance with tip missing (×600); *h,* iv (×100). (Micrographs reduced to 83%.)

DIAGNOSIS AND DESCRIPTION.—See Kornicker and Sohn, 1976b:107.

Ornamentation: See Kornicker and Sohn, 1976b:111, 112.

Carapace Size (mm): USNM 488668, LV, L = 0.77, H = 0.61, W = 0.28; USNM 488669, RV, L = 0.61, H = 0.47, W = 0.24; USNM 488670, RV, L = 0.74, H = 0.67, W = 0.29;

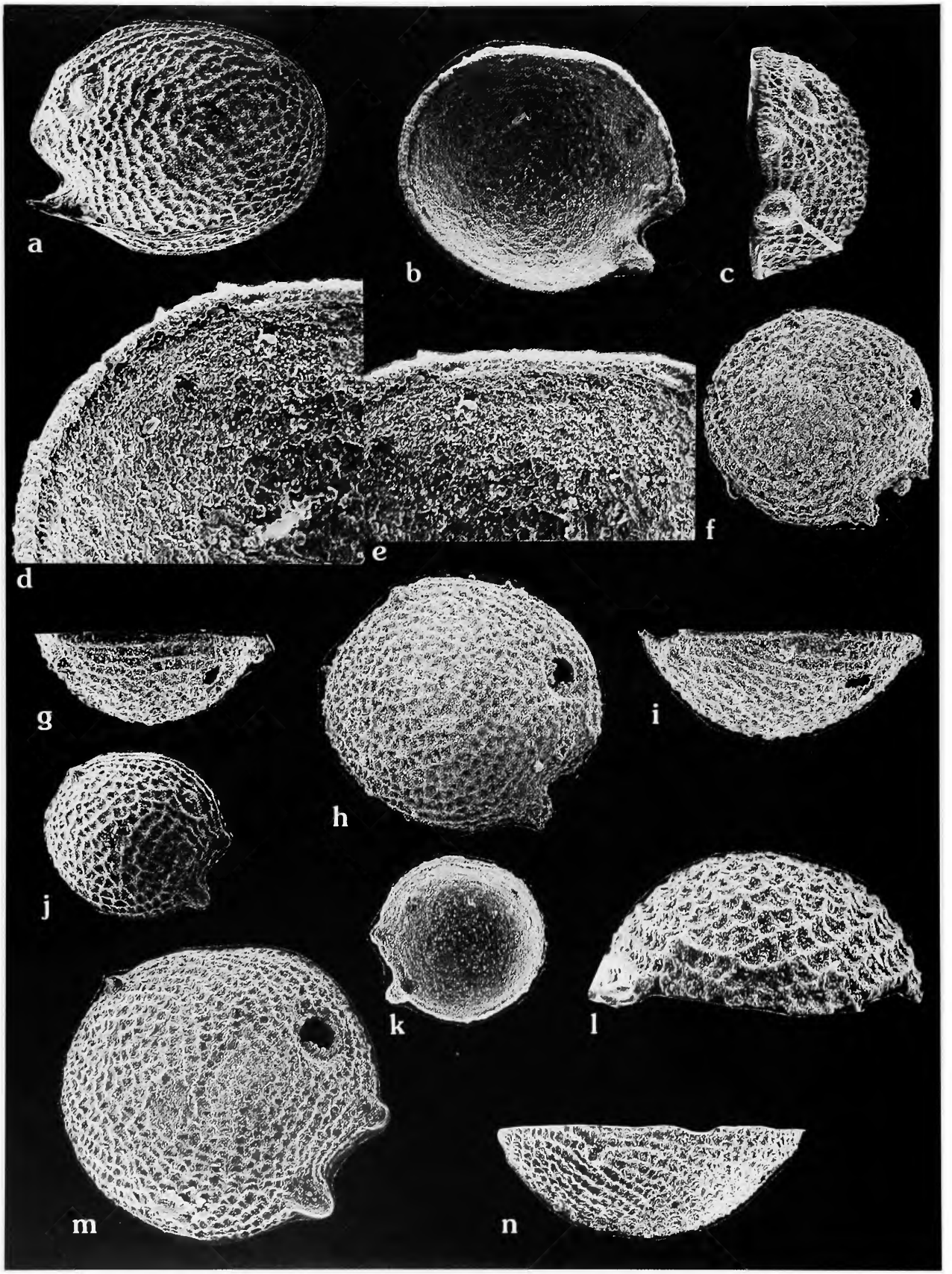
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FIGURE 15.—*Thaumatomma piscifrons* Kornicker and Sohn, figured specimens: USNM 488668, LV, length 0.77 mm: *a–c,* lv, iv, and av, respectively (×100); *d,e,* details from *b* showing posterodorsal corner and dorsal margin, respectively (×230). USNM 488669, RV, length 0.61 mm: *f,g,* lv and dv, respectively (×100) (debris present ventral to upper anteroventral protuberance). USNM 488670, RV, length 0.74 mm: *h,i,* lv and dv, respectively (×100). USNM 488671, RV, length 0.47 mm: *j,k,* lv and iv, respectively (×100); *l,* pv (×200). USNM 488672, RV, length 0.85 mm: *m,n,* lv and dv, respectively (×100). (Micrographs reduced to 67%.)

USNM 488671, RV, L = 0.47, H = 0.44, W = 0.22; USNM 488672, RV, L = 0.85, H = 0.77, W = 0.29. Kornicker and Sohn (1976b, fig. 87) gave a length range of 0.42–1.23 for 35 specimens that they measured.

Thaumatomma procax, new species

FIGURES 16, 17

ETYMOLOGY.—From the Latin *procax* (bold, forward, impudent).

HOLOTYPE.—USNM 488673, LV.

TYPE LOCALITY.—USNM locality 9260, Hydra, Greece, 21 Aug 1968.

PARATYPES.—USNM locality 9260, Hydra, Greece 1, 21 Aug 1968: USNM 488674, LV; USNM 488675, RV; USNM 488676, RV; USNM 488677, LV. USNM locality 9260, Hydra, Greece 2, 4 Jul 1974: USNM 488678, LV; USNM 488679, RV (specimen lost).

DIAGNOSIS.—*Thaumatomma* with convex dorsal margin; anteroventral margin terminates at each end in an upper protuberance near contact margin and a larger lower protuberance set back from contact margin; with anterodorsal node (?eye spot); posterodorsal tubercle located at about same height as anterodorsal node and in similar place on each valve; surface with reticulations formed by ridges and weaker cross-ridges; ridges parallel to anteroventral, ventral, and posteroventral margins, then curve around posterodorsal tubercle parallel to posterodorsal, dorsal, and anterodorsal margins; ridges around posterodorsal tubercle form U-shape with open anterior end.

DESCRIPTION.—Valves subovate, dorsal margin convex; anterodorsal margin broadly rounded to where it merges with upper smaller anteroventral protuberance; straight to slightly convex anteroventral margin trends downward and backward, length of anteroventral margin approximately 1/3 the greatest height, makes a distinct angle with larger lower protuberance; ventral margin convex; posterior margin rounded, merges with dorsal margin dorsal to posterodorsal tubercle; dorsal outline subovate; greatest width central, less than greatest height.

Ornamentation: Surface with ridges ventral to anterodorsal node and posterodorsal tubercle, subparallel to anteroventral, ventral, and posteroventral margins, then curve around posterior end of posterodorsal tubercle and parallel dorsal and anterodorsal margins; ridges form U-shape around posterodorsal tubercle with open end of U towards anterior; short cross-ridges between ridges form reticulations. Anterodorsal node (?eye spot) subhemispherical, with indented perimeter. Posterodorsal tubercle small, located about same distance in front of posterior margin and below junction of dorsal and posterodorsal margins. Upper anteroventral protuberance smaller than lower protuberance, located near contact margin; lower anteroventral protuberance located lateral to contact margin by distance of less than protuberance diameter.

Adductor Muscle Attachment Scar: Not visible.

Carapace Size (mm): Holotype, USNM 488673, LV, L = 0.69, H = 0.63, W = 0.32. Paratypes: USNM 488674, LV, L = 0.76, H = 0.72, W = 0.42; USNM 488675, RV, L = 0.72, H = 0.66, W = 0.35; USNM 488676, RV, L = 0.54, H = 0.50, W = 0.28; USNM 488677, LV, L = 0.62, H = 6.5, W not measured; USNM 488678, LV, L = 0.64, H = 0.61, W = 0.29; USNM 488679, RV, L = 0.55, H = 0.51, W = 0.29. Range of length: 0.54–0.76 mm.

COMPARISONS.—*Thaumatomma procax* is close to *T. piscifrons* from which it differs in two characters: (1) the posterodorsal tubercle is located farther from the contact margin, and (2) the surface ridges curve around the posterodorsal tubercle, forming a U-shape with the open end of the U facing towards the anterior. The more or less horizontal ridge just ventral to the posterodorsal tubercle is concave upward on *T. procax,* forming one arm of the U, whereas it is either straight or concave downward on *T. piscifrons. Thaumatomma procax* is without the anteroventral tubercle present on *T. granti. Thaumatomma procax* bears a posterodorsal tubercle not present on *T. elongata, T. permiana,* or *T. newelli. Thaumatomma procax* is without the vertical ridges located posterior to midlength on *T. doescheri.*

Thaumatomma aff. *T. procax*

FIGURE 18

MATERIAL.—USNM locality 9260, Hydra, Greece 2, 4 Jul 1974, USNM 488680, RV.

DIAGNOSIS.—The carapace is similar to that of *T. procax* except that the ridges around the posterodorsal tubercle are not U-shaped (Figure 18*a*). The specimen is left in open nomenclature because it may be a variant of *T. procax.*

Carapace Size: USNM 488680, RV, L = 0.78, H = 0.67, W = 0.32.

Thaumatomma species indeterminate

Twenty-six specimens selected from the collection and studied with the aid of SEM micrographs could not be referred

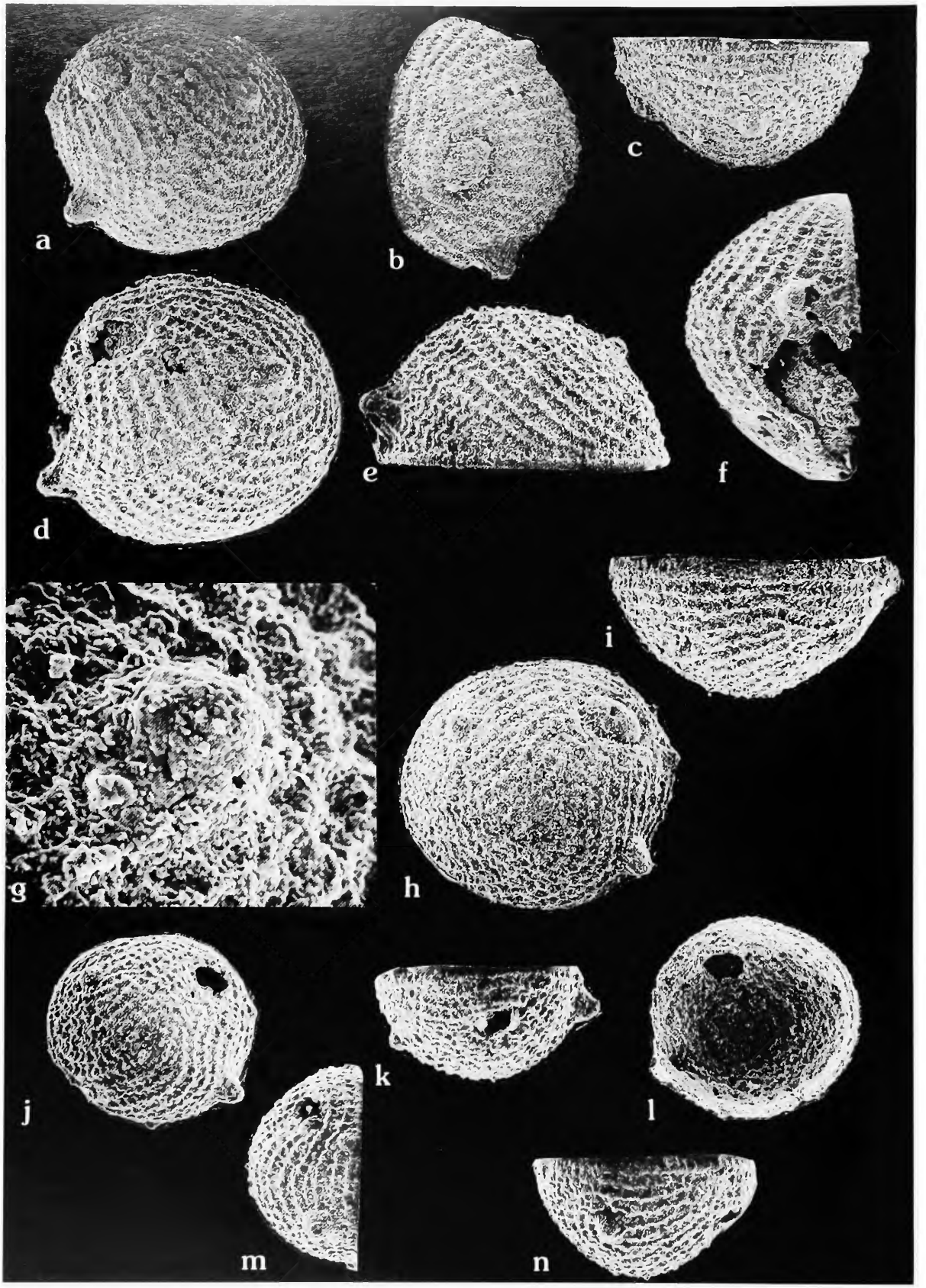

FIGURE 16.—*Thaumatomma procax,* new species: Holotype, USNM 488673, LV, length 0.69 mm: *a–c,* lv, dorsal oblique (anterior to bottom), and dv (anterior to left), respectively (×100). Paratypes: USNM 488674, LV, length 0.76 mm: *d–f,* lv, vv, and av, respectively (×100); *g,* detail from *d* showing posterodorsal tubercle (×500). USNM 488675, RV, length 0.72 mm: *h,i,* lv and dv, respectively (×100). USNM 488676, RV, length 0.54 mm: *j–n,* lv, dorsal oblique, iv, av, dv, respectively (×100). (Micrographs reduced to 67%.)

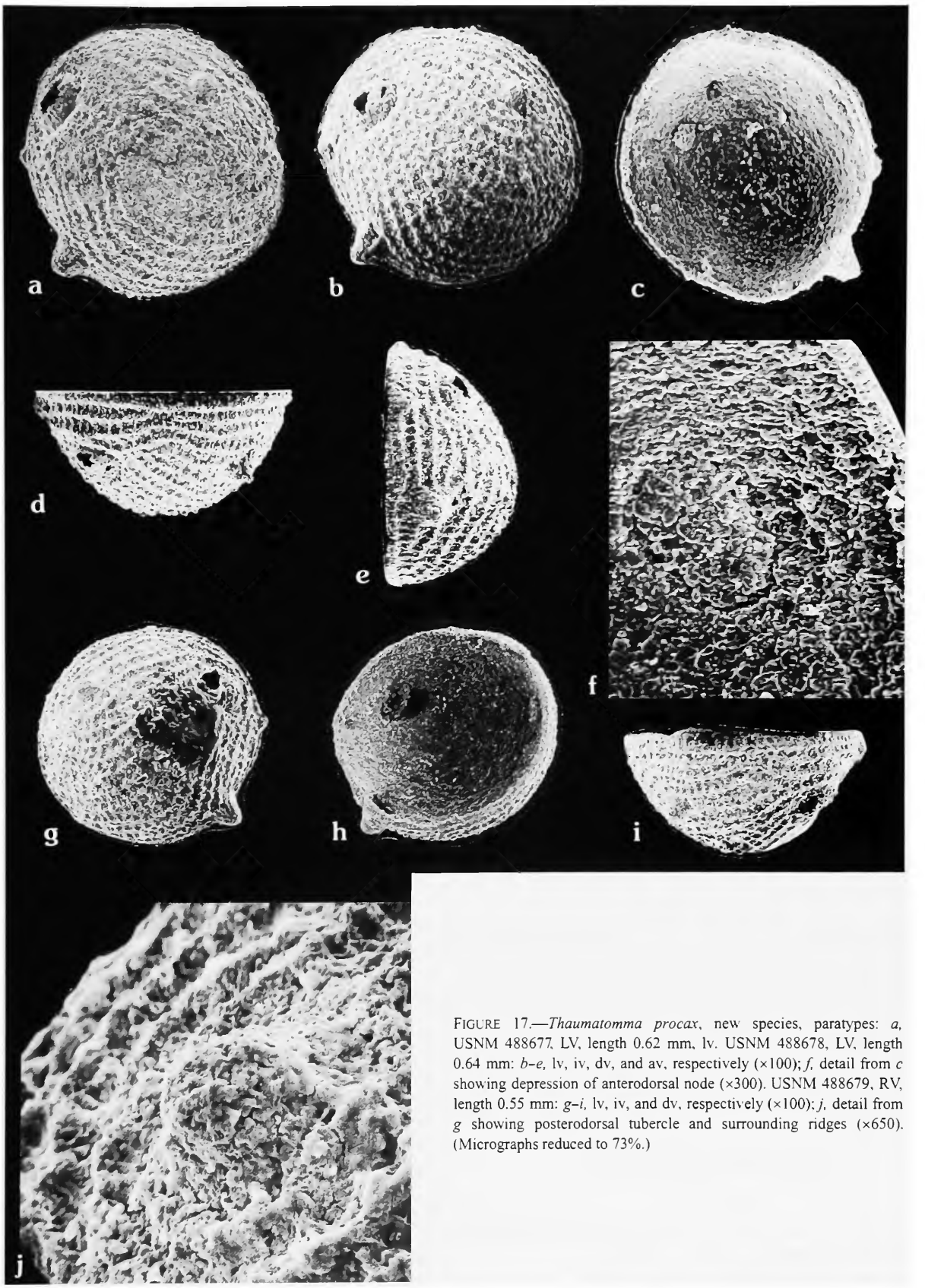

FIGURE 17.—*Thaumatomma procax*, new species, paratypes: *a*, USNM 488677, LV, length 0.62 mm, lv. USNM 488678, LV, length 0.64 mm: *b–e*, lv, iv, dv, and av, respectively (×100); *f*, detail from *c* showing depression of anterodorsal node (×300). USNM 488679, RV, length 0.55 mm: *g–i*, lv, iv, and dv, respectively (×100); *j*, detail from *g* showing posterodorsal tubercle and surrounding ridges (×650). (Micrographs reduced to 73%.)

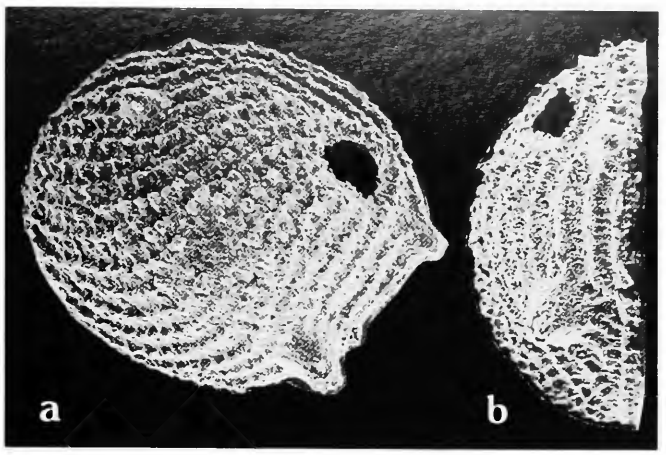

FIGURE 18.—*Thaumatomma* aff. *T. procax*, USNM 488680, RV, length 0.78 mm: *a,b*, lv and av, respectively (×100). (Micrographs reduced to 70%.)

to described species with certainty, mostly because of the poor condition of the specimens. These have been placed in the collection of the Department of Paleobiology, Smithsonian Institution, as *Thaumatomma* sp. indet., so that they will be readily available for future studies.

MATERIAL.—USNM locality 9260, Hydra, Greece 2, 4 Jul 1974: USNM 488681, LV; USNM 488682, RV; USNM 488683, RV; USNM 488684, RV. Greece 1, 21 Aug. 1968: USNM 488685, LV; USNM 488686, RV; USNM 488687, RV; USNM 488688, RV; USNM 488689, RV; USNM 488690, RV; USNM 488691, RV; USNM 488692, RV; USNM 488693, RV; USNM 488694, RV; USNM 488695, RV; USNM 488696, LV; USNM 488697, RV. USNM locality 9262, Hydra, Greece 1, 23 Aug 1968: USNM 488698, RV; USNM 488699, RV; USNM 488700, RV; USNM 488701, LV; USNM 488702, LV; USNM 488703, LV; USNM 488704, RV. USNM locality 9264, Salamis, Greece 1, 31 Aug 1968: USNM 488705, RV.

Suborder CLADOCOPINA Sars, 1866

Superfamily POLYCOPACEA Sars, 1866

Family POLYCOPIDAE Sars, 1866

Subfamily POLYCOPINAE Sars, 1866

Polycope Sars, 1866

TYPE SPECIES.—*Polycope orbicularis* Sars, 1866.

Polycope edithae, new species

FIGURES 19, 20

ETYMOLOGY.—Named in memory of the late Edith Kristan-Tollman, Vienna, Austria.

HOLOTYPE.—USNM 489943, LV.

TYPE LOCALITY.—USNM locality 9260, Greece 2, 4 Jul 1974, Late Permian, Hydra, Greece.

PARATYPES.—USNM locality 9260, Hydra, Greece 2, 4 Jul 1974: USNM 489944, single valve; USNM 489945, RV; USNM 489946, RV (lost); USNM 489947, RV (lost); USNM 489949, complete carapace (lost). USNM locality 9260, Hydra, Greece 3, 21 Jun 1975: USNM 489950, complete carapace (lost). USNM locality 9260, Hydra, Greece 1, 21 Aug 1968: USNM 489948, LV (lost).

ORIENTATION.—Orientation is uncertain. The inside view of Figure 20*d* shows a short straight part along an edge; this part is interpreted herein to be the location of the hinge. The straight part has been placed at the top in Figure 20*d*, and the top is described herein as being dorsal, to conform with descriptions in the literature of many other fossil cladocopids, although the straight part is probably posterodorsal in the living position of cladocopids. The valve is arbitrarily interpreted to be a right valve. The location of ridges on the outside of the valve in Figure 20*a* was used herein to determine the orientation of other illustrated specimens that did not show a short straight section in the valve margin.

DIAGNOSIS.—See "Description," below.

DESCRIPTION.—Carapace subround in lateral view, slightly longer than high; outer surface with ridges and reticulations; ridges with considerable variation in location on different specimens: on some specimens ridges concentric within valve margin (Figure 20*j*), on other specimens ridges parallel to anterior, dorsal, and posterior valve margins; ridges intersect ventral margin (Figure 20*a,e*) and may intersect near dorsal margin at valve midlength (Figure 20*a,c*); reticulations replace ridges in central part of valves; weak cross-ridges form reticulations in peripheral ridges, but cross-ridges not always evident (Figure 20*c*); carapace with greatest width near midlength and midheight; ventral part of valve not as broad as dorsal half in some specimens (Figure 20*b,f*); anteroventral edge with two rows of minute denticles on some specimens (Figure 19).

Carapace Size (mm): Holotype, USNM 489943, LV, L = 0.55, H = 0.51, width unknown. Paratypes: USNM 489944 (single valve), L = 0.65, H = 0.62, width unknown; USNM 489946, RV, L = 0.59, H = 0.55, W = 0.19; USNM 489947, RV, L = 0.73, H = 0.66, W = 0.18; USNM 489948, LV, L = 0.59, H = 0.53, W = 0.21; USNM 489949 (complete specimen), L = 0.64, H = 0.60, W = 0.37; USNM 489950 (complete specimen), L = 0.49, H = 0.44, W = 0.34. Range of length: 0.49–0.73 mm.

COMPARISONS.—The ornamentation on the carapace of *C. edithae* strongly resembles that of a paratype of *Discoidella convexa* Scott and Borger, 1941, from the Upper Pennsylvanian in Illinois, U.S. (Sohn, 1993, fig. 2:5–9). That specimen was referred to *Permopolycope? convexa* (Scott and Borger, 1941) by Sohn (1993:68). Kozur (1985b, pl. 1: fig. 2; table 1) reported *Discoidella convexa* Scott and Borger, 1941, from the

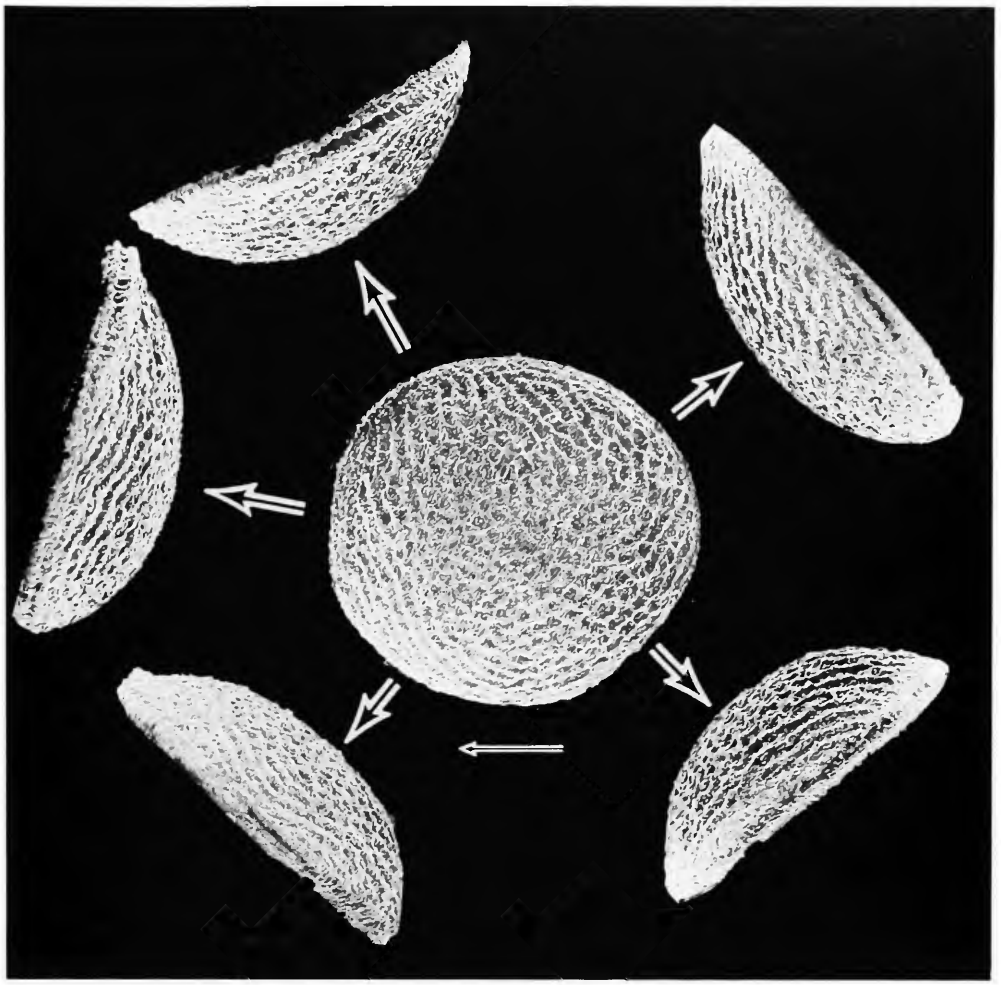

FIGURE 19.—*Polycope edithae,* new species, paratype, USNM 489946, RV, length 0.59 mm (×100), lateral view of valve in center and end views in circle. (Appearances of valve when viewed from ends are indicated by arrows.) (Micrographs reduced to 85%.)

Upper Pennsylvanian of Hungary. Sohn (1993:69) incorrectly assigned this form to the Upper Permian. The SEM micrograph showing a posterior view of the paratype of *P.*? *convexa* illustrated by Sohn (1993, fig. 2:7) shows three ridges that are parallel to the valve margin intersected by ridges at steep angles. Examination of the illustrated SEM micrographs of the Permian specimens from Greece do not show similarly intersecting ridges. Considering the different ages of the localities and the long distance between them, we deemed it expedient to separate the species on this small character difference.

The valve of *D. convexa* from the Upper Pennsylvanian of Hungary illustrated by Kozur (1985b, pl.1: fig. 2) appears to be more coarsely reticulated than that of *P. edithae.* Sohn (1993:69) previously stated that the valve illustrated by Kozur had ornamentation unlike that of the holotype and paratypes of *D. convexa.*

Discoidella suprapermiana Kozur (1985a:4, pl. 1: fig. 3a,b) and *Permopolycope buckkensis* Kozur (1985a:6, pl. 1: fig. 5) from the Permian of Hungary are more coarsely reticulated than *P. edithae.*

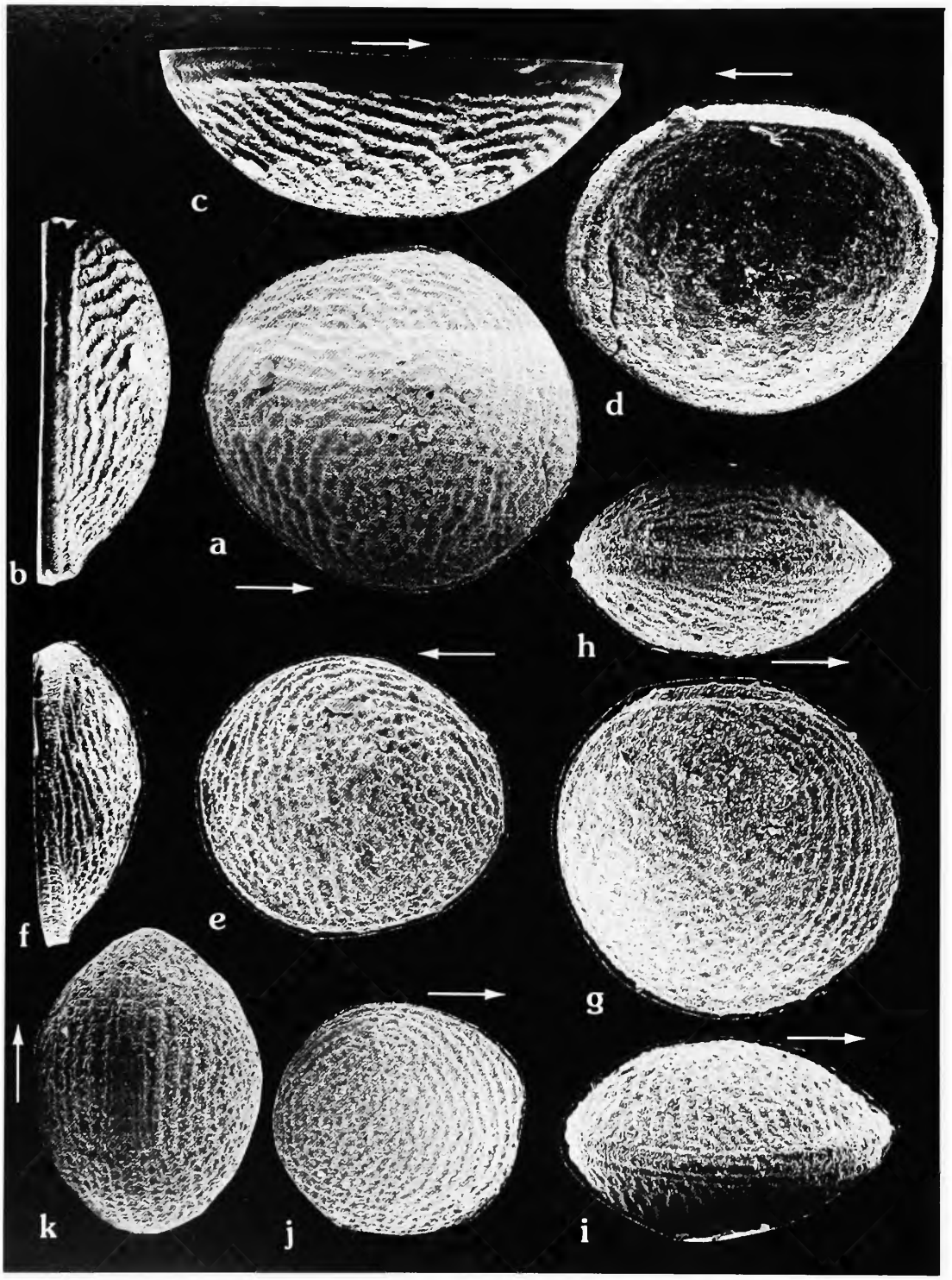

FIGURE 20.—*Polycope edithae,* new species, paratypes: *a–d,* USNM 489947, RV, length 0.73 mm, lv (×100), pv (×110), dv (×130), and iv (×100), respectively (small object on dorsal edge of valve shown in *d* is foreign). *e,f,* USNM 489948, LV, length 0.59 mm, lv and av, respectively (×100). *g–i,* USNM 489949, complete carapace, length 0.64 mm, lv (×105), dv (×105), and vv (×100), respectively. *j,k,* USNM 489950, complete carapace, length 0.49 mm, lv and dv, respectively (×100). (Micrographs reduced to 80%.)

Literature Cited

Aubrecht, R., and H. Kozur

1995. *Pokornyopsis* (Ostracoda) from Submarine Fillings and Cavities in the Late Jurassic of Czorsztyn Unit and the Possible Origin of the Recent Anchialine Faunas. *Neues Jahrbuch für Geologie und Paläontologie,* 196(1):1–17, figures 1–8.

Baltanás, A., and D.L. Danielopol

1995. Cladistic Analysis of *Danielopolina* Species (Ostracoda, Thaumatocyprididae) and the Origin of the Anchialine Fauna. *In* D. Keyser and R. Whatley, editors, Zur Zoogeographie und Systematik insbesondere der Polychaeten und Ostracoden. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut,* 92:315–324, figures 1–2, tables 1–2.

Bartenstein, H.

1949. *Thaumatocypris bettenstaedti* n. sp. aus dem nordwestdeutschen Lias zeta (Ostracoda). *Senckenbergiana,* 30(1/3):95–98, figure 1.

Breman, E.

1980. Differential Distribution of Left and Right Ostracode Valves in the Adriatic Sea. *Paleogeography, Palaeoclimatology, Paleoecology,* 32:135–141.

Dana, J.D.

1853. Tribe III: Cyproidea = Ostracoda. In *United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842, under Command of Charles Wilkes, U.S.N., with Atlas of 96 plates.* Volume 13 (Crustacea), part 2, pages 1277–1304, plates 90, 91. Philadelphia: C. Sherman.

Danielopol, D.L.

1972. Sur la présence de *Thaumatocypris orghidani* n. sp. (Ostracoda-Myodocopida) dans une Grotte de Cuba. *Comptes Rendus Academie des Sciences* (Paris), series D, 274:1390–1393, figures A–D.

Erwin, D.H.

1993. The Great Paleozoic Crisis: Life and Death in the Permian. In *Critical Moments in Paleobiology and Earth History Series,* 327 pages, figures 1–5, 1.1–10.6. New York: Columbia University Press.

Grant, R.E.

1972. The Lophophore and Feeding Mechanism of the Productidina (Brachiopoda). *Journal of Paleontology,* 46(2):213–248, figures 1–12, plates 1–9.

1993. The Brachiopod Family Gemmellaroiidae. *Journal of Paleontology,* 67(1):53–60, figures 1–7.

Grant, R.E., M.K. Nestell, A. Baud, and C. Jenny

1991. Permian Stratigraphy of Hydra Island, Greece. *Palaios,* 6:479–497, figures 1–7, tables 1–2.

Hartmann, G.

1985. *Danielopolina wilkensi* n. sp. (Halocyprida, Thaumatocyprididae), ein neuer Ostracode aus einem marinen Lava-Tunnel auf Lanzarote (Kanarische Inseln). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut,* 82:255–261, figures 1–7.

Herrig, E.

1964. Vier neue Ostracoden-Arten aus der Rügener Schreibkreide (Unter-Maastricht). *Geologie,* 13(8):1004–1012, 4 figures.

Kesling, R.V.

1954. Oncotechmoninae: A New Subfamily of Entomoconchid Ostracods from the Middle Devonian of New York. *Journal of Paleontology,* 28(5):575–580, plate 59, 1 text figure.

Kornicker, L.S.

1985. *Thaumatoconcha porosa,* a New Species of Abyssal Ostracode from the Indian Ocean (Halocyprida: Thaumatocyprididae). *Proceedings of the Biological Society of Washington,* 98(4):1012–1021, figures 1–4.

1992. *Thaumatoconcha pix,* a New Bathyal and Abyssal Species from off SE Australia and NE Tasmania (Crustacea: Ostracoda: Thaumatocyprididae). *Proceedings of the Biological Society of Washington,* 105(2):233–239, figures 1–3.

Kornicker, L.S., and M.V. Angel

1975. Morphology and Ontogeny of *Bathyconchoecia septemspinosa* Angel, 1970 (Ostracoda: Halocypridae). *Smithsonian Contributions to Zoology,* 195: 121 pages, 14 figures, 2 tables.

Kornicker, L.S., and T.M. Iliffe

1989a. New Ostracoda (Halocyprida: Thaumatocyprididae and Halocypridae) from Anchialine Caves in the Bahamas, Palau, and Mexico. *Smithsonian Contributions to Zoology,* 470: 47 pages, 22 figures, 8 tables.

1989b. Troglobitic Ostracoda (Myodocopa: Cypridinidae, Thaumatocyprididae) from Anchialine Pools on Santa Cruz Island, Galapagos Islands. *Smithsonian Contributions to Zoology,* 483: 38 pages, 17 figures, 13 tables.

1992. Ostracoda (Halocypridina, Cladocopina) from Anchialine Caves in Jamaica, West Indies. *Smithsonian Contributions to Zoology,* 530: 22 pages, 11 figures, 1 table.

1995. Ostracoda (Halocypridina, Cladocopina) from an Anchialine Lava Tube in Lanzarote, Canary Islands. *Smithsonian Contributions to Zoology,* 568: 32 pages, 16 figures, 1 table.

1998. Myodocopid Ostracoda (Halocypridina, Cladocopina) from Anchialine Caves in the Bahamas, Canary Islands, and Mexico. *Smithsonian Contributions to Zoology,* 599: 93 pages, 64 figures, 2 maps, 9 tables.

Kornicker, L.S., and I.G. Sohn

1976a. Evolution of the Entomoconchacea. *In* Gerd Hartmann, editor, International Symposium on Evolution of Post-Paleozoic Ostracoda. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut,* 18/19(supplement):55–61, 2 figures, 3 plates.

1976b. Phylogeny, Ontogeny, and Morphology of Living and Fossil Thaumatocyprididae (Myodocopa: Ostracoda). *Smithsonian Contributions to Zoology,* 219: 124 pages, 92 figures, 14 tables.

Kozur, H.

1974. Eine neue Gattung der Familie Polycopidae (Cladocopida, Ostracoda). *Zeitschrift für Geologische Wissenschaften* (Berlin), 2(7):853–855.

1985a. Neue Ostracoden-Arten aus dem Oberon Mittelkarbon (Höheres Moskovian) Mittel- und Oberperm des Bükk-Gebirges (N-Ungarn). *Geologisch-Paläontologische Mitteilungen* (Innesbruck), 2 (special volume): 145 pages, 22 plates.

1985b. Biostratigraphic Evaluation of the Upper Paleozoic Conodonts, Ostracods, and Holothurian Sclerites of the Bükk Mts, Part 2: Upper Paleozoic Ostracods. *Acta Geologica Hungarica,* 28(3–4): 225–256, 13 plates.

Monostori, M.

1995. Bajocian Ostracods from the Som Hill (Bakony Mts, Hungary). *Hantkeniana* (Budapest), 1:155–161.

Müller, G.W.
1906. Ostracoda. In *Wissenschaftliche Ergebnisse der Deutsche Tiefsee-Expedition ... 1898–1899,* 8(2): 154 pages, 31 plates.

Nakazawa, K., K. Ishii, M. Kato, Y. Okimura, K. Nakamura, and D. Haralambous
1975. Upper Permian Fossils from the Island of Salamis, Greece. *Memoirs of the Faculty of Science, Kyoto University,* Geology and Mineralogy Series, 16(2):21–44, 3 plates.

Neale, J.W.
1983. Geological History of the Cladocopina. *In* R.F. Maddocks, editor, *Applications of Ostracoda: Proceedings of the Eighth International Symposium on Ostracoda July 26–29, 1982,* pages 612–626, figures 1–5. Houston, Texas: Department of Geosciences, University of Houston, University Park.

Pennak, R.W.
1964. *Collegiate Dictionary of Biology.* 583 pages. New York: The Ronald Press Company.

Sars, G.O.
1866 ("1865"). Oversigt af Norges Marine Ostracoder. *Forhandlinger i Videnskabs-Selskabets, i Christiania,* 7: 130 pages. [Preprint, 1865.]

Scott, H.W., and H.D. Borger
1941. Pennsylvanian Ostracodes from Lawrence County, Illinois. *Journal of Paleontology,* 15:354–358.

Sohn, I.G.
1993. The "Ostracode" Genus *Discoidella* Croneis & Gale, 1939, Is Not a Bivalve. *In* K.G. McKenzie and P.J. Jones, editors, *Ostracoda in the Earth and Life Sciences,* pages 65–76, figures 1, 2. Rotterdam, Netherlands: A.A. Balkema.

Triebel, E.
1941. Zur Morphologie und Okologie der fossilen Ostracoden: Mit Beschreibung einiger neuer Gattungen und Arten. *Senckenbergiana,* 23(4/6):294–400, figures 1–2, plates 1–15.

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