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Note

Investigations on depredation by the deepsea swimming crab *Charybdis smithii*, during experimental gillnetting along the south-west coast of India

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Abstract

Depredation by crabs can have a negative impact on marine gillnet fishery. Despite this fact, limited studies are attempted to evaluate depredation. The present study is the first attempt to evaluate the qualitative and quantitative effects of crab depredation on marine gillnet fishery. Experimental gillnetting was conducted onboard *F V Sagar Harita* from February 2017 to January 2018 along the south-west Indian coast. Depredation by the deepsea swimming crab *Charybdis smithii* caused intentional discard of Indian mackerel (17.59%), kawakawa (14.77%), shrimp scad (10.74%) and horse mackerel (10.02%). Financial loss due to depredation was high for Indian mackerel (19.99%), followed by shrimp scad (19.17%), kawakawa (14.77%) and horse mackerel (14.16%). A total of ₹2554.30 per operation was lost due to crab depredation. *C. smithii* showed a preference towards scombrids (Indian mackerel and kawakawa) over carangids (shrimp scad and horse mackerel) due to the inherent flavour and texture of scombrids. Incidence of depredation were found exclusively during June to September (monsoon season).

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Depredation is the phenomenon where damage or complete removal of captured fish by predators that occurs in commercial fisheries. A wide range of marine fauna has been implicated in the depredation of fish in commercial fisheries, including killer whales, sperm whales, dolphins, pinnipeds, colossal squid, large teleost species such as goliath groper, many species of sharks and aquatic birds such as cormorants (Ryan *et al*., 2019) and crabs (Muhammed Sherief *et al*., 2015; FAO, 2017). Depredation can lead to a high risk of fishing mortality and an increased chance of overfishing, thereby imparting difficulty in the assessment and management of resources. This may further be defined as the case of unreported mortality and unseen or lost fish from the gear leading to inaccurate assumptions (Worm *et al*., 2013). This may also impact the direct behaviour of fishing practices such as scouting and increased fishing time of passive gears (Gilman *et al*., 2008; Romanov *et al*., 2013). Gillnet fisheries have always faced the risk of depredation due to the passive nature where predators can approach the catch without obstruction (Read *et al*., 2003; Cunningham *et al*., 2020).

Most crab species are benthic inhabitants, except for a few species that have adult pelagic phase during which off-shore distribution is observed (Losse, 1969). Despite their swimming capabilities, portunid crabs are predominantly benthic. However, *Charybdis smithii* McLeay, 1838 of Indian Ocean shows active swimming abilities (Allen, 1968; Balasubramanian and Suseelan, 1990). Swarms of *C. smithii* are often observed in the pelagic realm off the African as well as Indian coast during winter monsoon (Sankarankutty and Rangarajan, 1962; Della Croce and Holthuis, 1965; Losse, 1969; Rice, 1969; van Couwelaar *et al.*, 1997; Balasubramanian and Suseelan, 2001). In comparison with other portunids, *C. smithii* has a less calcified, light and smooth carapace which enables them to remain in the water column and subsequently colonise the pelagic waters of the Indian Ocean during monsoon season (Turkay and Spiridonov, 2006). Swarms of *C. smithii* have been reported to attack baits during long-line surveys conducted off East Africa at 0-10°S between October to February (Merrett, 1968). Surprisingly, all occurrences are reported at night time exclusively, coinciding with the time of gillnet operation during south-west monsoon. At such times, these swarms must play an important role in the ecosystem, essentially as prey and/or as alternative predator (Hull and Bourdeau, 2017).

A limited number of authors has reported depredation by crabs in commercial fisheries (Kaiser *et al.*, 1996; Muhammed Sherif *et al.*, 2015; Thomas *et al.*, 2020). This study is intended to give the extent of depredation caused by the deep-water crab *C. smithii* on *Alepes djedaba, Megalaspis cordyla, Rastreliger kanagurta, Euthynnus affinis* and *Scomberomorus commerson* in the south-west coast of India in qualitative and quantitative terms.

The study was conducted in the southern part of the Arabian Sea at a depth of 70-100 m off Kochi to Alappuzha, Kerala, India. The area of sampling, coincided with the artisanal deep-sea fishing zone (D'Cruz, 2004). Fishes were caught during experimental gillnetting conducted onboard *FV Sagar Harita* (19.5 m LOA) during the period from February 2017 to January 2018, using multifilament polyamide gillnet (210d×9×3) of 140 mm mesh size having 800 m length and 14 m height. Nets were deployed in the evening, around 17:30 hrs and hauled by 20:30 hrs, with 3 h of soaking time. The period of operation was classified into three *viz*. February to May as pre-monsoon, June to September as monsoon and October to January as post-monsoon to understand seasonality in depredation caused by *C. smithii* (Shamsan, 2008). Fortnightly sampling was undertaken for one year (n=24), and species-wise number of depredated fishes was noted for each season to understand the correlation between season and depredation.

Four species of fishes were observed to undergo depredation by *C. smithiii,* namely, horse mackerel (*Megalaspis cordyla*), shrimp scad (*Alepes djedaba*), Indian mackerel (*Rastrelliger kanagurta*) and kawakawa (*Euthynnus affinis*). Weight (W) and length (L) of each fish were recorded after hauling the net. Length of fish attacked by crabs was recorded and kept separately for further characterisation of damage. The weight of each damaged fish was calculated using the length-weight equation: $\ln W = \ln a + b \ln L$. The coefficients '*a*' and '*b*' were sourced from Fish Base (Froese and Pauly, 2019), due to the fish species' partial availability throughout the study period . To understand the total weight of the fish species landed during the study period, the back-calculated weight of depredated specimen was added to the rest of the catch. All depredated specimens were considered as discard as consumers prefer fish without any damage. The average retail value (₹) of fish species was obtained from consumer markets of Kochi, Kerala during the same period. Species-wise price was multiplied by the weight (landed + discarded) to estimate the value of total catch if depredation had not occurred. The value of the depredated catch was calculated, and subsequently percentage of depredation and monetary loss were worked out based on the total catch and total value.

The extent of depredation on catch was assessed by selecting individual specimens and the type of damages was categorised as per Humborstad *et al*. (2003) with suitable modifications. Here, three types of damages were identified and modified according to the present scenario as:

Type 1 damage (mild attack)-Dead, Slight damage (unclear scratches and nipped fin rays).

Type 2 damage (medium attack)-Dead, Extensive damage (damage indicators as given above plus small holes in the flesh caused by crab attack, but with most body parts still intact).

Type 3 damage (severe attack)-Dead, Severely damaged (bones partially exposed, sticking/protruding out from flesh, lacking intestine and larger parts of fish possibly missing).

In the present study, Type 1 damage (mild attack) was not considered for analysis as the damages were not reflected in the appearance of fish to be excluded from sale.

Considering the total weight of fish caught for the whole period of study, horse mackerel had the highest share (34.83 kg), followed by shrimp scad (26.13 kg), kawakawa (25.19 kg) and Indian mackerel (9.35 kg). In terms of weight, depredation was highest in Indian mackerel (17.65%), followed by kawakawa (14.78%), shrimp scad (10.75%) and horse mackerel (10.02%). While considering the number, depredation was maximum in shrimp scad (n=16), followed by Indian mackerel (n=10), horse mackerel (n=9) and kawakawa (n=6) (Table 1). We observed the highest monetary loss for Indian mackerel (17.66%), followed by kawakawa (14.78%) owing to the high price and market demand. Financial loss was comparatively less for shrimp scad (10.75%) and horse mackerel (10.02%) due to low market price (Table 1).

Seasonal variation was observed in depredation caused by the deepwater crab *C. smithii*, on horse mackerel, shrimp scad, Indian mackerel and kawakawa. Depredation was noticed only during monsoon season (Fig. 1). Quantity discarded due to depredation during the study was highest for kawakawa (3.72 kg), followed by horse mackerel (3.49 kg), shrimp scad (2.81 kg) and Indian mackerel (1.65 kg).

Table 1. Catch and monetary loss due to crab depredation during February 2017 to January 2018

Particulars	Horse mackerel	Shrimp scad	Indian mackerel	Kawakawa
Total catch (landed + discarded) (kg)	34.83	26.13	9.35	25.19
Catch landed (kg)	31.34	23.32	7.71	21.46
Catch discarded (kg)	3.49	2.81	1.65	3.72
Number caught (landed + discarded)	84	147	57	37
Number landed	75	131	47	31
Number discarded	9	16	10	6
Average price (₹ per kg)	140	140	220	200
Market value of total catch (₹)	4876.2	3658.2	2057	5038
Market value lost due to depredation (₹)	488.6	393.4	363	744
Weight discarded due to crab depredation (%)	10.02	10.75	17.65	14.89
Monetary loss due to crab depredation (%)	10.02	10.75	17.65	14.78

Types of damage due to depredation varied between species. Type 1 damage was found high in all species invariably, Type 2 was high in kawakawa and low in Indian mackerel, and type 3 damage was high in Indian mackerel and low in shrimp scad (Fig. 1).

C. smithii is reported to have a pelagic distribution where the abundance was highest during day sampling in monsoon and night sampling in pre-monsoon (Balasubramanian and Suseelan, 1990). A study by van Couwelaar (1997) reported an abundance of these crabs during the south-west monsoon in the Indian Ocean (July-August), coinciding with the present study. Reasons for the abundance may be attributed to oxygen concentration and diel vertical migration behaviour of most crab species (Park and Shirley, 2005). The present study also implies that *C. smithii* has a peculiar pelagic stage, as mentioned by previous authors (Balasubramanian and Suseelan, 1990; van Couwelaar, 1997), which correlated with pelagic feeding behaviour. Due to its abundance, the species has been considered prey for a large spectrum of predators (Romanov *et al*, 2009).

The highest incidence of type 1 and 3 damages were seen in Indian mackerel; hence it may be considered the most preferred prey for the crab. Fatty fishes like Indian mackerel readily undergo oxidation, and the soft body in the absence of thick scales aids the process (Frankel, 2005; Arola *et al*., 2017). Anecdotal reports by fishers confirm that mackerel, when used as bait in fresh condition, will fetch more catch, especially when squid is unavailable for use (based on commercial operations). Many studies suggested mackerel as suitable bait in longline fishery where predatory fishes were attracted (Foster *et al*., 2012; Amorin *et. al*, 2015). But the same predator preference has resulted in the loss of bait

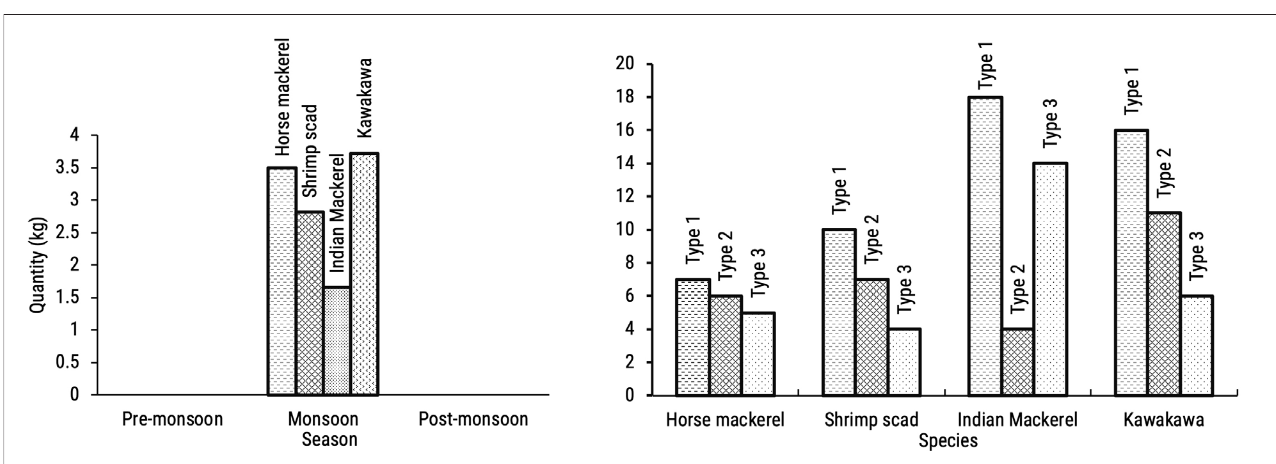

Fig.1. (a) Seasonal variation in depredation caused by the deep-water crab *C. smithii* on horse mackerel, shrimp scad, Indian mackerel and kawakawa; (b) Type-wise depredation between species, for the period February 2017 to January 2018

in the longline fishery (Coelho *et al.*, 2012). Preference for mackerel between predatory species should be evaluated individually, as a species-specific attraction is observed between predatory species (Foster *et al.*, 2012). Even though considered a predator in this study, crabs are also considered scavengers in the ecosystem (Boudreau and worm, 2012), which shows flexibility in feeding ecology. But preference towards mackerel is often indicated by many crab species and finfishes (Archdale and Kawamura, 2011) based on the availability of food items (Watanabe and Honda, 2005; Davenport *et al.*, 2016). Similarity in texture and flavour is observed in kawakawa, being a member of the same family Scombridae (Bannikov, 1981). This explains why the depredation rate in kawakawa is next to Indian mackerel. Kawakawa are strong and robust (Shadwick and Syme, 2008) fishes known to exhibit sudden movements (Bernal *et al.*, 2010), while Indian mackerel gets exhausted (Xu *et al.*, 1994) and die even after a short period of struggle on entangling with the net (Roth and Rotabakk, 2012). The prolonged struggle shown by kawakawa may inhibit predators from coming near and attacking but attract predators to approach the vicinity and feed on exhausted fishes (Mitchell *et al.*, 2018). The other two species caught during the study (horse mackerel and shrimp scad) have thick scales and robust bodies (Laroche *et al.*, 2005). Scales can act as protective barriers against predators (Wang *et al.*, 2019) which results in low predation by the crab. Similar results were reported earlier by Chinnadurai *et al.* (2018).

Predator mortality is hardly addressed in prey-predator interaction (Rafferty *et al.*, 2012), which must be considered apart from prey mortality. Mortality in marine predators arises due to entanglement (Northridge and Hofman, 1999) with fishing gear during prey removal. Recent innovations are relatively successful in avoiding such interactions. However, predators being part of various trophic levels, species-specific deterrent devices need to be deployed (Noatch and Susuki, 2012). We have observed crabs (predators) hauled in along with the catch, which can be described as bycatch. When the bycatch/predator forms an economical part of the fishery, a description for addressing this issue might need modifications. Although *C. smithii* is discarded from the fishery (Dineshbabu *et al.*, 2012), nutritional profile of the species indicates that it can be considered on par with any other edible crab species (Kumar *et al.*, 2019).

Our study reveals that the deep-water crab is prevalent in the Indian Ocean during monsoon season and prefers scombrids over carangids during the pelagic feeding time. Even though the scale of the attack is low, the occurrence of swarms, as reported in the Indian Ocean, can cause severe loss to the fishery, as observed in the present study. Published reports on depredation by crabs in gillnet fishery is limited as the scale of the attack is low as compared to the depredation caused by other organisms. However, further research is needed to understand depth-wise distribution of the crab species in the water column.

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