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# Emergent fishery of the catostylid jellyfish *Crambionella orsini* along the southern coast of India

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Original Article

## Abstract

Sporadic and seasonal landings of jellyfishes along the southern coast of India have been under investigation since 2018. The catostylid jellyfish *Crambionella orsini* is the only species that contributes to a fishery in this region. In the October to January months, a seasonal fishery exists along the Kanyakumari, Thiruvananthapuram and Neendakara coast, with catches being made variously by gillnetters, single day trawlers, multi-day trawlers and shore seines. An unprecedented 44 day fishery on the Neendakara coast from December 2020 to January 2021 was investigated in depth, with estimated landings of 453.16 metric tonnes landed at Sakthikulangara and Neendakara Fisheries Harbours in Kollam District, Kerala. Economic efficiency of the fishery from Sakthikulangara Fisheries Harbour was estimated as 44.76 gross value added as percentage of gross revenue and net operating income of ₹1313 per fishing trip with average earning to a crew member being ₹510 per trip. The oral arms of *C. orsini* is the only part of the jellyfish that are traded and exported, mainly to China and South east Asian countries after salt curing. Emergence of this augmentative fishery has come as a boon to fishers combating the regressive environment of the Covid-19 period. Promotion of this fishery with increased processing and export facilities and investigations into value added products from the resource is recommended.

***Keywords***: *Edible jellyfish, jellyfish fishery, economic efficiency, oral arms processing*

## Introduction

For centuries, different species of jellyfishes have been harvested for food and various other uses such as cosmetics, pharmaceuticals, fish feeds and baits; in agriculture as fertilizers and insecticides etc. (Brotz and Pauly, 2017). Regions of the eastern hemisphere remained as the major producers and consumers of jellyfishes until recently when they began being targeted by various countries across the western hemisphere, triggered by the depleted stocks and the resultant heavy demand for jellies from East Asia (Brotz *et al*., 2016; Bleve *et al*., 2019). Data regarding the past jellyfish fisheries and the population is available at least since ~1950s and it shows that their population is subject to the effects of interannual climatic variations. In the recent past, various factors have been identified as positively influencing their population. The human induced depletion of the resources of both finfishes and shellfish resources could act either as effective depressors of competitors or predators of jellyfishes across world oceans. In addition, the development of coastal regions over the past decades resulted in an increased nutrient input into the coastal waters, and the subsequent eutrophication events, especially the increased turbidity, favoured the proliferation of non-visual predators like jellyfishes over the visually feeding fishes (Purcell, 2012).Thus, increasing jellyfish swarms have been identified as a menace to the survival of regular fishery resources and various fishery operations, contributing to enormous quantities of unusable bycatch, fouling of nets etc. However, emergent fisheries have come into existence in the past three decades where edible and non-stinging or mildly stinging species of jellyfishes are being fished and traded in several countries, especially in Asia, establishing a multimillion dollar industry (Hsieh *et al*., 2001; Omori and Nokano, 2001; Kitamura and Omori, 2010). The most severe fishery impact of jellyfish occurs in the North Pacific followed by the Mediterranean and a few reported incidents from other parts of the world (Bosch-Belmar, 2020). In India, the jellyfish fishery began in the 1980s (Brotz and Pauly, 2017). However it remained more or less non-targeted, although often caught and landed on various parts of both the eastern and western coast of India (CMFRI, 2017; Baliarsingh *et al*., 2020). Thus jelly fishery in India can be seen as still in its emergent phase. Out of the 35 species of jellyfishes (29 scyphozoans and six cubozoans) occurring in Indian seas, four are actively fished along Kerala, Gujarat and Andhra Pradesh coasts and exported overseas (Saravanan, 2018) with the *Crambionella annandalei* fishery expanding to a regular one along the Andhra Pradesh coast (Behera *et al*., 2018, 2020a).

The reduction in total fish production in Kerala resulted in fishers exploiting alternative resources for livelihood. The present study on the jellyfish landings along the southern coast of India includes investigations into the biological aspects, fishery, processing, trade and economic efficiency of the fishery of *C. orsini*.

## Material and methods

In 2018 and 2019 monthly observations were made at Thengapattanam Fishing Harbour (Kanyakumari District, Tamil Nadu), Sakthikulangara and Neendakara Fisheries Harbours (Kollam District, Kerala) and jellyfish landings were monitored when present. Monitoring of *C. orsini* landings in shore seines was part of jellyfish landing investigations in Thiruvananthapuram district carried out on a regular basis from 2018 onwards. In 2020-21 (December-January) the fishery was thoroughly investigated through frequent monitoring at Sakthikulangara and Neendakara fisheries harbours in a season lasting 44 days. Landings were estimated using the stratified random sampling method (Srinath *et al*., 2005). Information was also gathered by interviewing fishers, boat crew, trawl labourers and traders dealing with the resource.

Primary data was collected on the cost incurred for fishing operations including fuel, crew wages, food expenses, repair and maintenance costs, and other expenses. The revenue was computed based on the landings from five randomly selected single day trawlers operating from Sakthikulangara Fisheries Harbour. The indicators of economic efficiency to assess economic performance were arrived at for a single species which included operating ratio, net profit, capital, labor productivity, input-output ratios, gross value added etc. following Sathiadhas (1996) and Swathipriyanka Sen *et al.* (2021).

Visits were made to the processing units at Thengapattnam to gather details on the processing and packaging of jellyfish oral arms for export.

Port-wise and market-wise statistics on jellyfish exports from 2016-17 to 2019-20 were sourced from the MP & Statistics Department, Marine Products Exports Development Agency (MPEDA), Kochi.

Biological aspects of the specimen were studied in the field as well as the laboratory at ICAR-CMFRI, Kochi and references such as Vanhöffen (1888), Menon (1930, 1936), Stiasny (1937), Daryanabard and Dawson (2008), Behera *et al.* (2020b) and World Register of Marine Species (WoRMS, 2021) were used for species confirmation and classification.

## Results

### *Biological aspects*

The samples collected and examined in detail in the laboratory were confirmed as belonging to a single species *Crambionella orsini* (Vanhöffen, 1888) (Scyphozoa: Discomedusae: Rhizostomeae: Daktyliophorae: Catostylidae) (Fig. 1). Specimen examined were characterised by Order Rhizhostomeae characters of not having tentacles on the bell margin of the umbrella of the medusa and possessing eight branched oral arms, and the suborder Daktyliophorae character where the gastric cavity does not communicate with the intra-circular canal system except through radial canals. An anastomosing network of intra-circular canals, absence of window-like openings in the oral arms, annular subumbrellar muscles and non-elongate marginal lappets of the umbrella were familial characters observed. Terminal mouthless clubs of oral arms which were short, broad and triangular in cross-section are characteristic of the genus Crambionella. All specimens examined were dark brown with 16 lappets in each octant and foliaceous appendages amongst the mouth frill in the distal trifoliate winged portion along with the absence of pointed conical tubercles on velar lappets, distal portion of oral arm three to four times of proximal portion and proportion of terminal club length to oral arm length which are characteristic of the species *C. orsini.*

The size range of the individual jellyfishes was 175-245 mm bell diameter (dorsal) and weight range 250 -1250 grams in the fishery at Sakthikulangara.

Fig. 1. Specimen of *C. orsini* with umbrella and oral arms separated.

## *Craft and gear, locations and depths of operation*

Thengapattinam, Kanyakumari coast, Tamil Nadu: *Crambionella orsini* has been observed and documented from the area starting in gillnet catches from Arokiyapuram, situated in the eastern part of Kanyakumari and in the western part i.e., Muttom and Colachel, mainly from shore seines. Further north, dense swarms were found from the western part of Kanyakumari (mainly Melmidalam, Enayam, Ramanthurai, Thoothur and Poothurai) with the catch being landed in the Thengapattanam Fishing Harbour. In a few regions modified gillnets with an increased number of floats are used for the *C.orsini* fishery. Fishery was mainly concentrated in the inshore waters at a depth of 6 to 12 m using FRP boats. Landings were observed from August to January along the Kanyakumari coast with peak landings from October to December. *C.orsini* was landed from the modified gillnets landed in the Thengapattanam Fishing Harbour between 6 to 7 pm for two weeks during December 2020. The focal point of the fishery, processing and trade was Thengapattinam.

Thiruvananthapuram coast, Kerala: *Crambionella orsini* swarms have been landed as bycatch by shore seines for several years in the post monsoon period from August-September to December-January with increased quantities being noticed in the recent three years. Observations of this bycatch have been made at Pozhitoor, Poovar, Kovalam (Fig. 2), Shangumukhom,

Fig. 2. *C. orsini* byecatch from shore seines at Kovalam, Thiruvananthapuram district, October 2020

Puthenthope and Kayikkara. During the peak swarming season in October-November, range of 200-800 *C. orsini* are found per shore seine hauled. There have been observations of labourers collecting oral arms from the bycatch discards on the beaches of Kovalam and Puthenthope for selling to agents who transport them to Thengapattinam. No organised fishery has been reported from this area though fishers claim that trawlers from Thengapattinam and Neendakara operate on the Thiruvananthapuram coast for fishing the resource.

Neendakara coast, Kerala: Sporadic landings of *C.orsini* have been observed at Neendakara Fisheries Harbour in the post monsoon season since 2018. An unprecedented organised fishery was seen during 2020-21 where the fishery began on 15/12/2020 and lasted up to 27/01/2021. The bulk of the catch was landed at Sakthikulangara Fisheries Harbour (Fig. 3 & 4) with lesser quantities at Neendakara Fisheries Harbour (Fig. 5) and Azheekal Fisheries Harbour, all in Kollam district. On certain occasions catches were unloaded at the Wadi landing centre also towards the end of the season. Single day fishing trawlers (10-15 m OAL) which usually

Fig. 3. Landings by multi-day trawlers

Fig. 4. *C. orsini* unloaded in plastic boxes @ 50 kg/box before processing at harbour

Fig. 5. *C. orsini* landed at Neendakara Fisheries Harbour, Kollam District on 17th December 2020

target shrimp were engaged in the fishery. The trawlers from Sakthikulangara reportedly made maximum hauls at 15-20 m depth between coordinates 8º 58' N, 76º 28' E and 8º 58' N, 76º 27' E in inshore waters.

## Catch estimates

An estimated 453.16 metric tonnes of *C. orsini* were landed at Neendakara and Sakthikulangara Fishing harbours during the 44 day fishery. Of these, Sakthikulangara emerged as the major landing centre with 412.3 tonnes landed by 451 single day trawler units. 310.63 tonnes were landed by them in December 2020 by 275 single day trawlers and 101.66 tonnes by 176 units in January 2021. In addition to the landings in Sakthikulangara single day trawlers also landed 2.36 tonnes of *C. orsini* at Neendakara Fisheries Harbour (1.75 tonnes in December 2020 and 0.61 tonnes in January 2021). Multi- day trawlers also landed 5.63 tonnes at Sakthikulangara during December 2020 and 32.9 tonnes in January 2021. *C. orsini* were also landed by single day trawlers at Azheekal Fisheries Harbour in December 2020 at the peak of the fishery but the catch was not monitored. Similarly, there were also reports of small landings at Wadi Fisheries Harbour, Kollam district in January 2021.

Trend in fishery: At Sakthikulangara, maximum catches were landed on the first four days of the fishery by 25-32 boats daily, each boat carrying about 800 kg to 1 ton of jellyfishes. The average landings were about 10-20 boats carrying 500-800 kg of jellyfish per boat for the next three weeks. A second peak of a total landings of approximately 15 tons each were landed on 7th and 08th January 2021. The catch began dwindling from around 11th January 2021 (Fig. 6). By 22nd January 2021 only about 4-5 boats were landing jellyfish at around 500 kg per

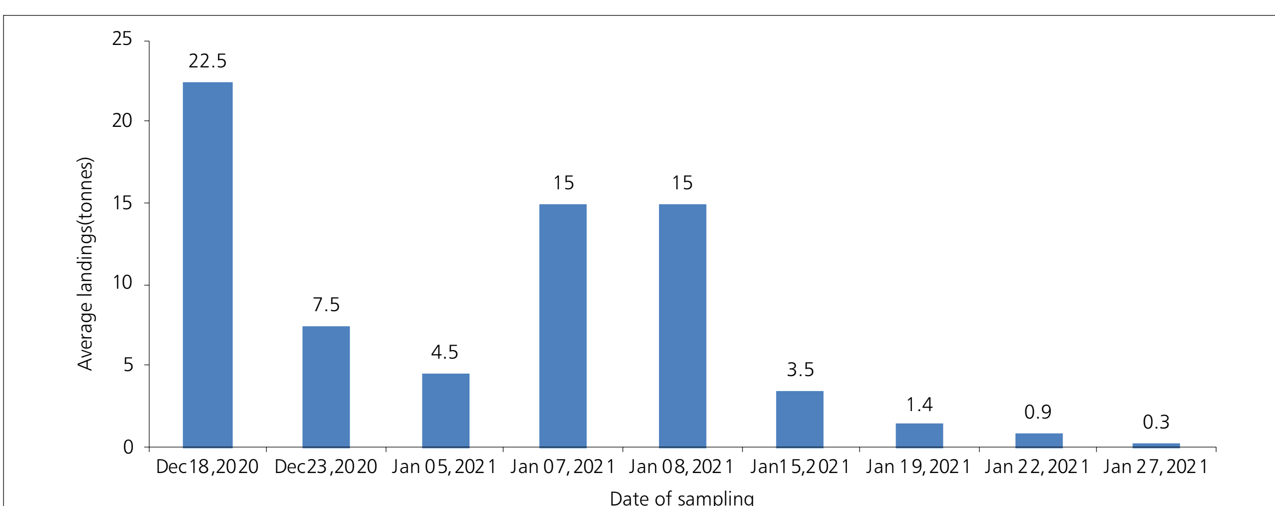


Fig. 6. Average landings at Sakthikulangara Fisheries Harbour

boat. The season ended on 27th January 2021 when two boats carrying approximately 300 kg each were landed. The average landings in December 2020 were 1129.54 kg per unit and in January 2021 577.61 kg per unit.

## *Economics of fishing operation*

The cost and income aspects were assessed from five randomly identified single day trawlers for 17 days during December 2020 and 27 days during January 2021. The average fuel price was estimated at ₹78.9/litre (December 2020) and ₹73.06/litre for January 2021. On an average 50 litres of fuel were consumed during the six-hour trip and fishing operations. The average price realised was ₹8/kgs ranging between ₹5- 10/kg. The net revenue realised was shared between the owner (33%) and crew (66%). 10% of the crews share was paid to the skipper. On an average a boat owner's generated a net profit of ₹57772 from the jellyfish fishery whereas a crew member earned an average of ₹22440. Economic efficiency of boat operated by Sakthikulangara fisheries Harbour is presented is Table 1. Various aspects of total operational costs per trip per unit were examined and fuel cost found to be the maximum input (Fig. 7).

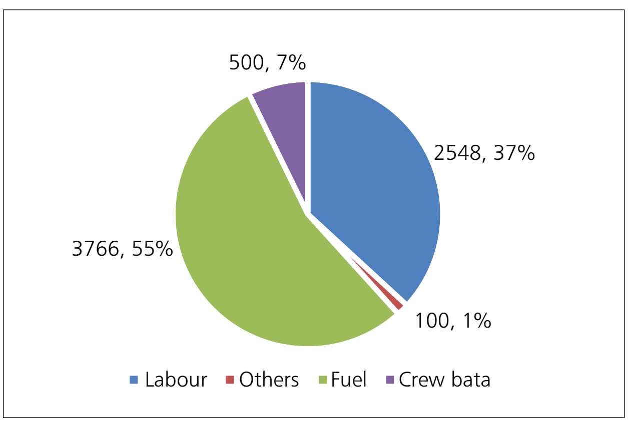


Fig. 7. Contributing factors to total operational costs per trip per unit in the jellyfish fishery from Sakthikulangara Fisheries Harbour

## *Processing*

At harbor: The *C.orsini* catch was transported without icing in the holds and decks of the trawlers. The catch was transferred to plastic boxes at the harbour, with each box holding approximately 50 kg of catch. The boxes were then handed over to a contract labour force that separated the oral arms of *C. orsini* from the umbrella (Fig. 8). The oral arms were stored back into the boxes while the umbrellas were discarded. The labourers were paid at the rate of ₹1 per kg of jellyfish processed. The maximum quantity processed by a labourer was 5 tons per day. The oral arms were then transported by truck without icing to ice plants near Kollam for further curing.

Table 1. Economic efficiency of the units operating for *C. orsini* from Sakthikulangara Fisheries harbour during December 2020-January 2021

| | | | |
|---|---|---|---|
| | | Location | Sakthikulangara |
| | | Craft gear combination | SD trawlers |
| | | Duration | Single day |
| Sl. No. | Category | Components | |
| 1 | Labour | Crew Wage (₹) | 2548 |
| 2 | | Crew bata value | 500 |
| | A | Sub-total labour costs | 3048 |
| 3 | Inputs | Fuel Cost (₹) | 3766 |
| 5 | | Other expenditure(₹) | 100 |
| | B | Sub-total input costs | 3866 |
| 6 | C | Total operating cost (Labour + Inputs) | 6914 |
| 7 | Output | Catch (kg) | 914.157 |
| 8 | | Gross revenue (in ₹) | 8227.41 |
| 9 | | Average crew size | 5 |
| 10 | Indicators | Net operating income =(Gross revenue-total operating cost) | 1316 |
| 11 | | Capital productivity (Operating ratio)=(Total operating cost/Gross revenue) | 0.84 |
| 12 | | Labour productivity =(Catch /average crew size) | 182.83 |
| 13 | | Input-output ratio =(Total input cost/Gross revenue) | 0.47 |
| 14 | | Gross value added=(Net operating income + crew share) | 3861.00 |
| 15 | | Gross value added as a percentage of gross revenue | 46.93 |

At Azheekal and Thengapattinam Fisheries Harbours, there was no processing or separation of oral arms at the harbour and the catch was transported whole to the ice plants for processing.

Fig. 8. Labourers separating oral arms from the umbrellas of the *C. orsini* jellyfish during preliminary processing at Sakthikulangara Fisheries Harbour

At ice plant/curing yard: Three private processing firms have undertaken the procurement and processing of *C. orsini* along the Kanyakumari coast. The jellyfish oral arms are separated from the umbrella and exported in salted condition. The landing centre/harbour price for *C. orsini* was at the rate of 5 to 10 per kg in 2020. The catch was transported by truck to the processing plants in plastic boxes. The jellyfish were laid out on wooden racks with asbestos sheets for further cleaning and processing. In the first stage of cleaning the mucous was removed using sea water (Fig. 9). This is followed by salt curing by soaking the oral arms in brine in tanks made of asbestos sheets for 1 to 2 weeks (Fig. 10).

Fig. 9. Freshly collected *Crambionella orsini* being cleaned for removing mucus

Fig. 10. Salt curing of *Crambionella orsini* (1 to 2 weeks)

Fig. 11. Dried salted oral arms

Fig. 12. Salted oral arms in 20 litre plastic container

Individual salted oral arm bunches were then dried (Fig. 11) and packed in 20 litre plastic containers, each holding 15 -16 numbers (Fig. 12).

### *Current jellyfish export trade scenario in India*

Dried salted jellyfish are exported the seven ports in India to China, Japan, Southeast Asian countries etc. Export quantities and earnings are presented in Table 2.

## Discussion

Jellyfish have been constituents in Chinese cuisine for millenia (Morikawa, 1984). The prediction of 'fishing down the marine food web' (Pauly *et al.*, 1998) has been endorsed with jellyfishes being increasingly fished for food and other products.

We found that the jellyfish fishery along the southern coasts of India is driven not by an impulse to harvest a lucrative resource but rather of exploiting a seasonal resource whenever it was found to be remunerative. *Crambionella orsini* is endemic to the western Indian Ocean region (Daryanabard and Dawson, 2008). In India, it was recorded from the south-west and south-east coast (Neethling *et al.*, 2011). Occasional heavy blooms occur across the north eastern Arabian Sea, purportedly driven by large scale oceanographic factors rather than locally confined ecosystem disturbances (Daryanabard and Dawson, 2008; Billet *et al.*, 2006). The present study reveals that the *C. orsini* swarming begins on the south- east coast of India following the end of the south-west monsoon and progressively spreads to the south western coast, moving northwards. Thus, it can be presumed as a true seasonal bloom rather than an apparent one resulting from a rapid increase in the population *in situ*

Table 2. Export and earnings of jellyfish traded from India (2016-17 to 2019-20)

Port wise export of dried jelly fish salted

Q: Quantity in M T, V: Value in ₹Lakh, $: US Dollar Million

| | | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|
| Tuticorin | Q: | 0 | 0 | 25 | 0 |
| | V: | 0.00 | 0.00 | 8.04 | 0.00 |
| | $: | 0.00 | 0.00 | 0.01 | 0.00 |
| Chennai | Q: | 36 | 574 | 414 | 33 |
| | V: | 78.20 | 1,145.68 | 779.39 | 38.43 |
| | $: | 0.12 | 1.80 | 1.11 | 0.06 |
| Vizag | Q: | 0 | 0 | 0 | 75 |
| | V: | 0.00 | 0.00 | 323.13 | 64.60 |
| | $: | 0.00 | 0.00 | 0.47 | 0.09 |
| Pipavav | Q: | 212 | 444 | 627 | 233 |
| | V: | 214.64 | 451.58 | 639.83 | 239.11 |
| | $: | 0.32 | 0.71 | 0.97 | 0.34 |
| Mundra | Q: | 130 | 573 | 364 | 722 |
| | V: | 118.64 | 585.39 | 328.28 | 639.11 |
| | $: | 0.18 | 0.92 | 0.47 | 0.92 |
| Krishnapatnam | Q: | 0 | 0 | 0 | 0 |
| | V: | 0.00 | 27.68 | 58.48 | 0.00 |
| | $: | 0.00 | 0.04 | 0.08 | 0.00 |
| Kattupalli/ Ennore | Q: | 0 | 77 | 258 | 132 |
| | V: | 0.00 | 172.85 | 523.13 | 128.67 |
| | $: | 0.00 | 0.27 | 0.78 | 0.18 |
| ** Grand Total ** | Q: | 378 | 1,667 | 1,689 | 1,195 |
| | V: | 411.48 | 2,383.18 | 2,660.29 | 1,109.92 |
| | $: | 0.62 | 3.75 | 3.90 | 1.60 |

Market wise export of dried jelly fish salted

Q: Quantity in M T, V: Value in ₹Lakh, $: US Dollar Million

| | | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|
| China | Q: | 0 | 0 | 412 | 1,118 |
| | V: | 0.00 | 0.00 | 382.06 | 1,025.47 |
| | $: | 0.00 | 0.00 | 0.54 | 1.48 |
| South East Asia | Q: | 374 | 1,667 | 1,276 | 76 |
| | V: | 405.98 | 2,383.18 | 2,278.23 | 84.45 |
| | $: | 0.61 | 3.75 | 3.36 | 0.12 |
| Others | Q: | 5 | 0 | 0 | 0 |
| | V: | 5.50 | 0.00 | 0.00 | 0.00 |
| | $: | 0.01 | 0.00 | 0.00 | 0.00 |
| ** Grand Total ** | Q: | 378 | 1,667 | 1,689 | 1,195 |
| | V: | 411.48 | 2,383.18 | 2,660.29 | 1,109.92 |
| | $: | 0.62 | 3.75 | 3.90 | 1.60 |

Source: MPEDA, 2021 (pers. comm.)

(Graham *et al*., 2001) which is facilitated by the monsoonal hydrographic changes along the southern coasts of India. Swarming appears to be at its peak along the Thengapattinam coast around October to December, Thiruvananthapuram coast in October-November and on the Neendakara coast in December-January. The swarms do not disappear from any of these areas until the end of January though they may diminish in intensity, hence the fishery also continues until the resource lasts. We confirmed that there was no fishery of *C. orsini* in the regions north of Kollam on the southwest coast, not because the fishers are disinterested but due to the absence of a sizable quantity to be caught or the lack of buyers or exporters. Since they are passive swimmers, their movement along the southern tip of the peninsula might be aided by the oceanic circulation patterns. During this study, though no environmental parameter studies were conducted, inferences could however, be drawn from opinions indicating that strong monsoon winds and high precipitation are non-conducive to jellyfish blooms along the east coast of India (Behera *et al.*, 2020b) where they dissipate with the onset of the monsoon. A differing view is proffered by Riyas *et al.* (2021) where they have observed higher numbers of jellyfish during the monsoons (June to November) on the southwest coast which they attribute to parameters such as a higher nutrient load, especially phosphate content coupled with higher plankton productivity. In our observation the end of the south west monsoons brings increases in salinity and less turbulent seas which encourages jellyfish blooms along the south eastern and south western coast from about mid-August. In-depth studies on various parameters including hypoxia, salinity, SST, plankton blooms, coastal current patterns and nutrient load are required for further correlations between jellyfish blooms and coastal sea conditions.

The fishery is heavily dependent on the traders procuring the resource and the traders follow the movement of the resource along the coast. Processing facilities have developed along the Neendakara coast from being initially concentrated around Thengapattanam. In the Neendakara fishery, fuel cost appears to be a decisive factor on the gross value added as percentage of gross revenue (Fig. 8). Fishers concentrated on the increased availability of the jellyfish resource in the beginning of the fishery. However, when the resource dissipated gradually, they optimised by fishing for the regular shrimp and finfish resources along with jellyfish. The multi-day trawlers have landed *C. orsini* as incidental catch along with their regular fishery. The per crew member income in January 2021 which appears low at ₹290 per day is augmented with other catches made during the trip. *C. orsini* fishery appears to have contributed substantially to enhance the fisher's income in an otherwise recessive environment brought about by the Covid-19 pandemic.

As evident from Table 2, the bulk of jellyfish exports takes place to China and Southeast Asia (Vietnam, South Korea, Thailand, Philippines and Japan) through ports in Gujarat, Chennai and Visakhapatnam. Although standing at a modest 0.91 % of the global production of approximately 293000 tonnes (FAO, 2020) it fetches foreign exchange to the tune of $1.6 to 3.9 million per annum. The export of *C. orsini* is so far through Visakhapatnam Port and to a lesser extent through Tuticorin port.

The lack of a more organised fishery and marketing in the Thiruvananthapuram district amounts to large scale wastage of the resource. In actuality, incidences of jellyfish blooms results in the loss of many fishing days for shore seines fishery, where manual labour is employed to drag the nets. Other fishing activities such as gill nets and ring seines also face major problems due to jellyfish swarms. Swarming decreases fish catches, causes fishing activities to be delayed, decreases value of fin- and shellfishes, and damages fishing gear. The slime from the jellyfish causes delay in the fishing process because the gear needs to be cleaned and the fishes clogged with the slime is less appealing and causes aversion to the people resulting in loss to the fish vendors .The coastal fishers suspend the fishing due to these reasons resulting in reduction in fishing days which in turn leads to huge economic loss when swarms are present. Channelising this hitherto undesirable phenomenon in the Thiruvananthapuram district through proper harvesting, efficient marketing, creating processing and export infrastructure facilities and sensitization of fishers will turn it into a profitable and desirable resource, augmenting fishers incomes.

Jellyfish have been gaining prominence as an important alternative marine food resource across the world. It is also regarded as having medicinal values in some cultures, though not scientifically proven, but which can be hypothesized to be contributed by the collagen content necessary for the growth of muscle tissues and bones (Hsieh *et al.*, 2001). Thus different species of jellyfishes provide opportunities for new research initiatives focusing on their medicinal as well as dietary aspects. Though the neighboring Asian regions traditionally make use of jellyfishes as a food item, India always remained as an exception, probably resulting from social and cultural constraints. But, now the increasing population and the economic needs as well as the dwindling regular fishery resources are forcing people to fish non-conventional resources like jellyfish in the country. Although occasional, such a fishery that is export driven has an ecological advantage of fishing out a harmful or invasive component from the food web that can otherwise damage the conventional marine resources on which our coastal communities traditionally depend upon. Developing value-added products from the available species of jellyfish in our coasts for the purpose of export, if not using domestically, may assure a topical financial benefit to fishermen like the case in *C. orsini* fishery. This will also ensure regional and periodic employment opportunities for traditional coastal communities.

## Conclusion

Great potential is envisaged in the development of an organised fishery and marketing system for *C. orsini* along the southern coast of India. Promotion of processing units and exporting facilities within Kerala and Tamil Nadu could facilitate local exporters and the fishers in getting better remunerations for the catch. Close monitoring of the seasonal fishery and in-depth studies into the swarming dynamics of the species are also recommended. Investigations into the innovative utilisation of the resource, especially the presently discarded bells, pharmaceutical properties of the mucus produced by the jellyfish and cosmetic usage of the derivatives need to be fully researched for product diversification.

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## References

Baliarsingh, S. K., A. Lotliker, S. Srichandan, A. Samanta, N. Kumar and T. B. Nair. 2020. A review of jellyfish aggregations, focusing on India's coastal waters. *Ecol. Process.,* 9: 1-9.

Behera, P. R., M. A. Jishnudev, P. B. Rao and S. Ghosh. 2018. Emerging fishery for the jellyfish *Crambionella annandalei* along the coast of Andhra Pradesh. *Mar. Fish. Infor. Serv. T & E Ser*., 236: 24-25.

Behera, P. R., S. S. Raju, M. A. Jishnudev, S. Ghosh and R. Saravanan. 2020a. Emerging jellyfish fisheries along Central South East coast of India. *Ocean Coast. Manag*., 191:1-7.

Behera P. R., M. A. Jishnudev, R. Saravanan, S. K. Roul, S. Ghosh, V. Uma Mahesh and K. K. Joshi. 2020. Redescription of the enigmatic jellyfish, *Crambionella annandalei* (Cnidaria: Scyphozoa) from Indian waters. *J. Mar. Biol. Assoc. U.K*., 100 (5): 691-699.

Billett, D., B. Bett, C. Jacobs, I. Rouse and B. D. Wigham. 2006. Mass deposition of jellyfish in the deep Arabian Sea. *Limnol. Oceanogr*., 51: 2077-2083.

Bleve, G., F. A. Ramires, A. Gallo and A. Leone. 2019. Identification of safety and quality parameters for preparation of jellyfish based novel food products. *Foods*, 8(7):263.

Bosch-Belmar, M., G. Milisenda, L. Basso, T. K. Doyle, A. Leone and S. Piraino. 2021. Jellyfish Impacts on Marine Aquaculture and Fisheries. *Rev. Fish. Sci. Aquac*., 29(2): 242-259.

Brotz, L. and D. Pauly. 2017. Studying jellyfish fisheries: toward accurate national catch reports and appropriate methods for stock assessments. In: Mariottini GL (ed) Jellyfish: ecology, distribution patterns and human interactions. Nova Publishers, Hauppauge. 383pp.

Brotz, L., A. Schiariti, J. López-Martínez, J. Álvarez-Tello, Y. P. Hsieh, R. P Jones, J. Quiñones, Z. Dong, A. Morandini, M. Preciado, E. Laaz and H. Mianzan. 2016. Jellyfish fisheries in the Americas: origin, state of the art, and perspectives on new fishing grounds. *Rev. Fish Biol. Fish*., 27:1-29.

CMFRI. 2017. Annual Report 2016-17. Central Marine Fisheries Research Institute, 178 pp.

Daryanabard, R. and M. N. Dawson. 2008. Jellyfish blooms: *Crambionella orsini* (Scyphozoa: Rhizostomeae) in the Gulf of Oman, Iran, 2002–2003. *J. Mar. Biol. Assoc. U.K.,* 88:477- 483.

FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome, 15 pp.

Graham, W., F. Pagès and W. Hamner. 2001. A physical context for gelatinous zooplankton aggregations: a review. *Hydrobiologia.,* 451:199-212.

Hsieh, Y-H. P., F-M. Leong and J. Rudloe. 2001. Jellyfish as food. *Hydrobiologia.,* 451: 11–17.

Kitamura, M. and M. Omori. 2010. Synopsis of edible jellyfishes collected from Southeast Asia, with notes on jellyfish fisheries. *Plankton Benthos Res.,* 5(3): 106–118.

Menon, M. G. K. 1930. The Scyphomedusae of Madras and the Neighboring Coast, *Bull. Madras Gov. Mus*., New Series, Natural History Section. 3 (1): 28.

Menon, M. G. K. 1936. Scyphomedusae of the Krusadai Island, Vol. 1. *Bull. Madras Gov. Mus*., New Series, Natural History Section, 3 (2): 1-32.

Morikawa, T. 1984. Jellyfish. *FAO INFOFISH Markt. Dig*., 1: 37–39.

MPEDA. 2021. Personal Communication to Director CMFRI via email dated 10/02/2021.

Neethling, S., A. Channing, L. Gershwin and M. Gibbons. 2011. A modern description of *Crambionella stuhlmanni* (Scyphozoa: Rhizostomeae) from St Lucia Estuary, South Africa. *J. Mar. Biol. Assoc. U.K.,* 91:357-367.

Omori, M. and E. Nakano. 2001. Jellyfish fisheries in Southeast Asia. *Hydrobiologia,* 451: 19-26.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. Torres. 1998. Fishing down marine food webs. *Science*, 279: 860-863.

Purcell, J. 2012. Jellyfish and ctenophore blooms coincide with human proliferations and environmental perturbations. *Annu. Rev. Mar. Sci.,* 4:209-35.

Riyas A., N. Dahanukar, A. N. Krishnan and A. Biju Kumar. 2021. Scyphozoan jellyfishes and their relation with environmental factors along the South-eastern Arabian Sea. *Mar. Biol. Res*., 17(2): 185-199.

Saravanan, R. 2018. Jellyfishes-Diversity, Biology-Importance in Conservation In: ICAR Sponsored Winter School on Recent Advances in Fishery Biology Techniques for Biodiversity Evaluation and Conservation, December 2018, Kochi. p. 1-21.

Sathiadhas, R. 1996. Economic Evaluation of Marine Fisheries in India for Sustainable Production and Coastal Zone Development, *Naga, ICLARM Quart*., p. 54 -56.

Srinath, M., S. Kuriakose and K. G. Mini. 2005. Methodology for the Estimation of Marine Fish Landings in India. CMFRI Special Publication, 86: 1-57.

Sen, S., S. S. Salim, D. Gyanaranjan and R. Narayanakumar. 2021. Economic efficiency indicators of multi-day trawler fleet in Digha, north-east coast of India. *J. Mar. Biol. Ass. India.,* 63 (1): 73-78.

Stiasny, G. 1937. Scyphomedusae. John Murray Expedition 1933–1934. *Sci. Rep*., 4, 203–242.

Vanhöffen E.1888. Untersuchungen uber semaeostome und rhizostome Medusen. *Bibl. Zool.,* 3:1–52.

WoRMS Editorial Board. 2021. World Register of Marine Species. Available from https://www.marinespecies.org at VLIZ. Accessed 2021-11-11.