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Do decomposing leaves of mangroves attract fishes?

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The present work proves experimentally that the decomposing leaves of mangroves 'attract' the fishes. Nylon bags containing senescent leaves of the mangrove plants, viz. *Rhizophora apiculata* and *Avicennia marina*, were immersed separately in experimental tanks, along a tropical mangrove estuary in south-east India. Juveniles of prawn, fish, crabs and hermit crabs were collected every two days, from the experimental tanks, and from control tanks. The experiment was conducted for 70 days, separately in four different seasons. It was inferred that there was a greater assemblage of fin- and shell-fishes, with the decomposing leaves of mangroves, in all the seasons. In general, the prawn resources increased with days of decomposition, up to around 30–50 days and declined thereafter. The association of fin- and shell-fishes was greater during premonsoon and postmonsoon than in other seasons and was higher with decomposing leaves of *Avicennia* than in *Rhizophora*.

MANGROVE litter provides an important nutrient base for food webs that support fishes and prawns in tropical estuaries[1–7]. Leaves are the major contributors for mangrove litterfall and to nutrient budget of estuaries[8]. During the decomposition of mangrove litter, a large amount of nutrients are released and detritus food is formed for fishes. The litter would need to be decomposed for about 2 months before it becomes fit for consumption by detritivores[8,9]. The detritus food has low C : N ratios (17 : 1) associated with high nutritional quality[9,10] and it supports various animal communities of the coastal ecosystem[11]. This aspect of the association of faunal communities with the detritus has little been studied[12]. The present study was conducted to examine the fishery resources associated with decomposing leaves of mangroves, and the possibility of enhancing fishery resources in tropical estuaries with mangrove litter.

The present study area of Pichavaram mangrove (lat. 11°27′N; long. 79°47′E) is located about 250 km south of Chennai city on the south-east coast of India. It is one of the typical mangrove swamps of India, with a high productivity of about 8 tonnes of organic plant detritus ha/year. It consists of small and large islets covering an area of 1100 ha. Of the total area, 50% is covered by the forest, 40% by the water ways and the remaining 10% by the sand and mudflats[13]. The tidal level of the study area is semi-diurnal, and the salinity level ranged from 13.2 to 34.6 g l^{-1}. The nutrient level varied from 0.03 to 18.2 $\mu g\ l^{-1}$ for nitrate nitrogen, 0.02 to 2.2 $\mu g\ l^{-1}$ for nitrite nitrogen, 0.07 to 8.02 $\mu g\ l^{-1}$ for total phosphate and 0.55 to 85.6 2 $\mu g\ l^{-1}$ for particulate organic carbon[14].

Senescent leaves of *Rhizophora apiculata* Blume and *Avicennia marina* (Forssk.) Vierh., were collected from the trees of the Pichavaram mangrove forest. For decomposing the leaves, the *in situ* litter bag method[15] was adopted. The litter bags (35 × 35 cm) were made of nylon having a mesh size of 2 mm. Each of the nylon bags having 500 g of senescent leaves, was placed in a tank of 1 m length, 1 m breadth, and 1 m depth constructed in the mid-intertidal zone of the Pichavaram mangrove water. The litter bags were immersed in the tanks throughout the experiment.

Five litter bags of each species were kept in separate tanks and maintained throughout the experiment. To avoid the floatation 500 g of stones were added to each bag. The inner sides of the tanks were covered by nylon nets of mesh size (2 mm) to trap the organisms, which were attracted during litter decomposition. The litter bags were maintained in ten treated tanks – five for *Avicennia marina* and another five for *Rhizophora apiculata*, along with a control tank, which was maintained simultaneously with a bag having 500 g stones without any leaf litter.

The organisms such as juveniles of prawn, fish, crabs and hermit crabs were collected from the experimental tanks every two days, during the low tide by lifting the inner net from the experimental tanks[15]. The organisms were identified and counted, for prawns[16], crabs[17], fish[18] and hermit crabs[19]. To find out the significant difference between species of mangroves and among the days of decomposition the data were treated with analysis of variance (ANOVA). This experiment was repeated during four different seasons in the same site: July–September 1994 (premonsoon), October–December 1994 (monsoon), January–March 1995 (postmonsoon), April–June 1995 (summer). The experiments were carried out for a period of 70 days in each of the four different seasons.

*For correspondence

Among the penaeid prawns, the most abundant species were *Penaeus indicus*, *Metapenaeus monoceros*, *M. dobsoni*, and *M. brevicornis*. The seasonal variation in the prawns associated with decomposing mangrove leaves is shown in Figure 1 *a*. The average number of penaeid prawn juveniles attracted to decomposing mangrove leaves in different seasons is shown in Figure 1 *b*. The data reveal that the penaeid juveniles were maximum in premonsoon and minimum in postmonsoon, with decomposing leaves of mangroves. The values ranged from 0.11/day in postmonsoon to 0.80/day in premonsoon months for *Rhizophora* leaves and from 0.30/day in postmonsoon to 1.6/day in premonsoon for *Avicennia* leaves. In the control tank, the values varied from 0.02/day in summer and monsoon to 0.16/day in premonsoon. Monsoon and summer seasons showed significant difference between the species of mangroves and the premonsoon season exhibited significance between mangrove species and also among the days of decomposition.

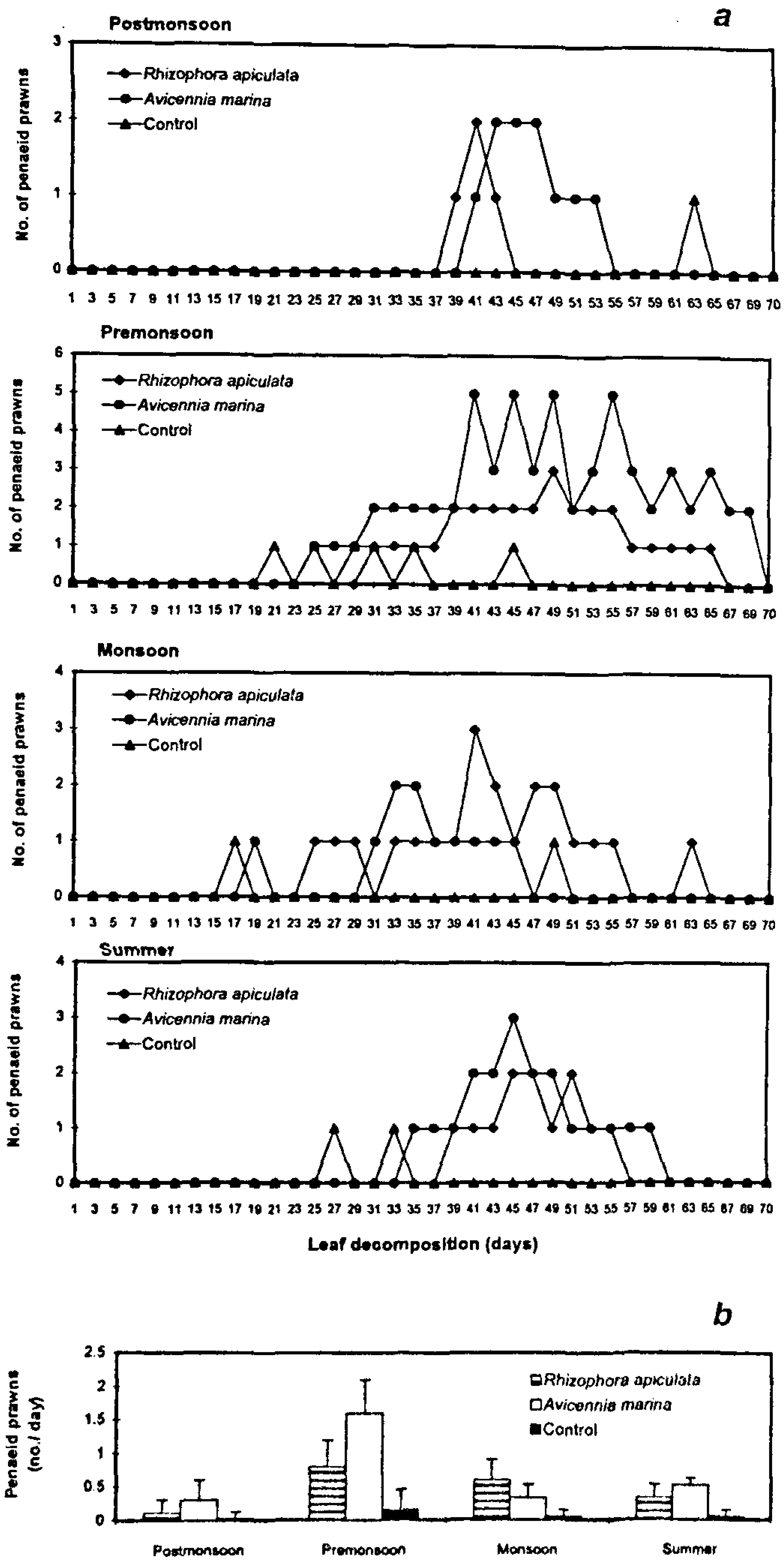

Figure 1. *a*, Number of penaeid prawns associated with decomposing leaves of mangroves in different seasons; *b*, Average number of penaeid prawns associated with decomposing leaves of mangroves in different seasons.

The seasonal variation in the non-penaeid prawns associated with decomposing mangrove leaves is shown in Figure 2 *a*. The non-penaeid prawn recorded was *Macrobrachium* spp. The data reveal that non-penaeid juveniles were maximum in premonsoon and minimum in summer. The average number of non-penaeid prawn juveniles attracted to decomposing mangrove leaves at different seasons is shown in Figure 2 *b*. The values ranged from 1.7/day in summer to 5.6/day in postmonsoon months for *Rhizophora* leaves and from 1.9/day in summer to 5.4/day in premonsoon for *Avicennia* leaves. In the control tank, the values varied between 0.08/day in summer and 0.16/day in premonsoon. Statistical analysis showed significant difference between the species of mangroves in all the seasons and the premonsoon, and monsoon seasons exhibited significance among the days of decomposition.

The seasonal variation in crab juveniles, associated with decomposing mangrove leaves is shown in Figure 3 *a*. The average number of crab juveniles attracted to decomposing mangrove leaves for different seasons is shown in Figure 3 *b*. The data reveal that the crab juveniles were maximum in summer and minimum in premonsoon. The average number was 0.13/day in postmonsoon and monsoon, 0.08/day in premonsoon months for *Rhizophora* sp. In *Avicennia*, the average number was 0.22/day in postmonsoon, 0.20/day in summer and 0.05/day in premonsoon months. However, crab juveniles were not found during the monsoon months. In the control tanks, the average number recorded was at 0.08/day in summer and 0.16/day in postmonsoon months, the juvenile crabs were not found during the premonsoon and monsoon months. The mangrove crabs *Sesarma* sp. and *Scylla serrata* were the dominant ones. However, statistical analysis showed significance in the postmonsoon only among the mangrove species.

The seasonal variations in fish juveniles, associated with decomposing mangrove leaves is shown in Figure 4 *a*. The average number of fish juveniles attracted to decomposing mangrove leaves for different seasons is shown in Figure 4 *b*. Fish juveniles were maximum in premonsoon and minimum in postmonsoon. The average number was 0.90/day in premonsoon, 0.13/day in monsoon, 0.08/day in summer and 0.05/day in postmonsoon season for *Rhizophora*. The average number was 1.6/day in premonsoon, 0.30/day in monsoon, and 0.22/day in postmonsoon season for *Avicennia*. No fish juveniles were found in summer months associated with decomposing leaves of *Avicennia*. The average number for the control was 0.11/ day in monsoon and premonsoon seasons. No fish juveniles were found in summer and postmonsoon in the control tank. Fish juveniles of *Mugil cephalus*, *Liza parsia*, *Etroplus suratensis*, *Plotosus canius* and *Ambassis gymnocephalus* were predominant. Statistical analysis showed significant difference between the species of mangroves and days of decomposition only in premonsoon.

In general, the assemblage of the fin- and shell-fishes showed an increasing trend till the 40th day of leaf decomposition and decreased later in all the seasons in both species of mangroves studied.

The seasonal variations in the hermit crabs, associated with decomposing mangrove leaves is shown in Figure 5 *a*. The average number of hermit crabs attracted to decomposing mangrove leaves for different seasons is shown in Figure 5 *b*. The hermit crabs were maximum in postmonsoon and minimum in premonsoon. The average number was 12.6/day in postmonsoon, 7.0/day in summer,

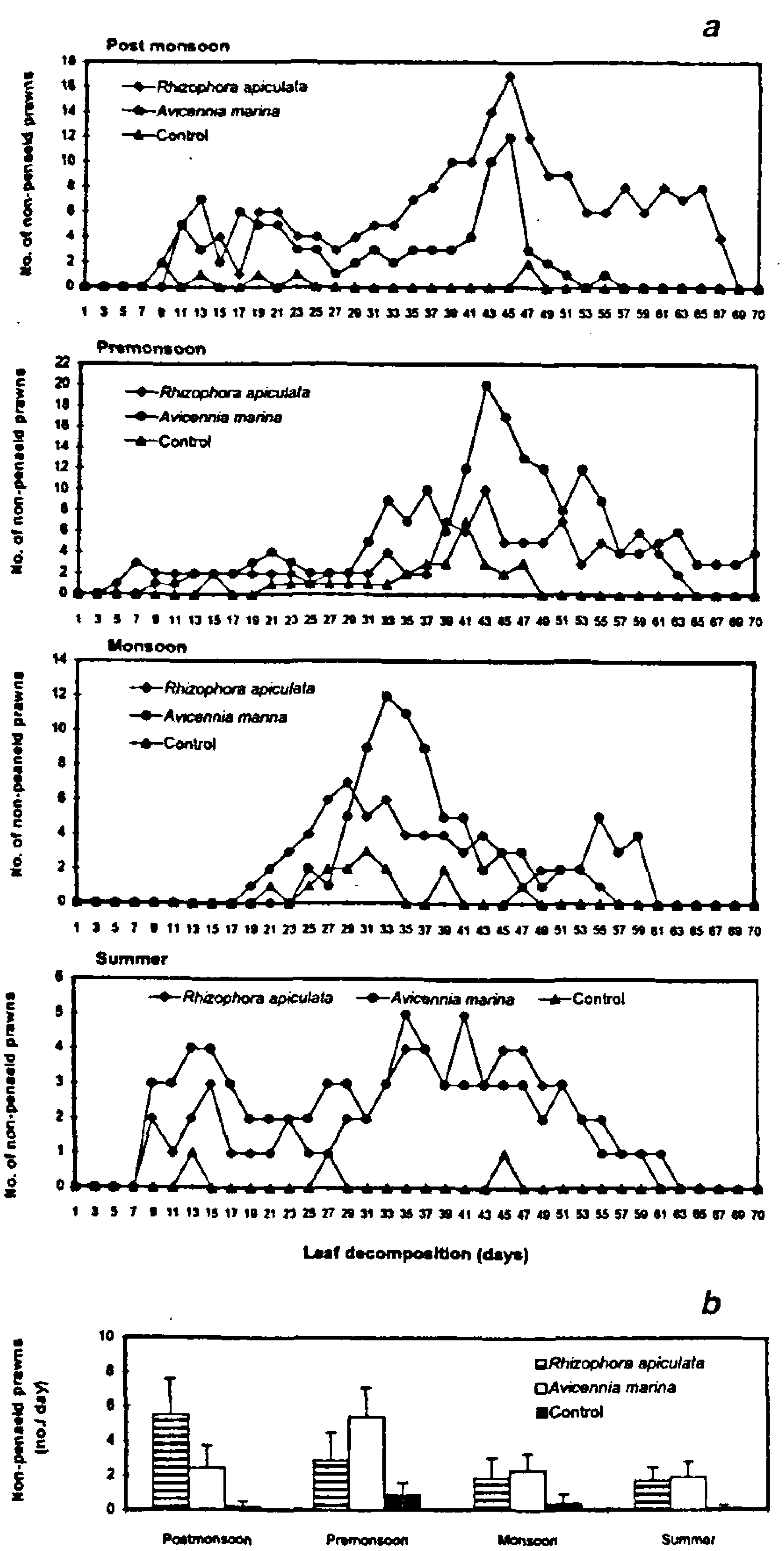

Figure 2. *a*, Number of non-penaeid prawns associated with decomposing leaves of mangroves in different seasons; *b*, Average number of non-penaeid prawns associated with decomposing leaves of mangroves in different seasons.

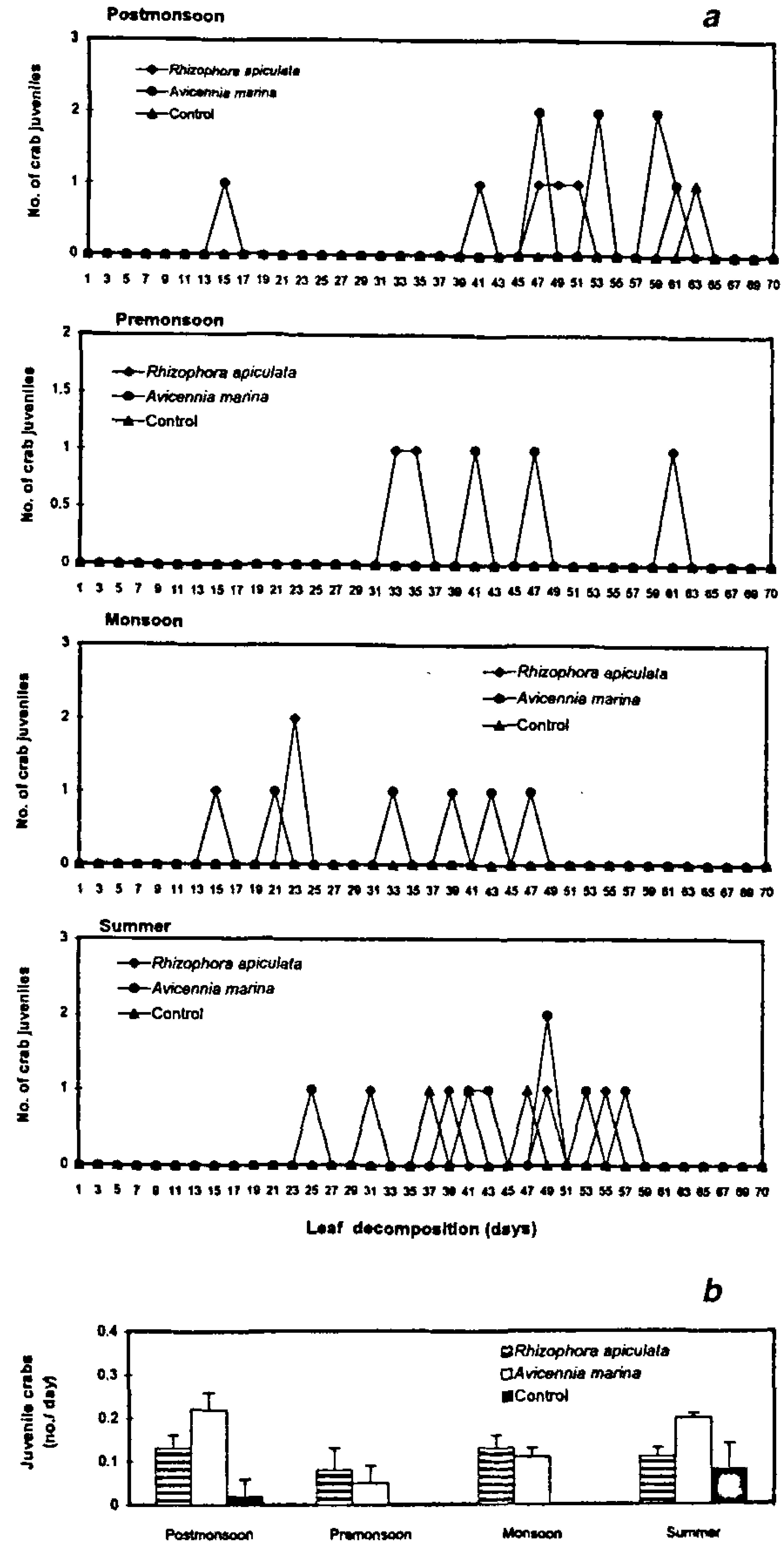

Figure 3. *a*, Number of juvenile crabs associated with decomposing leaves of mangroves in different seasons; *b*, Average number of juvenile crabs associated with decomposing leaves of mangroves in different seasons.

1.9/day in monsoon, and 2.0/day in premonsoon season, for *Rhizophora*. The average value was 42.1/day in postmonsoon, 8.1/day in summer, 1.4/day in monsoon and 0.86/day in premonsoon season for *Avicennia*. In the control tank, the average value was 2.7/day in summer, 0.41/day in monsoon, 5.8/day in postmonsoon, and 0.05/day in premonsoon. The species recorded were *Clibanarius olivaceus* and *Diogenes avarus*. Statistical analysis showed significant difference between the mangrove species in all the seasons, and among the days of decomposition in summer and monsoon seasons.

In general, the fish/prawns/crabs were found to occur only along the decomposing leaves of mangroves, but not in the control tank without any decomposing leaves (Figures 1–5). This is a strong evidence to state that the animal resources are 'attracted' towards the decomposing leaves of mangroves. However, there were hermit crabs found in the control tank (having no decomposing leaves); but their number was less when compared to that in the decomposing leaf tanks (Figure 5 *a* and 5 *b*).

In general, juvenile prawns were found to associate more with decomposing *Avicennia* leaves than with

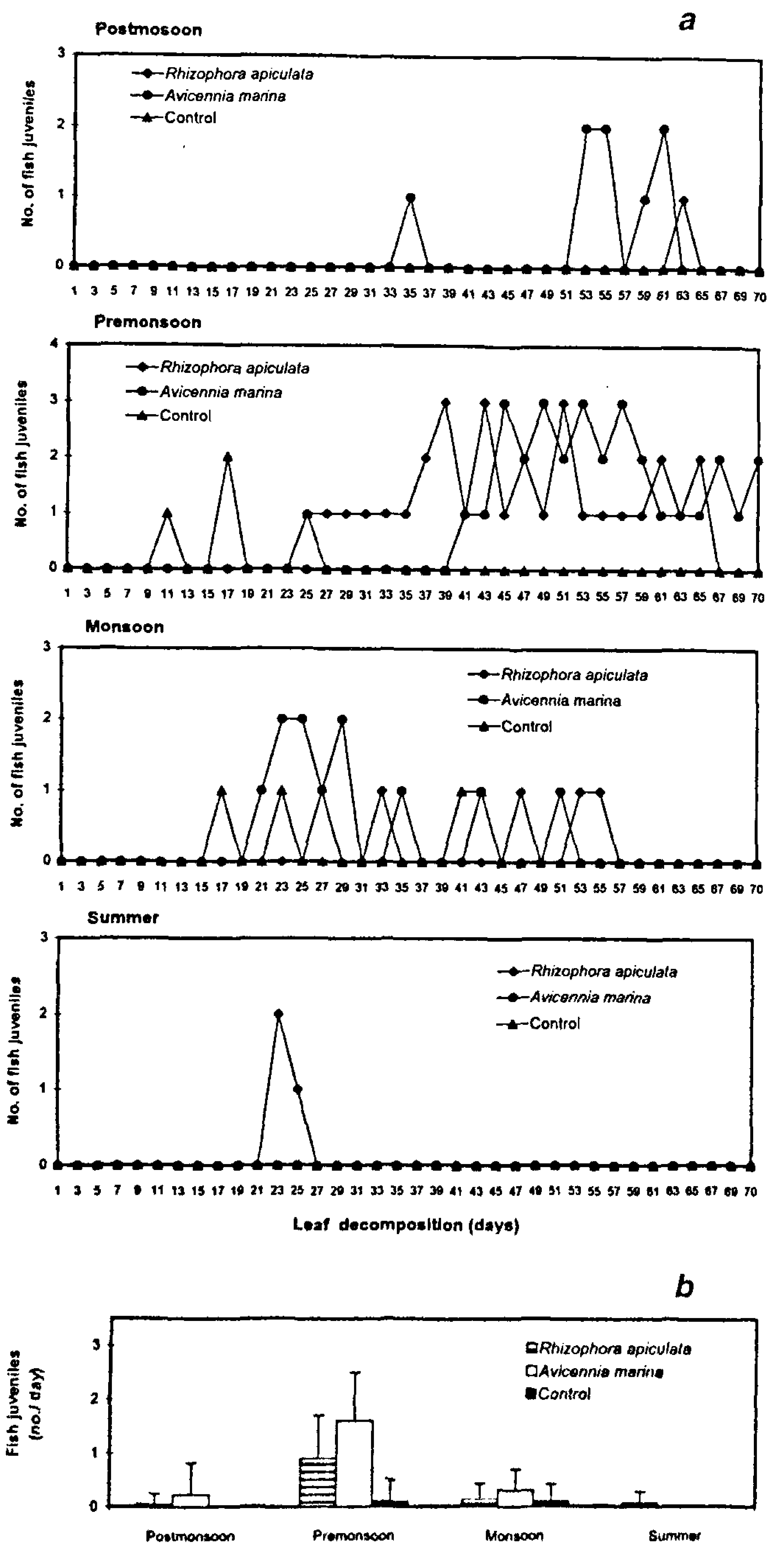

Figure 4. *a*, Number of fish juveniles associated with decomposing leaves of mangroves in different seasons; *b*, Average number of fish juveniles associated with decomposing leaves of mangroves in different seasons.

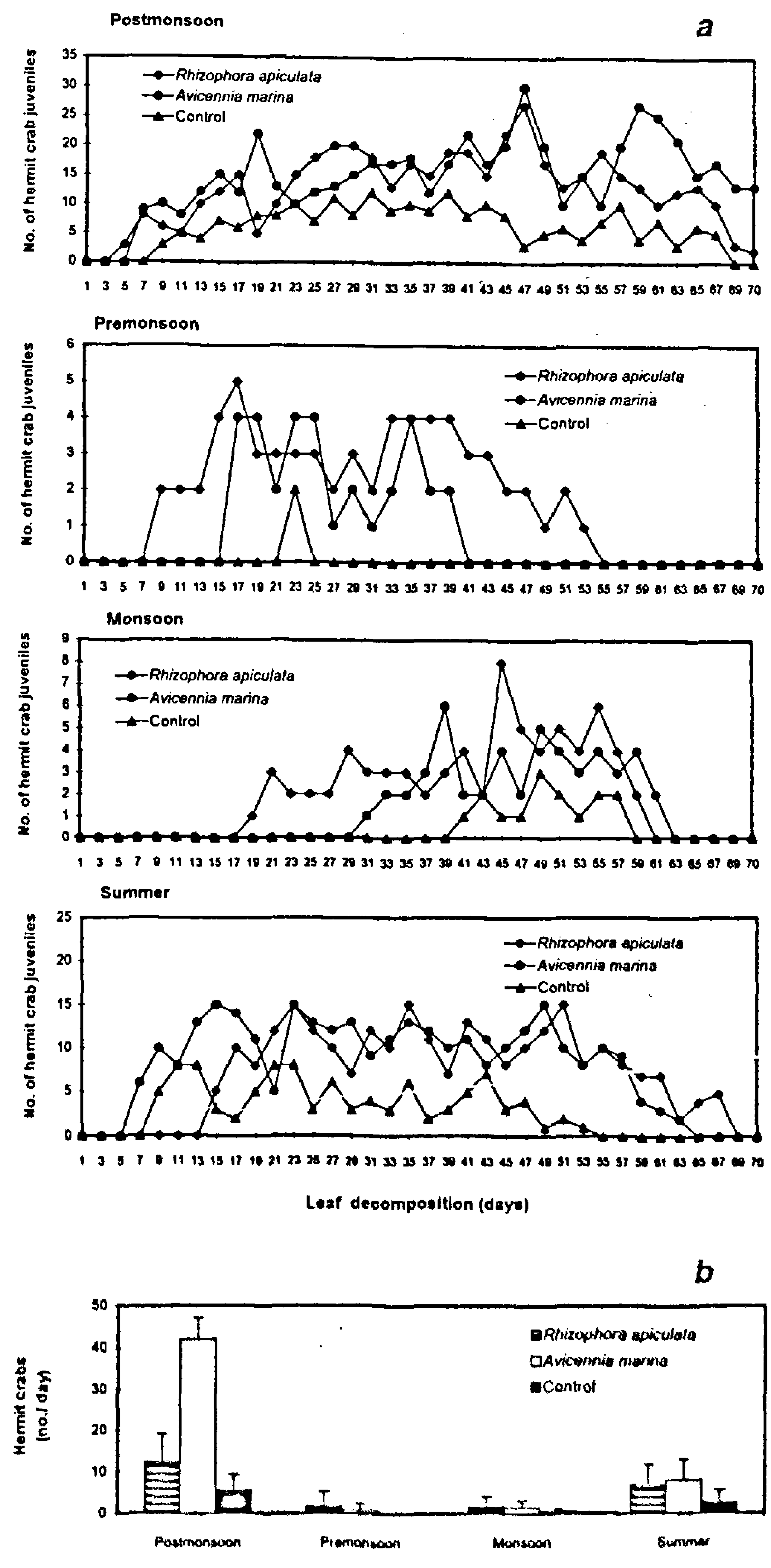

Figure 5. *a*, Number of hermit crabs associated with decomposing leaves of mangroves in different seasons; *b*, Average number of hermit crabs associated with decomposing leaves of mangroves in different seasons.

Rhizophora leaves (Figures 1, 2). In general, the non-penaeid forms were more in number than the penaeid forms, associated with the decomposing leaves of mangroves, in all the seasons. This may be attributed to high influx of freshwater and less influence of neritic water which may not be able to enter into the estuary of Pichavaram mangroves due to a narrow mouth opening. The dietary potential of mangrove leaves for prawns has already been proved. Prawns fed with decomposed leaves of *Rhizophora mucronata* have shown good growth and high food conversion efficiency[20,21]. This is further supported by the fact that the cholesterol diet prepared from *Rhizophora apiculata* leaves promoted the growth, assimilation and production of *Penaeus indicus*[22].

In the present study, juvenile crabs were found to occur mainly with the decomposing leaves (Figure 3 *a*). The ingestion of mangrove leaves and detritus by crabs (*Brachyura*) is well documented in the literature[23–27]. Lee[28] ascertained that sesarmid crabs (*Chiromanthes* spp.) ingest as much as 57% of the mangrove litterfall.

Fish juvenile resources were found to be high with decomposing leaves of mangroves (Figure 4 *a*). In general, the fish density recorded was high in mangrove waters. For instance, the number of fish species that are known to exist in coastal mangroves of Malaysia (119 spp.) are greater than in other biotopes – for inshore waters (92 spp.), mudflats (70 spp.), and nearshore (58 spp.)[29]. In a mangrove estuary in the eastern part of Australia, Morton[30] found almost ten times as much fish biomass in the mangroves as in the neighbouring waters.

In the present study, juveniles of prawns, crabs, fish and hermit crabs were collected during the decomposition of mangrove leaves. These organisms gradually increased in numbers from 10th day of decomposition and attained maximum number between 30 and 40th day of decomposition (Figures 1 *a*, 2 *a*, 3 *a*, 4 *a* and 5 *a*). Similar decomposition studies were also made in Panama waters by D'Croz *et al.*[12] who found that small marine invertebrates (polychaets, bivalves, gastropods, grapsid crabs and alpheid shrimps) were greater after 3rd week and increased up to 12th week of leaf decomposition of *Rhizophora mangal*.

In general, premonsoon and postmonsoon months are favourable for attracting more prawns, crabs and fish towards the decomposing leaves of mangroves (Figures 1 *b*–4 *b*). This finding supports our field observations that small-size groups of juvenile prawns/crabs/fish were abundant in those seasons in the mangrove estuaries[15]. Based on the results, it is concluded that the organisms are attracted significantly towards the decomposing mangrove leaves. This emphasizes the importance of developing tropical mangrove estuaries for enhancing the fishery resources.

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