



## A new species of *Pachycara* Zugmayer, 1911 (Teleostei: Zoarcidae) from deep-sea chemosynthetic environments in the Caribbean Sea

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### Abstract

The 28<sup>th</sup> species of the eelpout genus *Pachycara* Zugmayer, 1911, is described from specimens collected from an active hydrothermal vent field at a depth of about 2300 m at the Mid-Cayman Spreading Centre of the Caribbean Sea. A tentatively identified early juvenile is recorded at a methane seep at a depth of 1049 m near Tobago. The new species is distinguished from its congeners mainly by its few pectoral fin rays, low vertebral counts, single, mediolateral branch of the lateral line system and presence of scales on the nape and cheeks.

**Key words:** Zoarcidae, *Pachycara*, eelpout, Caribbean Sea, Mid-Cayman Spreading Centre, hydrothermal vents, methane seep

### Introduction

Eelpouts of the genus *Pachycara* are found from upper bathyal to abyssal depths in all oceans except the Arctic (Anderson, 1989, 1994). Anderson (2012) reviewed the systematic history of the genus and named the 26<sup>th</sup> known species. The 27<sup>th</sup> species was recently described from the southwestern Pacific (Corbella & Møller, 2014).

Zoarcid fish resembling the genus *Pachycara* were observed in the first video images obtained from the Von Damm Vent Field on the Mid-Cayman Spreading Centre of the Caribbean Sea in April 2010 (Connelly *et al.*, 2012). In February 2013, research cruise JC82 of the UK research ship *RRS James Cook* collected the first specimen of a *Pachycara* species from the Von Damm Vent Field at a depth of about 2300 m (Fig. 1). Two further specimens were collected from the Von Damm Vent Field in August 2013 during a research cruise of the US research ship *EV Nautilus*. In October 2014 an early juvenile we tentatively identify as conspecific with the three new specimens was collected by the *EV Nautilus* from a methane seep at a depth of 1049 m near Tobago (Fig. 1).

The purpose of these research cruises was to study the ecology and biogeography of deep-sea chemosynthetic environments in the Caribbean. This paper describes the 28<sup>th</sup> species of *Pachycara*, which is the 4<sup>th</sup> to be described from specimens collected from chemosynthetic environments, with comments on its relationships.

### Methods and material

All specimens were collected by suction sampler during remotely operated vehicle (ROV) dives (ROV *Isis* from *RRS James Cook*; ROV *Hercules* from *EV Nautilus*). Specimens were fixed in 10% seawater formalin aboard ship and subsequently transferred to 70% ethanol. The holotype was photographed in fresh condition prior to fixation.

Measurements were made with digital calipers to the nearest 0.1 mm. Terminology and definitions of characters follow Anderson (1989, 1994). Abbreviations in the text are as follows: BMNH, Natural History Museum, London; MCZ, Museum of Comparative Zoology, Harvard University, USA; HL, head length; SL, standard length.

The holotype was scanned using a Nikon HMX ST 225 micro-CT (Nikon Metrology, Tring, UK). Images acquired during the scanning process were subsequently reconstructed using the software CT Pro (Nikon Metrology, Tring, UK), VG Studio Max 2.1 (Volume Graphic GmbH, Heidelberg, Germany) and Drishti (ANU Vizlab, Canberra, Australia). Paratype specimens were also radiographed for features of the axial skeleton.



**FIGURE 1.** Locations (indicated by stars) of *Pachycara caribbaeum* **sp. nov.** Von Damm Vent Field (depth ca.2300 m). A methane seep near Tobago (depth 1049 m) is of tentatively identified early juvenile, MCZ 171653. Scale bar 1000 km.

***Pachycara caribbaeum* sp. nov.**

(Figs. 2–4, Table 1)

**Holotype.** BMNH 2015.9.10.1 (immature male, 199 mm SL), Von Damm Vent Field, Mid-Cayman Spreading Centre, 18°22.503' N, 81°47.858' W, collected by suction sampler from ROV *Isis*, dive 198, depth 2313 m, water temperature 4.4°C, *RRS James Cook* cruise JC82, 10 February 2013.

**Paratypes.** MCZ 171014 (immature male, 117 mm SL), Von Damm Vent Field, Mid-Cayman Spreading Centre, 18°22.62' N, 81°47.89' W, collected by suction sampler from ROV *Hercules*, dive H1295, depth 2309 m, water temperature 4.4°C, *EV Nautilus* cruise NA034, 26 August 2013. MCZ 171085 (immature female, 197 mm SL), same data as preceding specimen.

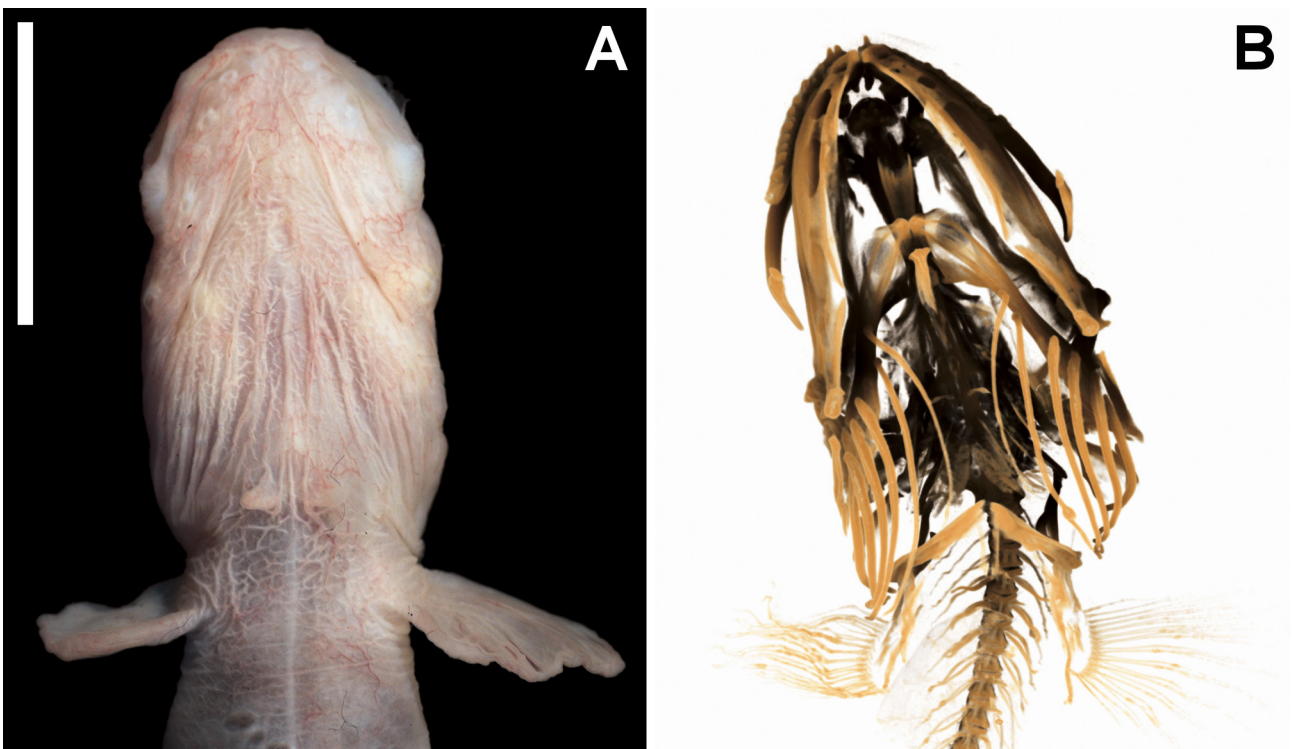
**Diagnosis.** A species of *Pachycara* as defined by Anderson (1989, 1994) with the following combination of characters: vertebrae 31–33 + 76–79 = 107–112; pectoral fin rays 12–14; pelvic fin rays 2; single mediolateral branch of the lateral line system; scales present on nape and cheeks.

**Description.** Head ovoid, deeper than wide in larger specimens than smallest, snout gently sloping in all. Scales cycloid, relatively sparsely distributed in these juveniles, absent on fins and pectoral base and axil; scales present in nape to about one eye diameter posterior to eye in smallest specimen, to interorbital area in others. Eye small, rounded, entering dorsal profile of head in larger of the three fish. Gill slit moderate, reaching ventrally to lower edge of pectoral base or just below it. Opercular lobe at dorsal margin of gill slit slightly rounded posteriorly, extending forward about one eye diameter except on right side of MCZ 171085 where it does not extend forward.

Pectoral-fin origin slightly below body midline, insertion on abdomen; posterior margin of fin wedge-shaped, with rays 4–6 from dorsalmost the longest; ventralmost rays not noticeably thickened, no ray tips exerted. Right pectoral fin of holotype appears deformed, shorter than the left (32.1 vs. 45.8 % HL; Fig. 3A), with the tips of the dorsalmost rays missing (Fig. 3B).



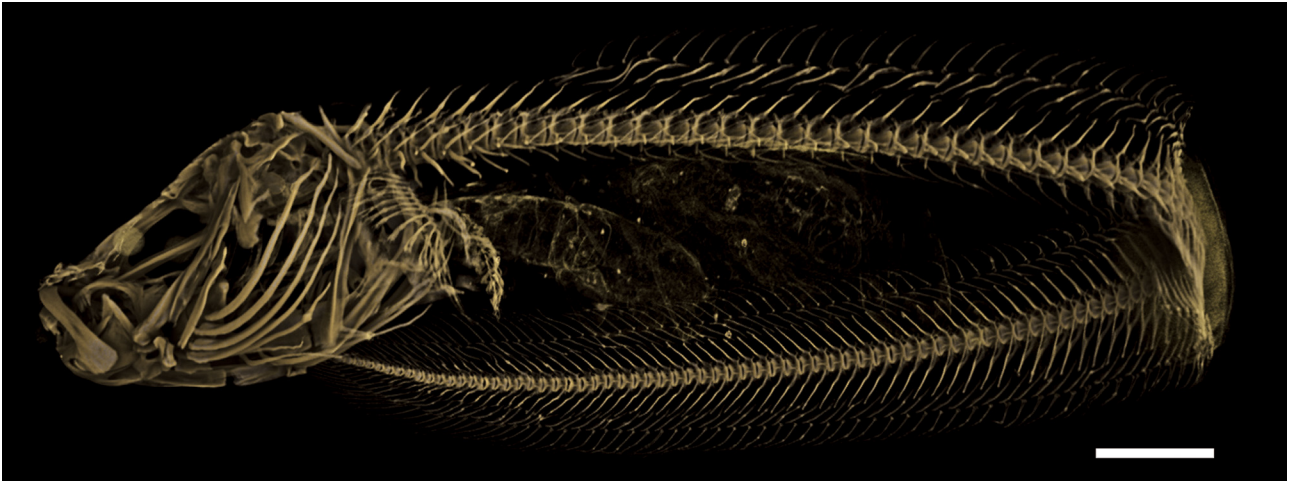
**FIGURE 2.** Photographic lateral view of *Pachycara caribbaeum* **sp. nov.** holotype in fresh condition (scale bar 50 mm; image by Adrian Glover, BMNH).



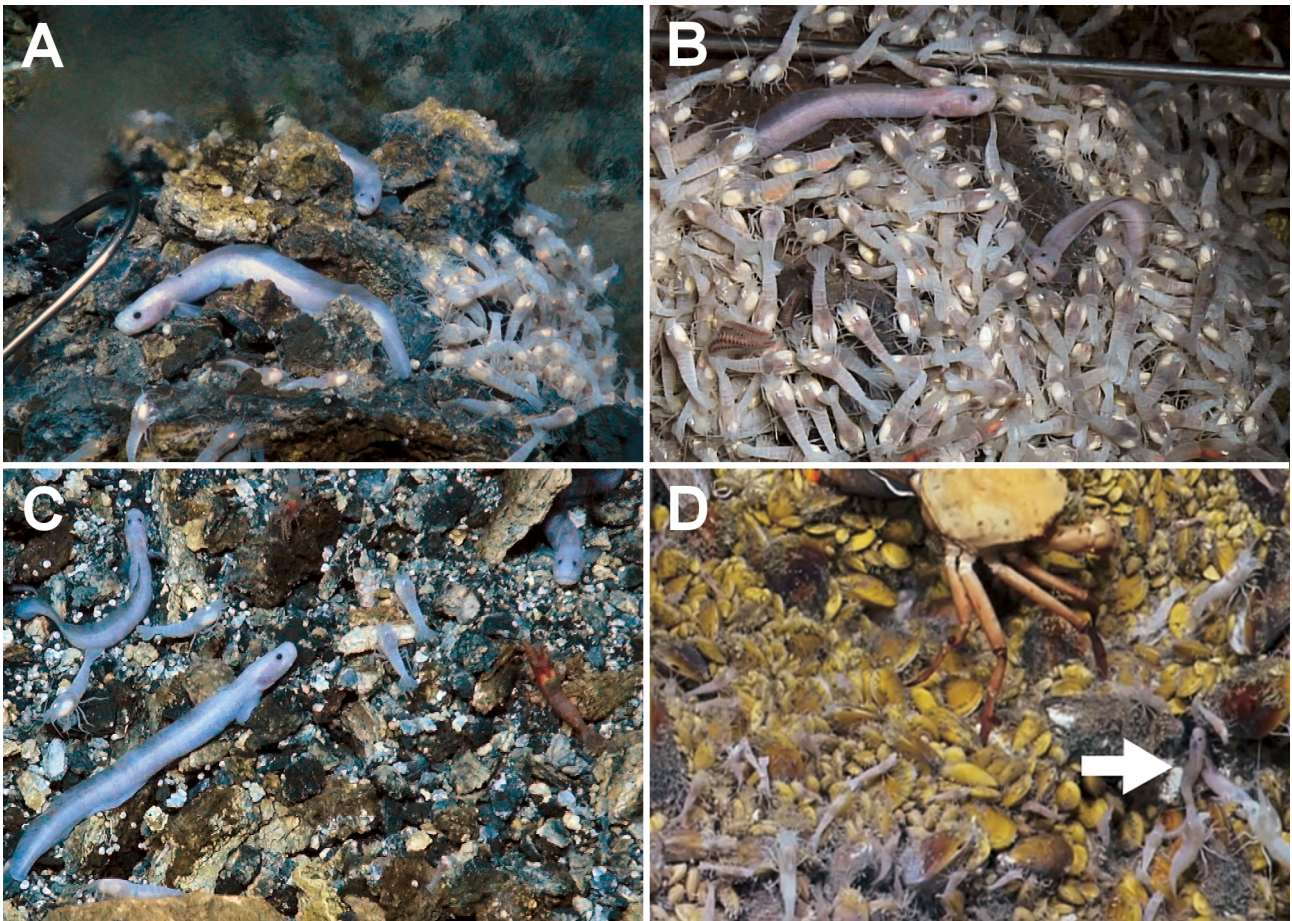
**FIGURE 3.** A) Photographic ventral view of head and pectoral region of *Pachycara caribbaeum* **sp. nov.** holotype in fresh condition (scale bar 20 mm; image by Adrian Glover, BMNH); B) microCT ventral view of holotype head and pectoral region (image by Daniel Sykes, BMNH).

Mouth very slightly subterminal and oblique, upper jaw extending posteriorly to middle of eye. Epidermal prickles absent on head. Nostril tube not reaching forward to upper lip. Oral valve reaching just posterior to anterior edge of vomer. Jaw teeth small, conical; premaxilla with single row of teeth in smallest, two or three anterior rows blending into single posterior row in larger specimens; dentary with three rows of teeth anteriorly blending into single posterior row in all. Vomerine teeth few in these juveniles. Palatine teeth in single row, also relatively few.

Cephalic lateralis system with no variation in pore counts. Two postorbital pores (one and four of Anderson 1994). Suborbital pores 6 + 0 on both sides of all. Eight preoperculo-mandibular pores. Two anterior supraorbital (nasal) pores, one set anteromesial to nostril tube, the other dorsoposteriorly. Interorbital and occipital pores absent. Body lateral line system with single, mediolateral branch originating just posterior to postorbital pore 4, running to tail tip. No trace of ventral or dorsolateral neuromasts.



**FIGURE 4.** MicroCT lateral view of *Pachycara caribbaeum* **sp. nov.** holotype (scale bar 10 mm; image by Daniel Sykes, BMNH).



**FIGURE 5.** *In situ* observations of *Pachycara caribbaeum* **sp. nov.**: A) at the exact location of holotype collection in the Von Damm Vent Field; B) among an aggregation of *Rimicaris hybisae* shrimp near the main vent orifice of the Von Damm Vent Field; C) in more peripheral conditions at the Von Damm Vent Field, with sparse *R. hybisae* and *Lebbeus virentova* shrimp; D) at the methane seep near Tobago (specimen indicated by arrow), among *Bathymodiolus* mussels and *Alvinocaris* shrimp. Images A–C from ROV *Isis*, February 2013; Image D from ROV *Hercules*, October 2014.

Dorsal-fin origin associated with vertebrae 7–8, with no free pterygiophores (Fig. 4). Anal fin origin associated with vertebrae 30–31 (ultimate precaudal), with 3–5 pterygiophores inserted anterior to haemal spine of first caudal vertebra. Last dorsal ray associated with fourth preural vertebra, last anal ray associated with second preural

vertebra. Caudal fin with two epural, four upper hypural and four lower hypural rays. Gill rakers short, those on upper limb (epibranchial) acute, lower rakers (ceratobranchial and hypobranchial) blunt, roughly triangular. Pseudobranchial filaments short and slender. Branchiostegal rays 4 + 2.

*Fresh colouration* of holotype (Figs. 2 and 3A) and paratype MCZ 171085 uniformly pinkish white, edges of unpaired fins translucent, abdomen bluish black, eye blue. In preservative all specimens dull whitish, orobranchial chamber pale.

**TABLE 1.** Comparison of meristic and morphometric characters among specimens of *Pachycara caribbaeum* **sp. nov.** Holotype measurements of left pectoral fin given, with right pectoral fin values in parentheses. MCZ 171653 is tentatively referred to *P. caribbaeum*.

|                            | Holotype<br>199 mm SL | Paratype range<br>(n = 2)<br>117–197 mm SL | MCZ 171653<br>56.5 mm SL |
|----------------------------|-----------------------|--------------------------------------------|--------------------------|
| <b>Counts</b>              |                       |                                            |                          |
| Vertebrae                  | 33 + 79 = 112         | 31–32 + 76–78 = 107–110                    | 28 + 72 = 100            |
| Dorsal fin rays            | 104                   | 99–101                                     | -                        |
| Anal fin rays              | 78                    | 77–82                                      | -                        |
| Caudal fin rays            | 10                    | 10                                         | 10                       |
| Pectoral fin rays          | 14                    | 12                                         | -                        |
| Pelvic fin rays            |                       | 2                                          | Absent                   |
| Vomerine teeth             | 8                     | 3–6                                        | -                        |
| Palatine teeth             | 6                     | 4–5                                        | -                        |
| Gill rakers                |                       | 2 + 11                                     | -                        |
| Branchiostegal rays        | 6                     | 6                                          | 6                        |
| Pseudobranchial filaments  | 4                     | 4–5                                        | -                        |
| <b>% SL</b>                |                       |                                            |                          |
| Head length                | 17.9                  | 17.0–17.4                                  | 19.5                     |
| Head width                 | 8.9                   | 7.5–9.1                                    | 6.6                      |
| Head depth                 | 8.8                   | 8.8–9.4                                    | 9.4                      |
| Pectoral fin length        | 7.6 (5.3)             | 9.2–11.0                                   | 8.7                      |
| Predorsal length           | 22.8                  | 21.3–22.1                                  | 24.1                     |
| Preanal length             | 42.7                  | 43.9–45.0                                  | -                        |
| Body depth                 | 9.2                   | 7.8–9.1                                    | 8.0                      |
| Gill slit length           | 5.3                   | 5.5–6.9                                    | 6.2                      |
| Caudal fin length          | 2.8                   | 1.7–2.5                                    | 2.7                      |
| <b>% HL</b>                |                       |                                            |                          |
| Head width                 | 53.9                  | 43.9–52.7                                  | 33.6                     |
| Head depth                 | 53.0                  | 50.7–55.8                                  | 48.2                     |
| Upper jaw length           | 42.2                  | 41.8–47.3                                  | 37.3                     |
| Pectoral fin length        | 45.8 (32.1)           | 54.3–63.5                                  | 44.6                     |
| Caudal fin length          | 11.8                  | 9.9–14.9                                   | 13.6                     |
| Snout length               | 24.2                  | 18.8–26.4                                  | 24.6                     |
| Eye diameter               | 14.2                  | 15.2–22.7                                  | 15.5                     |
| Gill slit length           | 32.1                  | 31.5–40.8                                  | 31.8                     |
| Bony interorbital width    | 11.8                  | 8.3–10.8                                   | 9.1                      |
| Fleshy interorbital width  | 15.7                  | 9.9–13.2                                   | -                        |
| Interpupillary width       | 29.5                  | 24.3–25.1                                  | -                        |
| Pectoral base/length ratio | 57.0 (73.6)           | 42.6–50.0                                  | 36.7                     |

**Etymology.** The specific name recognises the first records of the genus at deep-sea chemosynthetic environments in the Caribbean Sea.

**Distribution.** Known from two bathyal collections at chemosynthetic environments in the Caribbean at the hydrothermally active Von Damm Vent Field on the Mid-Cayman Spreading Centre (depth ca. 2300 m).

**Tentatively referred specimen.** MCZ 171653 (sex undetermined, 56.5 mm SL), methane seep near Tobago, 11°14.302'N, 59°20.681'W, suction sampler from ROV *Hercules*, dive H1392, 1049 m, temperature 5.3°C, EV *Nautilus* cruise NA054, 5 October 2014.

## Discussion

Of the 27 previously described *Pachycara* species, a summary comparison of 19 of them was given by Biscoito and Almeida (2004). Since then seven species have been described from the Indian, eastern and western Pacific, and southwestern Atlantic Oceans (Anderson, 2012; Corbella & Møller, 2014). In addition to *Pachycara caribbaeum*, three others with pelvic fins are known from the western North Atlantic: *P. sulaki* Anderson, 1989 (one specimen lacked pelvics), *P. thermophilum* Geistdoerffer, 1994 and *P. saldanhai* Biscoito & Almeida, 2004.

*Pachycara caribbaeum* is readily distinguished from all its congeners in having the fewest pectoral fin rays (12–14). *Pachycara caribbaeum* is similar to *P. thermophilum* from the Mid-Atlantic Ridge (pectoral rays 18) in its single mediolateral lateral line, but differs also in its nape scales (absent in *P. thermophilum*). *Pachycara thermophilum* also has furcate gill rakers (Anderson, 1997, fig. 3), but we hesitate to include this character as diagnostic for *P. caribbaeum* as these juveniles most probably do not exhibit the adult character state. *Pachycara caribbaeum* differs from *P. saldanhai* (pectoral rays 18–19) in its (probable) fewer vertebrae (100–112 in *P. caribbaeum* vs. 117–123 in *P. saldanhai*), its single lateral line (double in *P. saldanhai*) and its nape scales (absent in *P. saldanhai*). *Pachycara caribbaeum* differs from *P. sulaki* (pectoral rays 16–17) in its two pelvic fin rays (absent or three rays in *P. sulaki*), the single lateral line (double in *P. sulaki*) and presence of nape scales (absent in *P. sulaki*).

Three other species of *Pachycara* have been described from specimens collected at hydrothermal vents: *P. rimae* Anderson 1989 (Galapagos Rift), *P. thermophilum* and *P. saldanhai* (Mid-Atlantic Ridge), and those species may be endemic to vent habitats as they have not been recorded from other environments. Deformation of the right pectoral fin was also noted in the holotype of *P. rimae*, similar to the holotype of *P. caribbaeum* (Anderson, 1989). *Pachycara gymninium* Anderson and Peden 1988 has been recorded at vent fields on the Juan de Fuca Ridge, but has also been found in non-vent habitats, and *P. sulaki* has been recorded at a cold seep on the Florida Escarpment in addition to non-chemosynthetic environments (Biscoito et al., 2002). *Pachycara caribbaeum* is the first species of the genus known at both hydrothermal vent and cold seep chemosynthetic environments.

**Ecological observations.** Specimens of *Pachycara caribbaeum* have been observed in close proximity to sources of visible "diffuse flow" venting at the Von Damm Vent Field (Figure 5A), among aggregations of the alvinocaridid shrimp *Rimicaris hybisae* with amphinomid polychaetes and the gastropod *Itheyaspira bathycodon* also present (Figure 5B). Specimens are also present in locations further away from visible "diffuse flow" venting, among sparse *R. hybisae* and the hippolytid shrimp *Lebbeus virentova* (Figure 5C). The Von Damm Vent Field is also the type locality for *Rimicaris hybisae*, *Itheyaspira bathycodon*, and *Lebbeus virentova* (Nye et al., 2012; 2013a; 2013b), and microCT imagery of the gut of the holotype of *P. caribbaeum* shows the presence of shrimp carapaces consistent in morphology with *R. hybisae*. *In situ* temperature measurements of habitats by manipulator-deployed probe during research cruise JC82, rather than records of ROV onboard CTD, indicate that the habitat of *Pachycara caribbaeum* experiences temperatures ranging from 5–20°C in the Von Damm Vent Field, although the higher temperatures are undoubtedly avoided by the fish.

Only sparse and small specimens of *Pachycara caribbaeum* were observed at the methane seep near Tobago, among beds of *Bathymodiolus* mussels with *Alvinocaris* shrimp also present (Figure 5D). Although present at two chemosynthetic environments more than 2000 km apart in the Caribbean, *P. caribbaeum* has not been observed in extensive ROV and human-occupied vehicle surveys during five research cruises at the Beebe Vent Field of the Mid-Cayman Spreading Centre, which is located 30 km from the Von Damm Vent Field but at a depth of 5000 m (Connelly et al., 2012).

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