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A new species of *Provanna* (Gastropoda: Provannidae) from an Oligocene seep deposit in eastern Hokkaido, Japan

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Abstract. We describe a new species, *Provanna urahoroensis* sp. nov. from seep carbonates of the lower Oligocene Nuibetsu Formation in eastern Hokkaido, Japan. The new species is the second fossil record of *Provanna* from Paleogene rocks and resembles a smooth variant of the American Paleogene species, *P. antiqua* Squires, in having a smooth shell with very weak spiral cords. Based on its association with *Bathymodiolus* (s. l.), fossil *Provanna* including the new species possibly grazed preferably on bacteria on the surface of *Bathymodiolus* (s. l.) and of exposed carbonates.

Key words: Gastropoda, new species, Oligocene, *Provanna*, seep

Introduction

The genus *Provanna* Dall, 1918 is a characteristic gastropod of chemosynthetic faunas. Although Bergquist *et al.* (2007) suggested that *Provanna variabilis* Warén and Bouchet, 1986 may harbor symbiotic bacteria, the genus mainly feeds on filamentous bacteria or detrital organic material (e.g. Warén and Bouchet, 1993, 2001, 2009, Sasaki *et al.*, 2010). As summarized by Amano and Little (2012), eighteen modern species of *Provanna* have been described, from hydrothermal vent, hydrocarbon seeps, whale-fall and wood-fall sites. Two Cretaceous and three Miocene species have been described from Japan (Kaim *et al.*, 2008, 2009; Amano and Little, 2012), and the only other fossil records are one Eocene to Oligocene species from Washington State, USA and one from Miocene seeps in New Zealand.

The oldest *Bathymodiolus* (s. l.) from Japan was described from the seep carbonate of the lower Oligocene Nuibetsu Formation in eastern Hokkaido (Amano and Jenkins, 2011). From the same limestone, one new species of *Provanna* has now been recognized. In this paper, we describe the new species and discuss the fossil records of the genus.

Materials and methods

Thirty-eight specimens of *Provanna* were collected from

two localities along a small tributary of the Atsunai River near Kami-Atsunai, Urahoro Town, eastern Hokkaido (Figure 1; Loc. nos. 1 and 2). The *Provanna*-bearing carbonates crop out continuously along this stream up to the type locality of the oldest *Bathymodiolus* (s. l.) from Japan. These carbonates are hosted by siliciclastic sediments of the lower Oligocene Nuibetsu Formation. According to Amano and Jenkins (2011), the limestone was formed at a cold seep site, because they were highly depleted in ¹³C ($\delta^{13}\text{C}$ values as low as -49% vs. PDB; Pee Dee Belemnite standard).

Several float carbonate blocks at the mouth of the stream (Loc. 1) yielded thirty-six specimens of *Provanna*, associated with many specimens of the mussel *Bathymodiolus* (s. l.) *inouei* Amano and Jenkins, the thyasirid *Conchocele bisecta* (Conrad) and the vesicomimid *Hubertschenckia ezoensis* (Yokoyama), and with a few specimens of the naticid gastropod *Euspira meisen-sis* (Makiyama) and the cylichnid gastropod *Eocylichna multistriata* (Takeda). In the river bed 100 m upstream from the tributary (Loc. 2), two specimens of *Provanna* were collected with many specimens of *C. bisecta* and *H. ezoensis*. The next most abundant species is *B. inouei*. Among heterotrophic species, the nuculanid bivalve *Yoldia sobrina* Takeda, the turritellid gastropod *Oreco-tospira wadana* (Yokoyama) and the buccinid gastropod *Trominina japonica* (Takeda) are associated with *Provanna*. One specimen was collected of each.

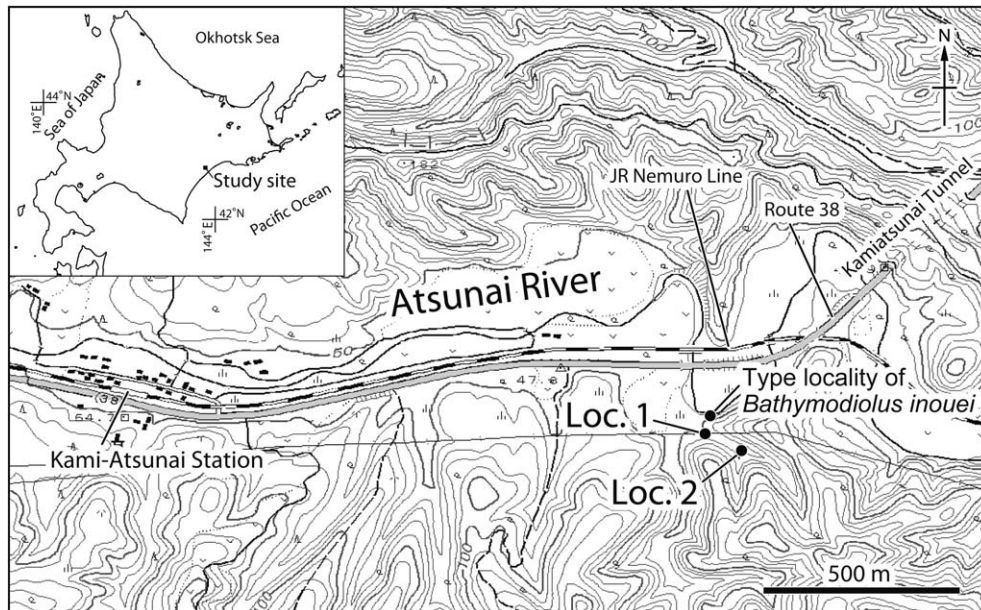


Figure 1. Localities for the new species of *Provanna*.

All this material is housed at the Joetsu University of Education (JUE). We have measured the following characters of fossils: height, diameter and number of whorls.

Systematic descriptions

Family Provannidae Warén and Ponder, 1991
Genus *Provanna* Dall, 1918

Type species.—*Trichotropis (Provanna) lomana* Dall, 1918

Provanna urahoroensis Amano and Jenkins sp. nov.
[Japanese common name: Urahoro-haikaburinina]

Figure 2

Etymology.—Named for the town at the type locality.

Type material: Holotype, JUE no. 15908; Paratypes, JUE nos. 15909-1, 15909-2, 15909-3, 15909-4, 15909-5.

Type locality.—Mouth of a small stream, a tributary of the Atsunai River 1.5 km east of Kami-Atsunai Railway Station, Urahoro Town, eastern Hokkaido.

Dimensions.—See Table 1.

Diagnosis.—Small *Provanna* with smooth surface and growth lines, crossed by several very weak spiral cords. Teleoconch consisting of three whorls. Shoulder of whorls rounded. Aperture pear-shaped.

Description.—Shell small, up to 5.1 mm high, ovate-fusiform; protoconch not preserved. Suture weakly impressed. Last whorl almost smooth, with fine growth lines and very weak spiral cords at shoulder and around

Table 1. Measurements of *Provanna urahoroensis* sp. nov.

Specimens	Type	NW*	Height (mm)	Diameter (mm)	Loc.
JUE no. 15908	Holotype	3	4.5	3.1	1
JUE no. 15909-1	Paratype	3	4.7	3.9	1
JUE no. 15909-2	Paratype	3	4.9	3.3	1
JUE no. 15909-3	Paratype	2.5	3.7	2.7	1
JUE no. 15909-4	Paratype	3	3.5	2.4	1
JUE no. 15909-5	Paratype	2.5	3.6	2.2	1
JUE no. 15910-1	Topotype	2	3.5	3.3	1
JUE no. 15910-2	Topotype	3	5.1	3.7	1
JUE no. 15910-3	Topotype	2	4.5	3.0	1
JUE no. 15910-4	Topotype	2	4.4	2.6	1
JUE no. 15910-5	Topotype	3	3.8	3.1	1
JUE no. 15910-6	Topotype	2	3.6	3.1	1
JUE no. 15910-7	Topotype	2	3.2	2.8	1
JUE no. 15910-8	Topotype	2	3.3	2.5	1
JUE no. 15911-1		2	3.8	3.5	2
JUE no. 15911-2		2	3.2	3.0	2

*NW = number of whorls.

periphery. Penultimate whorl and one earlier whorl of spire also smooth with growth lines and very weak spiral cords at shoulder. Shoulder of all whorls rounded, not

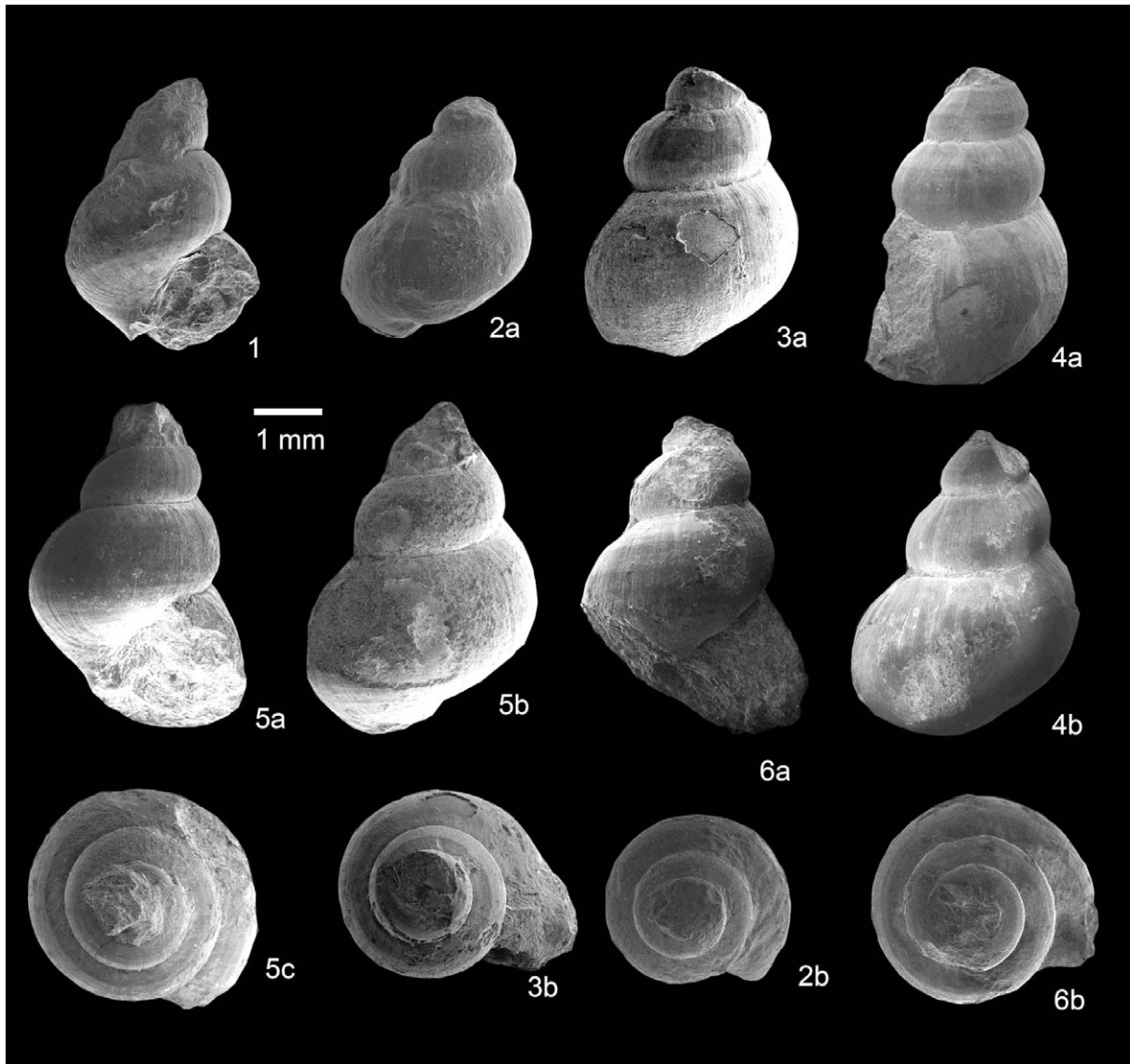


Figure 2. *Provanna urahoroensis* sp. nov. from the lower Oligocene Nuibetsu Formation. **1**, paratype, JUE no. 15909-4, apertural view; **2**, paratype, JUE no. 15909-5; **2a**, abapertural view; **2b**, apical view; **3**, paratype, JUE no. 15909-3; **3a**, abapertural view; **3b**, apical view; **4**, paratype, JUE no. 15909-1; **4a**, side view; **4b**, abapertural view; **5**, holotype, JUE no. 15908; **5a**, apertural view; **5b**, abapertural view; **5c**, apical view; **6**, paratype, JUE no. 15909-2; **6a**, apertural view; **6b**, apical view.

angulated. Aperture pear-shaped with weak siphonal notch.

Comparisons.—*Provanna antiqua* Squires, 1995 from Eocene and Oligocene deposits in Washington State shows wide morphological variation. Among this variation, two paratype specimens (LACMIP 12300 and 12301) resemble *P. urahoroensis* sp. nov. in having a smooth surface except for weak spiral cords over the whole surface. However, *P. urahoroensis* differs from *P. antiqua* by not having an angulated shoulder. *P. marshalli* Saether, Little and Campbell, 2010 from the lower to

middle Miocene in the East Coast Basin, North Island, New Zealand also shows a wide range of variation. Some specimens have an almost smooth surface. However, these specimens have an angulated shoulder and axial ribs, which are never seen in *P. urahoroensis*.

Three modern species of *Provanna* have shells with a smooth surface. *P. laevis* Warén and Ponder, 1991 from the Guaymas Basin is most similar to the new species, especially in the shape of the aperture. However, it reaches a larger size (height 10.0 mm), despite having only 2.5 whorls. *P. abyssalis* Okutani and Fujikura, 2002

Table 2. Occurrences of Paleogene and Neogene *Provanna* species and associated *Bathymodiolus* (s. l.) from seep deposits. LCF= Lincoln Creek Formation.

Species	Localities	Age and Formation	Associated mussels	Reference(s)
<i>Provanna antiqua</i>	LACMIP 5802	L. Eocene, LCF	<i>Bathymodiolus</i> (s. l.) <i>willapaensis</i>	Squires and Goedert (1991), Squires (1995)
	LACMIP 16504	L. Oligocene, LCF	<i>Bathymodiolus</i> (s. l.) <i>willapaensis</i>	Kiel (2006)
	LACMIP 6958	E. Oligocene, Makah F.	–	Squires (1995)
	LACMIP 15911	E. Oligocene, Makah F.	<i>Bathymodiolus</i> (s. l.) <i>willapaensis</i>	Goedert and Campbell (1995), Squires (1995)
<i>Provanna urahoroensis</i>	Kami-Atsunai	E. Oligocene, Nuibetsu F.	<i>Bathymodiolus</i> (s. l.) <i>inouei</i>	This study
<i>Provanna marshalli</i>	Rocky Knob	E.–M. Miocene	<i>Bathymodiolus</i> (s. l.) <i>heretaunga</i>	Saether <i>et al.</i> (2010)
	Puketawa	E.–M. Miocene	<i>Bathymodiolus</i> (s. l.) <i>heretaunga</i>	Saether <i>et al.</i> (2010)
	Ugly Hill	E. Miocene	<i>Bathymodiolus</i> (s. l.) <i>heretaunga</i>	Saether <i>et al.</i> (2010)
<i>Provanna</i> sp.	LACMIP 6132	M. Miocene, Astoria F.	–	Kiel (2010)
<i>Provanna hirokoae</i>	Kita-Kuroiwa Quarry	M. Miocene, Ogaya F.	<i>Bathymodiolus</i> (s. l.) <i>akanudaensis</i>	Amano <i>et al.</i> (2010), Amano and Little (2012)

from the Japan Trench resembles the new species in having similarly convex whorls. However, the larger size (height 7.1 mm) and oval aperture of *P. abyssalis* enable us to separate it from the new species. *P. glabra* Okutani, Tsuchida and Fujikura, 1992 from Sagami Bay can be distinguished from the new species by having a larger shell (height 10.55 mm) and less inflated whorls. Some paratypes of the Recent species *P. variabilis* Warén and Bouchet, 1986 also have shells with a rather smooth surface. However, such variants differ from the new species by having two distinct spiral cords on the last whorl and some weak axial ribs on the early whorls.

Stratigraphic and geographic range.—Only from the lower Oligocene Nuibetsu Formation in eastern Hokkaido.

Discussion

Only a single species of *Provanna* was known previously from the Paleogene: *P. antiqua* Squires, 1995, from upper Eocene to upper Oligocene seep deposits and from upper Eocene wood-fall sites in Washington State, USA (Squires, 1995; Goedert and Campbell, 1995; Squires and Goedert, 1995; Rigby and Goedert, 1996; Peckmann *et al.*, 2002; Kiel, 2006; Kiel and Goedert, 2006a, b). *P. urahoroensis* is the second record of a Paleogene species of *Provanna* from a methane seep environment.

P. urahoroensis occurred with the mussel *Bathymodiolus* (s. l.) *inouei*. In Japan, there are many Cenozoic seep sites with epifaunal or semiinfaunal vesicomyids (e.g. Majima *et al.*, 2005; Amano and Kiel, 2010, 2011; Amano and Jenkins, 2011) while *Provanna* has been

reported from only two localities. We noticed, however, that most Japanese and USA-Pacific Coast Cenozoic seep deposits yielding *Provanna* are also characterized by the presence of *Bathymodiolus* (s. l.). The two exceptions are the upper Oligocene seep deposit (LACMIP 6958; Squires, 1995) and the lower Miocene seep deposit (LACM loc. 6132; Kiel, 2010) in Washington (Table 2). Apart from these two exceptions, the occurrence of *Provanna* correlates well with *Bathymodiolus* (s. l.) in the Cenozoic. If the surface of *Bathymodiolus* (s. l.) shells accidentally provided a substrate for bacteria grazed by *Provanna*, then it is difficult to explain why specimens of *Provanna* have not been known at vesicomyid-bearing localities lacking *Bathymodiolus* (s. l.). Based on observations made using the research submersible “Shinkai 2000”, many specimens of *Provanna* live on rocks as well as on *Bathymodiolus* (s. l.) at Hatoma Knoll vent site, Okinawa Trough (Okutani, 2008). Warén and Bouchet (2009, fig. 13G) also showed specimens of *Provanna in situ* on *Bathymodiolus* (s. l.) shells off West Africa. Although the exact reason for the co-occurrence of these two epifaunal genera is unknown, *Provanna* possibly grazes preferably on bacteria on the surface of *Bathymodiolus* (s. l.) shells and of exposed carbonates.

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References

- Amano, K. and Jenkins, R. G., 2011: New fossil *Bathymodiolus* (sensu lato) (Bivalvia: Mytilidae) from Oligocene seep-carbonates in eastern Hokkaido, Japan, with remarks on the evolution of the genus. *Nautilus*, vol. 125, p. 29–35.
- Amano, K., Jenkins, R. G., Aikawa, M. and Nobuhara, T., 2010: A Miocene chemosynthetic community from the Ogaya Formation in Joetsu: Evidence for depth-related ecologic control among fossil seep communities in the Japan Sea back-arc basin. *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 286, p. 164–170.
- Amano, K. and Kiel, S., 2010: Taxonomy and distribution of fossil *Archivesica* (Bivalvia: Vesicomidae) in Japan. *Nautilus*, vol. 124, p. 155–165.
- Amano, K. and Kiel, S., 2011: Fossil *Adulomya* (Vesicomidae, Bivalvia) from Japan. *Veliger*, vol. 51, p. 76–90.
- Amano, K. and Little, C. T. S., 2012: Miocene abyssochrysid gastropod *Provanna* from Japanese seep and whale-fall sites. *Acta Palaeontologica Polonica*, doi:10.4202/app.2012.0002.
- Bergquist, D. C., Eckner, J. T., Urcuyo, I. A., Cordes, E. E., Hourdez, S., Macko, S. A. and Fisher, C. R., 2007: Using stable isotopes and quantitative community characteristics to determine a local hydrothermal vent food web. *Marine Ecology Progress Series*, vol. 330, p. 49–65.
- Dall, W. H., 1918: Descriptions of new species of shells, chiefly from Magdalena Bay, Lower California. *Proceedings of the Biological Society of Washington*, vol. 31, p. 5–8.
- Goedert, J. L. and Campbell, K. A., 1995: An Early Oligocene chemosynthetic community from the Makah Formation, northwestern Olympic Peninsula, Washington. *Veliger*, vol. 38, p. 22–29.
- Kaim, A., Jenkins, R. G. and Hikida, Y., 2009: Gastropods from Late Cretaceous Omagari and Yasukawa hydrocarbon seep deposits in the Nakagawa area, Hokkaido, Japan. *Acta Palaeontologica Polonica*, vol. 54, p. 463–490.
- Kaim, A., Jenkins, R. G. and Warén, A., 2008: Provannid and provannid-like gastropods from the Late Cretaceous cold seeps of Hokkaido (Japan) and the fossil record of the Provannidae (Gastropoda: Abyssochrysoidea). *Zoological Journal of the Linnean Society*, vol. 154, p. 421–436.
- Kiel, S., 2006: New records and species of molluscs from Tertiary cold-seep carbonates in Washington State, USA. *Journal of Paleontology*, vol. 80, p. 121–137.
- Kiel, S., 2010: On the potential generality of depth-related ecologic structure in cold-seep communities: Evidence from Cenozoic and Mesozoic examples. *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 295, p. 245–257.
- Kiel, S. and Goedert, J. L., 2006a: A wood-fall association from Late Eocene deep-water sediments of Washington State, USA. *Palaaios*, vol. 21, p. 548–556.
- Kiel, S. and Goedert, J. L., 2006b: Deep-sea food bonanzas: early Cenozoic whale-fall communities resemble wood-fall rather than seep communities. *Proceedings of the Royal Society B*, vol. 273, p. 2625–2631.
- Majima, R., Nobuhara, T. and Kitazaki, T., 2005: Review of fossil chemosynthetic assemblages in Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 227, p. 86–123.
- Okutani, T., 2008: 8. Mollusca. In: Fujikura, K., Okutani, T. and Maruyama, T. eds., *Deep-Sea Life—Biological Observations Using Research Submersibles*, p. 99–147. Tokai University Press, Hatana.
- Okutani, T. and Fujikura, K., 2002: Abyssal gastropods and bivalves collected by Shinkai 6500 on slope of the Japan Trench. *Venus*, vol. 60, p. 211–224.
- Okutani, T., Tsuchida, E. and Fujikura, K., 1992: Five bathyal gastropods living within or near the *Calyptogena* community of the Hatsushima Islet, Sagami Bay. *Venus*, vol. 51, p. 137–148.
- Peckmann, J., Goedert, J. L., Thiel, V., Michaelis, W. and Reitner, J., 2002: A comprehensive approach to the study of methane-seep deposits from the Lincoln Creek Formation, western Washington State, USA. *Sedimentology*, vol. 49, p. 855–873.
- Rigby, J. K. and Goedert, J. L., 1996: Fossil sponges from a localized cold-seep limestone in Oligocene rocks of the Olympic Peninsula, Washington. *Journal of Paleontology*, vol. 70, p. 900–908.
- Saether, K., Little, C. T. S. and Campbell, K. A., 2010: A new fossil provannid gastropod from Miocene hydrocarbon seep deposits, East Coast Basin, North Island, New Zealand. *Acta Palaeontologica Polonica*, vol. 55, p. 507–517.
- Sasaki, T., Warén, A., Kano, Y., Okutani, T. and Fujikura, K., 2010: Gastropods from Recent hot vents and cold seeps: Systematics, diversity and life strategies. In: Kiel, S. ed., *The Vent and Seep Biota. Aspects from Microbes to Ecosystems*, p. 169–254. Springer, Dordrecht, Heidelberg, London, New York.
- Squires, R. L., 1995: First fossil species of the chemosynthetic-community gastropod *Provanna*: localized cold-seep limestones in Upper Eocene and Oligocene rocks, Washington. *Veliger*, vol. 38, p. 30–36.
- Squires, R. L. and Goedert, J. L., 1991: New late Eocene mollusks from localized limestone deposits formed by subduction-related methane seeps, southwestern Washington. *Journal of Paleontology*, vol. 65, p. 412–416.
- Squires, R. L. and Goedert, J. L., 1995: An extant species of *Leptochiton* (Mollusca: Polyplacophora) in Eocene and Oligocene cold-seep limestones, Olympic Peninsula, Washington. *Veliger*, vol. 38, p. 47–53.
- Warén, A. and Bouchet, P., 1986: Four new species of *Provanna* Dall (Prosobranchia, Cerithiacea?) from East Pacific hydrothermal sites. *Zoologica Scripta*, vol. 15, p. 157–164.
- Warén, A. and Bouchet, P., 1993: New records, species, genera, and a new family of gastropods from hydrothermal vents and hydrocarbon seeps. *Zoologica Scripta*, vol. 22, p. 1–90.
- Warén, A. and Bouchet, P., 2001: Gastropoda and Monoplacophora from hydrothermal vents and seeps: new taxa and records. *Veliger*, vol. 44, p. 116–231.
- Warén, A. and Bouchet, P., 2009: New gastropods from deep-sea hydrocarbon seeps off West Africa. *Deep-Sea Research Part II: Topical Studies in Oceanography*, vol. 56, p. 2326–2349.
- Warén, A. and Ponder, W. F., 1991: New species, anatomy, and systematic position of the hydrothermal vent and hydrocarbon seep gastropod family Provannidae fam.n. (Caenogastropoda). *Zoologica Scripta*, vol. 20, p. 27–56.