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Ommastrephidae), with an unusually short arm

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## Notes on an exhausted Japanese common squid, *Todarodes pacificus* (Cephalopoda: Ommastrephidae), with an unusually short arm

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### Abstract

A Japanese common squid, *Todarodes pacificus* with an unusually short left fourth arm was captured from the Sea of Japan on October 1996. This specimen was a mature male (mantle length 216 mm, body weight 186 g) "Kawa-ika" squid that seemed to be nearing the end of its reproductive life. About two-thirds of the left fourth arm of this individual was lost and the surface of the arm's tip was completely covered with skin. This short arm was either caused by i) malformation or ii) accidental loss of the tip, followed by regeneration. Arm regeneration is common in cephalopods, and the left fourth arm of the present specimen was very similar to the regenerating arms of other cephalopods. Therefore, the arm of the present specimen may be regenerating. Since *T. pacificus* is a terminal spawner, this specimen indicates that regeneration can still occur even during later phases of the life cycle.

Abnormal specimens of the Japanese common squid, *Todarodes pacificus* have been reported by several authors, including specimens with an extra arm on the anterior margin of the mantle (Honma & Yada, 1960; Kasahara & Okiyama, 1974) and specimens with fused tentacles (Kasahara & Okiyama, 1974; Okutani & Kawaguchi, 1981). Murata *et al.* (1981) reported an unusually short tentacle for the neon flying squid, *Ommastrephes bartrami*, and they discussed this observation as an example of regeneration. Although Murata *et al.* (1981) also referred to an unpublished observation of two individuals of *T. pacificus* with supposedly regenerated tentacles, further description of these specimens has not appeared. In this note, we report an abnormal mature male *T. pacificus* with an unusually short arm, and discuss it as a possible example of arm regeneration.

A specimen of abnormal *Todarodes pacificus* was caught by jigging in the Sea of Japan (37° 00'N and 133° 30'E) between 18:30 p.m. on 16 October and 3:00 a.m. on 17

October 1996, together with 12 normal individuals (7 females and 5 males). The latter 12 squids were retained for comparison with the abnormal specimen. Whole individuals were fixed immediately in 10% neutral buffered formalin in seawater followed by preservation in 75% ethanol. Dorsal mantle length (ML), body weight (BW), gonad weight, digestive gland weight and mantle weight were measured from the fixed specimens.

The abnormal specimen lacked the distal two-thirds of the left fourth arm (Fig. 1A; Table 1). The surface of the left fourth arm's tip was completely covered with skin without any sign of injury (Fig. 1B). By contrast, inner muscular tissue is clearly exposed on a recently injured *Todarodes pacificus* arm (e.g., a recently lost left second arm, Fig. 1C).

Based on BW and ML relationships, growth of the abnormal specimen was similar to growth of the normal specimens (Fig. 2A). Comparisons between hepatosomatic indices (HSI=digestive gland weight/BW) and mantle indices (MI=mantle weight/BW) of the normal and abnormal specimens indicate that the abnormal specimen (HSI, 6.8 %; MI, 37 %) was an exhausted, individual nearing the end of its reproductive life, a so-called "Kawa-ika" squid (Hamabe, 1963; Adachi, 1988) (Fig. 2B). The testis of this specimen was also small (2.4 % of BW), which is another characteristic of male Kawa-ika squid (Adachi, 1988).

Regeneration in cephalopods has been reported mainly for octopuses (Lange, 1920; Okada, 1935) although a few examples of regeneration in common cuttlefish (a *Sepia esculenta* with a branched arm) (Okada, 1938) and neon flying squid, *Ommastrephes bartrami* (Murata *et al.*, 1981) are available. The only possible causes of the unusual shortness of the left fourth arm of the present specimen are i) the left fourth arm is malformed, or ii) a part of the left fourth arm has been lost by an accident (e.g., feeding,

**Table 1.** Measurements (after 10% formalin fixation) of abnormal *Todarodes pacificus* caught at the Sea of Japan on October 1996

Parts	Measurements	
Dorsal mantle length	216 mm	
Body weight	186 g	
Head length	31 mm	
Head width	38 mm	
The 1st arm length	(Left) 98 mm	(Right) 80 mm*
The 2nd arm length	115 mm	116 mm
The 3rd arm length	114 mm	108 mm
The 4th arm length	29 mm**	92 mm
Tentacle length	154 mm	152 mm
Club length	98 mm	98 mm

\* Tip of arm was lost probably due to recent accident

\*\* Unusually short arm

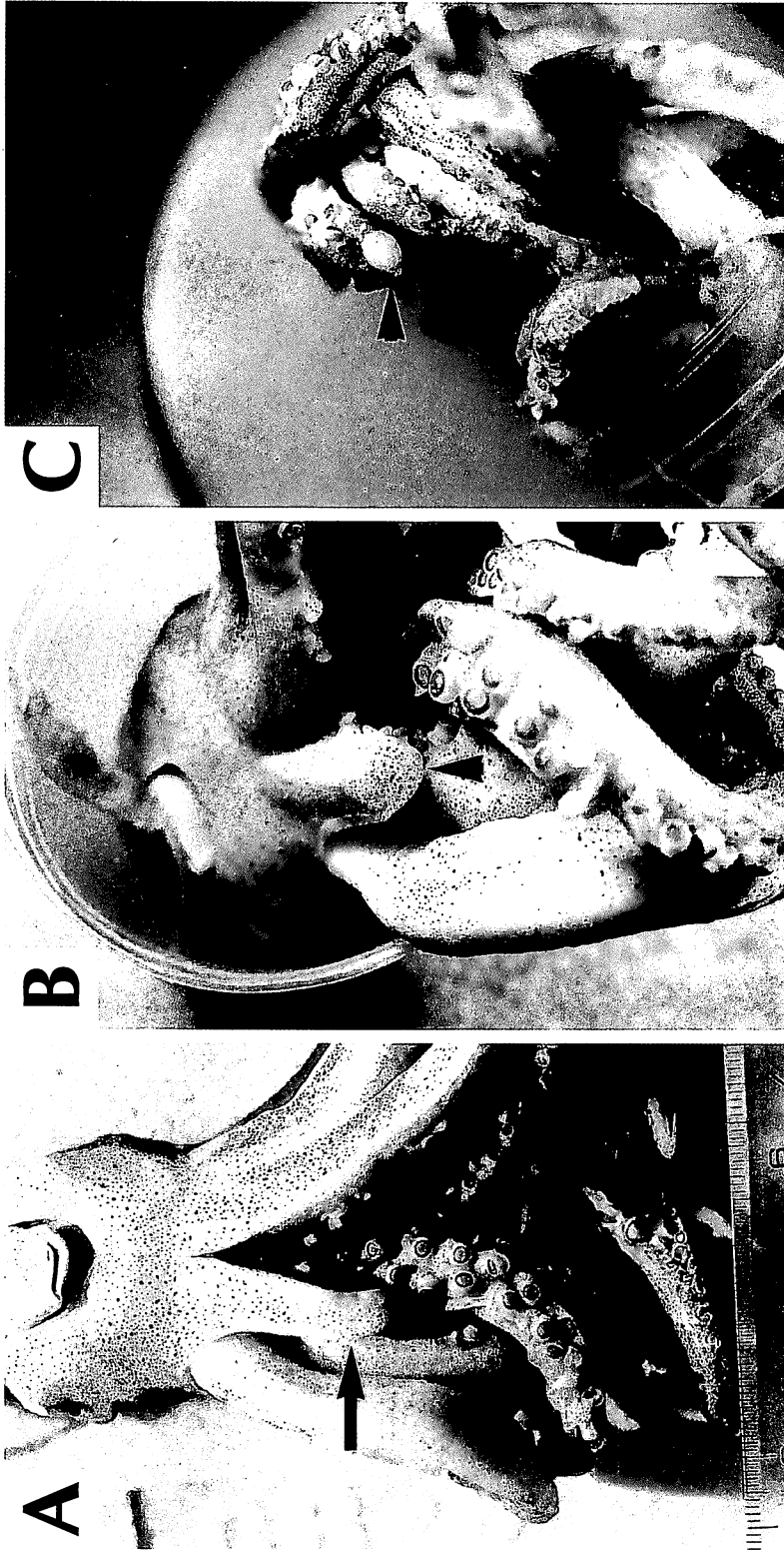
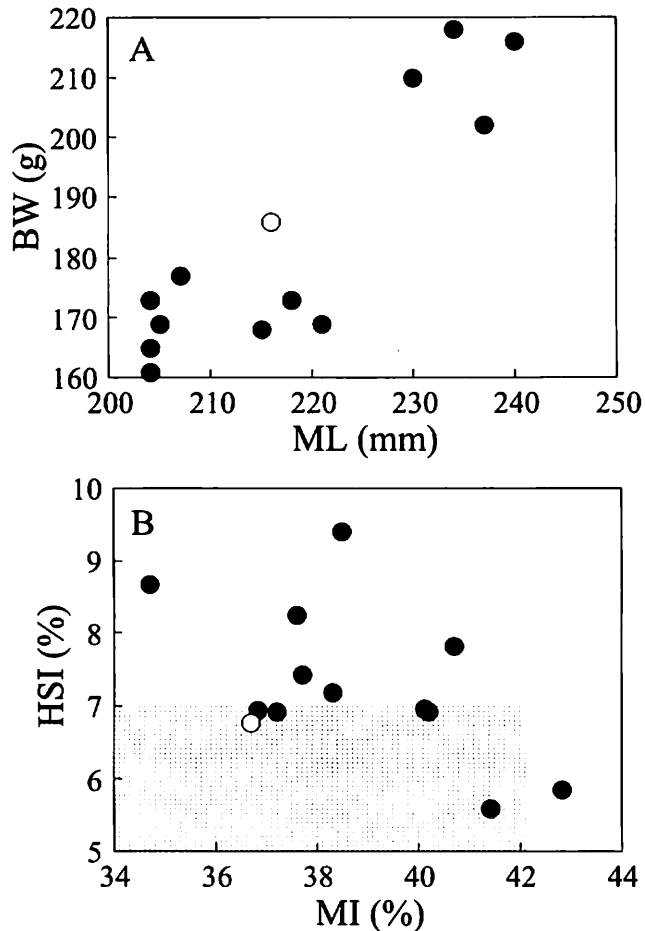


Figure 1. Photographs of *Todarodes pacificus* caught in the Sea of Japan. The specimen was fixed in 10% neutral buffered formalin with seawater followed by preservation in 75% ethanol. (A) Abnormal *T. pacificus* with unusually short left fourth arm (arrow); (B) Tip surface of the left fourth arm of the abnormal specimen (arrowhead). Note the complete covering of the arm tip surface with skin; (C) Tip surface of the injured left second arm of a normal *T. pacificus* (arrowhead). Note that the musculature of the injured arm is exposed.



**Figure 2.** Comparisons of body dimensions between the *Todarodes pacificus* specimen with an unusually short left fourth arm (open circle) and control specimens (solid circles). (A) Dorsal mantle length (ML) versus body weight (BW). (B) Mantle index (MI; Mantle weight/BW %) versus hepatosomatic index (HSI; digestive gland weight/BW %). The shaded area indicates exhausted, spent individual (a so-called "Kawa-ika" squid) (MI and HSI values following Adachi (1988)).

fighting, jigging), and we are observing the regeneration process. We think the latter possibility is more likely for the following two reasons. First, in octopuses, the initial phase of arm regeneration is the covering of the injured region with skin (Lange, 1920). This seems very similar to the appearance of the surface of the left fourth arm's tip of the specimen described here. Second, Murata *et al.* (1981) described a similar situation for the regenerating tentacle of *O. bartrami*, and they noted that "the outer skin and the chromatophore are smoothly continuous at a border between the original and the regenerated portion". However, even if regeneration is the case for the present specimen, it is not clear whether such regeneration often occurs in *Todarodes pacificus*, since tentacle

regeneration had been observed only in two individuals among 1,180 *T. pacificus* examined from nature (unpublished observation cited in Murata *et al.* (1981)).

Since *Todarodes pacificus* is a terminal spawner, and the present abnormal *T. pacificus* was a male nearing the end of its reproductive life, the present observation suggests that regeneration still occurs even during the final phase of the life cycle in this species. This may relate to the continuous mating potential of male *T. pacificus* even after they become mature (Ikeda *et al.*, 1993). Arm regeneration in male *T. pacificus* may be an important adaptation, because the arms play an important role in grasping the female during mating in this species.

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