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Fishes living in deepsea thermal vents in the tropical eastern Pacific, with descriptions of a new genus and two new species of eelpouts (Zoarcidae)

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Abstract. A new genus and two new species of zoarcid fishes are described from deep sea hydrothermal vent systems in the eastern Pacific. The new genus *Thermarces* is distinguished from other zoarcids by reduction of suborbital bones to one or two, unossified pectoral radials, and lack of fourth infrapharyngobranchial bone, postcleithrum, scales and pelvic fins. One species of the genus has been taken at 21°N, 109°W, and near the Galápagos Islands, the other at 12°48′N, 104°W. The new species are diagnosed and described. The otoliths examined show clear growth rings.

The objectives of this paper are to distinguish so far as possible the various fishes known to live in warm water vented from deepsea springs in the tropical eastern Pacific. Two species of eelpouts appear to be heretofore unknown, and we describe them here.

One so-called vent fish that has been observed and photographed from the submersible ALVIN in and near vents along the Galápagos Rift was referred by Cohen and Haedrich (1983) to the genus *Diplacanthopoma* of the ophidiiform family Bythitidae (Cohen and Nielsen 1978). Photographs of the same or a similar form taken by Harmon Craig, Scripps Institution of Oceanography (SIO) from ALVIN at a vent system at 10°57′N, 103°41′W have been seen by us, and Robert R. Hessler, SIO, has seen small individuals at 13°N from CYANA. No bythitid fish has yet been seen at 21°N despite extensive observations. As of this writing specimens have not been captured, and the species is not further discussed in the present paper.

The Zoarcidae, or eelpout family, also includes species of vent-associated fishes. At the Galápagos Rift vent area, eelpouts are cryptic and have been questionably identified from ALVIN only twice; however, two species are common in time-lapse photographs (Cohen and Haedrich 1983). Two specimens have been captured, one a relatively large, light-brown individual taken in a trap; the other, a smaller, pale fish, was washed from ALVIN after the submersible surfaced. The two specimens have very similar counts and head pore patterns. At 21°N a pale zoarcid was observed to be common in warm water. Several specimens were captured incidentally, and enzyme activities were described by Hand and Somero (1983). We have also examined two pale specimens trapped among pogonophorans by a French expedition working at vents near 13°N, where eelpouts were common.

Recently a sulfide-rich area with a community having many features of the Pacific vent communities has been discovered off the Florida escarpment (Paull et al. 1984). Color photographs seen by us show an elongate, pale fish on the bottom, certainly a zoarcid, and with a considerable general resemblance to our new genus. However, neither specimens nor close-up pictures are available.

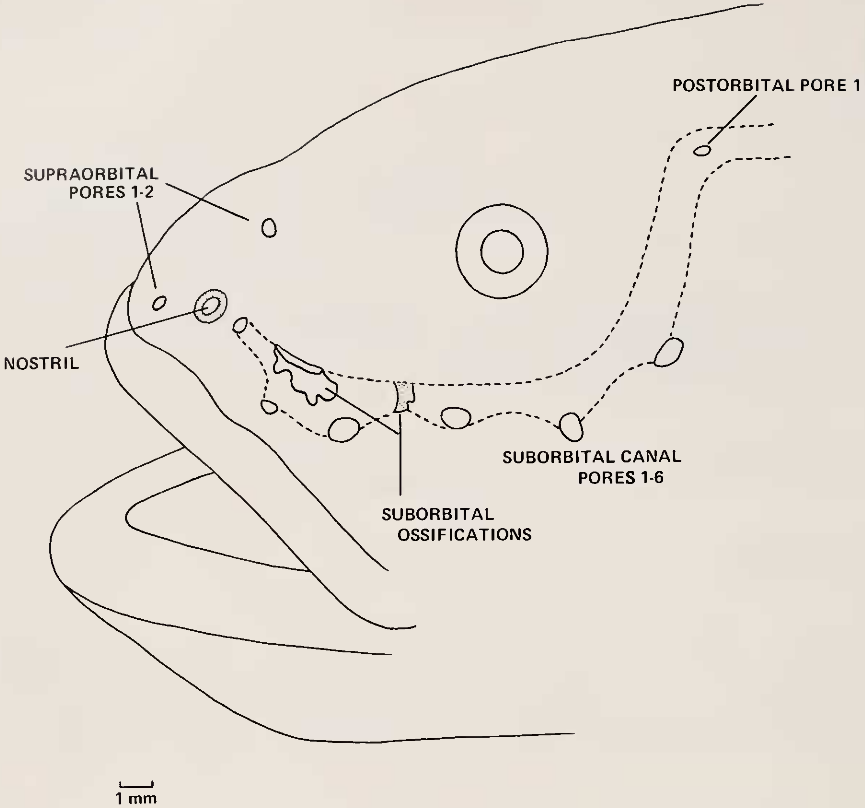

FIGURE 1. *Thermarces cerberus* new species (SIO82–46). Lateral view of left side of head showing suborbital canal and ossifications (posterior ossification actually present on right side only), suborbital pores, and first preorbital pore.

We have been unable to place our zoarcid material in a genus or species. The specimens cannot be included in any genus as presently defined. We have had more success in referring our material with the aid of a Ph.D. dissertation by Eric Anderson (1984).

Although all eight of our specimens have approximately similar counts, one is notably different from the others in its light-brown color, and in having scales, vestigial pelvic fins, and a long tail (62% SL). This specimen was captured in a baited trap and photographed in the general area of one of the Galápagos vents where, although cryptic in habit, the species is apparently abundant (Cohen and Haedrich 1983). It may represent an undescribed species of *Pachycara* Zugmayer, 1911 (M. E. Anderson *personal communication*). Because this species is not known to occur in warm water and because our single example is in poor condition, we are not able to comment further upon it.

Our other seven specimens, all directly or indirectly associated with warm water, are pale, lack scales and pelvic fins, and have short tails (48.9 to 54.8% SL). These fishes do not fall within the bounds of any zoarcid genus as defined by Anderson (1984), and we place them in a new genus that agrees in part with *Pachycara*. The measurements as given in Table I are self-explanatory. Head-pore terminology is that of Gosztonyi (1977). Fin rays and vertebrae were determined from radiographs. Description of cranial osteology is based on a trypsin-cleared preparation stained for cartilage and bone.

Thermarces new genus

Type species.—*Thermarces cerberus*, new species.

Diagnosis.—Lycodine zoarcids with precaudal vertebrae 29–31, total vertebrae,

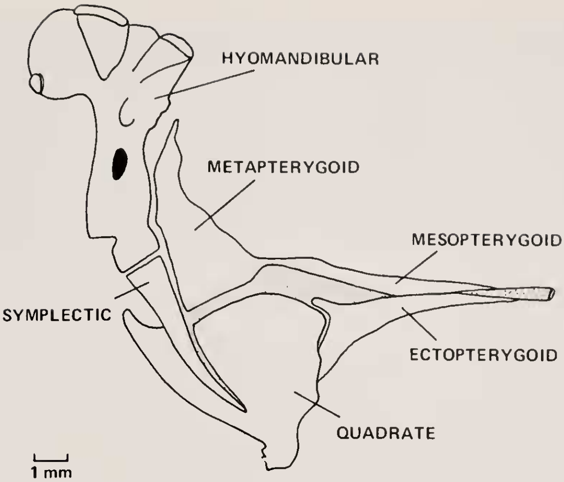

FIGURE 2. *Thermarces cerberus* new species (SIO82–46). Lateral view of right suspensorium.

94–97; suborbital bones 1 or 2; ectopterygoid in contact with a small area of the quadrate, and mesopterygoid with no contact; pectoral radials 4, unossified; postcleithrum lacking; infrapharyngobranchials 2; pelvic bone and fin rays lacking; no scales, no body lateral line.

Description. — Body relatively deep, 9.8–13.4% standard length; tail relatively short, 48.9–55% standard length; snout blunt and rounded, with subterminal jaws. Scales lacking.

Ventral face of dentary lacking cartilaginous ridges (mental crests of Anderson 1984). Pseudobranch reduced to a continuous membrane with several small nubbins. Infrapharyngobranchials with ossified tooth plates on arches two and three only.

Suborbital bones one or two (Fig. 1), no cartilaginous elements; a slight, irregular ossification roofs the sensory canal dorsal to pore number 2. There is also a slight ossification on the medial wall of the canal midway between pores 3 and 4 on the right side of the specimen but not on the left (shown on the left in Fig. 1).

Abdominal vertebrae 29–32; total vertebrae 94–97.

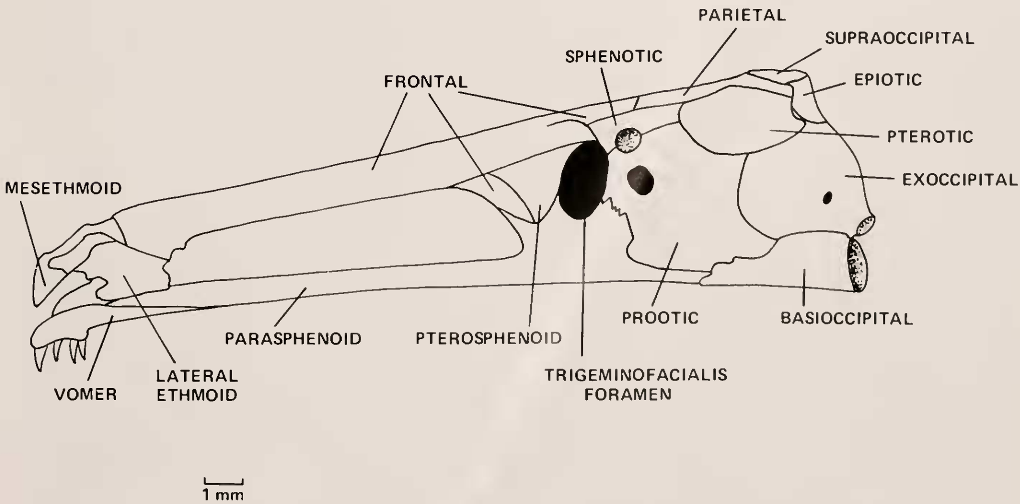

FIGURE 3. *Thermarces cerberus* new species (SIO82–46). Lateral view of left side of cranium. Ossification is thin, location of sutures approximate and based on a single specimen.

FIGURE 4. *Thermarces cerberus* new species, holotype.

Ectopterygoid a slender splint anteriorly, expanded posteriorly but in contact with no more than the dorsal section of the leading edge of the quadrate (Fig. 2). Mesopterygoid represented by a long, tissue-thin ossification in a band of cartilage, narrowly connected with metapterygoid posteriorly. Nearly all of dorsal margin of quadrate bordered by cartilage, except at the extreme anterior end where a narrow, ossified lappet extends posteriorly from the ectopterygoid.

Pectoral girdle with cleithrum well-ossified, scapula and coracoid poorly ossified and tissue-thin, radials unossified and scarcely visible; postcleithrum lacking.

Pelvic fin rays and pelvic bone lacking.

Ascending wing of parasphenoid not reaching mid-height of trigeminofacialis foramen, pterosphenoid not separating frontal and parasphenoid (Fig. 3).

Etymology.—The name *Thermarces* is derived from the Greek *thermos,* heat, and the generic name *Zoarces,* the type genus of the family.

Discussion.—Most of the diagnostic characters presented above are reductional. *Thermarces* could be a derivative of a *Pachycara*-like fish. It shares with *Pachycara* the following characters: body robust; tail short; mental crests absent; parasphenoid wing below mid-height of trigeminofacialis foramen; abdominal vertebrae 26–32; pseudobranch filaments 0–6; head blunt and rounded (characters for *Pachycara* from Anderson 1984).

Thermarces cerberus new species
Figures 4, 5

Description.—Counts and measurements are given in Table I. Head and body laterally compressed, body width contained about twice in depth at mid-trunk, about 7 in depth just before caudal fin. Head and trunk slightly shorter than tail. Head 1.8 in trunk (1.4 in small Galápagos specimen). Eye small, covered by skin, 4.5–5 in snout (4 in smallest specimen). Mouth terminal, moderately oblique, anterior tip of mandible well above mandibular symphysis; jaws subequal. Lips distinct, thick and fleshy, continuous and smooth. Oral valves obsolete. Nostril in a short tube, which does not reach upper lip. Head pores large and conspicuous. Occipital pores absent, suborbital 6, supraorbital 2, postorbital 2, preopercular 4, mandibular 4 (symphysial pores closely opposed).

Teeth in both jaws stout, conical and pointed. Dentary teeth in a triserial patch

TABLE 1. Counts, and measurements in millimeters of *Thermarces*. Proportions in thousands of Standard length, or, for measurements below Head length, in that dimension, are in parentheses.

	T. cerberus						*T. andersoni*	
Character	Holoytpe SIO81-155	SIO81-155		LACM 43719-1	LACM 43531-1	$\bar{x} \pm$ SD	Holotype MNHM 85-400	MNHM 85-401
Total length	259 ♀	244 —	181 ♂	232 ♀	127 ?		272 ♀	249 ♂
Standard length	250	232	174	218	122		261	239
Preanal	128.5 (514)	114 (491)	81.6 (469)	113.5 (520)	56.1 (460)		139 (533)	113 (472)
Body depth at anus	32.3 (129)	—	22.9 (132)	23.0 (106)	13.3 (109)		36.4 (139)	28.6 (120)
Head length	45.5 (182)	42.0 (181)	30.9 (178)	38.6 (177)	22.9 (189)		50.2 (192)	47.9 (200)
Body width	15.9 (349)	11.9 (283)	9.6 (311)	13.0 (366)	5.9 (258)		24.0 (478)	19.9 (415)
Head depth at occiput	27.0 (593)	24.4 (580)	17.9 (580)	22.2 (575)	11.7 (511)		33.7 (671)	30.0 (626)
Snout	15.9 (349)	14.4 (343)	9.9 (320)	13.4 (347)	7.9 (345)		17.6 (351)	15.9 (332)
Upper jaw	19.4 (426)	16.9 (402)	12.2 (395)	15.8 (409)	8.9 (389)		19.9 (396)	21.4 (447)
Eye	2.5 (55)	2.5 (60)	1.9 (61)	2.4 (62)	2.0 (87)		4.5 (90)	3.9 (81)
Nostril-orbit	11.7 (257)	10.5 (250)	7.4 (239)	9.9 (256)	5.9 (258)		10.5 (209)	10.9 (228)
Gill opening	16.9 (371)	12.9 (307)	11.4 (369)	13.2 (341)	6.2 (271)		18.2 (363)	15.2 (317)
Pectoral length	17.4 (382)	17.4 (414)	13.0 (421)	17.5 (453)	12.5 (545)		19.9 (396)	20.1 (420)
Dorsal	89	90	87	88	90	88.9 ± 1.3	89	89
Anal	66	67	69	67	69	67.6 ± 1.3	64	65
Pectoral	13	13	13	13	12	13.2 ± 0.45	12	12
Vertebrae	30 + 65	32 + 65	30 + 65	31 + 65	29 + 65	95.4 ± 1.1	30 + 66	31 + 64
Caudal	6 + 5	6 + 5	6 + 5	6 + 5	6 + 5		6 + 4	6 + 4
Gill-rakers	1-1-14	—	—	1-1-14	1-1-14		1-1-13	1-1-13

FIGURE 5. Otoliths of *Thermarces cerberus* new species, from a 244 mm paratype, SIO81-155. Upper, right otolith, inner face; lower, left otolith, outer face.

FIGURE 7. *Thermarces cerberus in situ* near the type locality. In the foreground the vestimentiferan worm *Riftia* and part of the submersible ALVIN.

FIGURE 8. Otolith of *Thermarces cerberus*, same data as Figure 5, viewed in transmitted light.

anteriorly and a single posterior row. Teeth of upper jaw uniserial except for a few slightly enlarged teeth in outer row at symphysis. Vomer with patch of about 15 teeth, autopalatines with a row of about a dozen teeth. Teeth in roof of mouth about as large as largest jaw teeth. Gill openings relatively unrestricted, ending about at level of lower

FIGURE 6. *Thermarces andersoni* new species, holotype.

end of pectoral base, about 3 in head. Isthmus width slightly less than gill-opening length. Gill rakers 1-1-14 on first arch, rakers short but flattened, some on ceratobranchial with pair of teeth at tip. Gill filaments well-developed, about 3 in snout. Pectoral fin small, rounded, its base about 2.2 in gill opening, its length about 0.8 in snout. Pectoral rays covered by thick skin. Vertical fins relatively well-developed, covered by skin. Dorsal origin obscure, on radiographs seen to be between sixth and seventh vertebrae. Caudal pointed, with 6 + 5 rays. Dorsal and anal rays mostly unbranched. Color *in situ* pale. Freshly dead individuals white with pink suffusion, dark peritoneum showing through body wall. Holotype with a series of dark flecks along dorsum, beginning just behind head. Paratypes from SIO81-155 with a few melanophores scattered on the dorsum. Body otherwise immaculate. Peritoneum dusky.

Etymology.—Cerberus is the dog-like monster which in Greek mythology guards the gates of Hades.

Holotype.—SIO81-155, a 259 mm SL ♀ with ripening eggs. Taken off Mexico at 20°51′N, 109°04′W, at a hydrothermal vent site in 2600 m by Expedition "Pluto," leg 4, ALVIN Dive 1157 on 21 November 1981. The specimen was found accidentally trapped in the conning tower of the submersible ALVIN, and returned to Scripps Institution of Oceanography by Harmon Craig.

Paratypes.—SIO81-155, collected with, and bearing the same data as the holotype 2(181–244). Natural History Museum of Los Angeles County, LACM43719-1, formerly SIO82-45, off Mexico at 20°49.05′N, 109°06.40′W at a hydrothermal vent site, at 2600 m on 20 April 1982 by Expedition "Oasis," station 1214–4. Found in the conning tower of the submersible ALVIN and returned to SIO by Robert R. Hessler.

Additional material.—SIO82-46. Same data as SIO82-45, but taken on 14 May 1982 from a pipe draining sail of ALVIN. 1, head and part of trunk. Cleared and stained. LACM43531-1, Galápagos Rift zone, from conning tower of ALVIN, 22 August 1977.1(127).

Thermarces andersoni new species
Figure 6

Description.—Counts and measurements are given in Table 1. *Thermarces andersoni* is similar to *T. cerberus* in most respects, and characters in agreement are not repeated here. Head and body compressed, but robust, head 1.4 in trunk. Eye small 3.3–3.5 in snout. Gill opening 2.75 in head in holotype, 3.0 in paratype. Isthmus width equal to gill opening. Most dorsal and anal rays branched, dorsal rays branched for about one-half their length, anal rays branched for one-third to one-half their length.

Color of freshly dead individuals pale, belly dark. Body, fins and dorsal part of head flecked and mottled with brown. Peritoneum of holotype pale, that of paratype blotched with pigment, mostly dorsally. Photographs of three fresh individuals supplied by R. R. Hessler show a dark belly, indicating a dark peritoneum.

Holotype.—Museum National d'Histoire Naturelle, MNHN 1985-400, CENTOB, BIOCYATHERM, DIVE 82-35. A 272 mm ♀ taken in an amphipod trap at 12°48.85′N, 103°56.60′W on 12 March 1982 at 2620 m depth, by the submersible CYANA.

Paratype.—MNHN 1985-401, a 249 mm ♂ taken with the holotype.

Etymology.—Named for M. Eric Anderson, student of zoarcids, who freely shared his knowledge with us.

Comparison.—*Thermarces andersoni* is similar to *T. cerberus* in many respects, including meristics. It differs most notably in the more robust head and body, a larger eye, and in coloration. Also, there appears to be a difference in number of anal, and possibly caudal, rays (Table 1).

Due to the small number of available specimens, the morphological differences, though readily apparent, are difficult to establish and validate through measurement. However, Table 1 shows that the values for Body Width and Head Depth for the *Thermarces andersoni* specimens are higher, and well outside the range for the five specimens of *T. cerberus.* The eye of the types of *T. andersoni* is proportionately larger than in the comparably sized specimens of *T. cerberus.* The smallest specimen of *T. cerberus* (127 mm) does have an eye which is proportionately as large as that of the much larger type specimens of *T. andersoni,* but typically the eye exhibits negative allometry.

The specimens of *Thermarces andersoni* are much more heavily pigmented, especially about the head, body and fins, than are those of *T. cerberus,* which are almost completely colorless, with at most a few flecks of pigment on the dorsum.

The differences in coloration and body shape are not sexual, as males and females are represented in both species. Nor is it likely that the *andersoni* types represent the chance capture of two rare variants. Color slides of three additional *Thermarces andersoni* from 13°N supplied by Robert Hessler show individuals closely resembling the types in having a robust body and being relatively heavily pigmented. It thus appears that the type material of *T. andersoni* fairly represents the population at 13°N.

The two nominal species will probably be found to differ also in number of anal rays. The range for *Thermarces cerberus* is 66–69, $\bar{x}$ 67.6, SD 1.3. The holotype of *T. andersoni* has 64 and the paratype 65. The available material also differs in number of caudal rays, 10 in *T. andersoni* and 11 in *T. cerberus.*

Natural History

Individuals of *Thermarces cerberus* are commonly seen near vents, either in the open, or nestled among mussels or clams. Their relative abundance in some places is shown in Figure 7. Hand and Somero (1983) have noted that the activity of the enzymes lactate dehydrogenase and pyruvate kinase in white muscle of *T. cerberus* is the highest thus far measured for a deepsea fish, and "within the range noted for many shallowliving demersal species." The ability to sustain a high metabolic activity was attributed to the food-rich environment of the vents.

We examined the stomach contents of two *Thermarces cerberus.* One contained 5 white trochiform snails (undescribed) about 7 mm diameter. The other contained two lysionassid amphipods (undescribed), and a moss-green material with a strong sulfurous smell that proved to be from the trophosome of the pogonophoran *Riftia pachyptila.* The trophosome contains a large number of symbiotic sulfur-oxidizing bacteria (Cavanaugh 1983). A radiograph of the holotype shows that there are two snails in the intestine and another in the pharynx.

The pogonophoran is in a stout tube which should deny small fishes access to its soft parts. However, the submersible ALVIN had been lying on the bottom while an experiment was being performed and had undoubtedly crushed numerous worm tubes making an otherwise inaccessible food available. That a probably unaccustomed prey was taken indicates a generalized feeding habit. Moreover the fact that *Riftia,* which may have concentrations of up to 1.1 mM hydrogen sulfide in the blood (Arp and Childress 1983) was eaten, indicates a considerable tolerance for this poison by *Thermarces cerberus.*

There is less information available concerning *Thermarces andersoni.* The types were trap-caught, and the stomach of the paratype proved to be empty. The trap entered was baited with fish, which may also indicate a generalized food habit for this species.

Otoliths were removed from four specimens of *Thermarces cerberus.* All show clear and opaque bands (Fig. 8). Given the limited nature of the material it would be premature to ascribe significance to the banding, but it is suggestive that otoliths from the three large specimens (250, 244, 239 mm) have two clear zones and that of a smaller one (181 mm) has but one.

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