

Fishery, growth, mortality and exploitation status of *Daysciaena albida* (Cuvier, 1830) from Vembanad Lake, a Ramsar site on the south-west coast of India

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Abstract

The fishery, growth, mortality and exploitation status of Bengal corvina *Daysciaena albida* were investigated from the Vembanad Lake, the largest brackish Ramsar wetland in southern India. *D. albida* ranks as the fourth important finfish species fished from the lake contributing 3.79% of the total fish production. Our study aimed to analyse the fishery and stock status of *D. albida* to facilitate the formulation of fishery management options that enhance the livelihoods of artisanal fishermen. The estimated annual catch of *D. albida* from the Vembanad Lake was 10.84 t. The length-weight relationship (LWR) was derived as $W = 0.032 TL^{2.94}$ ($r^2 = 0.98$; $SE = 0.072$). Growth parameters for the species were recorded as - asymptotic length (L_{∞}) = 47.25 cm and growth coefficient (K) = 0.98 y^{-1} . The natural mortality (M) was estimated at 0.83 y^{-1} , and fishing mortality (F) was 1.13 y^{-1} . The exploitation level (E) was calculated to be 0.58 which surpassed the optimum value (E_{50}), indicating overfishing. To safeguard the species from depletion, it is imperative to put in place management strategies, such as regulating mesh sizes, establishing closed fishing seasons, reduction of fishing effort and enforcing catch quotas for fishers.

Introduction

Small-scale fisheries (SSF) represent a vital and valuable component of the global fishing industry, providing essential livelihoods and food security for millions of people across the globe, in both developed and developing nations (Mozumder, 2020). In numerous local communities worldwide, fish serves as the principal protein source, playing a vital role in promoting human health (Youn *et al.*, 2014). About 107 million people in global fisheries and fish trade are engaged in SSFs (Mozumder, 2020). SSFs provide livelihoods for approximately 11% of the global population; however, they face multiple threats, including habitat destruction, indiscriminate exploitation, and climate change (Giri, 2018). Despite their vital contribution to national and

local economies, SSFs face significant challenges due to inadequate planning and regulation. In India, coastal resources, like estuaries, backwaters and coastal lakes, play an important role in the country's fish production, supporting the livelihoods of millions of people residing in coastal areas (Sreekanth *et al.*, 2019). India was ranked as the second largest inland fish producing country in the world, with a yield of 1.31 million t in 2022 (DoF, 2023). Despite this important contribution, accurate information on inland fisheries is difficult to obtain due to the small-scale nature of fishing activities, wide geographic dispersion, and the lack of reporting to government authorities (Nesslage and Pauly, 2023).

Croakers (family Sciaenidae) are significant coastal fishery resources with a widespread distribution across tropical and temperate



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regions (Liting *et al.*, 2022). The family Sciaenidae is one of the most diverse groups of perciform fishes, comprising 286 species under 66 genera (Froese and Pauly, 2022). The Indian marine ecosystem supports a rich sciaenid diversity, comprising 48 species, with 34 species holding significant commercial value (Lal, 1991). On a global scale, the croaker fishery has experienced significant growth, with commercial landings increasing steadily from 0.25 million t (1950) to 1.5 million t (2018) (Rahangdale *et al.*, 2022). Croakers are in high demand in global markets, particularly in USA, the European Union (EU) and the Middle East, where they are traded in both fresh and dried forms. Many sciaenid stocks worldwide are showing signs of decline, with 5.6% of species are categorised as threatened, while 1.4% are classified as near threatened according to IUCN (Rahangdale *et al.*, 2022). Sciaenid species in India inhabits a wide range of habitats such as deep waters, coastal regions, estuaries and freshwater areas (Lal, 1991). Indian sciaenid species fall into two categories: large sciaenids (≥ 150 cm) and smaller sciaenids (30-60 cm) (Rahangdale *et al.*, 2022). *Protonibea diacanthus* and *Otolithoides biauritus* are two prominent species of large sciaenids frequently landed along the Indian coastline. Smaller sciaenids from the genera such as *Atrobucca*, *Daysciaena*, *Johnius*, *Nibea*, *Otolithes*, *Paranibea* and *Pennahia* serve as an affordable source of protein for low-income households in coastal communities (Rahangdale *et al.*, 2022). The swim bladders of croakers fetch a high demand in international markets ranging from ₹1000 to 7350 per kg depending up on their sizes (Roul *et al.*, 2022). Dried swim bladders commonly referred to as fish maws are mainly exported to China and Singapore. These fish maws are used to produce isinglass, a key ingredient in beverage and cosmetic industries as well as in traditional Chinese medicines (Dutta *et al.*, 2014). Smaller and medium-sized sciaenids are primarily marketed fresh in local markets or iced and transported to inland areas for human consumption (Roul *et al.*, 2022).

Daysciaena albida commonly known as Bengal corvina, is a carnivorous benthopelagic amphidromous food fish species that inhabits marine and brackishwaters of India, Sri Lanka and Pakistan (Akhilesh *et al.*, 2020). Bengal corvin is highly valued in various Asian countries due to its exceptional nutrient profile such as high-quality protein content, abundant unsaturated fatty acids, and essential amino acids (Francis and Sajeevan, 2022). Additionally, its ability to potentially ward off diseases such as cancer, cholesterol-related issues, and cardiovascular diseases further enhances its economic value (Torriss *et al.*, 2018). *D. albida* is an important exploited species among the finfish harvested from Vembanad Lake in Southern India, contributing 2.74% of the total fish production and is routinely consumed by the local population residing in and around the estuarine system (Kurup and Samuel, 1988; Kurup *et al.*, 1995; Renjithkumar *et al.*, 2025). A recent study in the Vembanad Lake revealed that *D. albida* is facing a severe exploitation pressure due to rising demand and premium value of the species (Renjithkumar *et al.*, 2025). Several studies have been conducted on the stock status of croakers in Indian waters which includes *Johnius borneensis* (Muthiah, 1982; Chakraborty, 1993), *J. carutta* (Murty, 1986; Bhuyan *et al.*, 2012), *J. gangeticus* (Mandal and Nagesh, 2007), *Johnieops sina* (Chakraborty, 1994, 1996; Manojkumar, 2011), *Nibea maculata* (Santhoshkumar *et al.*, 2011), *Otolithoides brunneus* (Kutty, 1967), *O. biauritus* (Chakraborty, 2006), *O. pama* (Bhakta *et al.*, 2020), *Otolithes ruber* (Bhuyan *et al.*, 2012; Santhoshkumar *et al.*, 2014), *P. macrophthalmus* (Bhuyan *et al.*, 2012), *Pennahia aneus* (Menon *et al.*, 2016), *Pseudosciaena diacanthus* (Rao,

1963) and *P. coibor* (Rajan, 1964). However, there is a significant knowledge gap on the stock status of *D. albida* in any water body. This study investigates the fishery, growth pattern, mortality rates and exploitation of *D. albida* in the Vembanad Lake, with observations aimed at supporting the sustainable management of the stock.

Materials and methods

Vembanad Lake or Vembanad Estuary which is one of the largest coastal wetlands and an important Ramsar site of India covers 1512 km² (Srinivas *et al.*, 2003). The lake extends parallel for a stretch of 89 km and connects directly to the Arabian Sea through two openings. The first opening located at Fort Kochi is 450 m wide and over 15 m deep and the second one at Munambam is 250 m wide and has a depth greater than 7 m (Roshni *et al.*, 2021). To protect the region's low-lying paddy fields from saltwater intrusion, a 1402 m long permanent barrage was constructed across the lake at Thanneermukkom (Gopalan *et al.*, 1983). The lake sustains several aquatic forms, including 96 species of finfishes (Roshni *et al.*, 2023; Renjithkumar *et al.*, 2025). The lake also showcases a diverse coexistence of livelihood activities, including different types of fishing, houseboat tourism, pokkali farming, sub-sea level farming, and associated endeavours, all reliant on its abundant resources (Giri, 2018).

Monthly catch details of *D. albida* were obtained from three landing centers Aroor (9°53'35.21" N; 76°17'45.05" E); Fort Kochi (9°58'05.09" N; 76°14'29.05" E) and Vypin (10°00'18.68" N; 76°14'21.52" E) along the Vembanad Lake system from February 2023 to January 2024. Catch data (kg) from gill net hauls were documented and catch per unit effort (CPUE) was computed following the method described by Scaria *et al.* (1999). The daily landings from different type of fishing gears were determined using the methodology developed by Kurup *et al.* (1993) applying the formula:

$$W = (w/n) \times N$$

where W = total weight of fish, w = total weight of fish collected from the sampled gear, n = number of gears sampled and N = total number of similar gears operated.

The monthly catch was determined by multiplying the daily catch by the total number of fishing days in a month (assumed to be 25 days). The annual catch was then estimated by summing the monthly landings over 12 months.

In the field, the total length (TL) of the species was calculated with precision to the nearest 0.1 cm and the weight was evaluated with an accuracy to the nearest 0.1 g. The LWR was established using the equation:

$$W = aL^b$$

where W = wet body weight (g), L = total length (cm) and 'a' and 'b' = regression parameters (Le Cren, 1951; Froese, 2006). Goodness of fit was calculated using the coefficient of determination (R²) and the 95% confidence interval (CI) of parameters 'a' and 'b' also were calculated (Froese, 2006). To check if the calculated value of b = 3 (isometric growth), the two-tailed t-test was used (b=3, P<0.05).

The length-frequency data were collected from the three landing centres (409 samples) and grouped into 2.5 cm class intervals for growth analysis. The von Bertalanffy growth parameters viz., asymptotic length (L_∞) and growth coefficient (K) were estimated

with the ELEFAN-1 (electronic length frequency analysis) module in FiSAT-II (FAO-ICLARM Stock Assessment Tools II) software (Gayanilo *et al.*, 2005). The von Bertalanffy growth formula (VBGF) was fitted using $L_t = L_\infty [1 - \exp^{-k(t-t_0)}]$, where L_t is the length at time 't', which denotes the age of the fish and t_0 is the theoretical age at length zero calculated from Pauly's (1983) equation: $\text{Log}(-t_0) = -0.392 - 0.275 \text{Log} L_\infty - 1.038 K$. The longevity was calculated using the formula $t_{\text{max}} = 3/K$ (Pauly, 1984). The growth performance index (ϕ) was estimated using the equation $\log K + 2 \log L_\infty$ (Moreau *et al.*, 1986). Total mortality (Z) was calculated from the length-converted catch curve method (Pauly, 1984) and natural mortality (M) was recorded using the empirical equation given by Pauly (1980): $\ln M = -0.0152 - 0.279 \ln L_\infty + 0.6543 \ln K + 0.463 \ln T$, where T is the mean annual temperature (29°C). Fishing mortality (F) was derived from the equation $F = Z - M$ (Ricker, 1975) and exploitation rate (E) was calculated as $E = F/Z$ (Gulland, 1970). The length at which 50% of the fishes are selected by the gear (L_c = size at first capture) was computed using ogive selection (Pauly, 1984). Recruitment pattern was assessed by reconstructing the recruitment pulses from a time series of length-frequency data (Gayanilo *et al.*, 2005). The relative yield per recruit (Y/R) and relative biomass per recruit (B/R) analysis were conducted using the knife selected method described by Beverton and Holt (1966), to assess stock exploitation status and to estimate key reference points, including, E_{max} (exploitation rate producing maximum yield) and E_{50} (exploitation rate that maintains 50% of the spawning biomass).

Results

Fishery

Stake nets, gill nets and seine nets were the major fishing gears employed in the lake, with gill nets being the predominant gear for catching *D. albida*. The total annual catch of the species from the three landing centres of the Vembanad Lake was calculated to be 10.84 t. The highest landing (6.22 t) of *D. albida* occurred during the pre-monsoon season (February-May) while the lowest landing (1.27 t) was recorded during monsoon season (June-September) (Fig. 1). The CPUE in gill nets varied significantly across months, ranging from 0.19 kg h⁻¹ in May 2023 to 1.84 kg h⁻¹ in June 2023.

Size frequencies and length-weight relationship

The catch composition analysis of *D. albida* from Vembanad Lake showed its year-round availability. The size range of 409 specimens of *D. albida* varied from 11.2 to 46.8 cm in TL and 16.20 to 1462 g in TW. The smallest specimens were reported in February and March while largest specimens were recorded in August, September and February. The length frequency analysis revealed that the commercial catches of the species were dominated by the length groups 30.1-32.5 cm (13.45%), 32.6-35 cm (12.71%) and 35.1-37.5 cm (12.47%) (Fig. 2). The LWR is expressed by the equation $W = 0.032 TL^{2.94}$ ($r^2 = 0.98$; SE = 0.072).

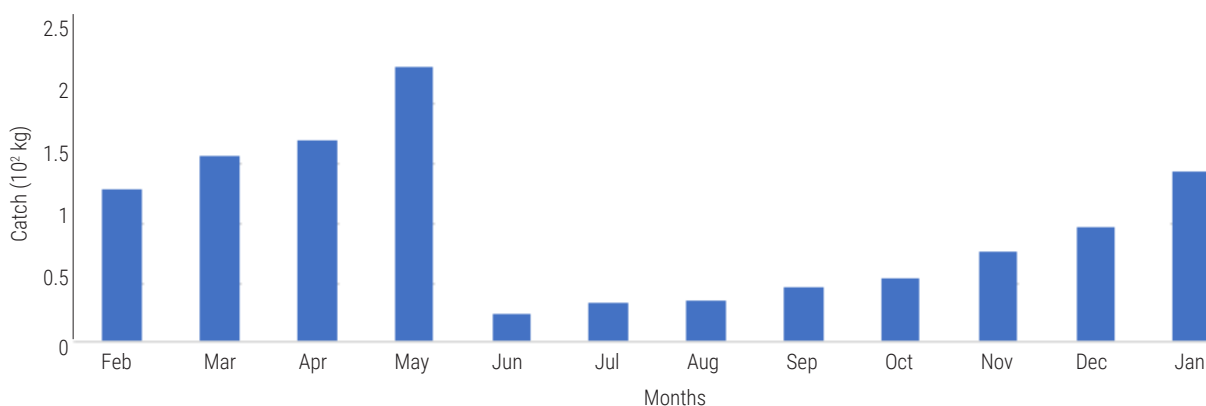


Fig. 1. Monthly landings of *D. albida* from Vembanad Lake, India (February 2023 to January 2024)

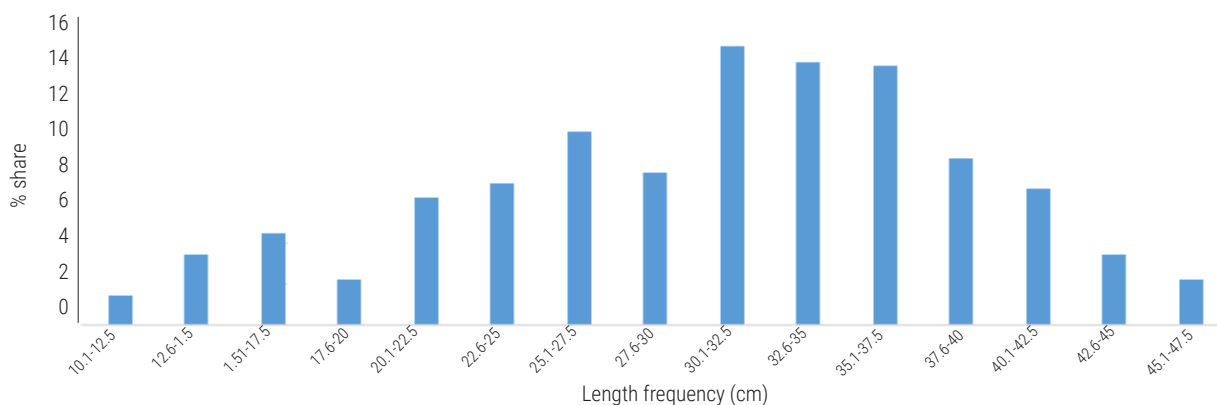


Fig. 2. Length-frequency distribution (%) of *D. albida* from Vembanad Lake, India

The allometric coefficient (b) was found to be less than 3 (95% CL for b: 2.87-3.00), indicating negative allometric growth.

Growth, mortality and exploitation

The growth parameters of *D. albida* were estimated as: asymptotic length (L_{∞}) = 47.25 cm TL and growth coefficient (K) = 0.98 y^{-1} (Table 1). The growth curve analysis indicated that the population consisted of a single cohort that originated between December and January (Fig. 3). The growth performance index (ϕ) was estimated to be 3.33, while the longevity (t_{max}) was found to be approximately 5.33 years. Total mortality (Z), natural mortality (M) and fishing mortality (F) were 1.96 y^{-1} , 0.83 y^{-1} and 1.13 y^{-1} respectively (Fig. 4). The estimated fishing mortality rate of the species in Vembanad Lake exceeded its natural mortality rate, indicating significant fishing pressure. The length at first capture (L_c) was estimated to be 31.49 cm. Virtual Population Analysis (VPA) indicated that smaller individuals (<25.0 cm) experience high natural mortality rates, while those above >27.5 cm face significant fishing mortality (Fig. 5). The relative yield per recruit (Y/R) and biomass per recruit (B/R) calculated based on knife-edge selection indicated exploitation rate (E) of 0.58 (Fig. 6). The present exploitation (E) was estimated to be around 71% of maximum sustainable exploitation level (E_{max} =0.82) and exceeded E_{50} (0.41), the level required to maintain 50% of the spawning biomass (Fig. 6). The recruitment pulses of *D. albida* indicated a single major peak (May to September). The highest recruitment was noticed in July (17.55%), while the lowest was recorded in February (1.89%).

Discussion

Fishery and length-weight relationship

LWRs are vital for analysing and understanding the biological characteristics of fish groups (Renjithkumar and Roshni, 2022). The LWR ($b = 2.94$) for *D. albida* indicates negative allometric growth with the fish's weight increasing at a slower rate than its length. This result aligns with the findings of Kurup and Samuel (1987) and Kitty

Table 1. Growth, mortality and exploitation parameters of *D. albida* from Vembanad Lake, India

Population parameter	Value
Asymptotic length (L_{∞} ; cm)	47.25
Growth coefficient (K; y^{-1})	0.98
Growth performance index (ϕ)	3.33
Longevity (t_{max} ; years)	5.33
Total mortality rate (Z)	1.96
Natural mortality rate (M)	0.83
Fishing mortality rate (F)	1.13
Length at first capture (L_c ; cm)	31.48
Annual exploitation (E)	0.58
E_{50}	0.41
E_{max}	0.82

and Sajeevan (2023), who documented negative allometric growth ($b = 2.40$ - 3.06 and $b = 2.91$ respectively) for *D. albida* in Vembanad Lake, India, while the species exhibited positive allometric growth ($b = 3.05$) in the Chilka Lagoon (Karna *et al.*, 2020). The deviations in the b-value for the same species across different habitats could be attributed to a range of factors including sample size and composition, length range, sampling gear and mesh size, sex ratio, dietary difference and gonadal maturity stages (Froese, 2006; Roshni and Renjithkumar, 2021). The maximum recorded length for *D. albida* in the Vembanad Lake (46.8 cm TL) was similar to the maximum length reported from Narreri Lagoon, Pakistan (47 cm) (Awan *et al.*, 2017). However, it is comparatively lower than the maximum length of 64.5 cm reported from Chilka Lake, India (Karna *et al.*, 2020). The fishery of *D. albida* from Vembanad Lake declined from 146.6 t (Kurup *et al.*, 1995) to 10.84 t in this study. This decline could be attributed to shifts in the fish landing pattern in the study area primarily driven by changes in the environmental variables such as salinity and temperature, habitat destruction, water pollution and other related factors (Roshni *et al.*, 2021, 2023).

Growth parameters

Information on the stock status of fishes is essential in fisheries

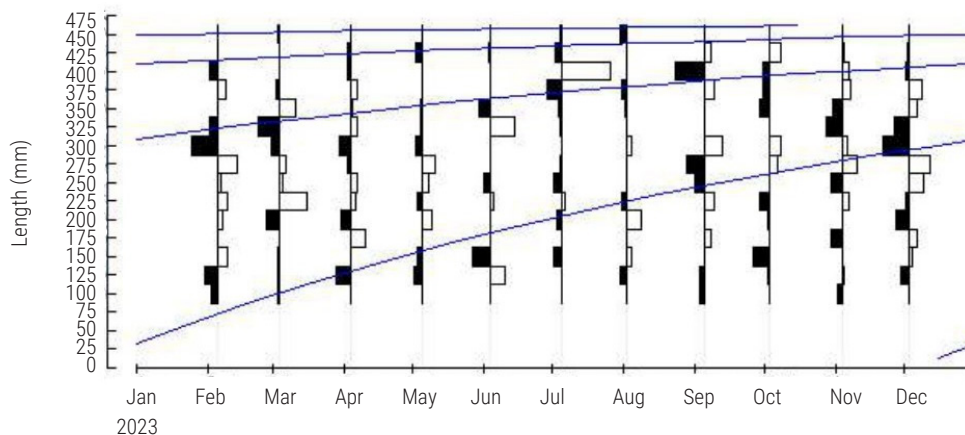


Fig. 3. Growth curves of *D. albida* from Vembanad Lake, India

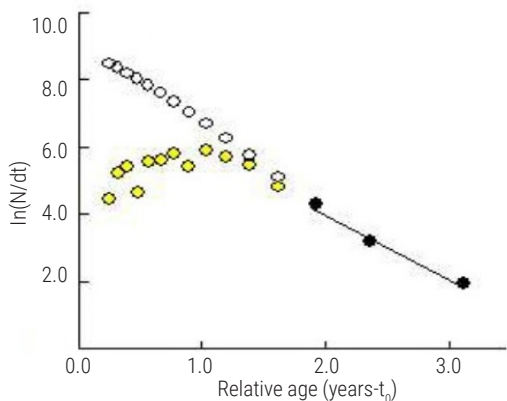


Fig. 4. Length converted catch curve of *D. albida* from Vembanad Lake, India

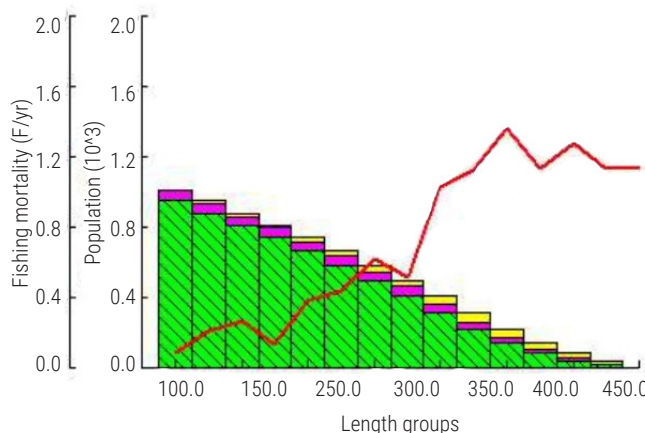


Fig. 5. Length-structured virtual population analysis (VPA) of *D. albida* from Vembanad Lake, India

science for assessing the impacts of various threats on species and their effects on the population (Alhassan and Armah, 2011). Several mathematical models are used to study age and growth in fishes, with von Bertalanffy models being commonly applied. This model is often estimated using size-frequency distribution and is especially suited for tropical fish species. This research marks the first investigation into the growth and mortality patterns of Bengal corvina croaker, *D. albida* from any aquatic environment. The asymptotic length (L_{∞}) was estimated as 47.25 cm and growth coefficient (K) was determined to be 0.98 y^{-1} . The relatively high growth coefficient of *D. albida* indicates that the species reaches its asymptotic length quickly. This finding supports the observation by Pauly and Munro (1984), who reported that species with shorter life span tend to have higher 'K' values, reaching their L_{∞} within 1-3 years of their life cycle. According to Branstetter (1987), a species is considered to have slow growth when its K value falls between 0.05 and 0.10 y^{-1} , intermediate growth when K is between 0.10 and 0.20 y^{-1} , rapid growth when K falls between 0.20 and 0.50 y^{-1} , and very rapid growth when K is equal to or greater than 0.50. According to Ingles and Pauly (1984), a wide range of growth coefficients ($K = 0.21\text{-}2.0$) for various lesser sciaenid species in Indian waters, indicating considerable variability in growth rates among these species. *D. albida* in the Vembanad Lake exhibits very rapid growth, which corresponds well with the high food production observed in the ecosystem (Roshni *et al.*, 2021, 2023). The growth parameters of karut croaker, *J. carutta* along the Indian coast have been reported as 25.9 to 33.33 cm for L_{∞} and 0.40 to 0.84 y^{-1} for K (Vivekanandan, 1985; Murty, 1986; Rao *et al.*, 1992; Rajkumar *et al.*, 2004; Bhuyan *et al.*, 2012). For big-head pennah croaker, *P. macrophthalmus*, the recorded values were within the range of 23.3 to 30.3 cm for length (L_{∞}) and 0.86 to 1.04 y^{-1} for the growth coefficient (K) (Jayasankar, 1995; Chakraborty *et al.*, 2000; Bhuyan *et al.*, 2012). Studies on *O. ruber* have recorded L_{∞} values ranging from 31.5 to 51.1 cm and K values between 0.47 to 0.67 y^{-1} (Chakraborty *et al.*, 2000; Bhuyan *et al.*, 2012). According to Murty and Ramalingam (1986), the growth parameters of *N. maculata* from Kakinada waters were reported as 31.5 cm (L_{∞}) and 0.61 y^{-1} (K). The growth parameters of *J. gangeticus* from Kakdwip, West Bengal was determined as $L_{\infty} = 48 \text{ cm}$ and $K = 1 \text{ y}^{-1}$ (Mandal and Nagesh, 2007). The growth parameters of pama croaker (*O. pama*) were recorded as 41.8 cm (L_{∞}) and 0.58 y^{-1} (K) from Hooghly-Matlah Estuary, West Bengal (Bhakta *et al.*, 2020).

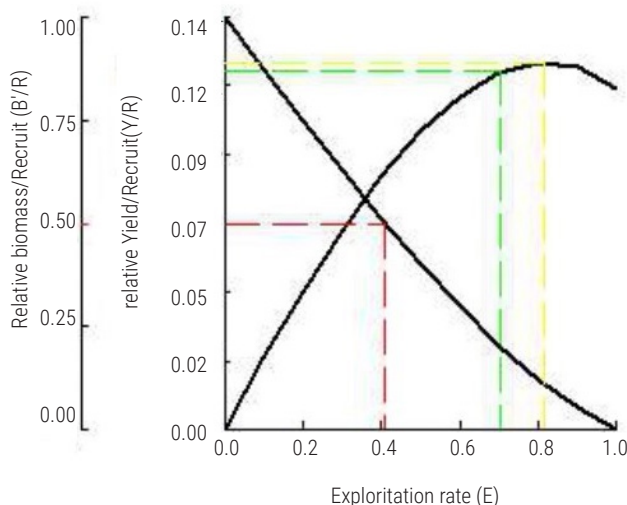


Fig. 6. Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) plots of *D. albida* from Vembanad Lake, India

Growth parameters of Sin croakers, *J. dussumieri* from west coast of India ranged from $L_{\infty} = 23.8\text{-}26.8 \text{ cm}$ and $K = 0.45\text{-}0.77 \text{ y}^{-1}$. Chakraborty (1996) documented that *P. macrophthalmus* sampled from the coastal waters of Bombay region in the west coast had $L_{\infty} = 26 \text{ cm}$ and $K = 1.10 \text{ y}^{-1}$. Bronze croaker, *O. bauritus* attained an asymptotic length of 178.2 cm and growth rate of 0.58 y^{-1} from Mumbai waters (Chakraborty, 2006). The growth parameters of *J. glaucus* were documented as 30 cm (L_{∞}) and 1.04 y^{-1} (K) from the Gujarat coast, India (Kamath and Devraj, 1995). Murty and Ramalingam (1986) documented that *Johnnieops vogleri* had L_{∞} and K values of 35.4 cm and 0.51 y^{-1} , respectively off Bombay waters. The growth parameters of *J. macrorhynchus* were recorded as 33.1 cm (L_{∞}) and 0.54 y^{-1} (K) from Bombay waters (Chakraborty *et al.*, 2005). The growth parameters (L_{∞} and K) of *P. diacanthus* and *O. bauritus* along the west coast of India were 145.3 cm, 0.14 y^{-1} and 160 cm, 0.19 y^{-1} respectively (Kumar *et al.*, 2014).

Growth performance index (ϕ) for *D. albida* based on length index was calculated to be 3.33. There are no available reports on the growth performance index for the species in any other aquatic habitats. The growth performance index for lesser sciaenid fishes along the east coast of India varied between 2.54 to 3.36 (Rao *et al.*, 1992; Jayasankar, 1995; Chakraborty *et al.*, 2000; Mandal and Nagesh, 2007; Bhuyan *et al.*, 2012), slightly lower than the values reported in this study. Relatively high values of the growth performance index (6.13 to 6.87) have been reported for large sciaenid species in Bombay waters (Chakraborty, 2001). Similar growth performance index value (3.36) was reported for *J. gangeticus* from the Hooghly Matlah Estuary (Mandal and Nagesh, 2007). Bhuyan *et al.* (2012) recorded ϕ -value 2.9 for *J. carutta* and *P. macrophthalmus* and 3.24 for *O. ruber* (3.24) from the Paradeep coast, Odisha. The estimated ϕ -value for *D. albida* in this study falls within a comparable range to previously reported values. In general, ϕ -values range from 2 to 4 and remained relatively constant within species or family groups. Variations in growth performance among various species are mainly driven by differences in growth coefficients, environmental factors, and levels of fishing intensity (Bhakta *et al.*, 2020).

Mortality parameters

The decline in fish population is due to two types of mortality-natural mortality (M) (caused by natural factors including infections, competition and water pollution) and fishing mortality (F). The mortality parameters of *D. albida* were estimated as $M = 0.83 \text{ y}^{-1}$ and $F = 1.13 \text{ y}^{-1}$. Due to the lack of reports on the mortality parameters of *D. albida* from its distributional range, the current study was compared with those of other sciaenid species from Indian coast. The values of M and F for *O. biauritus* from Mumbai waters were reported as 0.65, and 1.18 y^{-1} respectively (Chakraborty *et al.*, 2005), and 0.33, and 0.37 yr^{-1} respectively from Veraval coast (Ghosh *et al.*, 2010). Manojkumar (2011) reported that the natural and fishing mortalities of *J. dussumieri* from Malabar coast were 1.10 and 2.31 y^{-1} respectively. In another study from the Bombay coast, the values of M and F for *J. dussumieri* were 1.76 and 2.59 y^{-1} respectively (Chakraborty, 1994). The M and F values of *P. macrophthalmus* were estimated as 2.81 and 0.43 y^{-1} respectively from Bombay waters (Chakraborty, 1996). Kamath and Devraj (1995) reported that the annual M and F of *Johnius glaucus* from the north-west coast of India were 1.49 and 0.85, respectively. The natural and fishing mortality coefficients (M and F) of *Johnius macrorhynchus* from Mumbai waters were 1.18 and 1.69 y^{-1} respectively (Chakraborty, 1994). The mortality rates M and F recorded for *P. diacanthus* were 0.31 and 0.30 y^{-1} from Vanakbara, Diu, India (Ghosh *et al.*, 2010). Murty and Ramalingam (1986), reported M and F of *N. maculateas* as 1.26 and 1.67 y^{-1} , respectively for samples collected from Kakinada coast. Rajkumar *et al.* (2004) recorded the M and F of *J. carutta* as 2.05 and 0.97 y^{-1} , respectively from Visakhapatnam waters. Mortality estimates for *J. gangeticus* in the estuarine regions of West Bengal were $M = 1.53$ and $F = 2.98 \text{ y}^{-1}$ (Mandal and Nagesh, 2007). The values of M and F of *Otolithoides pama* were reported as 1.14 and 3.02 y^{-1} respectively from Hooghly Matlah Estuary (Bhakta *et al.*, 2020).

Exploitation level

The calculated exploitation level (E) of 0.58, suggested that the stocks of *D. albida* within the Vembanad Lake system are

experiencing overexploitation. For a sustainably managed fish stock, the exploitation rate (E) should ideally be around 0.5. Since the estimated E for the species exceeds this threshold, implementation of effective management strategies is necessary to reduce fishing pressure and ensure the long-term sustainability of the lake's resources. Chakraborty (1994) reported a high exploitation level (0.59) for *J. sina* from Bombay coast. *O. cuvieri* exhibited a high exploitation rate ($E=0.71$) from Veraval, exceeding the E_{max} value, indicating severe overexploitation for the species (Manojkumar, 2011). Chakraborty (1988) reported an optimum exploitation rate (0.50) for a similar species in the waters off Bombay. Ghosh *et al.* (2010) reported an E value of 0.47 for *O. biauritus* in Diu waters indicating that the stock of the species is being harvested at an optimal level. Manojkumar (2011) reported a relatively high E value of 0.64 for *J. sina* along the Malabar coast, indicating intense fishing pressure. Ghosh *et al.* (2010) reported relatively low exploitation pressure for *P. diacanthus* ($E = 0.49$) and *O. biauritus* ($E = 0.47$) from Diu along west coast of India. *N. maculata* showed a low exploitation ($E = 0.39$) in Thoothukudi coast, Tamil Nadu (Santhoshkumar *et al.*, 2011). Rajkumar *et al.* (2004) documented a high exploitation rate ($E = 0.68$) for *J. carutta* from the waters of off Visakhapatnam. Bhakta *et al.* (2020) reported a high level of exploitation ($E = 0.73$) for *O. pama* in Hooghly-Matlah Estuary.

The length at first capture (L_c) for *D. albida* was calculated as 31.48 cm. However, the absence of reproductive data for this species, makes it difficult to determine whether immature fish groups are being caught. VPA analysis indicated that a high natural mortality was observed in smaller individuals (<25 cm) likely resulting from multiple aspects such as competition, predation, starvation, disease or environmental stressor (Caveriviere and Toure, 1996; Yongo and Outa, 2016). The recruitment peaks observed in *D. albida* during May and September coincide with the south-west monsoon across the Western Ghats region, India. This suggests that the recruitment of the species is likely influenced by favourable environmental conditions and increased food availability during rainy season.

D. albida is a commercially important fish species exploited from Vembanad Lake system. The present exploitation rate exceeds the E_{50} , suggesting that the population is experiencing overfishing. Juveniles (<25 cm) of the species experience high natural mortality rates while adults (>27.5 cm) face significant fishing mortality. Since there are currently no management measures in place for *D. albida*, the species faces a risk of depletion or even extinction in the near future. To achieve optimum exploitation and ensure sustainability of *D. albida*, conservation measures such as implementing size limit regulations, reducing fishing effort, enforcing catch quotas for local fishermen, and establishing a closed fishing season are advisable. To better manage and conserve the species, further research is strongly recommended to investigate the reproductive characteristics of the species in the estuarine system.

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