

Deep associations: the symbiotic relationships between amphipods and large invertebrates from bathyal of the Sea of Okhotsk

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ABSTRACT: Deep-sea photos taken during the cruise of r/v “Akademik M.A. Lavrentyev” in the Sea of Okhotsk in 2013 revealed interesting symbiotic associations between marine amphipods (probably, Stenothoidae) and predatory sponge *Chondrocladia* cf. *lampadiglobus* Vacelet, 2006 (Demospongia: Cladorhizidae) at a depth of 1587 m as and with large hydroids of the family Tubulariidae Goldfuss, 1818, probably *Ectopleura* L. Agassiz, 1862 or *Tubularia* Linnaeus, 1758, at a depth of 1580 m. These data represent the evidence of symbiotic relationships between amphipods and deep dwelling marine invertebrates as well as the first record of their relationship with a deep-sea predatory sponge of the family Cladorhizidae.

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KEY WORDS: Associations, symbiosis, Amphipoda, Hydrozoa, Tubulariidae, sponge, Cladorhizidae, bathyal, Sea of Okhotsk, North Pacific.

Глубинные ассоциации: симбиотические взаимоотношений между амфиподами и крупными беспозвоночными из батииали Охотского моря

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РЕЗЮМЕ: Глубоководные фотографии, сделанные во время рейса и/с “Академик М.А. Лаврентьев” в Охотском море в 2013 году, выявили симбиотические ассоциации между морскими амфиподами (вероятно, Stenothoidae) и хищной губкой хондрокладией *Chondrocladia* cf. *lampadiglobus* Vacelet, 2006 (Demospongia: Cladorhizidae) на глубине 1587 м, а также с крупными гидроидами семейства Tubulariidae Goldfuss, 1818, вероятно, *Ectopleura* L. Agassiz, 1862 или *Tubularia* Linnaeus, 1758, на глубине 1580 м. Эти данные представляют собой свидетельство симбиотических отношений амфипод с глубоководными морскими беспозвоночными, а также первое свидетельство таких взаимоотношений с глубоководной хищной губкой семейства Cladorhizidae.

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КЛЮЧЕВЫЕ СЛОВА: Ассоциации, симбиоз, Amphipoda, Hydrozoa, Tubulariidae, губки, Cladorhizidae, батииаль, Охотское море, северная часть Тихого океана.

Introduction

Associations between marine animals (symbiosis) are found everywhere in the World Oceans, but still remains feebly studied, especially from deeper waters. First of all, it could be explained by a complexity of the joint collection of all animals from the associations, as well as the difficulty of underwater *in situ* observations of their lifestyle. In this view, any evidences, including photos, showing the relationships of marine animals expand our knowledge on their ecology and distribution. Due to the limited opportunities for direct observations and sampling, such evidences provided by the deep-water operated vehicles are most interesting and important.

Marine amphipods (Crustacea: Amphipoda) are known as members of associations with different larger marine organisms, from jellyfishes to cetaceans (e.g., Vader, 1972, 1984a, b; Krapp-Schickel, Vader, 2015). However, the diversity and ecology of such associations are not well studied. For example, most stenothoid amphipods (Amphipoda: Stenothoidae) collected from deep waters are described only morphologically, without any data on their ecology. As a result, we have very a poor knowledge about their symbiotic relationships in a deep water at whole. Probably, the symbiotic associations of amphipods are very diverse in terms of the sets of hosts, ecology, geographical and bathymetric distribution.

The presented deep-water photographs show that the associations of symbiotic amphipods and large marine invertebrates are not limited to the shallow waters of warm tropical seas, but are also quite common and diverse in deep waters of high latitudes. Moreover, these associations contain (with a very high probability) undescribed species and require further study.

Material and methods

The photos were taken during the expedition on the r/v "Akademik M.A. Lavrentyev" in the Sea of Okhotsk in 2013 using the digital camera of ROV "Comanche 18" (Sub-Atlantic, Great Britain). The photographed animals were not collected.

Results and Discussion

The first photo (Fig. 1a) represent a predatory sponge *Chondrocladia* (*Chondrocladia*)

cf. *lampadiglobus* Vacelet, 2006 (Demospongia: Cladorhizidae) at a depth of 1587 ms with numerous associated amphipods covered its body. Amphipods associated with marine sponges in these photos could belong to two families, namely Stenothoidae Boeck, 1871 and Cyproideidae J.L. Barnard, 1974, as they possess the large and broadened coxae 3 and 4 of ambulatory pereopods III–VII detectable in the photo (Fig. 1).

The family Cyproideidae presently includes 19 genera and 44+ species of small marine amphipods mainly widespread in the Indo-West Pacific ecosystems and Southern Hemisphere (Lowry, Stoddart, 2003; Lowry, Azman, 2008; Ortiz, Winfield, 2014). These amphipods can be separated from morphologically similar symbiotic amphipod families by shorter antenna and antennula. Members of the cyproideids are characterized by: coxae 1 and 2 being very small, with immensely enlarged and broadened coxae 3 and 4, uropod 3 biramous with elongated peduncle and often with dorsal keel. Only two cyproideid genera are known in the northern higher latitudes (e.g., Ortiz, Winfield, 2014), and both of them were not previously recorded deeper than 50 m. Morphologically, representative of these genera are different from the specimens from the presented photographs.

On the other hand, the only amphipods in the Northern Pacific morphologically similar to our specimens are representatives of the family Stenothoidae Boeck, 1871. The family is also characterized by enlarged coxal plates 3 and 4, which are clearly visible in the photos (see Fig. 1). Stenothoid amphipods presently includes nearly 34 genera with about 200 valid species of mostly symbiotic marine benthic amphipods recorded from subtidal communities to the depths of more than 3000 m (e.g., Gurjanova, 1951; Barnard, Karaman, 1991; Krapp-Schickel, Koenemann, 2006; Krapp-Schickel, 2009; Tandberg, Vader, 2015; Krapp-Schickel, Vader, 2015; Vader, Tandberg, 2013, 2015). Representatives of the family are known to be associated with different large marine invertebrates such as hydroids (e.g., Tandberg, Vader, 2015; Marin, Sinelnikov, 2017, 2018), sea anemones (e.g., Vader, 1984a; Vader, Krapp-Schicke, 1996, Krapp-Schickel, Vader, 1998) and other invertebrates (e.g., Vader, 1972, 1984b; McGrath, 1978; Vader, Beehler, 1983; Tho-



Fig. 1. Large marine invertebrates and associated amphipods from the bathyal of the Sea of Okhotsk: *a* — predatory sponge *Chondrocladia* cf. *lampadiglobus* Vacelet, 2006 (Demospongia: Cladorhizidae) at a depth of 1587 m; *b* — large hydroids of the family Tubulariidae Goldfuss, 1818 from a depth of 1580 m, probably belonging to the genus *Ectopleura* L. Agassiz, 1862 or *Tubularia* Linnaeus, 1758. The photos are provided by the National Scientific Center for Marine Biology, Far Eastern Branch of the Russian Academy of Sciences. Рис. 1. Крупные морские беспозвоночные и ассоциированные с ними амфиподы из батиали Охотского моря: *a* — хищная губка хондрокладия *Chondrocladia* cf. *lampadiglobus* Vacelet, 2006 (Demospongia: Cladorhizidae) на глубине 1587 м; *b* — крупные гидроиды семейства Tubulariidae Goldfuss, 1818 с глубины 1580 м, вероятно, относящийся к роду *Ectopleura* L. Agassiz, 1862 или *Tubularia* Linnaeus, 1758. Фотографии предоставлены Национальным научным центром морской биологии Дальневосточного отделения Российской академии наук.

mas, Cairns, 1984; Tandberg *et al.*, 2010; Marin, Sinelnikov, 2012, 2016, 2018a, b; Marin *et al.*, 2013).

Cyproideid amphipods most often recorded as symbionts of marine sponges (Ortiz *et al.*, 2000); in contrast, stenothoid amphipods are mostly associated with coelenterate hosts (see above). Associations of stenothoid amphipods with sponges are quite rare (e.g., Pearse, 1934; Vader, 1984b; Padua *et al.*, 2013), especially in the North Pacific, e.g. *Stenothoe estacola* J.L. Barnard, 1962 is known in association with *Sphaciospongia* sp. (Demospongia: Clionidae) (Barnard, 1962) and *Stenothoides burbanki* J.L. Barnard, 1969 has been reported among sponges and tunicates without a confirmation of its symbiotic status (see Barnard, 1969). However, most probably, the amphipods in the photo (Fig. 1a) belong to the family Stenothoidae.

The second photo (Fig. 1b) represent large hydroids of the family Tubulariidae Goldfuss, 1818, probably belonging to the genus *Ectopleura* L. Agassiz, 1862 or *Tubularia* Linnaeus, 1758, from a depth of 1580 m with several amphipods sitting on its hydranths (Fig. 1b). The photo shows small stenothoid amphipods sitting on the hydranths of large oaten pipe hydroid of the family Tubulariidae Goldfuss, 1818, at a depth of 1580 m. Marine tubulariid hydroids are widespread in shallow waters around the world (Petersen, 1990), and individuals of circumpolar *Tubularia regalis* Boeck, 1860, *Tubularia indivisa* Linnaeus, 1758 and *Ectopleura larynx* (Ellis, Solander, 1786) are recorded from a depth of more than 500 m in the North Pacific (Christiansen, 1972; Schuchert, 2010; Sirenko, 2012). Associations between stenothoid amphipods and tubulariid hydroids in shallow waters are quite common and well described (e.g., Marin, Sinelnikov, 2017, 2018b), while information from deeper water are still very poor. Our report contributes to understanding of their biology.

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