

Occurrence of Antarctic flying squid *Todarodes filippovae* Adam, 1975 in Southern Indian Ocean

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Antarctic flying squid *Todarodes filippovae* is poorly known in Southern Indian Ocean. About 27 kg of *T. filippovae* consisting of 37 individuals were opportunistically collected on 1st February 2011 at 38° 59'S, 57° 29'E of northern Subtropical Convergence during the 5th Indian Expedition to Southern Ocean. Among the 37 individuals, 36 were females with dorsal mantle length (ML) of 331±21 mm. The ML of single male was 210 mm. Heavy metals detected in mantle samples were, Pb<DL, Cd 0.80 ± 0.64, Fe 22.62 ± 14.6, Mn 2.01 ± 0.3, Ni 6.0 ± 0.5, Cu 20.18 ± 2.4, Zn 111.61 ± 7.1 and Hg 1.64 ± 0.35 µg/g dry weight. These trace element concentrations were within the permissible limits recommended for human consumption. The present study gives the preliminary information about the abundance of *T. filippovae* in Southern Indian Ocean.

[**Keywords:** Antarctic flying squid, *Todarodes filippovae*, hand jig, heavy metals, Southern Indian Ocean.]

Introduction

Cephalopods are gaining economic importance as evidenced by the rapid rise in their global landings over recent decades. Commodity and supportive services provided by cephalopods in 22 Large Marine Ecosystems (LME), contributed as much as 55% of fishery landings and 70% of landed values¹, with an annual harvest of two million metric tons of squid alone in global landings². Based on the structure of the funnel groove, the family Ommastrephidae (Mollusca: Cephalopoda) is classified into three subfamilies Illicinae, Todarodinae and Ommastrephinae³. In this family, 23 species are recognized, which includes many commercially important species distributed in the world oceans⁴. The estimated ommastrephids fishery potential is ~ 6 to 9 million t including 4 to 7 million t of oceanic species. Thus ommastrephids are one of the most important resources for increasing high-quality food protein catch in the world oceans⁵. The ommastrephids are caught

offshore over continental shelves and off-shelf over the deep ocean. They ascend close to the surface at night, but may migrate down to depths of 1000 m during the day⁶.

Southern Ocean is the oceanic region south of the Antarctic convergence. Among the most powerful, non-buoyant squid in the Southern Ocean are the ommastrephids, namely *Martialia hyadesi* and *Todarodes filippovae* which are the only Southern Ocean species known to form schools^{7,8}. In the Tasman Sea, *T. filippovae* is the most abundant ommastrephid in the subtropical convergence zone and in slope waters of southeastern Australia⁹. *T. filippovae* is a temperate subantarctic species, though it is regularly caught in Antarctic waters of the Southern Ocean. It also enters subtropics. The Antarctic flying squid *Todarodes filippovae* Adam, 1975 is a large muscular oceanic pelagic ommastrephid squid with circumpolar distribution south of 35°S, and is the most common in the Subtropical Convergence Zone around continental sea mounts and slope

waters¹⁰. *T. filippovae* is a temperate subantarctic species, though it is regularly caught in Antarctic waters of Southern Ocean. It also enters subtropics and is reported to occur up to 1000 m depth, its abundance is mostly between the surface and 200 m in depth in the open ocean up to the continental slope, and appears not to extend into shelf waters⁷. Holotype of the species was first described by Adam¹¹ based on the specimen collected from the continental slope of Amsterdam Island (35°40'S, 66°10'E) in Southern Indian Ocean on 22 December 1967¹². Present paper is the first report on the occurrence of *T. filippovae* in the Indian sector of Southern Indian Ocean.

Materials and Methods

About 27 kg of *T. filippovae* consisting of 37 individuals were opportunistically collected on 1st February 2011 at 38° 59'S, 57° 29'E of northern Subtropical Convergence from the research vessel ORV *Sagar Nidhi* during the 5th Indian Expedition to Southern Ocean, organized by the National Centre for Antarctic & Ocean Research (NCAOR), Goa (India). During the survey, a powerful lamp in the vessel hanging above the deck was focused on the sea surface. Squid were found near the surface in large numbers at night. The squid shoal was attracted by the light and were caught from 1.00 AM to 2.05 AM using a pink coloured jig armed with arrays of barbless hooks which was lowered and raised on line by hand operation. About 37 squids per one jig per hour were caught during the operation. In the present study, the bioaccumulation of heavy metals in *T. filippovae* tissues was analyzed. The edible portions of squid are mantle, arm and tentacle, and the mantle has high export value. As the mantle muscle (Figure 1e) is the standard tissue for

sampling in squid, the mantle was collected for analysis. Mantle muscle of individuals were cut in to small pieces; washed in distilled water and dried in an oven at 60 ± 2°C. Trace metals were extracted from dried tissue samples (5 g) in duplicate by following acid digestion procedure¹³ using Microwave Laboratory System (START D, Milestone, Italy). Trace metal concentrations of lead (Pb), cadmium (Cd), iron (Fe), manganese (Mn), nickel (Ni), copper (Cu), zinc (Zn) were determined by Flame Atomic Absorption Spectrometry and mercury (Hg) was determined by Hydride Atomic Absorption Spectrometry (Perkin Elmer AA700, USA).

Results and Discussion

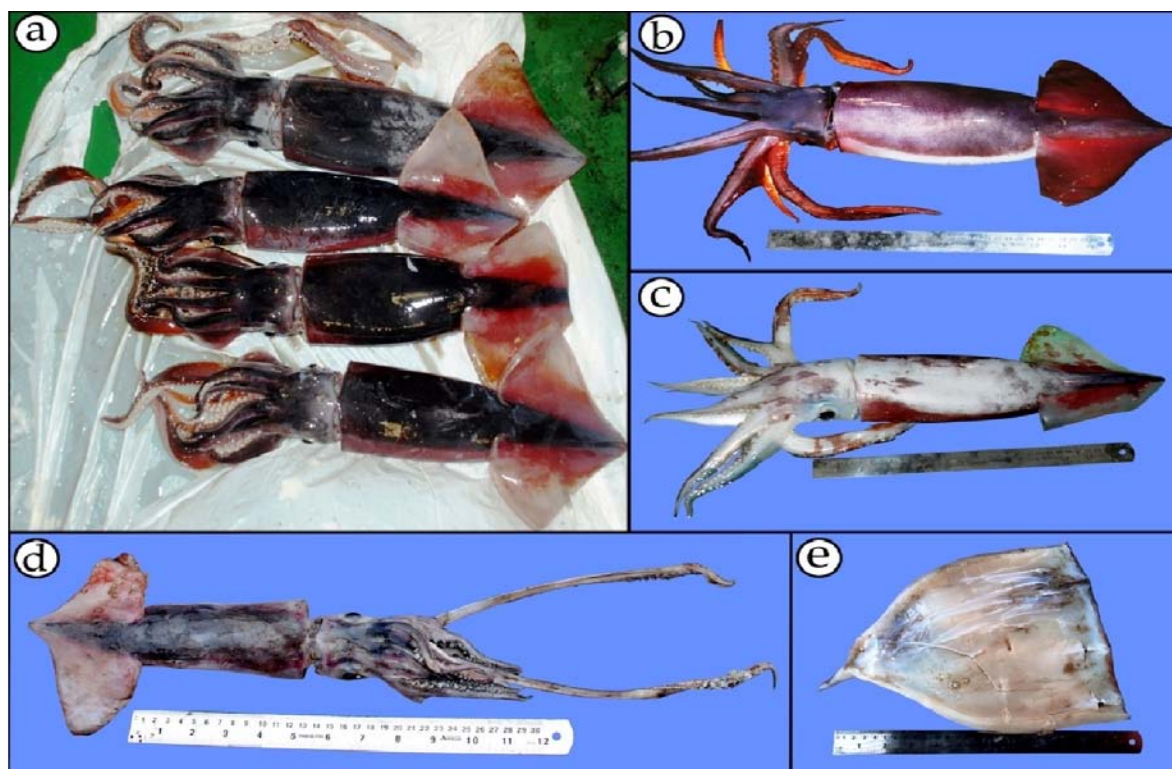
Among the 37 individuals, 36 were females (Figure 1a & 1b) with dorsal mantle length (ML) of 331±21 mm. Such a sex ratio with a strong female predominance is particular for foraging aggregations of immature oceanic ommastrephids at the periphery of the species range¹⁴. The ML of single male was 210 mm. It is reported that *T. filippovae* had a life cycle of about a year with the sexually dimorphic females reaching larger size by predominantly growing faster than males and a semelparous life-history strategy, with a single spawning followed by death soon thereafter¹⁵. Mean age of mature females (294 days) was 34 days greater than mature males (260 days)¹⁶. Identification of the species was done based on Rodhouse's taxonomic key⁷. It looks similar to the Neon flying squid *Ommastrephes bartramii*. The largest tentacular (manus) sucker rings of *T. filippovae* have 7-13 long teeth which is the distinguishable character for identification, while those of *O. bartramii* have one tooth in each quadrant greatly enlarged. The main and most

obvious difference is a very long tentacular club in *T. filippovae*, and a short club in *O. bartrami*. Male right arm IV (modified ventral arm) of *T. filippovae* is hectocotylized, like in all ommastrephids (Figure 1d). The live specimens of *T. filippovae* were dark purplish red in colour. After it was caught in the jig and exposed to air,

the skin colour turned pale white and became colourless (Figure 1c) and again changed to red. Coloration is from the pigment cells called chromatophores, located in the outer layer of skin. The squid appeared colourless when it retracts all chromatophores. Some of the squids ejected

Table 1 Trace metal concentrations in the mantle muscles of *T. filippovae* in different sites; DL refers to detectable level.

Metal	Present study area (mg/kg dry wt)	Tasmania ²⁰	Ille Amsterdam ²⁰	WHO ²³ permissible limit (mg/kg wet wt)	WHO values recalculated on dry weight basis (mg/kg dry wt)
Pb	<DL	<DL	<DL	2	9
Cd	0.80 ± 0.64	0.20 ± 0.14	0.93 ± 0.79	2	9
Fe	22.62 ± 14.6	9.70 ± 5.21	9.85 ± 4.76	30	42.6
Mn	2.01 ± 0.3	<DL	<DL	3	5.4
Ni	6.0 ± 0.5	<DL	<DL	2	9
Cu	20.18 ± 2.4	7.20 ± 2.43	6.36 ± 1.33	30	130
Zn	111.61 ± 7.1	63.1 ± 7.0	55.6 ± 4.1	50	217
Hg	1.64 ± 0.35	0.75 ± 0.42	0.25 ± 0.11	0.5	2.2



ink when it came out of water and made noise. Environmental parameters were collected in the sampled area where the air temperature was 21.0°C; sea surface temperature (SST) was 20.5°C; salinity 35.37‰; depth of the sea in the place of surface occurrence 5217 m; and wind speed 9 knot/hr. It has been reported¹⁷ that *T. filippovae* occurs in the SST range of 5.4°C-17.4°C. In this survey, it has been collected at SST of 20.5°C. Fatty acid profiles of the digestive glands suggest that the diet of *T. filippovae* consists primarily of myctophid fishes, with cephalopods and crustaceans as supplementary components¹⁸.

Squid are having capacity to accumulate very high concentrations of various essential and non-essential metals. Hitherto, trace metal concentrations have not been analyzed in any fauna of Indian sector of Southern Indian Ocean. Trace metal concentrations in sediments of this area was reported recently¹⁹. The trace metals detected in the mantle muscles of present study and other sites along with recommended permissible limits recommended by WHO²⁰ are shown in Table 1. These trace metal concentrations were within the permissible limits recommended for human consumption. *T. filippovae* from Tasmania and Île Amsterdam contain levels of Hg and Cd often exceeding the recommended guidelines, especially in their digestive glands²¹. Variation in the trace metal concentration of *T. filippovae* from different region might be diet related. However, recent studies on Hg biomagnification processes in sub-Antarctic waters of the southern Indian Ocean suggests the need for further oceanographic investigations²². Storelli *et al.*²³ reported high concentrations of cadmium in the hepatopancreas

of cephalopods and recommended that this tissue may not be consumed on a regular basis. World Health Organization of the United Nations, which issued a provisional tolerable weekly intake (PTWI) for cadmium as 400–500 mg and total mercury as 300 mg per person, respectively²⁴. The following toxicological re-evaluations maintained these PTWIs, and expressed in terms of intake per kg body weight (bw) (cadmium = 7 µg kg⁻¹bw; total mercury = 5 µg kg⁻¹bw)²⁵. Considering these recommendations, it may be concluded that the Cd and Hg in the Antarctic flying squid collected from Indian sector of Southern Indian Ocean is within the prescribed limit.

This report, based on single haul, indicates the abundance of *T. filippovae* in the region. However, this species is not commercially harvested by India at present due to long distance of the Southern Ocean from India. To harvest this resource, huge investment on fishing boats and related operations is required. Before investing on this venture, a proper stock assessment and economics of harvesting is required.

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