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Opisthoteuthis borealis: a new species of cirrate octopod from Greenland waters

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A new species of cirrate octopod, *Opisthoteuthis borealis* sp. nov. is described from specimens caught at depths of 957–1321 m off the coast of Greenland. *Opisthoteuthis borealis* sp. nov. is the most northerly of the Atlantic species of the genus and can be distinguished from the other species by the form of the digestive gland and the arrangement of enlarged suckers on the arms of mature males.

INTRODUCTION

The cirrate octopods are deep-sea cephalopods, possessing a gelatinous body, paired fins, well developed webs, a large internal shell and paired cirri between a single row of suckers (Nesis, 1987; Voss, 1988). Although known from all oceans at depths from 500 to 7500 m (Voss, 1988), cirrates are usually caught in small numbers, are frequently damaged on capture and do not preserve well (Vecchione et al., 2002). Many of the early descriptions of cirrate species were based on single, badly damaged specimens, and consequently the taxonomy of the group was rather confused, with considerable uncertainty about generic diagnoses and assignment of species to genera (Voss, 1988). The recent expansion of both commercial and scientific fishing into deeper waters has provided many new specimens of this enigmatic group and stimulated new taxonomic research, which has led to detailed taxonomic studies of many of the genera (e.g. O'Shea, 1999; Villanueva et al., 2002; Collins, 2003), with many new species described.

Recent molecular work suggests that the cirrates should be divided into four families (Piertney et al., 2003), of which the shallowest and most speciose is Opisthoteuthidae, which includes the genus *Opisthoteuthis*. There are five species of *Opisthoteuthis* presently recognized in the Atlantic (Villanueva et al., 2002), with *O. agassizii* in the western Atlantic, *O. calypso*, *O. massyae* and *O. grimaldii* in the eastern Atlantic and *O. hardyi* in the south-west Atlantic. Recently, Collins (2002) investigated the cirrate fauna from the coasts of Greenland and Iceland from collections in the Zoological Museum of the University of Copenhagen (ZMUC) and reported specimens of *Opisthoteuthis* from the east and west coasts of Greenland. A detailed study of these specimens, and comparison with other Atlantic *Opisthoteuthis* species, revealed them to be an undescribed species, and a full description is herein provided.

MATERIALS AND METHODS

Definitions of counts and measurements used here generally follow Guerra et al. (1998) and Voss & Pearcy (1990), and the basic measurements are defined in Collins (2003).

The dorsal mantle length (ML) was measured as for other octopods (Roper & Voss, 1983). Fin length and fin width are measured in accordance with Voss & Pearcy (1990) where the length of the fin (in contrast to fin length in teuthoids) is measured from the midpoint of the base of the fin to the outer tip, and fin width is the greatest width across the fin measured perpendicular to the fin length. Fin span follows Guerra et al. (1998), and is the distance between the apices of the fins. The gill lamellae counts refer to the total number of lamellae on each gill; 7/6 means 7 lamellae on one gill and 6 on the other. Specimens were considered sexually mature on the basis of the presence of spermatophores in the seminal vesicle and/or penis of the males, and presence of eggs in the oviducts and/or oviducal gland of the females.

SYSTEMATICS

Family OPISTHOTEUTHIDAE Verrill, 1896
Genus *Opisthoteuthis* Verrill, 1883
Opisthoteuthis borealis sp. nov.
Opisthoteuthis sp. Collins, 2002.

Type material

Holotype: mature ♂, 60 mm ML; 'Shinkai Maru' Station 44; 6 December 1992; 63°10′N 54°14′W; 1321–1319 m; ZMUC CEPH-3.

Paratypes: 1♀, 65 mm ML, 1♂, 55 mm ML; 'Paamuit'; 1 October 1997; 63°37′N 53°47′W; 1116 m; ZMUC CEPH-4. 1♀, ~70 mm ML, 1♂, 75 mm ML; 'Shinkai Maru' Station 41; 6 December 1992; 63°26′N 55°10′W; 1146–1148 m; ZMUC CEPH-5. 1♀, 68 mm ML; 'Shinkai Maru' Station 39; 5 December 1992; 63°26′N 56°08′W; 1228–1232 m; ZMUC CEPH-6.

Other Material: 1♀, ~65 mm ML; 'Shinkai Maru' Station 45; 4 December 1992; 63°17′N 53°48′W; 1228–1232 m; ZMUC. 1♂, 65 mm ML; 'Shinkai Maru' Station 40; 5 December 1992; 63°27′N 56°00′W; 1191–1195 m; ZMUC. 1♀, 55 mm ML; 'Thor' Station 166; 14 July 1902; 62°57′N 19°58′W; 1228–1232 m; ZMUC.

Comparative material examined

Opisthoteuthis calypso Villanueva et al., 2002: holotype, mature ♂, 38 mm ML; 'Cape Breton' Cruise Station

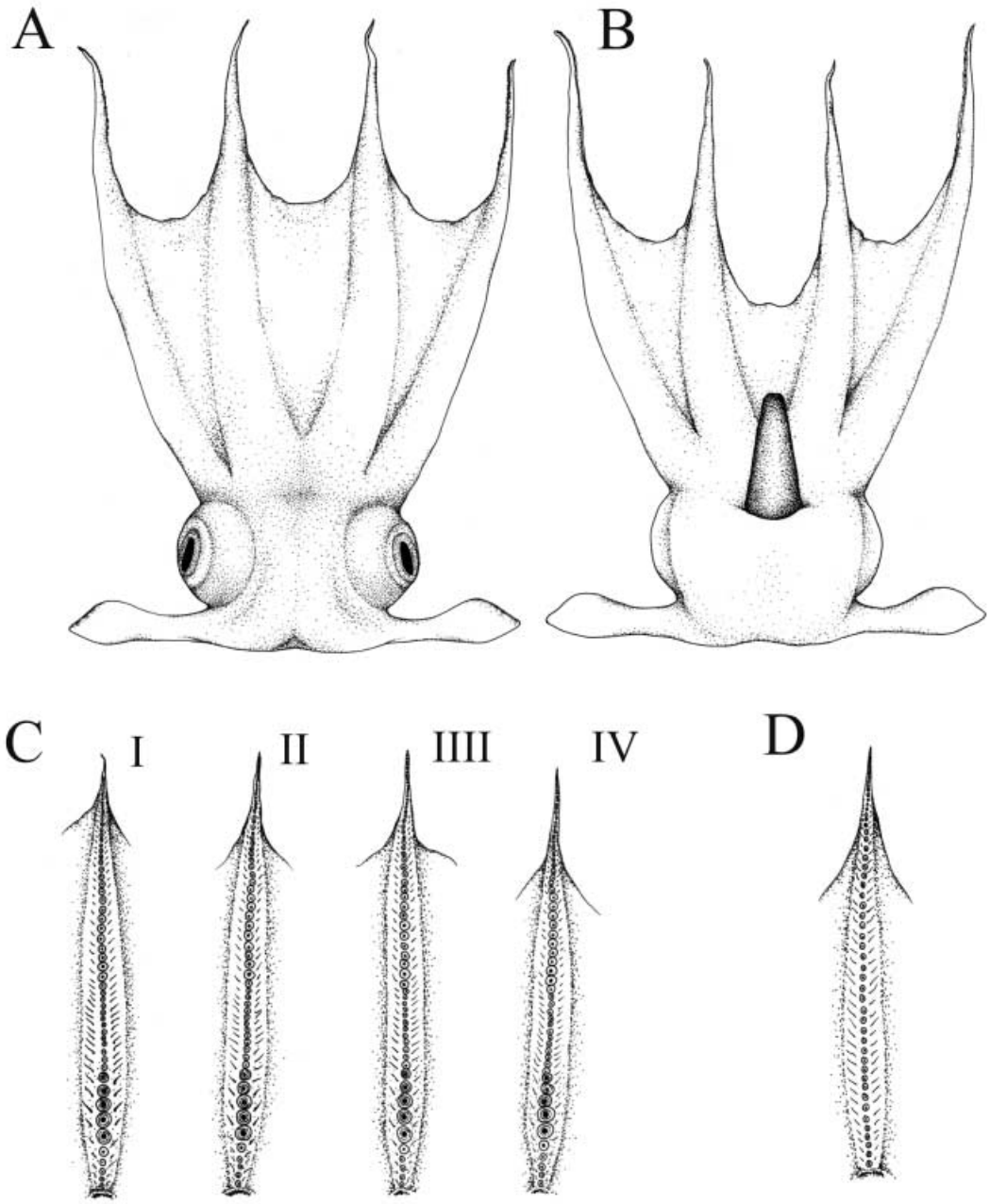

Figure 1. *Opisthoteuthis borealis* sp. nov. (A) Dorsal and (B) ventral views of the holotype. Sucker arrangement on arms of (C) male and (D) female.

CM08/CB87; Cantabric Sea; 43°34.64′N 02°16.47′W; 495 m; Marinovich bottom trawl; 30 June 1987; ICM199/2000. *Opisthoteuthis grimaldii* (Joubin, 1903): holotype, mature ♂, 39 mm ML; Açores Islands, 55 miles north-west of Fayal; 'Princesse Alice' Station 1334; bottom trawl; 1900 m; 13 August 1902; MOM295148. Other material: 2 mature ♂ (31 and 45 mm ML); off Namibia; Benguela IX Criuse Station PP1; 24°01.4′S 12°57.4′E; 1142 m; 15 February 1986; ICM196/2000 and ICM 197/2000. *Opisthoteuthis massyae* (Grimpe, 1920): holotype, mature ♂, 66 mm ML; off Ireland, 50°31′N 11°31′W; 1226–1450 m; 1 August 1908; bottom trawl; NMI 459.1909. *Opisthoteuthis hardyi* Villanueva et al., 2002: holotype, mature ♂, 45 mm ML, frozen before fixation; FV 'Argos Galicia' Station 97–25; near South Georgia; 53°18′S 42°12′W; pelagic trawl fished close to the sea-floor at 800–1000 m; 11 September 1997; NMSZ1999158.088. *Grimpoteuthis umbellata* (Fischer, 1883): lectotype: immature ♀, 25 mm ML; Azores, between Fayal and San Miguel; 37°55′N 20°22′W; 2235 m; 'Talisman' 130; 16 August 1883; MNHN 3.6.698.

Diagnosis

Medium sized species (up to 75 mm ML). First arms of mature males slightly thickened. Distal enlarged sucker field in males comprise 9–14 suckers beginning at about sucker 23 or 24, with suckers 27–30 usually largest. In mature males, the sucker enlargement in distal field is approximately equal on all arms. Maximum sucker diameter in distal and proximal fields approximately equal. First cirrus usually occurs between suckers 3 and 4. Digestive gland entire. Basal portion of shell with concave outer surface, and convex inner surface. Single muscular nodule or multiple, trabecula-like muscular supports extending from ventral margins of arms absent. Arm

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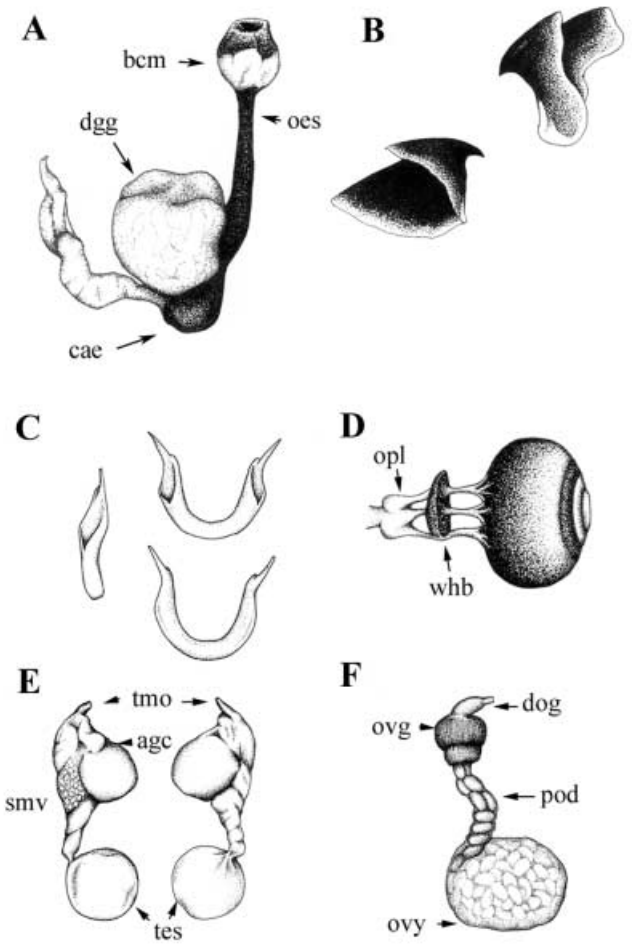

Figure 2. *Opisthoteuthis borealis* sp. nov. Internal anatomy: (A) digestive system; (B) upper and lower beak; (C) dorsal, ventral and lateral views of the internal shell; (D) optic nerve arrangement; (E) male and (F) female reproductive systems. agc, accessory gland complex; bcm, buccal mass; cae, caecum; dgg, digestive gland; dog, distal oviduct; oes, oesophagus; opl, optic lobe; ovg, oviducal gland; ovy, ovary; pod, proximal oviduct; smv, seminal vesicle complex; tes, testes; tmo, terminal organ; whb, white body.

sucker count in adult 75–82. Pigment-free spots not known to occur on skin.

Description

Description based on nine specimens (5♀; 4♂), which were frozen prior to preservation and are in rather poor condition. Medium-sized species (up to 75 mm ML). Body semi-gelatinous, ovoid in form (Figure 1A,B). Eyes and fins superior. Mantle moderately short, approximately 20% total length (TL), and broadly rounded posteriorly. Head slightly wider than mantle. Pallial aperture small, closely surrounding funnel. Funnel flaccid, moderately long, 64% ML and darkly pigmented. Funnel organ not discernible. Olfactory organs rounded and prominent, located just within mantle aperture and to either side of funnel. Fins distorted on preservation and appear of moderate size and positioned postero-laterally. Anterior and posterior margins of fins thin, slightly convex; without lobe near the anterior insertion. Eyes of moderate size, bulbous, 50% ML, occupy entire sides of head. Skin surface smooth, reddish-brown in preserved specimens. Oral surface of the web deeply pigmented. Pigment-free spots on skin not apparent in any specimens.

Arms long, approximately four times ML, and subequal in length (Figure 1C,D), with no consistent arm formulae. Arms moderately stout, with first (dorsal) arms thicker than other arms in males. Single muscular nodule or multiple, trabecula-like, muscular supports extending into web from ventral margins of arms absent. Arms enveloped in web, occupying approximately 2/3 of arm length. Web extends further on the dorsal arms, but is slightly damaged on most specimens, with general formula A=B>C=D>E. Single row of approximately 80 suckers deeply set in semi-gelatinous tissue of all arms. Mature male with two fields of markedly enlarged, bulbous suckers on all arms (Figure 1C). Suckers 5–10 usually enlarged in the proximal (oral) field, with suckers 6 or 7 the largest. Sucker enlargement in proximal field approximately equal on all arms. Distal enlargement field comprises nine to 14 suckers beginning at about sucker 23 or 24, with suckers 27–30 the largest. Sucker enlargement in distal field, approximately equal on all arms. Maximum sucker diameter approximately equal in proximal and distal fields. Females lacking distinctly enlarged sucker fields, suckers increase in size from oral to maximum size between suckers 10 and 20, then decline gradually to arm tip (Figure 1D). Cirri short, first appear between suckers 3 and 4 on most arms. Longest cirri on mid portion of arms, length 3.0–6.1 mm or 5–10% ML.

Gills small, compact, spherical, with seven or eight lamellae. Median pallial adductor muscle thin and narrow. Branchial heart rounded, approximately half the size of the gill. Oesophagus, stomach and intestine a deeply pigmented dark purple colour (Figure 2A). Two digestive ducts unite before emptying into caecum. Intestine wide forming an S-shape, shorter than the oesophagus. Anal flaps and ink sac absent. Digestive gland entire. Radula and posterior salivary glands absent. Beak of typical *Opisthoteuthis* form (Figure 2B). Each fin supported by an internal, flexible cartilage that extends from the shell sac, to which it closely adheres. Shell U-shaped (Figure 2C), with short, flaring lateral wings. Basal portion of inner surface convex; and outer surface concave. Lateral wings with in-rolled margins, tapering to acute points. Optic lobes large, kidney-shaped, with three bundles of optic nerves running to each eye (Figure 2D). White body, closely associated with optic lobe, large, dark brown/purple. Optic lobes larger than semi-circular brain.

Male genitalia (Figure 2E) composed of large, oval testis located in median portion of mantle cavity and dorsal in position; short vas deferens; large, convoluted seminal vesicle complex; three accessory glands, with gland 2 the largest; and with a short terminal organ (penis) projecting from accessory gland 3. Spermatophores, perhaps damaged by freezing, appear oval in shape. Female genital complex (Figure 2F) consists of medial ovary, with a thin walled proximal oviduct leading to an oviducal gland, through which the distal oviduct protrudes. The distal oviduct of a mature female contained ten eggs of length 11–12 mm, with a further 220 oocytes of size ranging from 3–12 mm in the ovary.

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Table 1. Opisthoteuthis borealis *sp. nov.: details of measurements and counts of the holotype, paratypes and other material examined.*

Specimen catalogue number	ZMUC CEPH-3 Holotype	ZMUC CEPH-4 Paratype	ZMUC CEPH-4 Paratype	ZMUC CEPH-5 Paratype	ZMUC CEPH-6 Paratype	ZMUC CEPH-5 Paratype	ZMUC	ZMUC
Vessel (Station)	Shinkai Maru (44)	Paamuit	Paamuit	Shinkai Maru (41)	Shinkai Maru (39)	Shinkai Maru (41)	Shinkai Maru (45)	Shinkai Maru (40)
Date	6/12/1992	1/10/1997	1/10/1997	6/12/1992	5/12/1992	6/12/1992	4/12/1992	5/12/1992
Sex	M	M	F	M	F	F	F	M
Dorsal mantle length	60	55	65	75	68	~70	~65	65
Head width	88	105	—		*	102	*	102
Fin span	—	130	—	150	120	135	*	*
Fin length	32	32		48	40	37	*	28
Fin width	16	16		32	22	20	*	19
Eye diameter	25	31		42	42	35	33	23
Funnel length	38	39	30	**58**	52	37	38	35
Gill lamellae	8/8	7		7/7	7/8	8/8	7/7	7/7
Web Formula	A=B>C =D>E	*	*	*	A=B>C =D>E	*	*	B=C=D >A>E
Ovarian egg length	—	—	12	—	12	11	12	—
Arm length—I	*	260	*	280	190	*	*	165
Arm length—II	*	230	*	280	205	*	*	160
Arm length—III	*	250	240	255	185	*	*	*
Arm length—IV	*	245	235	230	*	*	*	160
Arm width—I	23	*	*	31	22	*	*	20
Maximum sucker diameter (proximal)	5.8	6.3	4.5	7.2	4.2	*	*	5.3
Maximum sucker diameter (distal)	4.8	6.0	—	7.0	—	*	*	4.8
Proximal enlarged sucker field	4–9	5–9	—	5–10	—	*	*	5–9
Distal enlarged sucker field	22–33	24–34	—	24–35	—	*	*	24–33
Maximum cirrus length	5.0	6.0	*	6.8	6.0	*	*	3.0
Sucker count	*	*	*	~81	~80	*	*	~75

Measurements in mm. *, The count or measurement could not be obtained due to damage.

Table 2. *Comparison of Atlantic species of* Opisthoteuthis.

	Opisthoteuthis borealis sp. nov.	*Opisthoteuthis agassizii*	*Opisthoteuthis massyae*	*Opisthoteuthis grimaldii*	*Opisthoteuthis calypso*	*Opisthoteuthis hardyi*
Digestive gland	Entire	Entire	Bilobed	Bilobed	Entire	Entire
Increased thickness of 1st arms of mature males	Slight	Absent	Marked	Absent	Absent	Slight
Distal enlarged sucker field	22–36	30–41	34–50	22–39	23–29	18–32
Location of maximum sucker diameter	27–30	34–36	40–41	29–31	26	22–24
Arm sucker count	75–82	58–80	82–106	73–80	47–58	60–67
Suckers in distal enlarged sucker field	9–14	7–8	9–11	9–10	2–3	9–14
Location of 1st cirrus: between suckers	3 & 4	3 & 4	3 & 5	2 & 3	1 & 2	3 & 4
Ovarian egg length (mm)	11–12	8–10	9–11	no data	7–7.5	no data

Distribution

East and west coast of Greenland at depths of 957–1321 m and water temperature 3.0–3.5°C.

Etymology

From the Latin for north *boreas*, reflecting the northerly distribution.

DISCUSSION

The fragility of the cirrates, and the distortion associated with preservation (Vecchione et al., 2002) make it difficult to compare morphological characters. Freezing probably distorts the internal shell, which is one of the few hard parts and little intra-specific variability has

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been identified in the beaks. The specimens of *Opisthoteuthis borealis* sp. nov. described here were in poor condition, but clearly differ from other Atlantic species (Villanueva et al., 2002) in the arrangement of enlarged suckers in the distal field of mature males (Table 2), the thickening of the dorsal arms and in the form of the digestive gland. The arrangement of enlarged suckers falls within the (rather broad) range of *O. grimaldii*, but *O. grimaldii* has a bilobed digestive gland and has no discernible thickening of the first arms. The females of the Atlantic *Opisthoteuthis* species are rather difficult to distinguish, as most of the key characters are found on mature males. *Opisthoteuthis borealis* sp. nov. females could be confused with *O. massyae* females as both species possess a bilobed digestive gland, but the arm sucker count is generally greater in *O. massyae*.

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REFERENCES

Collins, M.A., 2002. Cirrate octopods from Greenland and Iceland waters. *Journal of the Marine Biological Association of the United Kingdom*, **82**, 1035–1036.

Collins, M.A., 2003. The genus *Grimpoteuthis* (Octopoda: Grimpoteuthidae) in the north-east Atlantic, with descriptions of three new species. *Zoological Journal of the Linnean Society*, **139**, 93–127.

Guerra, A., Villanueva, R., Nesis, K.N. & Bedoya, J., 1998. Redescription of the deep-sea cirrate octopod *Cirroteuthis magna* Hoyle 1885, and considerations on the genus *Cirroteuthis* (Mollusca: Cephalopoda). *Bulletin of Marine Science*, **63**, 51–81.

Nesis, K.N., 1987. *Cephalopods of the world*. New York and London: T.N.P Publications.

O'Shea, S., 1999. *The marine fauna of New Zealand: Octopoda (Mollusca: Cephalopoda)*. Wellington: NIWA Research.

Piertney, S.B., Hudelot, C., Hochberg, F.G. & Collins, M.A., 2003. Phylogenetic relationships among cirrate octopods (Mollusca: Cephalopoda) resolved using mitochondrial 16S ribosomal DNA sequences. *Molecular Phylogenetics and Evolution*, **27**, 348–353.

Roper, C.F.E. & Voss, G.L., 1983. Guidelines for taxonomic descriptions of cephalopod species. *Memoirs of the National Museum, Victoria, Australia*, **44**, 49–63.

Vecchione, M., Collins, M.A. & Sweeney, M.J., 2002. Systematics, ecology and biology of cirrate octopods: workshop report. *Bulletin of Marine Science*, **71**, 79–94.

Villanueva, R., Collins, M.A., Sanchez, P. & Voss, N.A., 2002. Systematics, distribution and biology of the cirrate octopods of the genus *Opisthoteuthis* (Mollusca, Cephalopoda) in the Atlantic Ocean, with description of two new species. *Bulletin of Marine Science*, **71**, 933–985.

Voss, G.L., 1988. The biogeography of the deep-sea Octopoda. *Malacologia*, **29**, 295–307.

Voss, G.L. & Pearcy, W.G., 1990. Deep-water octopods (Mollusca: Cephalopoda) of the northeastern Pacific. *Proceedings of the California Academy of Sciences*, **47**, 47–94.

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