Population dynamics of *Donax faba* (Family: Donacidae)in the coastal waters of Padukere, Karnataka (India)

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Introduction

Macrobenthic organisms that live in constantly disturbed high-energy sandy substrata, have evolved specific morphological and equally important behavioural features for them to flourish (Ansell and Trevallion, 1969). Species of the tropical mollusc family Donacidae, are well known to exploit the swash and the backwash to keep within the zone of breaking waves in order to feed on the sparse nutrients held briefly in suspension by them (Ansell, 1981). These filter-feeding clams inhabit sandy beaches along the Indian coast, including the Indian Island (Rao and Dey, 1986, 2000). The members of the genus *Donax*arean abundant component of the intertidal fauna in many parts of the world (Coe, 1953; Laudien *et al.,* 2003; Herrmann *et al.,* 2009). Growth checks can be caused by high seas, inhibition of growth at low or high temperature, attacks by predators, physical disturbances, pollution and spawning events (Lutz and Rhodes, 1980; Wilbur and Owen, 1983), and can be periodic (an effect of tides, lunar months or seasons), or irregular (due to random events such as cyclones) (Jones, 1981). In this case, there is some disagreement about the interpretation of growth lines (Jones, 1981; Bourget *et al.,* 1991), and without validation such data may be unreliable. The population of donacidsuch as *Donax incarnatus* generally reaches high densities and is the most abundant species yielding high biomass along Karnataka coast, India (Thippeswamy, 1985). *D. faba* is easily recognizable from other wedge clams compared to other species like *D. incarnatus* and *D. scortum* co-occurring

in the Padukere beach. Recently, Tenjing *et al.* (2011, 2016a) studied the population dynamics of *D. faba* and *D. scortum* from Mangalore and Padukere coasts (Karnataka), respectively. For the management of mollusc resources, information on various population parameters and exploitation levels of the population of wedge clams is essential. Throughout the world, bivalve exploitation plays an important role in the national economy of many countries (Vakily, 1992). There are many tools for assessing exploitation levels and population biology of a stock. Of those, FAO-ICLARM Stock Assessment Tools (FiSAT) was used for calculating population parameters of *Donax* species (Zeichen *et al.,* 2002; Cardoso and Veloso, 2003; Tenjing *et al.,* 2011). *D. faba* and large sized *D. scortum* are the important test organisms which had been used recently to study bioaccumulation of heavy metal contents in the meat from the polluted and unpolluted areas along Karnataka coast (Tenjing *et al.,* 2012a,b; 2013). However, no detail studies on population dynamics are carried out on *D. faba* at Padukere (India).

Materials and methods

Wedge clam, *Donax faba* of different sizes were collected from the intertidal region of Padukere sandy beach (13º20'51.80"N; 74º41'30.92"E), Karnataka for a period of 12 months (May 2009-April 2010) (Fig. 1). The length (maximum distance along the long axis of the valves) was measured using Vernier calipers (Fig. 2) (FAO, 1998). For estimating von Bertalanffy growth parameters, asymptotic length (L_∞) and growth co-efficient (K), and the length measurements of one year data were pooled and grouped with class interval, month-wise and analysed using the ELEFAN I of FiSAT software (Gayanilo *et al.,* 1996). The parameter t_o of the growth equation was estimated using the equation of Pauly (1979).

The estimates of L_∞ and K were used to estimate the growth performance index (ϕ') using the equation, $\phi' = 2\log L_\infty + \log K$ (Pauly and Munro, 1984). Growth was described by the von Bertalanffy growth function (*VBGF*) (von Bertalanffy, 1938). The *VBGF* is defined by the equation, $L_t = L_\infty [1-e^{-K(t-to)}]$, where L_t is the length at time t, e is the base of the natural logarithm, t the time of observation and t_o the age to which the clam belongs at zero size. Using the values of L_∞, K and t_o, the growth curve was fitted from the von Bertalanffy growth equation. Since non-linear growth functions are difficult to compare, several authors (Pauly, 1979, Munro and Pauly, 1983) demonstrated the suitability of composite indices for overall growth performance (*OGP*) for inter and intra-specific comparisons. The *OGP* is calculated as $OGP = \log(K[L_\infty]^3)$. The total mortality ($Z$) was estimated by a length converted catch curve method (Pauly, 1984).
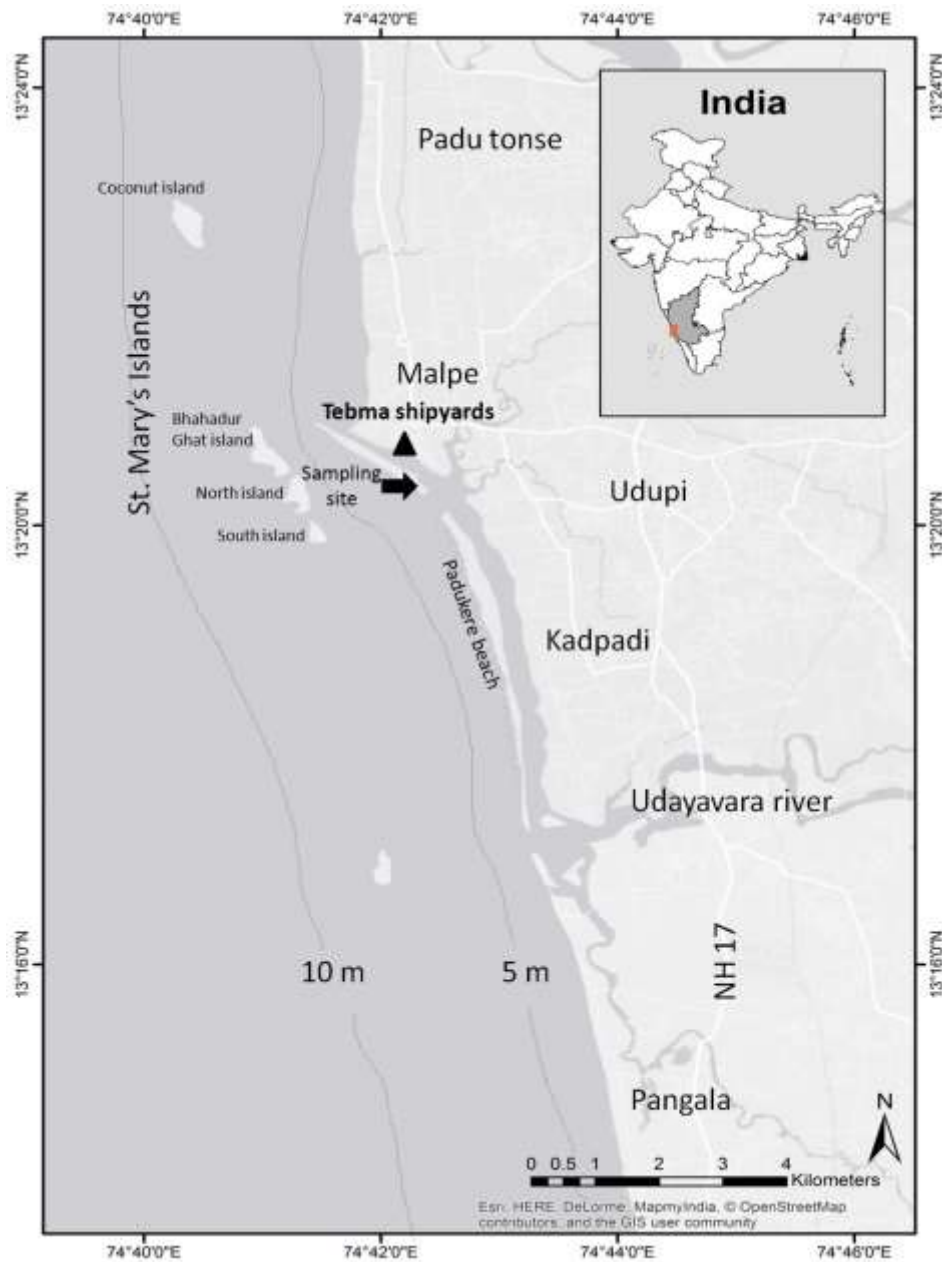
Figure 1: Location of sampling site located along Karnataka coast.

The natural mortality coefficient (M) was determined using $M \approx K$ approximation (Gayanilo *et al.,* 1996). On the other hand, the population of *Donax faba is* known to be unexploited.Therefore, F is equal to 0. The recruitment pattern was obtained by projecting the length-frequency data backwards on the time axis using growth parameters (Moreau and Cuende, 1991).
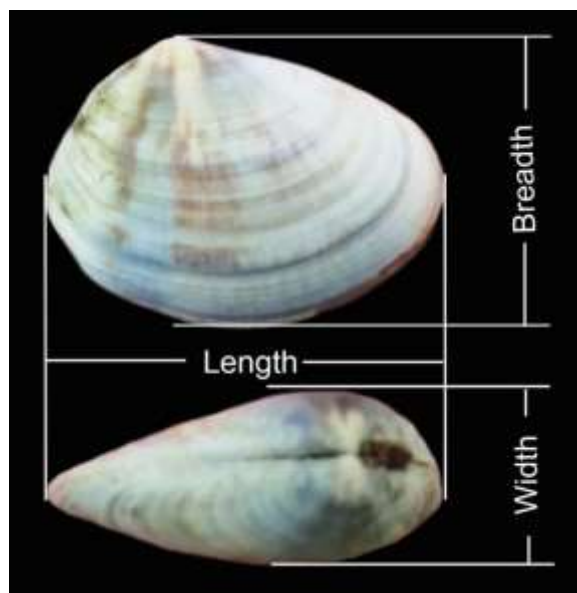
Figure 2: Measurement of shell length of *Donax faba* according to FAO (1998)

Results and discussion

In India, donacidsmostly live in sandy beaches of India (Rao and Dey, 1986). For the entire period, the data on the length frequency distribution of clams is given in Fig. 3. The distribution shows the distinct modes in the months. Asymptotic length (L_∞) of the *VBGF* was 27.09 mm and the growth coefficient (K) was 0.90 yr^{-1} for *Donax faba*. The computed growth curve is shown over the length distribution in Fig. 3. Estimation of K was shown in Fig. 4. The calculated t_o was -0.019 yr. Thus the Bertalanffy growth equation for *D. faba* was written as L_t= 27.09 [1-e$^{-0.90 (t + 0.019)}$]. The growth performance index (ϕ) was 2.82 (Table 1), whereas the overall growth performance index (*OGP*) was 4.25. The results showed estimates of asymptotic length (L_∞) for *D. faba*, which are very similar to*D. faba* reported from the Gulf of Mannar

and Panambur (Alagarswami, 1966; Tenjing *et al.,* 2011), but the growth coefficient (K) value (0.10 yr^{-1}) from the Gulf of Mannar (Tamil Nadu) is lower than the K values reported from Panambur and Padukere (Table 1).

Most species of *Donax* have a short life expectancy of 1-2 yrs (Ansell, 1983). Various environmental factors are known to influence molluscan growth (Alagarswami, 1966; Thippeswamy and Joseph, 1991). Several investigations have found that both in tropical and temperate waters growth rates of the molllusc are not uniform throughout the year. The von Bertalanffy growth curve is presented in Fig. 5. The life span of *Donax faba* collected from Padukere in the present study is about 3.4 yrs (40 months). The sizes attained by *D. faba*were 16.26, 22.69, and 25.30 mm in the first, second and third years, respectively.
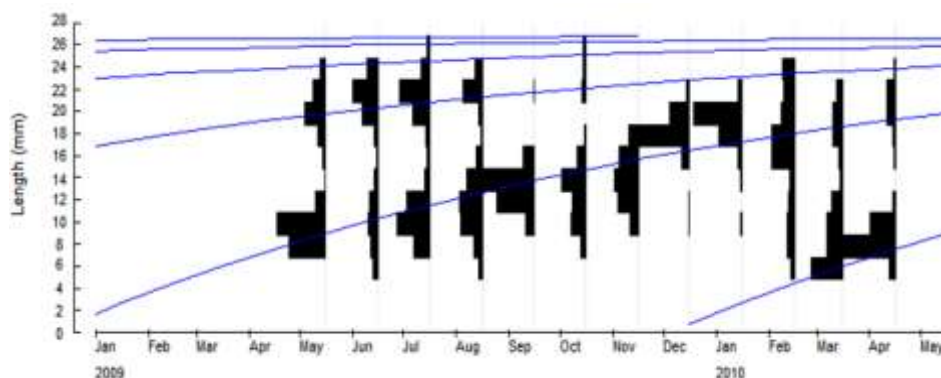
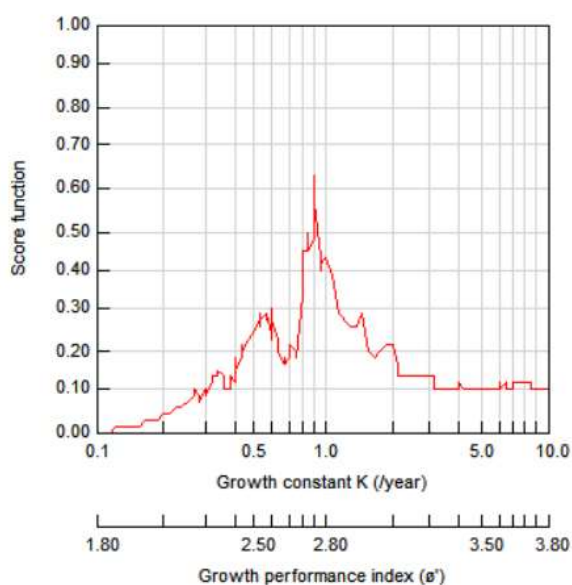**Figure 3: Growth curves fitted by ELEFAN I to length-frequency of *Donax faba.***

Figure 4: Estimation of growth constant (*K*) and growth performance index (*GPI*) *Donax faba* from Padukere beach.

Table 1: von Bertalanffyparameters L_α (mm), K (yr^{-1}) and ϕ' of donacids from Indian regions for *Donax* species.

Species	L_α (mm)	K (yr^{-1})	ϕ'	Climate area	Location	Source
Donax incarnatus[1,2]	25.13	0.09	1.86	Tropical	Cochin, India	Ansell *et al.* (1972)
D. incarnatus[1,2]	29.04	0.09	1.86	Tropical	Shertallai, India	Ansell *et al.* (1972)
D. incarnatus[1,2]	20.06	0.09	1.55	Tropical	Benaulim, India	Nair *et al.* (1978)
D. incarnatus[1]	30.94	0.16	2.19	Tropical	Panambur, India	Thippeswamy and Joseph(1991)
D. cuneatus[1]	22.87	0.06	1.48	Tropical	Palk Bay, India	Nayar(1955)
D. cuneatus[1,2]	33.02	0.04	1.67	Tropical	Miriya Bay, India	Talikhedkar *et al.*(1976)
D. faba[1,2]	26.15	0.10	1.84	Tropical	Gulf of Mannar, India	Alagarswami(1966)
D. faba[1]	26.67	0.89	2.80	Tropical	Panambur, India	Singh *et al.*(2011)
D. scortum[1]	70.88	0.64	3.51	Tropical	Padukere, India	Singh (2016b)
D. faba[1]	27.09	0.90	2.82	Tropical	Padukere, India	Present study

[1]Age estimated from length-frequency distributions.
[2] Values calculated on monthly basis from raw data reported by the authors.
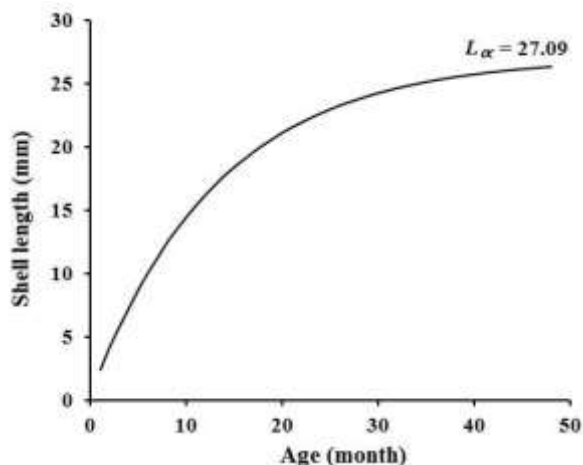
Figure 5: Plot of age and growth of *Donax faba* based on computed growth parameters.

The calculated average growth rates of *D. faba* in the first, second and third years were 1.36, 0.54 and 0.22 mm respectively. For the remaining four months, the calculated average growth rate was 0.02 mm. The growth rate is faster in their early part of life than during the latter. Longevity of *D. faba* was found to be 3.4 yrs. The estimated life span for *D. incarnatus* and *D. faba* along Karnataka coast were less than 1.5 and 3.6 yrs respectively at Panambur, Karnataka (Thippeswamy and Joseph, 1991; Tenjing *et al.,* 2011). The growth of *D. faba* estimated by employing the size (length) frequency method using von Bertallanffy's equation. The growth rate of *D. faba* decreases with an increase in age. From Fig. 5, the first year group showed the maximum growth rate attaining the length of 16.3 mm. The growth rate declined gradually during the second and third years. The present observation

is substantiated by the statement of Tenjing *et al.*(2011).

Of the other species of *Donax*, two spawnings per year has been reported for *D. sordidus*, which has a life span of around two years, giving a total of around four spawnings per individual (McLachlan and van der Horst, 1979), and a similar bi-annual spawning has been reported for *D. semistriatus* (Neuberger-Cywiak *et al.,* 1990). For most other *Donax*, only a single spawning per year has been reported, even for tropical species with short lives, although here again the evidence is rather inconclusive and Ansell *et al.* (1972) suggested that some individuals of *D. incarnatus* from Kerala coast (India) may be in spawning condition at all times.

The recruitment pattern of *D. faba* was continuous throughout the year and the only major peak observed was during May-July. The peak pulse produced 25.59% of the observed

recruitment in June, followed by 20.11% (May) and 16.74% (July) (Fig. 6). Recruitment by settlement of post larvae is a critical period within the life cycle. It is conditioned by various factors that, in the long run, affect the dynamics and structure of the population (Eckman, 1996). Defeo (1996) stated that variability of recruitment may be considered as the main factor affecting the abundance of benthic populations. One recruitment was observed during this study; while in June recruits surpassed 50% of the total number of individuals in the population, recruitment was very low in January (0.19%). However, more one recruitment was already mentioned for *D. faba* in another locality of Panambur, Karnataka (Tenjing *et al.,* 2011).

Settlement intensity may show important fluctuations, causing common alternations of high and low recruit abundance in *Donax* (Tenjing *et al.,* 2011). These variations could be related to changes in the environmental conditions, to prey-predator interactions and/or to density dependent factors. It should be also caused, at least in part, by events that occurred before the pediveliger settlement (Hemachandra, 2011). The inverse relation between growth rate and age assumed by the von Bertalanffys equation has been confirmed for *D. faba* (Alagarswami, 1966; Singh *et al.,* 2011) as it was also present in *D. faba* from Padukere beach. Tenjing (2013, 2016a) and Thippeswamy (1985) stated that temperature controls both the beginning and the end of the growth season in donacids in the coastal waters of Karnataka. Food availability has also been reported as controlling the growth in the same species, by determining if either one or two growth periods occur during a year (Beukema and Desprez, 1986).

The total mortality (Z) based on the length converted catch curve based on ambient temperature (28.7°C) is presented in Fig. 7.
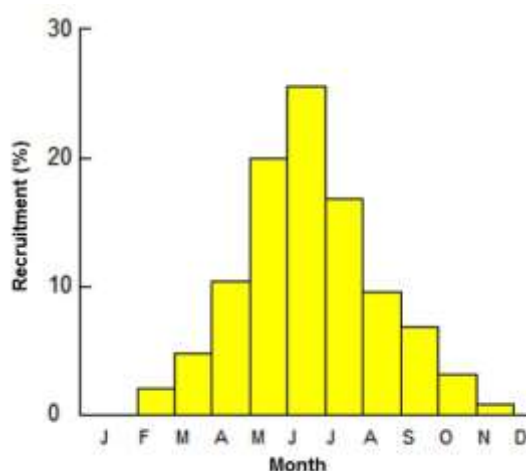

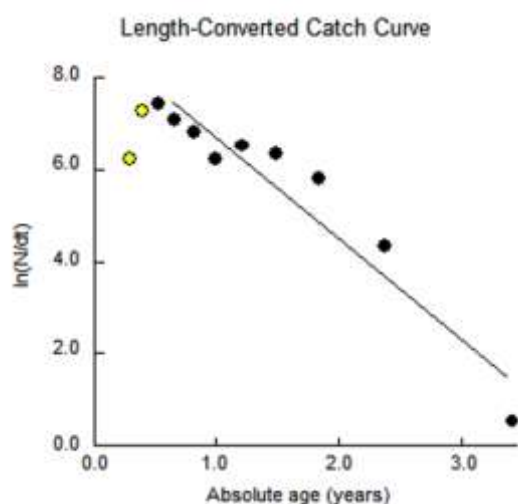**Figure 6: Recruitment pattern of *Donax faba*.**

Figure 7: Length converted catch curve of *Donax faba*.

The estimated total mortality (*M*) was 2.17 yr^{-1}. *Donax faba* is not a commercially important species in Karnataka. Fishing mortality was not calculated at the unexploited site, Padukere. Therefore, natural mortality (*M*) was also 2.17 yr^{-1} since *Z* was 2.17 yr^{-1}, *i.e., Z=M*. On the other hand, the exploitation level (*E*) was not possible to be estimated at the unexploited site. The low mortality (2.17 yr^{-1})registered for *D. faba* in the present study might be related to lower predation rates (Cardoso and Veloso, 2003).

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