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TODARODES PACIFICUS PUSILLUS NEW SUBSPECIES (CEPHALOPODA: OMMASTREPHIDAE) FROM NORTHERN AUSTRALIA

By Malcolm Dunning

Maritime Estate Management Branch, Queensland National Parks and Wildlife Service, PO Box 190, North Quay, Qld 4002, Australia

Abstract

Dunning, M., 1988. *Todarodes pacificus pusillus* new subspecies (Cephalopoda: Ommastrephidae) from northern Australia. *Memoirs of the Museum of Victoria* 49: 149-157

A new squid subspecies, *Todarodes pacificus pusillus,* is described from northern Australian continental shelf and upper slope waters on the basis of morphological differences and apparent geographic isolation from northern hemisphere populations of *T. pacificus* Steenstrup, 1880. Basic life history information is presented. The subspecies reaches maturity at less than 80 mm mantle length compared with greater than 200 mm ML for *T. pacificus* from Japanese waters.

Introduction

Seven species of arrow squid of the oegopsid family Ommastrephidae have been recorded from waters around Australia (Lu and Dunning, 1982). Small numbers of a previously unrecorded form were collected recently during research and exploratory fishing surveys in northern Australian waters. The specimens showed the general characters of the genus *Todarodes* Steenstrup, 1880, i.e., presence of simple foveola in the funnel groove with no side pockets, quadriserial suckers on the dactylus of the tentacular club, absence of light organs and hectocotylization of only the distal portion of the right ventral arm in males.

Three nominal species assigned to the genus *Todarodes* have been recorded from the Indo-Pacific region. *T. pacificus* Steenstrup, 1880 generally is considered to be restricted to waters adjacent to Japan (Okutani, 1980), *T. angolensis* Adam, 1962 occurs in oceanic and continental slope waters of the southern Tasman Sea and around South Africa (Dunning, unpublished data; Roper et al., 1984) and *T. filippovae* Adam, 1975 is abundant south of the Subtropical Convergence in the Indian and South Pacific Oceans (Dunning and Brandt, 1985).

Most measurements, indices and abbreviations follow Wormuth (1976). Counts of arm suckers were made using a binocular dissecting microscope and indices are expressed as a percentage of dorsal mantle length (ML) unless otherwise specified. Measurements of spermatophores are as defined by Roper and Voss (1983). Interpretation of tentacular club structure follows Roeleveld (1982) and the criteria described in Dunning and Brandt (1985) were used to assess reproductive condition. Type material is in the Museum of Victoria, Melbourne (NMV), Queensland Museum, Brisbane (QM), and the National Science Museum, Tokyo (NSMT).

Ommastrephidae Steenstrup, 1857

Todarodes Steenstrup, 1880

Type species. Todarodes pacificus Steenstrup, 1880.

Todarodes pacificus pusillus subsp. nov.

Figures 1, 2

Material examined. Holotype: Timor Sea (13°48′S, 124°19′E), bottom trawl in 102m, RV "Hai-Kung", 28 Mar 1981, NMV F31571 (male, ML 65 mm).

Paratypes: Timor Sea (8°53′S, 135°12′E), bottom trawl in 78 m,FRV "Soela", 27 Jun 1981, NMV F31569 (female, ML 64 mm); (9°52′S, 129°12′E), bottom trawl in 138 m, FRV "Soela", 9 Jul 1980, NMV F31570 (female, ML 64 mm).

Coral Sea (17°46.2′S, 146°50.2′E), FRV "Soela", 30 Nov 1985, QM Mo16359 (male, ML 68 mm); (17°16.1′S, 146°41.5′E), bottom trawl in 250 m, FRV "Soela", 1 Dec 1985, QM Mo16358 (female, ML 74 mm).

North-west Shelf (19°04′S, 118°57′E), bottom trawl in 82 m, FRV "Soela", 29 Aug 1983, QM Mo16357(male, ML 53 mm); (19°31′S, 116°02′E), bottom trawl in 130 m, FRV "Soela", 13 Oct 1983, NSMT Mo66640 (male, ML 53 mm); (19°31′S, 116°02′E), bottom trawl in 130 m, FRV "Soela", 13 Oct 1983, NSMT Mo66641(female, ML 61 mm).

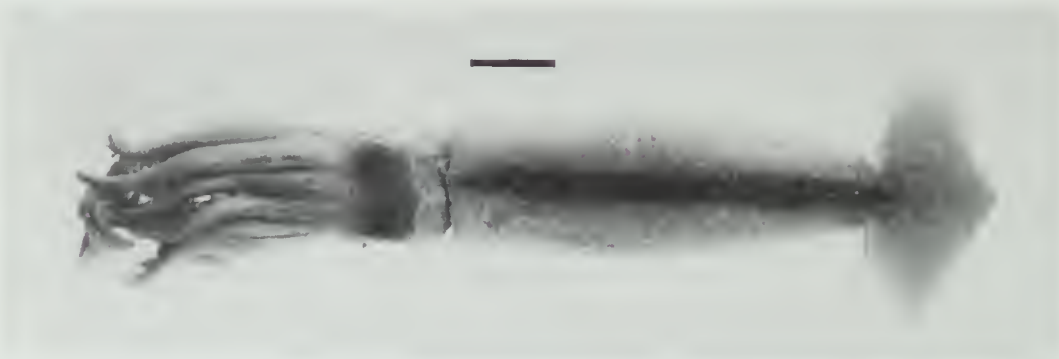

Figure 1. Holotype of *Todarodes pacificus pusillus* new subspecies, 63 mm ML male from the Timor Sea. (Scale = 10 mm)

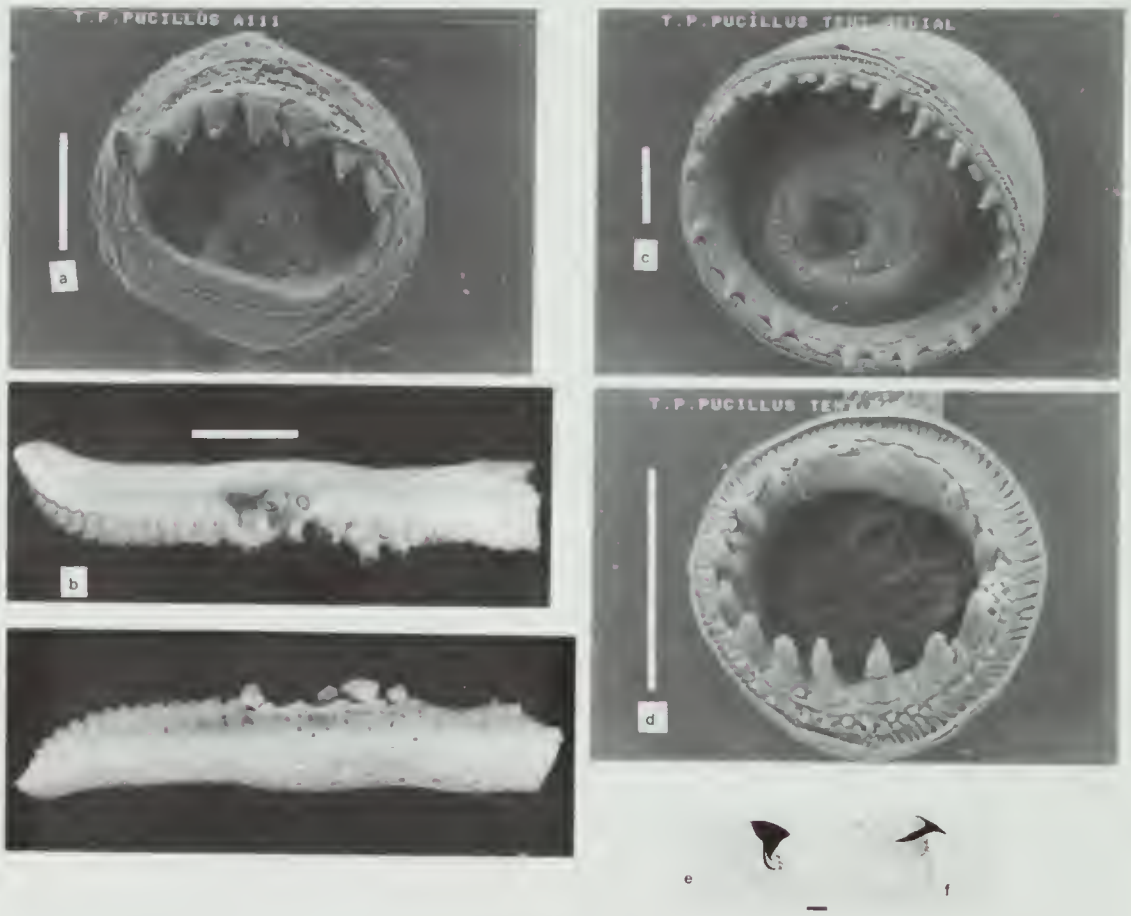

Figure 2. Arm III sucker (a), hectocotylized arm of a 68 mm ML male from off the northern Queensland coast (b), tentacular manus sucker (c), tentacular marginal sucker (d), upper (e) and lower (f) beaks. (a, c, d from the holotype, e, f from a 69 mm ML female from off the southern Queensland coast). (Scale = 0.25 mm for suckers and beaks, 5 mm for the arm)

Off southern Queensland (27°S, 153°45'E), bottom trawl in 120 m, FV "Harvest Moon", 5 Mar 1983, QM Mo13400 (female, ML 69 mm); (27°S, 153°45'E), bottom trawl in 150 m, FV "Harvest Moon", 27 Feb 1983, QM Mo13399(male, ML 62 mm).

Other material examined is listed in Appendix 1 and measurements of the type specimens of *T. p. pusillus* are shown in Table 1.

Description. Mantle cylindrical, slender, only moderately muscular, with abrupt caudal taper. Fins short rhombic. Head large, only slightly narrower than mantle. Mantle element of T-shaped locking device with straight ridge, no muscular fusion to funnel element. Funnel groove with simple foveola without side pockets.

Arms subequal and large, the longest (either II or III) slightly less than half the mantle length. Swimming keels present on aboral surface show greatest development on arms III. Basalmost arm sucker rings with 6-8 sharp subequal somewhat flattened teeth on distal half and smooth proximally. Toothed area increasing to approximately two-thirds on largest arm suckers which have 9-11 teeth. Protective membranes and their supports of uniform height, not higher than suckers.

Hectocotylization in males involving distal half of right ventral arm only. Arm slightly thicker and shorter than its partner. Dorsal aboral edge produced distally to form "spatula" at tip. 11-13 normal arm suckers present proximally. On distal half, suckers lost leaving prominent broad based trabeculae. In dorsal column, sucker stalks and bases disappear almost immediately but ventrally are still evident for at least 10 rows before fusing completely with trabeculae. Ventral trabeculae broaden and join together to form low serrated fan which diminishes in height rapidly at arm tip. Approximately 20 pairs of trabeculae present in modified section.

Tentacles approximately 1.5 times length of longest arm. Carpal suckers arranged as 2, 2, 1 on right club and 1, 2, 1 on left with similar dentition to largest arm suckers. Fixing apparatus absent. Suckers of manus in 6-8 quadriserial rows. Largest medial manus sucker rings with 16-18 moderately large subequal conical teeth interspersed with low horny plates, their diameters approximately 2.5 times those of adjacent marginal suckers. Proximally marginal suckers with a dentition similar to carpal suckers. By fourth manus row, they possess a complete ring of 18-20 sharp teeth somewhat larger laterally. Protective membrane beginning in carpal region never exceeds sucker height and its supports not strongly developed.

Chromatophores (of frozen specimens) chestnut brown on a silver-white background, smaller and more densely packed on fins and largest dorsally on mantle. A distinct deep blue-black dorsal stripe along the mantle midline broadening over head and extending anteriorly as thin stripes along aboral edges of dorsal and dorsolateral arms.

Light organs absent.

Spermatophores with sperm reservoir approximately equal to 40 % and cement body fifteen percent of spermatophore length. Cone at oral end of cement body in shape of an equilateral triangle.

Eggs ovoid, 1.2 mm maximum diameter.

Gladius with free rachis long and widest anteriorly, ending in a stiff, acute point. Posterior vanes reduced to a small spoon-shaped cone that accounts for slightly more than 10% of gladius length. Posterior end with a small conus.

Upper beak with deeply recessed jaw angle and moderate rostral edge. Wing base inserted halfway down anterior margin of lateral wall, crest strongly curved. Inner margin of hood wing almost straight and outer margin of rostral hood strongly curved.

Lower beak with recessed jaw angle barely visible in profile. Strong sharp knob present. Lateral wall with no apparent folds and hood notch moderately deep. Width of hood wing moderate and rostral edge slightly curved. Crest lateral wall moderately wide and crest fold strong.

Distribution. Australian continental shelf and upper slope north of 27°S at bottom depths between 78 and 357 m (Fig. 3).

Etymology. From the Latin *pusillus* (dwarf) referring to the small size at maturity of this subspecies relative to the North Pacific subspecies.

Discussion. Morphological characters of the Australian specimens were compared with those of specimens of Japanese common squid, *T. pacificus* Steenstrup, 1880, and the larger "neritooceanic" forms, *T. angolensis* Adam, 1962 and *T. filippovae* Adam, 1975. The specimens from northern Australian waters are separated from the last two on the basis of fin proportions (fin length index 24-31 compared with 51-55 for *filippovae*, 48-53 for *angolensis*, fin width index 42-50 compared with 55-63 for *filippovae*, 51-64 for *angolensis*), medial tentacular sucker dentition (18-20 teeth compared with 13-15 in *angolensis* and 10-13 in *filippovae*) and on the number of quadriserial sucker rows on the tentacles (6-7 compared with 12-13 in both *angolensis* and *filippovae*).

Table 1. Measurements and counts of *Todarodes pacificus pusillus* subsp. nov.

ML – Dorsal mantle length, MWI – Mantle width index, FLI – Fin length index, FWI – Fin width index, FA – Fin angle, HLI – Head length index, HWI – Head width index, IRAI – Right arm I length index, SR(IRA)I – Largest sucker on IRA diameter index, ISC – Sucker rows on IRA, IIISC – Sucker rows on IIIRA, SR(RT)I – Largest right tentacular sucker diameter index, ClLI – Club length index, MaSC – Sucker rows on the manus of the right tentacle, Arm formula – Lengths of the arms, HcLI – Length of the hectocotylized portion relative to the arm length, HDC – Sucker rows in the dorsal column of the hectocotylized arm, HVC – As previous but ventral column, SpLI – Spermatophore length index, SpWI – Spermatophore width index, SpRI – Sperm reservoir index.

	Holotype NMV F31571	Paratypes NMV F31570	NMV F31569	QM Mo13400	QM Mo13399	QM Mo16357	NSMT Mo66640	NSMT Mo66641	QM Mo16358	QM Mo16359
ML (mm)	65	63	64	69	62	53	53	61	74	68
Sex	M	M	F	F	M	M	M	F	F	M
MWI	22	21	24	–	–	24	29	28	23	21
FLI	30	29	30	25	27	27	27	31	26	29
FWI	48	47	50	45	45	49	48	48	45	43
FA	58°	59°	63°	61°	60°	62°	56°	64°	59°	56°
HLI	21	23	21	18	24	21	22	23	19	25
HWI	18	18	20	19	22	18	19	21	22	23
IRAI	33	31	36	36	35	34	44	30	30	30
SR(IRA)I	1.7	1.3	1.6	1.7	1.8	1.5	1.5	1.8	1.4	1.3
ISC	17	14	16	13	13	17	17	16	16	15
IIISC	16	17	19	17	17	17	16	17	17	17
SR(RT)I	2.6	2.1	2.8	2.9	2.9	2.6	3.0	2.8	2.4	2.5
ClLI	46	44	40	–	–	41	39	40	–	–
MASC (rows)	–	–	7	–	6	7	–	7	7	6
Arm Formula	3≈2>4>1	3≈2>4>1	3≈2>4>1	3≈2>4>1	2≈3>4>1	2≈3>4>1	3≈2>4>1	3≈2>4>1	–	–
HcLI	45	47	–	–	57	49	45	–	–	49
HDC	6	6	–	–	5	6	5	–	–	5
HVC	7	7	–	–	6	7	8	–	–	4
SpLI	11	–	–	–	11	10	12	–	–	–
SpWI	8.4	–	–	–	–	6.6	5.7	–	–	–
SpRI	36	–	–	–	–	41	–	–	–	–

Todarodes pacificus was described from specimens from east of Hokkaido and subsequent workers have considered it restricted to temperate shelf and upper slope waters in the northern North Pacific, principally around Japan (Sasaki, 1929; Voss, 1963; Clarke, 1966; Wormuth, 1976; Okutani, 1980; Roper et al. 1984) (Fig. 3). Occasionally this species has been reported from the South China Sea (Shojima, 1970; Tung, 1977) and around Hong Kong (Voss and Williamson, 1971). The paratype of *Nototodarus sloani philippinensis* Voss, 1962 from the southern Philippines should be referred to *T. pacificus* (Dunning, 1988). "Juvenile" *T. pacificus* were reported by Rancurel (1976) from the stomachs of yellowfin tuna caught in the north-west Coral Sea but these specimens were not available to the author for examination. With the exception of the above, no records of *T. pacificus* from south of 5°45′ have been found in the literature.

Comparison of the Australian specimens with specimens of *T. pacificus* from Japan, Taiwan and Hong Kong, with the paratype of *N. sloani philippinensis* and with values reported in the literature is presented in Table 2. It should be noted that since body proportions change with growth, more valid comparisons can be made among specimens of the same mantle length. However, the effect of the advanced state of reproductive maturity of the Australian specimens should also be taken into account.

Specimens from Hong Kong and Taiwan and the paratype of *N. sloani philippinensis* are intermediate in some characters and in size at maturity between the Australian and Japanese specimens. However, they show greater affinity with Japanese specimens in fin proportions, tentacular manus and arm sucker counts and size of arm suckers.

The simple structure of the hectocotylus of Australian males is not significantly different from that of Japanese males described and illustrated by Ishikawa (1913), Sasaki (1929) and Wormuth (1976) or from the hectocotylus of a 62 mm ML male from off Hong Kong. The right ventral arm of a 68 mm male from the Coral Sea is illustrated in Figure 2. In Australian specimens, a significantly greater proportion of the ventral arm is modified and the number of proximal suckers present is significantly fewer than for *T. pacificus* from Japanese waters.

Although less than 80 mm ML and weighing less than 15 g, the majority of the Australian specimens examined were mature. The oviducts and ovary of a recently copulated 64 mm ML female (Fig. 4) contained approximately 3000 ova between 0.75 and 1.20 mm maximum diameter (gravimetric extrapolation of egg count). All females larger than 60 mm ML were mature and all males greater than 50 mm ML carried fully formed spermatophores in their spermatophoric sacs (40 spermatophores in a male 75 mm ML).

Of the 103 specimens of *T. p. pusillus* examined 49 individuals were female and 59 male. Neither size disparity between sexes nor geographic separation was apparent in the material examined. Female *T. pacificus* from Japanese waters attain slightly greater mantle lengths than contemporary males and in exploited stocks usually outnumber males (Okutani, 1983).

Variation in size at maturity has been observed in northern hemisphere populations of *T. pacificus*. In Japanese waters, females reach maturity between 190 and 300 mm ML dependent on whether they belong to the so-called "winter", "autumn" and "summer" populations. Males reach maturity at more than 200 mm ML (Hamabe et al., 1974). Shojima (1970, Plate 11, figs. 8, 9) illustrated females of 138 and 152 mm ML from the South China Sea, evidently mature with well developed nidamental glands and eggs in their oviducts.

High water temperatures and increased day length have been related to accelerated maturation in cephalopods. Mangold (1966) observed that higher water temperature regimes and increased photo-period accelerated growth and maturation in *Sepia* in the Mediterranean and the physiological basis of this phenomenon was elucidated by Richard (1966). Other ommastrephids are also reported to display this phenomenon (O'Dor et al., 1977).

Around Japan, *T. pacificus* is not generally abundant where temperature at 50 m depth exceeds 15°C and it has been caught where temperatures are as low as 5°C (Kasahara and Nasumi, 1976). The Australian specimens were caught where temperatures at 50 m depth were in excess of 23°C, and surface temperatures reach 29°C in summer. Higher temperatures and an increased average day length at the lower latitudes of northern Australian waters may have contributed to the precious maturation of this subspecies of *T. pacificus*.

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Table 2. Morphometric comparison of *T. pacificus pusillus* from northern Australian waters with *T. pacificus* from Japan, Taiwan, Hong Kong and the Philippines.

	T. pacificus pusillus N. Australia				*T. pacificus pacificus* Japanese juveniles				*T. pacificus pacificus* Adults (Wormuth, 1976)				Hong Kong		Taiwan	Philippines
	Median	Max.	Min.	N	Median	Max.	Min.	N	Mean (Median)	Max.	Min.	N				
ML (mm)	–	76.5	52	25	–	78	42.4	8	*	*	*	–	62(M)	81(F)	151(M)	101(F)
MW1	24	29	21	15	19	23	18	6	17.5	19	16	14	–	22	–	19
FL1	27	31	24	23	34	37	30	8	41.5	45	39	14	35	34	39	33
FW1	45	50	42	23	45	47	41	8	55.2	58	49	14	50	46	50	45
FA	59	64°	56°	11	49°	52	46	8	(52°)	62°	45°	14	43°	46°	–	52°
HL1	21	25	17	17	16.5	20	11	8	13.2	15	11	14	–	19	20	19
HW1	21	23	18	17	18	21	15	6	16.5	18	15	14	–	–	–	20
IRA1	31	44	28	24	27.5	31	27	8	35.9	38	32	14	29	33	–	28
SR(IRA)1	1.5	2	1	23	1.2	1.4	1.1	8	0.8	1.1	0.7	14	–	–	–	1.4
ISC	15	17	12	23	28.5	37	25	8	(47)	52	44	14	–	–	–	21
IIISC	17	19	12	23	28	36	26	8	–	–	–	–	25	27	–	23
SR(RT)1	2.5	3	2.1	20	2.2	2.6	1.8	8	2.3	2.7	1.9	14	2.2	–	–	2.2
CIL1	40.5	46	39	6	26	27	24	3	33.8	41	28	14	36	–	–	31
MaSC (rows)	7	7	6	17	10	10	9	5	–	–	–	–	–	–	–	9
Arm Formula	3≈2>4>1	–	–	7	2≈3>1>4	–	–	8	2≈3>4≈1	–	–	–	2>3>4>1	–	–	2≈3>1>4
HcL1	44	57	31	14	–	–	–	–	–	–	–	–	39	–	34	–
HDC	5	6	4	14	–	–	–	–	(24)	29	18	4	10	–	12	–
HVC	6	8	5	14	–	–	–	–	(26)	32	25	4	10	–	13	–
SpL1	11	12	11	4												
SpW1	6.6	8.4	5.7	3												
SpR1	–	41	36	2												

* males 172.5-230 mm ML, females 151.5-261.5 mm ML

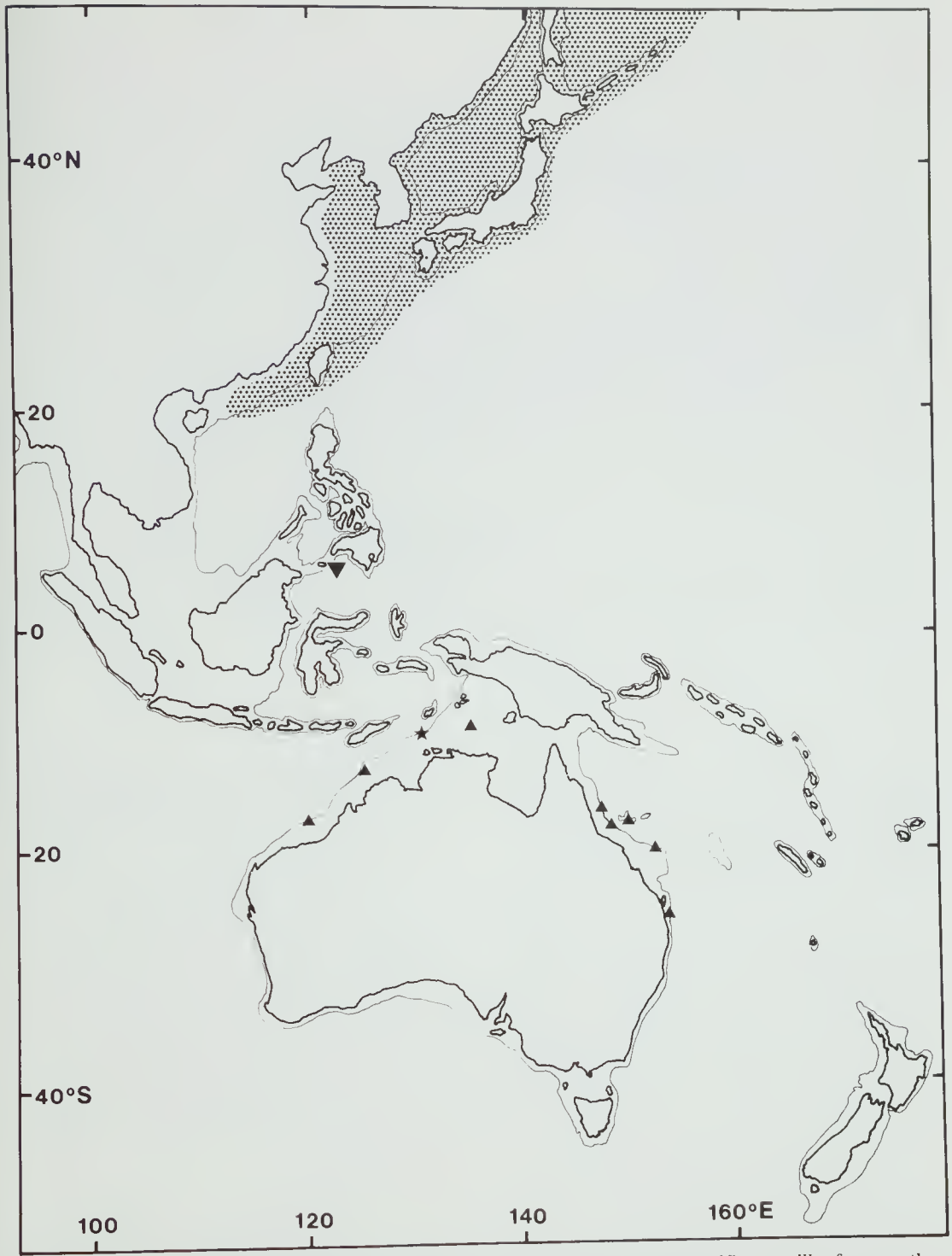

Figure 3. Capture localities of the holotype (star), other specimens of *Todarodes pacificus pusillus* from northern Australian waters (triangles) and the paratype of *Nototodarus sloani philippinensis* Voss, 1962 from the southern Philippines (inverted triangle).

Figure 4. Mature 64 mm ML female *Todarodes pacificus pusillus* from the Timor Sea, June 1981. (Scale = 10 mm)

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Appendix 1. Other material examined.

Todarodes pacificus Steenstrup, 1880

3 juveniles, ML 42-75 mm, North-west Pacific, south-east of Japan (38°15.5′N, 155°01.5′E), RV "Soyo-maru", surface scoop net, 24 May 1972, NMV F52555;

5 juveniles, ML 53-78 mm, North-west Pacific, off Fukushima Prefecture, Japan, surface scoop net, June 1985, QM Mo16360;

Female, ML 101 mm, Off Jolo Island, Philippines (~5°45′N,121°40′E), "Albatross", bottom trawl in 294 m, 7 February 1908, United States National Museum 575452 (Paratype of *Nototodarus sloani philippinensis* Voss, 1962);

Male, ML 151 mm, Off Pingtou, Taiwan, bottom trawl, October 1971, NMV F30321;

Male and female, ML 62,81 mm, South China Sea, off Hong Kong (19°05′N, 115°15′E), RV "Tai-shun", bottom trawl in 120 m, 8 April 1983, Australian Museum C140404;

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3 males and 6 females, ML 58-63, 64-74 mm, Coral Sea (17°46.2′S, 146°50.2′E), FRV "Soela", bottom trawl in 201 m, 30 November 1985, NMV F52542;

4 males, ML 61-72 mm, Coral Sea (17°16.1′S, 146°41.5′E), FRV "Soela", bottom trawl in 250 m, 1 December 1985, NMV F52543;

Male, ML 77 mm, Coral Sea (17°36.5′S, 150°10.3′E), FRV "Soela", bottom trawl in 224 m, 4 December 1985, NMV F52544;

Male and 3 females, ML 61, 52-72 mm, Coral Sea (18°00.7′S,147°01.4′E), FRV "Soela", bottom trawl in 203 m, 29 November 1985, NMV F52545;

4 males and 4 females, ML 49-66, 68-76 mm, Coral Sea (18°40.8′S,148°02.8′E), FRV "Soela", bottom trawl in 204 m, 9 December 1985, NMV F52546;

2 females, ML 60 and 69 mm, Coral Sea (17°43.7′S, 146°52.8′E), FRV "Soela", bottom trawl in 302 m, 30 November 1985, NMV F52547;

2 females, ML 66 and 71 mm, Coral Sea (18°39′S, 148°03.4′E), FRV "Soela", bottom trawl in 204 m, 9 December 1985, NMV F52548;

Male, ML 66 mm, Coral Sea (17°55.8′S, 146°58.2′E), FRV "Soela", bottom trawl in 250 m, 30 November 1985, NMV F52549;

Male and 2 females, ML 55, 60, 65 mm, Coral Sea (18°05′S, 147°10.8′E), FRV "Soela", bottom trawl in 248 m, 8 December 1985, NMV F52550;

Male and 3 females, ML 64, 66, 72, 72 mm, Coral Sea (17°53.7′S,146°53.9′E), FRV "Soela", bottom trawl in 162 m, 1 December 1985, NMV F52552;

Female, ML 58 mm, Coral Sea (19°57.4′S, 151°44.4′E), FRV "Soela", bottom trawl in 357 m, 30 November 1985, NMV F52553;

36 males and 18 females, ML 64-75mm and 61-82 mm, Coral Sea (17°59′S,147°E), FRV "Soela", bottom trawl in 220 m, 8 January 1986, NMV F53156;

Male, ML 77 mm, Coral Sea (18°S, 147°01′E), FRV "Soela", bottom trawl in 224 m, 8 January 1986, NMV F53157;

Male and female, ML 69, 72 mm, Coral Sea (17°59′S, 147°E), FRV "Soela", bottom trawl in 218 m, 9 January 1986, NMV F53158.