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UNUSUAL INCIRRATE OCTOPODS FROM THE SOUTH SHETLAND ISLANDS, ANTARCTICA, INCLUDING *BATHYPURPURATA PROFUNDA*, A NEWLY DISCOVERED GENUS AND SPECIES OF DEEPWATER PYGMY OCTOPOD (CEPHALOPODA)

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ABSTRACT: Among the many octopods collected during recent Antarctic trawling were several species that do not belong to the common Antarctic pareledonin fauna. Three species are either poorly known or new to science, so we describe their morphology and anatomy. A very small (23 mm dorsal mantle length, ML) mature female of a fragile, dark purple species without an ink sac has suckers in a single series and proportionally huge salivary glands. We consider it to be a new genus and species. A single *Graneledone antarctica* Voss is unusual because it is the largest reported specimen (104 mm ML) and the first mature female. Six *"Bentheledone"* from a single deep (3213 m) sample and another, mature male caught nearby over five years later, may be *B. albida* (Berry), until now known only from the holotype. They are characterized by tiny posterior salivary glands, a small triangular calamus and small almost circular ligula.

INTRODUCTION

Incirrate octopods are common members of the Antarctic marine benthos (Dell, 1972). Most of the octopods collected in Antarctic samples belong to the genera *Pareledone* and *Megaleledone* or close relatives (*e.g.*, Taki, 1961; Kuehl, 1988; Daly and Rodhouse, 1994; Kubodera and Okutani, 1994; Lu and Stranks, 1994; Allcock *et al*. 2001). During recent trawling cruises in the vicinity of the Antarctic Peninsula, we collected representatives of unusual polar and deep-sea incirrate taxa. The *Pareledone* and *Megaleledone* that were collected on these cruises are being treated, together with several species that appear to be closely related, separately as part of a systematic revision of that group (Allcock, in prep.), as are the non-pareledonin genera *Thaumeledone* (Allcock *et al*., in press) and *Benthoctopus* (Vecchione *et al*., in prep.). Three other taxa that we collected are rare in archival collections and either incompletely described or new to science. We therefore present observations on their morphology and anatomy, including the description of a new genus and species.

MATERIALS AND METHODS

The second leg of R/V Polarstern's cruise ANT XIV (November–December 1996) and the third leg of ANT XIX (January–February 2002) focused on the South Shetland Islands northwest of the Antarctic Peninsula. One research component of each cruise was a fisheries survey using commercial-sized bottom trawls (Piatkowski *et al*. 1998). Sampling was conducted on ANT XIV at 40 stations around Elephant Island based on a stratified-random survey design in depths to 500 m. Two transects of stations at depths of 400, 600, and 800 m northwest of King George Island also were sampled with the same gear. A similar survey during ANT XIX trawled at 49 stations around Elephant Island and 20 stations from 100–500 m depth in the southern South Shetlands.

Additionally, 23 samples were collected with an Agassiz beam-trawl on ANT XIV and nine with a smaller Agassiz trawl on ANT XIX at various depths between 100–5200 m.

All cephalopods were retrieved from all samples. Station locations and distribution of these cephalopods are presented by Piatkowski *et al*. (1998; 2003). Dorsal mantle length (ML) and total length were measured and sex and maturity stage determined for all specimens. The criteria we used for male and female maturity stages (Tables 1 and 2) are as follows:

male

stage 1 sex undeterminable
stage 2 testes developing or developed, but no spermatophores developing
stage 3 spermatophores developing, but none are mature
stage 4 few mature spermatophores present
stage 5 four or more mature spermatophores present
stage 6 Needham's sac swollen but empty

female

stage 1 sex undeterminable
stage 2 ovary small and round, eggs spherical
stage 3 eggs begin to elongate
stage 4 ovaries swollen and oviducal glands enlarged
stage 5 ovaries completely distended with many mature eggs
stage 6 ovaries swollen but empty, oviducal glands enlarged

Under material examined, we list stage 1 as juvenile, stages 2–3 as immature, stages 4–5 as mature, and stage 6 as spent. Additionally, the following measurements and counts were recorded as recommended by Roper and Voss (1983): measurements — ventral mantle length, mantle width, head width, eye diameter, width of pallial aperture, full funnel length, free funnel length, web formula, depth of deepest web segment, arm width, length of each arm, sucker diameter; counts — numbers of suckers on left and right ventrolateral arms, number of suckers on the longest arm, number of inner and outer gill lamellae. The lengths of the calamus and ligula were recorded for males. Measurements and counts are presented in Tables 1 and 2. In the description of *"Bentheledone"* cf *albida* below, measurements and counts are summarized as minimum-median-mean ± standard deviation-maximum. Specimens of *"Bentheledone"* cf *albida* were dissected to examine internal anatomy. Dissections emphasized male and female reproductive anatomy and comparative anatomy of digestive tracts. Dissections of the remaining two species examined sex and maturity but otherwise were minimal to preserve these unique specimens.

Observations

Bathypurpurata profunda gen. et sp. nov.

Material examined Holotype. ANT XIV Sta. 40, 1 mature female, 23 mm DML U.S. National Museum of Natural History (USNM) cat no. 1020572.

Description External (Figures 1–2). Small dark incirrate octopod with numerous uniserial suckers on thin, rather long arms (about 2.5 X ML) and with very shallow web. Arms II>III>I=IV. Head narrower than mantle. Large eyes appear to be oriented postero-dorsally. Color when freshly collected purple dorsally, ventrally, and orally, but pigment leached rapidly into formalin fixative. Skin badly eroded ventrally but very small papillae on dorsal mantle. Ventral mantle and funnel damaged. Internal (Figure 2). Ink sac absent. Funnel organ W-shaped. Ovary swollen, filling posterior mantle cavity, containing ca 8–10 eggs of 4 × 3 mm. Proximal oviducts very short, barely extending beyond common junction with ovary. Oviducal glands ca 3.5 × 3.0 mm. Distal oviducts swollen, about equal in size to oviducal glands, each with nipple-like terminal papilla. Digestive tract not dissected. Dorsal mantle cavity heavily pigmented. Posterior salivary glands comparatively huge (each 9 X 8 mm; 45% ML).

Distribution Collected in a large bottom trawl at 61 02 S 054 49 W, 509–565 m depth. NE of Elephant Island, South Shetland Islands, off Antarctic Peninsula.

Etymology The genus and species names refer to the deep purple color of the animal when first collected and the depth at which it was found.

Comments The holotype, and only known

Table 1. Counts and measurements (mm) for *Bathypurpurata profunda* gen. et sp. nov.and *Graneledone antarctica*.

Character	*B. profunda*	*G. antarctica*
Sex	female	female
Maturity stage	5	4
Total length	80	420
Dorsal mantle length	23	104
Ventral mantle length	21	81
Mantle width	18	113
Head width	12	68
Eye diameter	4	28
Pallial aperture width	9	69
Full funnel length	6	41
Free funnel length	2	22
Deepest web depth	11	95
Arm width	5	20
Left dorsal arm length	53	310
Left dorsolateral arm length	57	310
Left ventrolateral arm length	56	280
Left ventral arm length	53	240
Right dorsal arm length	52	310
Right dorsolateral arm length	57	310
Right ventrolateral arm length	53	280
Right ventral arm length	53	240
Left ventrolateral arm sucker count	42	58
Longest arm sucker count	43	58
Sucker diameter	1	6
Inner gill lamellae count	5	6
Outer gill lamellae count	4	6

specimen, was in fairly good condition when it was first collected (Fig. 1), but it was damaged by collection of a tissue sample and it further deteriorated rapidly when fixed in formalin/ seawater. This very unusual octopod can be distinguished from other genera with uniserial suckers because of the small size at which it matures and because of the comparatively huge posterior salivary glands and shallow web. Although pygmy-sized octopods with large salivary glands are well known from shallow, warm-water environments, these are unexpected characters in a deep-water polar species. The lack of an ink sac and small number of gill lamellae are, however, common among deep-sea species (Voss, 1988). Other genera of deep-water octopods with uniserial suckers but lacking an ink sac include

Figure 1. Photograph of *Bathypurpurata profunda* gen. et sp. nov. holotype, dorsal view of freshly-collected specimen.

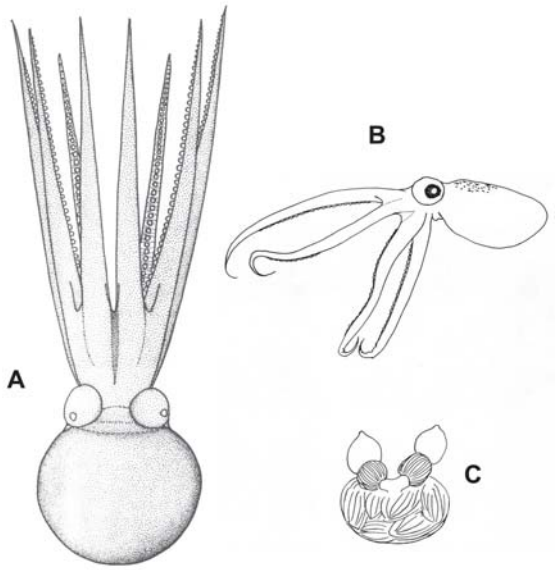

Figure 2. *Bathypurpurata profunda* gen. et sp. nov. holotype: A. Drawing of dorsal aspect; B. Sketch of lateral aspect from freshly-collected specimen; C. Ovary, oviducts, and oviducal glands.

Table 2. Counts and measurements (mm) for *"Bentheledone"* cf *albida*.

Character							
Sex	female	male	male	male	male	male	male
Maturity stage	2	2	2	2	2	2	5
Total length	248	250	258	266	233	273	390
Dorsal mantle length	63	66	64	62	61	61	82
Ventral mantle length	54	58	60	58	55	57	73
Mantle width	64	68	63	65	62	66	87
Head width	41	44	41	43	38	44	60
Eye diameter	14	15	14	14	13	15	24
Pallial aperture width	37	43	36	39	37	41	63
Full funnel length	29	28	27	29	23	30	35
Free funnel length	16	17	20	19	14	25	28
Deepest web depth	55	55	53	60	50	60	
Arm width	13	14	13	13	12	15	22
Left dorsal arm length	186	186	192	201	162	196	
Left dorsolateral arm length	189	195	189	204	166	204	240
Left ventrolateral arm length	181	189	180	203	154	203	220
Left ventral arm length	171	175	175	192	147	200	205
Right dorsal arm length	184	191	189	203	166	204	280
Right dorsolateral arm length	188	192	187	208	166	205	245
Right ventrolateral arm length	182	150	160	179	139	179	245
Right ventral arm length	179	178	178	197	149	190	255
Hectocotylized sucker count		39	38	38	40	42	38
Left ventrolateral arm sucker count	59	55	61	62	60	66	60
Longest arm sucker count	59	55	61	63	61	66	65
Sucker diameter	4	4	3	4	3	4	5
Ligula length		6	8	8	6	8	13
Calamus length		3	4	4	3	4	9
Inner gill lamellae count	8	8	8	8	7	8	6
Outer gill lamellae count	7	8	7	7	7	7	7

Graneledone, *"Bentheledone"* (see discussion below), and *Thaumeledone*. *Graneledone* is characterized by prominent cartilaginous tubercles on the dorsal mantle and head, lacking in the current specimen. *"Bentheledone"*, which currently is poorly defined and in need of systematic revision, and *Thaumeledone* both have very deep webs. None of these genera have huge posterior salivary glands. We therefore consider this unique specimen to be the type species of a previously unknown genus. In shallow-water octopods, very large posterior salivary glands are characteristic of small species that use venom to overcome large prey. It therefore seems likely that the present species occupies a feeding niche very different from those of most deep-sea octopods, which generally have small to very small posterior salivary glands.

Graneledone antarctica Voss 1976.

Material examined ANT XIV Sta. 77, 1 mature female, 104 mm DML, USNM 1008299. Comparative material. *Graneledone antarctica* Voss 1976. Holotype, USNM 729679, male, 41 mm ML, 74 05.6 S 175 05.2 W, Ross Sea, 2341 m,

Description External (Figure 3). Large dark incirrate octopod with long arms bearing uniserial suckers. Head much narrower than mantle. Small, multipointed, apparently cartilaginous tubercles cover dorsal surfaces of mantle and head and proximal aboral surfaces of all but ventral arms, extending more distally on dorsal and dorsolateral arms. Color purple-gray, generally lighter over eyes, and tubercles; suckers lighter than other surfaces. Web depth moderate, but extending as broad membrane along ventral sides of arms to

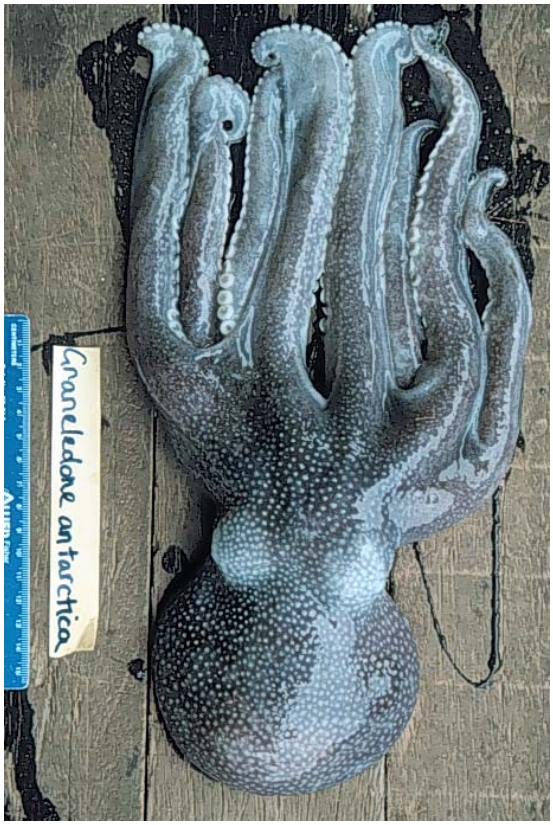

Figure 3. Photo of freshly collected *Graneledone antarctica*.

arm tips. Arms 2.3–3.0 X ML; I=II>III>IV. Internal. Ink sac absent. Gills small.

Distribution Collected in an Agassiz trawl at 61 19 S 057 03 W, 1440–1555 m depth from the slope west of Elephant Island, South Shetland Islands, off Antarctic Peninsula. Also known from the type locality somewhat deeper in the Ross Sea.

Comments A revised diagnosis of the genus is provided by Allcock *et al*. (2003), based on redescription of the type species, *G. verrucosa* (Verrill, 1881). Although our specimen was collected a long distance from the type locality of *G. antarctica*, it matches well with the holotype and with Voss' (1976) description. This is the largest specimen collected to date and the first mature female.

"Bentheledone" cf. *albida* Berry 1917.

Material examined ANT XIV Sta. 39, 5 immature males, 61–66 mm DML, 1 immature female, 63 mm DML, USNM 1020991. ANT XIX Sta. 46–8, 1 mature male, 82 mm DML, National Museums of Scotland (NMSZ) 2002038.011. Comparative material. *Moschites albida* Berry. Holotype, female. Australian Museum C040888. Mawson Antarctic Expedition, sta. 5., 64 34 S 127 17 E, off Wilkes Land, 3109 m. *Eledone rotunda* Hoyle. Lectotype, mature female. Natural History Museum, London BMNH 1890.1.24.6. Challenger Expedition, sta. 157, 53 55 S 108 35 E, Southern Ocean, 3600 m.

Description External (Figure 4). Large pale incirrate octopods with long arms bearing uniserial suckers and deep webs. Color light violet. Mantle width approximately equal to ML (0.98–1.03–1.03±0.03–1.08). Head narrower than mantle (.61–.65–.65±.02–.69). Arm lengths variable, without consistent pattern but longest arm ca 3 X ML (2.7–3.0–3.1±0.2–3.4). Hectocotylized right ventrolateral arm not much shorter than opposite arm (.79–.89–.91±.11–1.11). Ligula very small, almost circular (Figure 4) length ca 12% of ML (.09–.13–.12±.03–.15), 5% of hectocotylized arm length (.04–.05–.05±.01–.06). Calamus triangular, about half the length of ligula (.05–.06–.07±.02–.11 ML). Web depth ca 30% arm length (.27–.29–.29±.01–.30). Internal. Ink sac absent. Dorsal mantle cavity pigmented. Posterior salivary glands very tiny (Figure 5). Esophagus broad but flaccid. Intestine very thin and transparent; apparently straight, but very difficult to see. Stomach white, caecum dark. Immature female reproductive system with proximal oviducts joined separately to developing ovary, small oviducal glands, and long, broad distal oviducts.

Distribution This species has only been found very deep compared to most other cephalopods. Our specimens were collected at 2900 and 3220 m depths, separated by over five years in time but only about 20 nmi in distance. Coincidentally, both samples were filled with mud and both also captured the deep-sea octopod *Thaumeledone brevis*. These were the only tows made in that area and none of the other 30 Agassiz samples that we examined caught either of these species. Although

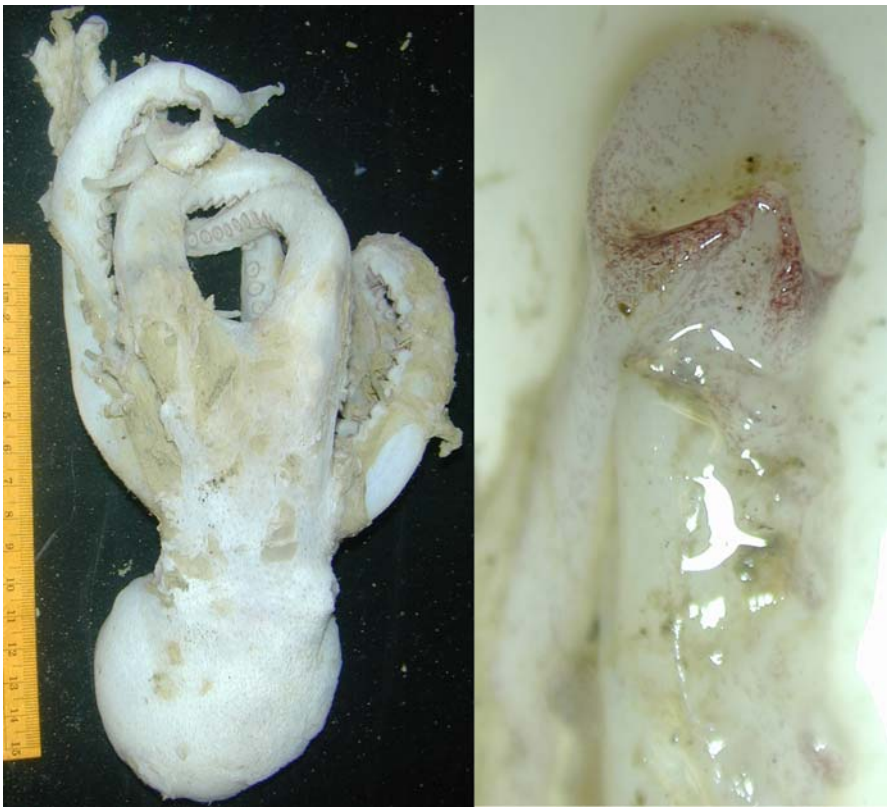

Figure 4. *"Bentheledone"* cf *albida*, photograph of freshly-collected male and closeup of distal hectocotylized arm.

two samples is not enough for confident inference, these coincidences are intriguing hints that a local concentration of *B. albida* and *T. brevis* may exist in the deep muddy area where these samples were taken. The type locality of *B. albida* was in "thick ooze and rock" at a similar depth in the Southern Ocean, but on the Australian side of Antarctica. If our specimens are indeed this species, then a circumpolar distribution in soft, muddy depths of about 3000 m is indicated. None of the six specimens collected in November 1996 were mature whereas the sole specimen from February 2002 was fully mature.

Comments Robson (1930) erected the genus *Bentheledone* to distinguish Hoyle's (1885) *Eledone rotunda* taxonomically, and he tentatively included *Moschites albida* Berry "on account of its general resemblance." We base our tentative identification on comparison with the published descriptions of *B. albida* and *B. rotunda* (Berry, 1917; Hoyle, 1886; Robson, 1930) and with what is left of the type material. Our specimens differ from *B. rotunda*, which is actually subantarctic, in numbers of gill lamellae and relative arm length. Oviduct morphology differs also, although this could be a result of different maturity stages or preservation artifacts. The holotype of *Moschites albida* Berry is in very poor condition. The mantle and arms are separated. The mantle is unmeasurable and the funnel and webs are gone. All arms are approximately equal in length, each with about 55–60 suckers, but it is impossible to determine which arms are dorsal, *etc*. Egg sizes vary considerably, with the largest eggs about 6 X 2 mm. We find no major inconsistencies between our specimens and what is known of *B. albida*. However, because of many uncertainties about the taxonomic characters of the latter species and the great distance between

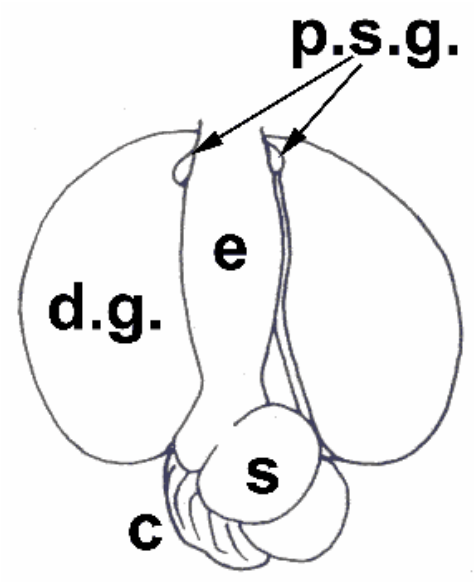

Figure 5. Schematic dorsal view of *"Bentheledone"* cf *albida* digestive tract. p.s.g., posterior salivary glands; d.g., digestive gland; e, esophagus; s, stomach; c, caecum.

our capture locations and Berry's, we cannot be confident that our specimens are conspecific with *B. albida*. If our specimens are the same species as Berry's, it is possible that neither belong in the same genus as *B. rotunda*. Our specimens are not consistent with the generic diagnosis presented by Robson (1930). DNA was extracted from one of our specimens and used by Carlini *et al*. (2001) in an analysis of the higher-level phylogeny of the Octopoda based on a partial sequence of the cytochrome *c* oxidase subunit I gene. Both maximum-parsimony and maximum-liklihood analyses of the sequence data placed our specimen within a clade of *Graneledone* spp., including *G. verrucosa*, *G. boreopacifica*, and *G. antarcticus* (the specimen described above). The shared lack of an ink sac is not truly informative because it is impossible to distinguish synapomorphy from homoplasy. However, *"Bentheledone"*, as represented by the present specimens, shares with *Graneledone* the markedly reduced size of the posterior salivary glands, although it lacks the numerous and prominent tubercles characteristic of the latter genus. Allcock *et al*. (submitted) have examined the generic problem and question the validity of the genus *Bentheledone*. Because the present specimens may be the same as *Moschites albida* Berry but are not consistent with any other valid genus, we refer to them here as *"Bentheledone"* cf *albida* until the taxonomic issues are resolved in a peer-reviewed publication.

DISCUSSION

The only general conclusion that can be reached from examination of specimens such as these is the need for more deep-sea trawling in the Southern Ocean. Only by collecting fresh specimens for detailed examination of morphological characters and tissue for molecular studies can we determine the diversity and relationships of deep-sea octopods.

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