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Population Structure of the Krill Prey of the Spinetail Devil Ray *Mobula japanica* (Chondrichthyes, Mobulidae) from Southeastern Bohol Sea, Philippines

Shirlamaine Irina G. Masangcay
Caraga State University

Ephrime B. Metillo*
Mindanao State University-Iligan Institute of Technology

Shuhei Nishida
University of Tokyo

In our recent study on the feeding biology of the Spinetail Devil Ray *Mobula japanica* Müller and Henle, 1841 from Butuan Bay, Southeastern Bohol Sea (Figure 1) (Masangcay et al. 2018), we observed the predominance of euphausiids or krill in the stomach content of the ray. The Norwegian term 'krill' refers to holoplanktonic shrimp-like crustaceans that belong to the Order Euphausiacea (Mauchline 1980).

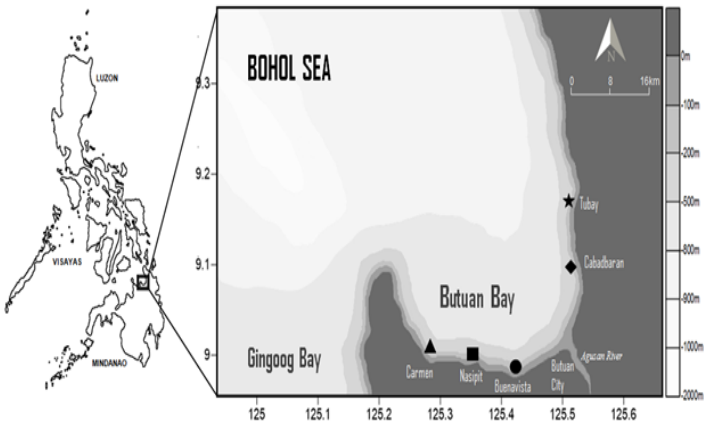

Figure 1. Geographical location of Butuan Bay in Northeastern Mindanao (Southeastern Bohol Sea) and collection sites of landed Spinetail Devil Ray *Mobula japanica* off the Municipality of Carmen (triangle), Nasipit (square), Buenavista (dot), Cabadbaran (diamond), and Tubay (star) in the Province of Agusan del Norte. Inset is the map of the Philippines with the study site enclosed in a square.

*Corresponding Author

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Having an adult body size range of about 1 to 6 cm long, the 86 known species and 11 genera of krill (Baker et al. 1990) usually form dense swarms, and dwell exclusively in oceans and seas at depths of 73 to 220 m (Mauchline 1980). They generally graze upon phytoplankton and detritus, and prey on small zooplankton at surface layers, and through their instinctive diel vertical migration, krill help shunt tons of carbon down to the greater depths of the ocean (Sameoto et al. 1987). Krill are widely known as food of baleen whales, seals, fish, and marine birds (Mauchline 1969, 1980), but recent studies include whaleshark and manta and devil rays in the list of animals feeding on krill (Notarbatolo-di-Sciara 1988; Wilson et al. 2001; Wilson and Newbound 2001; Jarman and Wilson 2004; Sampson et al. 2010; Masangcay et al. 2018). Population structure analysis, which is a major aspect of demography, provides data on the proportions of different life stages, sex ratio, individual size-frequency, and reproductive state of individuals—information that have important ramifications on the species interactions and the population itself (Ranta et al. 2006). Demographic studies of tropical krill species are very limited, but most warm water species are small, mature and breed in 10-12 months, reach 16 to 20 mm in total length of infinity, and a life span of 1 year (Mauchline 1980). Krill are difficult to collect using conventional conical plankton nets (Masangcay 2016), but their high abundance in the stomach of *M. japanica* provided the opportunity to characterize the size structure of intact krill individuals from Butuan Bay. The objective of this study is to describe the population structure of these ingested krill from January to May 2016, during the peak season period of *M. japanica* fishing in Butuan Bay, Southeastern Bohol Sea, Philippines.

Krill samples were obtained from the stomachs of bycatch *M. japanica* individuals (n = 16; for ray body lengths, see Masangcay et al. 2018) caught monthly from January to May 2016 in Butuan Bay, Southeastern Bohol Sea, Philippines (Figure 1). Krill were carefully identified following the descriptions of Weigmann (1971) and Brinton (1975). In order to determine krill size-structure, a sub-sample was randomly collected from the entire *M. japanica* stomach content samples. Since stomach samples contain >1000 individuals per stomach, $1/10^{th}$ sub-sample was obtained for krill size-structure analysis (Brinton 1975). Intact individuals of juvenile and adult male and female stages were meticulously sorted out since partially digested individuals were common in the sub-samples. We made sure that, apart from juveniles, at least 50 males and 50 females were obtained from the sub-sample, with the total number of sorted individuals greater than the 100 mentioned by Watkins (1986). Krill were measured individually based on their total length (from the medial tip of the rostral plate to the end of the telson excluding any setae) using a Vernier caliper with an accuracy of 0.01 mm (Juáres et al. 2017). The size of every krill individual was recorded, and size-frequency histograms were constructed

for different body length categories. Variation of sizes of *Pseudeuphausia latifrons (P. latifrons*) in the stomach population structure analysis based on the influence of size, sex, and sampling month was examined using multifactorial ANOVA (SPSS 2002).

We identified the krill as *Pseudeuphausia latifrons* (G.O. Sars, 1883) (Figure 2). The population structure of ingested *P. latifrons* from each of the 16 ray individuals are shown in Figure 3. Krill total lengths ranged between 4.0 mm and 10.9 mm for

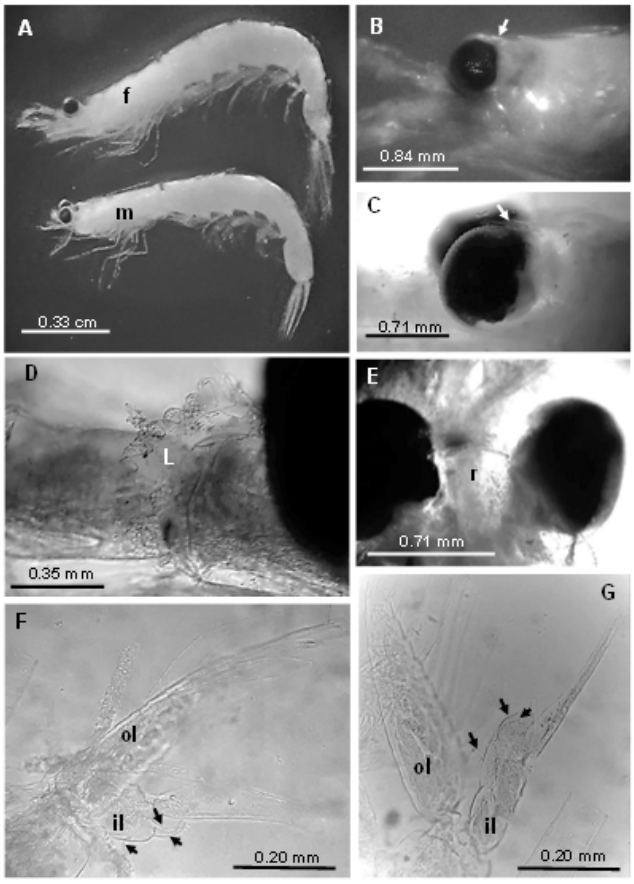

Figure 2. *P. latifrons* (G.O. Sars, 1883), the krill species dominating the ingested prey of the Spinetail Devil Ray *Mobula japanica* from Butuan Bay, Southeastern Bohol Sea. A: Adult female (f) and male (m) individuals. Lateral view of anterior cephalothorax of male (B) and female (C) showing the frontal plate (white arrows). D: Lateral view of the lappet (L) on the left antennular peduncle of an adult female. E: Dorsal view of frontal plate (r) in female. F: Left adult male petasma with processes (black arrows) on the inner lobe (il); ol – outer lobe. G: Right adult male petasma with processes on the inner lobe (il); ol – outer lobe.

both sexes. Individuals that were within the range of 4.0 mm – 6.9 mm were classified as juveniles, while those larger than 7.0 mm were adults. Sizes of prey differed according to the monthly collection of predator (F = 5.52, df = 24, p = 0.00), with males larger than females (F = 2.25, df = 6, p = 0.04). Ingested krill between January to early March ranged between 4.0 mm and 9.9 mm, and the juveniles were abundant until late March. Towards the end of March, the sizes of krill were definitely larger by 1 mm for both sexes (F = 21.83, df = 6, p = 0.00), and a switch in frequency

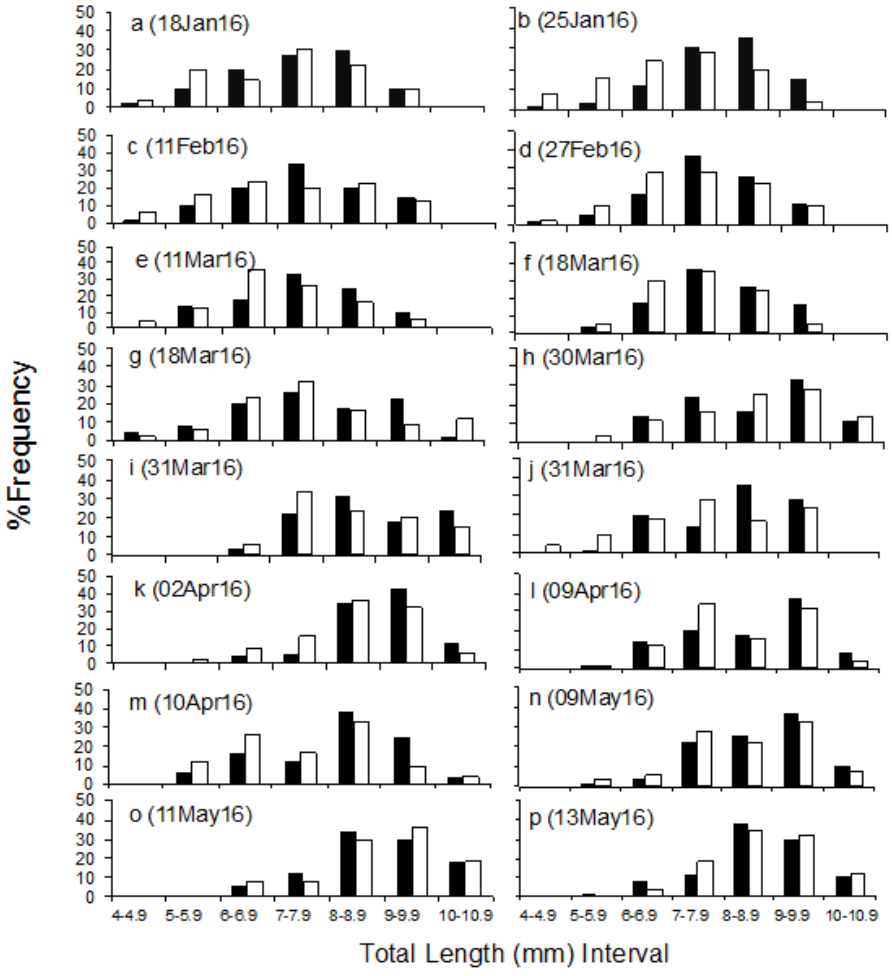

Figure 3. Length-frequency distribution of *P. latifrons* (G.O. Sars, 1883) collected from the stomach contents of the Spinetail Devil Ray *Mobula japanica* individuals (a-p) from Butuan Bay, Southeastern Bohol Sea, Philippines. Solid bar - males; open bar - females. Dates indicate day of collection of the Spinetail Devil Ray.

values with less juvenile krill and more adult krill was observed (F = 20.72, df = 1, p = 0.00). By April and May, both adult male and female prey were noticeably larger, ranging between 5.0 mm and 10.9 mm, than the preceding months which visibly show fewer juvenile prey (F = 18. 06, df = 1, p = 0.05).

The length-frequency histograms clearly show changes in the size-structure of *P. latifrons*, reflecting the individual growth from January to May (Figure 3). Except in January when there were no significant differences in krill sizes between sexes, we observed that male krill were generally larger than female, which agree with the findings of Hanamura et al. (2003) on stranded *P. latifrons* in Western Japan. The histograms show a decrease in the number of juveniles as evidenced by the absence of krill of the smallest length interval and only a few second to the smallest length interval during the warm months of April and May. There was also an increase in the number of adult individuals from the largest length interval in the same warm months. The data on krill lengths show that, towards the warm month of April, body size of krill was bigger and the number of egg-carrying females was greater. This can be related to reproduction, as the tropical krill *P. latifrons* tends to be smaller before warmer months (April and May in Butuan Bay) and becomes larger in warmer months due to mature females carrying eggs (Wilson et al. 2003). If we assume that the minimum maturity length of *P. latifrons* is at 8mm (Wilson et al. 2003), our data indicate that the breeding of this krill species occurs from January to May, with the peak of breeding season occurring in the warmer months of April and May, on account of the many large egg-carrying females during these months. Moreover, for *P. latifrons*, larger females were found to carry more eggs (Wilson et al. 2003). Our findings seem to slightly differ from the report that *P. latifrons* peak in spawning at the end of the Northeast monsoon in Vietnam waters in the South China Sea (Brinton 1975). Our study provides evidence that spawning can also occur during the intermonsoon months of April and May for *P. latifrons* in Butuan Bay.

The temporal change in the size structure of Spinetail Devil Ray-ingested populations of *P. latifrons* indicates that juvenile and adult male and female individuals are present from January to May in Butuan Bay. While juveniles became rare, the largest male and female individuals appeared during the warmer months of April and May. These females bore eggs, indicating spawning in April and May. Krill species *P. latifrons* dominated the ingested food of *M. japonica* from January to May in Butuan Bay. The January to May window is within the fishing season of the Spinetail Devil Ray *M. japanica* in Bohol Sea (Alava et al. 2002; Acebes 2013; Freeman 2014) and Butuan Bay (Metillo and Masangcay 2016), which fall on

September to May, with peak season during February to April. It remains to be studied if there is a link between the temporal pattern of *P. latifrons* abundance and the upwelling events associated with a strong northeast monsoon and the estuarine plume formation during highest river discharge in Butuan Bay (Cabrera et al. 2011; Villanoy et al. 2011).

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REFERENCES

Acebes JMV. 2013. Hunting "Big Fish": A marine environmental history of a contested fishery in the Bohol Sea [Doctoral dissertation]. Western Australia: Murdoch University.

Alava MNR, Dolumbalo ERZ, Yaptinchay AA, Trono RB. 2002. Fishery and trade of whale sharks and manta rays in the Bohol Sea, Philippines. In: Fowler SL, Reed TM, Dipper FA, editors. Elasmobranch biodiversity, conservation and management: Proceedings of the international seminar and workshop; Sabah, Malaysia: Occasional paper of the IUCN Species Survival Commission No. 25. p. 132-148.

Baker A, De C, Boden BP, Brinton E. 1990. A practical guide to the euphausiids of the world. London: British Museum (Natural History). 96 pp.

Brinton E. 1975. Euphausiids of the Southeast Asian waters. Scientific results of marine investigations of the South China Sea and the Gulf of Thailand 1959-1961, Volume 4. USA: University of California. Naga Report. p. 1-287.

Cabrera OC, Villanoy CL, David LT, Gordon AL. 2011. Barrier layer control of entrainment and upwelling in the Bohol Sea, Philippines. Oceanography. 24:130-141.

Freeman AL. 2014. Mobulidae fishery in Bohol, Philippines: An assessment of its sustainability [MRes thesis]. UK: Swansea University.

Hanamura Y, Saito N, Hayashi KI. 2003. Shore stranding of the neritic euphausiid *Pseudeuphausia latifrons* (G.O. Sars, 1883) in Western Japan. Crustaceana. 76(9):1147-1152.

Jarman SN, Wilson SG. 2004. DNA-based species identification of krill consumed by whale sharks. Journal of Fish Biology. 65:586-591.

Juáres MA, Casaux R, Corbalán A, Blanco G, Pereira GA, Perchivale PJ, Coria NR, Mercedes Santos MM. 2018. Diet of Adélie penguins (*Pygoscelis adeliae*) at Stranger Point (25 de Mayo/King George Island, Antarctica) over a 13-year period (2003–2015). Polar Biology. 4(2):303-311.

Masangcay SI. 2016. Feeding biology of devil rays (Mobulidae, Chondrichthyes) in Butuan Bay, Northeastern Mindanao, Philippines [MSc Thesis]. Iligan City, Philippines: Mindanao State University-Iligan Institute of Technology.

Masangcay SI, Metillo EB, Hayashizaki K, Tamada T, Nishida S. 2018. Feeding habits of *Mobula japanica* (Chondrichthyes, Mobulidae) in Butuan Bay, Mindanao Is., Philippines. Science Diliman. 30(1):24-44.

Mauchline J, Fisher LR. 1969. The biology of euphausiids. Advances in Marine Biology. 7:1-454.

Mauchline J. 1980. The biology of mysids and euphausiids. Advances in Marine Biology. 18:1-681.

Metillo EB, Masangcay SIG. 2016. Rapid assessment of rays (Mantas and Mobulids) in Sulu Sea and Bohol Sea. Technical Report submitted to the Manta Trust Fund, UK; Save Our Seas and Mindanao State University-Iligan Institute of Technology.

Notarbartolo-di-Sciara G. 1988. Natural history of the rays of the genus *Mobula* in the Gulf of California. Fishery Bulletin. 86(1):45-66.

Ranta E, Lundberg P, Kaitala V. 2006. Ecology of populations. London: Cambridge University Press. 373 p.

Sameoto DL, Guglielmo L, Lewis MK. 1987. Day/night vertical distribution of euphausiids in the Eastern Tropical Pacific. Marine Biology. 96:235-245.

Sampson L, Galván-Magaña F, De Silva-Dávila R, Aguíñiga-García S, O'Sullivan JB. 2010. Diet and trophic position of the devil rays *Mobula thurstoni* and *Mobula japanica* as inferred from stable isotope analysis. Journal of the Marine Biological Association of the United Kingdom. 90(5):969-976.

SPSS. 2002. SPSS for Windows version 11. Chicago, IL: SPSS Inc.

Villanoy C, Cabrera O, Yniguez A, Camoying M, de Guzman A, David L, Flament P. 2011. Monsoon-driven coastal upwelling off Zamboanga Peninsula, Philippines. Oceanography. 24(1):156-165.

Watkins JL. 1986. Variations in the size of Antarctic krill, *Euphausia superba* Dana, in small swarms. Marine Ecology Progress Series. 31(1):67-73.

Weigmann R. 1971. Eine isolierte Population von *Pseudeuphausia latifrons* (Crustacea: Euphausiacea) im Persischen Golf. Marine Biology. 8(4):351-355.

Wilson SG, Newbound DR. 2001. Two whale shark faecal samples from Ningaloo Reef, Western Australia. Bulletin of Marine Science. 68(2):361-362.

Wilson SG, Meekan M, Carleton J, Stewart T, Knott B. 2003. Distribution, abundance and reproductive biology of *Pseudeuphausia latifrons* and other euphausiids on the southern North West Shelf, Western Australia. Marine Biology. 142(2):369-379.

Wilson SG, Pauly T, Meekan MG. 2001. Daytime surface swarming by *Pseudeuphausia latifrons* (Crustacea, Euphausiacea) off Ningaloo Reef, Western Australia. Bulletin of Marine Science. 68(1):157-162.

Shirlamaine Irina G. Masangcay is a graduate of B.S. Marine Biology from Mindanao State University-Iligan Institute of Technology. She graduated M.S. Marine Biology from Mindanao State University-Iligan Institute of Technology on time as a DOST-ASTHRDP scholarship in 2016, and was hired immediately after graduation as Instructor at the Caraga State University, Butuan City, Philippines.

Ephrime B. Metillo <ephrime.metillo@g.msuiit.edu.ph> is B.S. Zoology graduate at the Mindanao State University Marawi City. He was University Research Assistant at the Marine Science Institute of the University of the Philippines Diliman before doing a straight Ph.D. Program at the University of Tasmania at Hobart, Australia under the Australian International Development Assistance Bureau (AIDAB) Equity and Merit Scholarship Scheme. He is now Professor at the Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines.

Shuhei Nishida is a recently retired Professor at the Atmosphere and Ocean Research Institute of the University of Tokyo, Japan. He has published more than 110 papers in the field of marine biology and became Editor of the Springer journal Marine Biology. His main field of interest is marine zooplankton biology and ecology.