Cah. Biol. Mar. (2002) 43 : 359-362

Fishes from the hydrothermal vents and cold seeps - An update

Manuel BISCOITO[1], Michel SEGONZAC[2], Armando J. ALMEIDA[3], Daniel DESBRUYÈRES[2], Patrick GEISTDOERFER[4], Mary TURNIPSEED[5], Cindy VAN DOVER[5]

(1) *Corresponding author: IMAR – Museu Municipal do Funchal (História Natural). Estação de Biologia Marinha do Funchal, Cais do Carvão - 9000-107 Funchal, Madeira, Portugal. Fax: (351)- 291766339. E-mail: manuel.biscoito@mail.cm-funchal.pt*

(2) *IFREMER, Centre de Brest, DRO-EP/CENTOB, BP 70, 29280 Plouzané Cedex, France.*

(3) *Laboratório Marítimo da Guia – IMAR, DZA - Faculdade de Ciências de Lisboa, Estrada do Guincho, 2750-642 Cascais, Portugal.*

(4) *Laboratoire d'Ichtyologie, Muséum national d'Histoire naturelle, 43 rue Cuvier, 75231 Paris Cedex 5, France.*

(5) *Biology Department, College of William & Mary, Williamsburg, VA 23187, U.S.A.*

Introduction

Since the discovery of animal communities in oceanic hydrothermal vents in 1977 and in deep-sea cold seeps in 1984 (Londsdale, 1977; Paull et al., 1984) fishes have been regularly observed in association with these chemosynthetically-driven communities, but in most cases they are difficult to catch and therefore species identification can only rely on images taken by the diving vehicles.

Ichthyological information pertaining to species inhabiting the deep-sea hydrothermal vents and cold seeps is mentioned in over 30 papers and even in the more detailed and updated lists (Geistdoerfer, 1991; 1996; 1999; Sibuet & Olu, 1998; Tunnicliffe, 1991) there are species missing. The situation is even less clear concerning the bathyal species inhabiting the periphery of the active fields, the vast majority of their identifications having been based on video records or photographs.

Material and methods

Part of the information given herein was obtained from hundreds of hours of videos and photographs from several research cruises, in the Atlantic, Pacific and Indian Oceans, using the deep submersibles *Nautile* and Rov *Victor* (IFREMER, France), and *Alvin* and Rov *Jason* (WHOI, USA).

In some of the above mentioned cruises, specimens were captured and therefore subject to an accurate identification process. Additional information on the bathyal species associated with hydrothermal vents was also obtained by the *R/V Arquipélago* (University of the Azores) at Lucky Strike and Menez Gwen hydrothermal vent fields, on the Mid-Atlantic Ridge.

Species were separated into two groups: 1) species living within the vent and seep environments, including the so-called *vent-endemic* species and the species that also occur elsewhere; 2) species pertaining to the bathyal environment, but recorded from the close proximity to the vents and seeps.

Results

Species living inside active fields

A complete list of species of fish found living inside active fields is given in Tables 1 and 2. A total of seven families and one unidentified member of the Anguilliformes, have been recorded up to the present, comprising at least 21 species. Of these, 11 (52%) have been described and, perhaps with the exception of *Thermarces andersoni* Rosenblatt & Cohen, 1996, offer little doubt as for their validity. Five (24%) are new to science and are being described elsewhere. The remaining five species (24%) could only be identified to the genus or family level. The family Zoarcidae (genera *Thermarces* and *Pachycara*) is by far the commonest at both hydrothermal vents and cold seeps, accounting for 50% of the total number of species recorded. It is followed by the Bythitidae (three species) and the Synaphobranchidae (three species). The other four families are represented by one species each.

Bathyal species living in the vicinity of the vents and seeps

An updated list of species cannot be presented here. Our literature search and personal observations yielded 32 families and approximately 90 species, recorded from the

Table 1. Species recorded from the active hydrothermal vent fields in the Pacific Ocean (Biscoito et al., 2001; Geistdoerfer, 1996 [reviews records prior to 1995]; Hashimoto et al., 1995; 1998; Munroe & Amaoka, 1998; Ono et al., 1996; Segonzac et al., 1997; Tunnicliffe et al., 1998; Yamamoto et al., 1999).

Species	**Lau Basin 22°S**	**Manus Basin 3°S**	**Juan de Fuca 45-47°N**	**EPR 21°N**	**EPR 11-13°N**	**EPR 9°N**	**EPR 17-19°S**	**Galap. Ridge 0°47'N**	**Minami Ensei-Knoll (Japan) 28°25'N**	**Kaikata Seamount (Japan) 26°42'N**	**Kasuga 2 Seamount (Mariana Trough) 21°36'N**	**North Knoll (Iheya Ridge-Okinawa Trough) 27°47'N**
Depth (m)	1750	1650-1710	1540-2200	2600	2600	2500	2600	2500	670-780	450	400-500	1000-1400
Anguilliformes *sensu lato*							+					
Synaphobranchidae												
Thermobiotes mytilogeiton Geistdoerfer, 1991	+											
Zoarcidae												
Thermarces sp. 1							+					
Thermarces cerberus Rosenblatt & Cohen, 1986				+	+	+						
Thermarces andersoni * Rosenblatt & Cohen, 1986					+							
Thermarces sp. 2						+						
Pachycara rimae Anderson, 1989								+				
Pachycara gymninium Anderson & Peden, 1989			+									
Gen. sp.		+							+			+
Ophidiidae												
Gen. sp. Geistdoerfer et al., 1995							+					
Bythitidae												
Bythites hollisi Cohen, Rosenblatt & Moser, 1990				+	+	+		+				
Gen. sp.							+					
Cyclopteridae												
Careproctus hyaleius Geistdoerfer, 1994					+	+						
Cynoglossidae												
Symphurus sp.									+	+	+	
Total number of species recorded	1	1	1	2	4	4	4	2	2	1	1	1

* Possibly a synonym of *T. cerberus*

immediate vicinity of deep-sea vents and cold seeps in the Atlantic and Pacific Oceans. It was possible to identify 64% of the records to species level. The remaining records belong to species whose identification is only possible with the specimens in hand. Nearly half of the identified species belong to five families: Macrouridae (13), Ophidiidae (9), Squalidae (7), Moridae (7) and Synaphobranchidae (6). Forty three species were recorded from the Atlantic hydrothermal fields (48%) and 38 from the Pacific Ocean vents (42%). From the cold-seep environments 21 species were recorded (23%).

Discussion and conclusions

Vent-living fishes were found at only 20 of some 50 active vent fields discovered to date. The specific diversity found is low and the degree of endemism is high, which seems to be an overall characteristic of the hydrothermal vent faunas (Tunnicliffe, 1991). Of the ~20 known cold-seeps, only four revealed the presence of seep-living fishes, showing again an extremely low diversity and a high degree of endemism.

The family Zoarcidae dominates in terms of the number of species and biomass. The eelpouts form a highly diverse family with over 220 known species, mostly benthic (Weitzman, 1997) and are one of the more successful fish families to occupy continental slopes, down to 5000 metres (Anderson, 1994; Weitzman, 1997). Nonetheless, it is remarkable that they have been able to adapt (and evolve) to the vent and seep environments. As pointed out by Geistdoerfer (1996) these adaptations are neither anatomical, nor trophic. In order to cope with the chemical conditions of vents and seeps, these species must have biochemical adaptations. These adaptations, as well as the factors conditioning the distribution of the species need further investigation. At the present level of knowledge on the taxonomy and distribution of the species, zoogeographical considerations cannot be produced.

As for the peripheral bathyal fauna, data available are far from being satisfactory. The five best-represented families correspond to the commonest families in the deep-sea (Weitzman, 1997) and our results are therefore not a surprise. However, the variations in numbers of recorded species from field to field are enormous and definitely reflect insufficient research.

Table 2. Species recorded from the active hydrothermal vent fields in the Atlantic and Indian Oceans and from the deep-sea cold seeps (Anderson, 1989; Anderson & Bluhm, 1996; Biscoito et al., 2001; Gebruk et al., 2000; Karmovskaya & Parin, 1999; Geistdoerfer, 1996; 1999; Hashimoto et al., 2001; Saldanha & Biscoito, 1997; Segonzac, 1992; Sibuet & Olu, 1998; Tunnicliffe, 1991).

	Atlantic Ocean						**Indian Ocean**		**Cold seeps**			
Species	**Logatchev 14°45'N**	**Snake Pit 23°N**	**TAG 26°N**	**Broken Spur 29°N**	**Rainbow 36°13'N**	**Lucky Strike 37°18'N**	**Kairei 25°S**	**Edmond 24°S**	**Barbados Accretionary Prism 10-11°N**	**Florida Escarp. 26°N**	**Peru Trench 5-6°S**	**Sagami Bay 35°N**
Depth (m)	2940-3005	3500	3700	3090	2320	1700	2420 2450	3290-3320	1950	3500	3000 4500	900-1200
Synaphobranchidae												
Ilyophis saldanhai Karmovskaya & Parin, 1999				+								
Gen. sp.*		+	+									
Gadidae												
Gaidropsarus sp.						+						
Zoarcidae												
Thermarces pelophilum Geistdoerfer, 1999									+			
Pachycara thermophilum Geistdoerfer, 1994	+	+	+	+								
Pachycara sulaki Anderson, 1989										+		
Pachycara sp.					+							
Gen. sp.							+	+			+	+
Bythitidae												
Cataetyx sp.					+							
Gen. sp.		+										
Total number of species recorded	1	3	2	2	2	1	1	1	1	1	1	1

* Possibly *Ilyophys saldanhai*

Although there are twice as many known active sites in the Pacific as in the Atlantic, the number of species recorded in the latter is higher (38 *vs* 43). Depth may well be the main responsible for this, as vent fields in the Atlantic range from 850 m down to 3650 m and the ones in the East Pacific are all around 2500 m depth. As pointed out by Merrett & Haedrich (1997) for the Porcupine Seabight, demersal fish abundance tends to increase with depth attaining a maximum around 1000 m and then decreasing sharply. This is in accordance with our data, where the highest number of records is from Menez-Gwen (850 m) and Lucky Strike (1700 m) on the Mid-Atlantic Ridge.

For the cold seeps, apart from the depth factor, insufficient ichthyological research may be the main reason for the low number of fish records.

The fact that the fields near the Azores Triple Junction have been more intensively studied by professional ichthyologists can also have influence in the results obtained. This bias precludes us from drawing conclusions on abundance, diversity and zoogeography of this fauna. To overcome it, scientific teams working on this field should be reinforced with fish biologists as well as more ship-time should be made available for this kind of research.

Acknowledgements

The authors are particularly indebted to the chief-scientists and crews of several research vessels, deep-submersibles and Rovs of IFREMER, France and WHOI, USA, in which they were allowed to dive or from which they have obtained video footage and photographs. Much of the work done here was only possible due to grants from the European Union, the National Science Foundation (USA), the CNRS, URM 7 IFREMER and Dorsales Programme (France) and the Foundation for Science and Technology (Portugal). Part of the unpublished data presented was obtained under the framework of EU-MAST3 AMORES Project (contract MAS3-CT95-0040), the Portuguese PRAXIS XXI AMAR Project (Contract n° PRAXIS/2/2.1/MAR/1748/95), the EU-5th Framework Programme VENTOX Project (contract n° EVK3 CT1999 00003) and the ICCTI-IFREMER Franco-Portuguese Agreement in Oceanology.

References

Anderson M.E. 1989. Review of the eelpout genus *Pachycara* Zugmayer, 1911 (Teleostei: Zoarcidae), with descriptions of six new species. *Proceedings of the California Academy of Sciences,* **46**: 221-242.

Anderson M.E. 1994. Systematics and Osteology of the Zoarcidae (Teleostei: Perciformes). *Ichthyological Bulletin of the J.L.B. Smith Institute,* **60**: 1-120.

Anderson M.E. & Bluhm H. 1996. Description of a new species of *Pachycara* Zugmayer, 1911 from the abyssal south-eastern pacific and redescription of *P. thermophilum* Geistdoerfer, 1994, with a new key to the species. *Transactions of the Royal Society of South Africa*, **51**: 219-227.

Biscoito M., Segonzac M. & Almeida A.J. 2001. New zoarcid fish species from the deep-sea hydrothermal vents of the Atlantic and Pacific Oceans. *InterRidge News*, **10**: 15-17.

Gebruk A.V., Chevaldonné P., Shank T., Lutz R.A. & Vrijenhoeck R.C. 2000. Deep-sea hydrothermal vent communities of the Logatchev area (14º45'N, Mid-Atlantic Ridge): diverse biotopes and high biomass. *Journal of the Marine Biological Association of UK*, **80**: 383-393.

Geistdoerfer P. 1991. Ichthyofaune associée à l'hydrothermalisme océanique et description de *Thermobiotes mytilogeiton*, nouveau genre et nouvelle espèce de Synaphobranchidae (Pisces, Anguilliformes) de l'Ocean Pacifique. *Comptes Rendus de l'Académie des Sciences, Paris, Série III,* **312**: 91-97.

Geistdoerfer P. 1996. L'ichthyofaune des écosystèmes associés à l'hydrothermalisme océanique: état des connaissances et résultats nouveaux. *Oceanologica Acta*, **19**: 539-548.

Geistdoerfer P. 1999. *Thermarces pelophilum*, espèce nouvelle de Zoarcidae associée à l'emission de fluides froids au niveau du prisme d'accrétion de la Barbade, Océan Atlantique nord-ouest. *Cybium*, **23**: 5-11.

Hashimoto J., Ohta S., Auzende J.M., Fiala-Médioni A. & others. 1998. Hydrothermal vent communities in the PACMANUS site, Manus Basin. Results of the BIOACCESS Cruise '96 in the Manus Basin. *Jamstec Journal of Deep-Sea Research*, **14**: 91-102.

Hashimoto J., Ohta S., Fujikura K. & Miura T. 1995. Microdistribution pattern and biogeography of the hydrothermal vent communities of the Minami-Ensei Knoll in the Mid-Okinawa Trough, Western Pacific. *Deep-Sea Research I,* **42**: 577-598.

Hashimoto J., Ohta S., Gamo T., Chiba H., Yamaguchi T., Tsuchida S., Okudaira T., Watabe H., Yamanaka T. & Kitazawa M. 2001. First hydrothermal vent communities from the Indian Ocean discovered. *Zoological Science*, **18**: 717-721.

Karmovskaya E.S. & Parin N.V. 1999. A new species of the genus *Ilyophis* (Synaphobranchydae, Anguilliformes) from the Broken Spur Hydrothermal vent field (Mid-Atlantic Ridge). *Journal of Ichthyology*, **39**: 353-362.

Londsdale P. 1977. Clustering of suspension-feeding macrobenthos near abyssal hydrothermal vents at oceanic spreading centers. *Deep-Sea Research*, **24**: 857-863.

Merrett N.R. & Haedrich R.L. 1997. *Deep-sea demersal fish and fisheries*. Chapman & Hall, London. 282 pp.

Munroe T.A. & Amaoka K. 1998. *Symphurus hondoensis* Hubbs, 1915, a valid species of Western Pacific tonguefish (Pleuronectiformes: Cynoglossidae). *Ichthyology Research*, **45**: 385-391.

Ono T., Fujikura K., Hashimoto J., Fujiwara Y. & Segawa S. 1996. The hydrothermal vent community at the Kaikata Seamount near Ogasawara (Bonin) Islands, South Japan. *Jamstec Journal of Deep-Sea Research,* **12**: 221-230.

Paull C.K., Hecker B., Commeau R., Freeman-Lynde R.P., Neumann C., Corso W.P., Golubic S., Hook J.E., Sykes E. & Curray J. 1984. Biological communities at the Florida escarpment resemble hydrothermal vent taxa. *Science*, **226**: 65-67.

Saldanha L. & Biscoito M. 1997. Fishes from the Lucky Strike and Menez Gwen hydrothermal vent sites (Mid-Atlantic Ridge). *Boletim do Museu Municipal do Funchal*, **49**: 189-206.

Segonzac M. 1992. Les peuplements associés à l'hydrothermalisme océanique du Snake Pit (dorsale médio-atlantique; 23ºN, 3480 m): composition et microdistribution de la mégafaune. *Comptes Rendus de l'Académie des Sciences, Paris, Série III,* **314**: 593-600.

Segonzac M., Hekinian R., Auzende J.M. & Francheteau J. 1997. Recently discovered animal communities on the South East Pacific Rise (17-19ºS & Easter Microplaque Region). *Cahiers de Biologie Marine*, **38**: 140-141.

Sibuet M. & Olu K. 1998. Biogeography, biodiversity and fluid dependence of deep-sea cold-seep communities at active and passive margins. *Deep-Sea Research II,* **45**: 517-567.

Tunnicliffe V. 1991. The biology of hydrothermal vents: ecology and evolution. *Oceanography and Marine Biology An Annual Review*, **29**: 319-407.

Tunnicliffe V., McArthur A.G. & McHugh D. 1998. A biogeographical perspective of the deep-sea hydrothermal vent fauna. *Advances in Marine Biology,* **34**: 253-451.

Weitzman S.H. 1997. Systematics of deep-sea fishes. *In*: *Deep-sea Fishes* (J. E. Randall & A. P. Farrell eds), pp. 43-78. Academic Press, London.

Yamamoto T., Kobayashi T., Nakasone K. & Nakao S. 1999. Chemosynthetic community at North Knoll, Iheya Ridge, Okinawa Trough. *Jamstec Journal of Deep-Sea Research*, **15**: 19-24.