Influence of Deer (*Axis axis*) on the Newly Recruited Seedlings of Some Major Mangrove Species in the Sundarban of Bangladesh

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Abstract

A study was conducted from 1998 to 2001 in the Sundarban mangrove forests of Bangladesh covering three salinity zones to determine the effect of deer (*Axis axis*) on the newly recruited seedlings of sundari (*Heritiera fomes*), gewa (*Excoecaria agallocha*), kankra (*Bruguiera sexangula*), passur (*Xylocarpus mekongensis*), baen (*Avicennia officinalis*), goran (*Ceriops decandra*) and amur (*Amoora cucullata*) in the fenced and unfenced plots. The browsing effect of deer was found to vary from species to species because of differences in palatability. A significant damage of deer was found in the regenerated seedlings of *B. sexangula*, *X. mekongensis*, *A. officinalis* and *H. fomes*. No significant effect was found for *E. agallocha*, *C. decandra* and *A. cucullata*.

সারসংক্ষেপ

বাংলাদেশের সুন্দরবন ম্যানগ্রোভ বনের তিনটি লবণাক্ত অঞ্চলে সুন্দরী (*Heritiera fomes*), গেওয়া (*Excoecaria agallocha*), কাকড়া (*Bruguiera sexangula*), পশুর (*Xylocarpus mekongensis*), বাইন (*Avicennia officinalis*), গরান (*Ceriops decandra*) ও আমুর (*Amoora cucullata*) প্রজাতির গাছের প্রাকৃতিকভাবে গজানো নতুন চারা বেড়া দেওয়া এবং বেড়া ছাড়া অবস্থায় হরিণের দ্বারা কি পরিমাণ ক্ষতিগ্রস্ত হয় তার উপর ১৯৯৮ থেকে ২০০১ সাল পর্যন্ত একটি নিরীক্ষা চালানো হয়। হরিণের খাদ্য রুচির পার্থক্যের কারণে প্রজাতি ভেদে গাছ ভক্ষণের পরিমাণও ভিন্ন। হরিণের প্রভাবে *B. sexangula, X. mekongensis, A. officinalis* and *H. fomes* এর চারাসমূহ তাৎপর্যপূর্ণভাবে ক্ষতিগ্রস্ত হয় কিন্তু *E. agallocha, C. decandra* and *A. cucullata* এর উপর তাৎপর্যপূর্ণ ক্ষতিকর প্রভাব দেখা যায় না।

Key words: Deer effect, browing, fenced and unfenced, mangrove species, salinity zone, seedling regeneration, Sundarban.

Introduction

The Sundarban of Bangladesh is the single tract largest natural mangrove forest in the world. It is located at the southern part of the Gangetic delta bordering the Bay of Bengal in the south. The forests cover an area of about 10,000 km² of which 6,000 km² falls within the territory of Bangladesh and remaining 4,000 km² in India. The Sundarban of Bangladesh lies between 21°31′ N to 22°30′ N latitude and 89° E to 90° E longitude.

The Sundarban is an unique mangrove forest and very important in many ways. The forest was recognized as an important resource base about five centuries ago. Timber, fuelwood and other non-timber produces are regularly harvested from this mangrove forest. However, the productivity are being depleted day by day due to the adverse effect of several biotic and abiotic factors. The merchantable growing stock of the major mangrove species such as sundari (*Heritiera fomes*) and gewa (*Excoecaria agallocha*) has also been depleted 40% and 45% within a period from 1969 to 1984 (Chaffey *et al.* 1985). This may further be depleted by inadequate regeneration in some parts of the forest (Das and Siddiqi 1985). Siddiqi (1994) and Faizuddin *et al.* (1996) reported that plenty of seedlings of different species appear every year, though recruitment density varied considerably in different parts of the forest, but most of the seedlings disappear soon from the forest floor. Shafi (1982) stated that regeneration rates decreased by as much as 100% by 1981 as compared with the level of 1959-60. The Sundarban is absolutely dependent on natural regeneration for future stocking. But inadequate seedling recruitment or failure of establishment of the seedlings was the main cause for a low density stocking in the greater parts of the forests (Das and Siddiqi 1985; Siddiqi 1989; Siddiqi 1992).

A number of factors, both biotic and abiotic, may be responsible for inadequate seedling recruitment and their successful establishment. Among the biotic factors, the spotted deer (*Axis axis*) plays an important role in the regeneration of the Sundarban (Champion *et al.* 1965; Blasco 1977; Siddiqi 1992; Siddiqi and Husain 1994; Faizuddin *et al.* 1996). Chaffey *et al.* (1985) recommended for carrying out research to find out factors affecting the natural regeneration of major tree species. A few information is available about the interaction of flora and fauna especially the extent of damage caused by deer in the Sundarban. Therefore, the present study was carried out for several years to determine the flora-faunal interaction (mainly of deer) in this natural mangrove forest.

Material and Methods

The experimental plots were established in three salinity zones of the Sundarban of Bangladesh in Compartment Nos. 24 (less saline zone), 30 (moderately saline zone) and 46 (strongly saline zone). In each place, 10 plots were fenced with barbed wire to prevent the entrance of wildlife especially deer (*Axis axis*) and another 10 unfenced plots were laid out 5 m away from the fenced plots. These plots were demarcated with painted goran posts and the bordering trees in the unfenced plots. The size of each plot was 25 m^2 (5m x 5m). Thus, a total of 60 plots were laid out for this study in three salinity zones.

Data on the appearance of newly recruited seedlings of major mangrove species were recorded in December each year from 1998 to 2001. The new seedlings were tagged with colour tapes to differentiate them from the older ones. It is noted that seed dispersal from most of the species in the Sundarban generally takes place in July and August, and the data were recorded in December. So, about four months old seedlings were recorded in each year. A comparison of the number of recruited seedlings in fenced and unfenced plots would provide information on the initial damage caused by deer.

Recorded data for each year were analyzed separately in Randomized Complete Block Design with several observations. Two-way analysis of variance (ANOVA) were performed to see whether any difference existed on the number of seedlings between the fenced and unfenced plots, and among the three salinity zones. One-way analysis of variance was also done to know the yearly variation of seedlings recruitment.

Results and Discussion

The number of four-month-old seedlings of seven major species such as sundari (*Heritiera fomes*), gewa (*Excoecaria agallocha*), kankra (*Bruguiera sexangula*), passur (*Xylocarpus mekongensis*), baen (*Avicennia officinalis*), goran (*Ceriops decandra*) and amur (*Amoora cucullata*) were recorded in each year from 1998 to 2001.

Table 1 gives the number of seedlings of each species recruited during 1998-2001 in the fenced and unfenced plots in the less saline zone. Among those species *H. fomes*, *E. agallocha* and *C. decandra* constituted the major part of the total seedlings in every year. The higher number of seedlings were recorded in the fenced plot than the unfenced plot in almost every year. But in 2000, a higher number of seedlings of *E. agallocha* were found in the unfenced plot than the fenced plot (Table 1). This may be due to abundance of seeds or mother trees in the unfenced plot.

Table 1. Number of new seedlings regeneration over an area of each 10 plots in the fenced and unfenced areas in the less saline zone.

Year	Treatment	No. of seedlings regeneration							
		Sundari	Gewa	Kankra	Passur	Baen	Goran	Amur	Total
1998	Fenced	24	30	0	3	0	37	6	100
	Unfenced	13	6	0	0	0	20	10	49
1999	Fenced	30	11	58	28	0	14	5	146
	Unfenced	22	5	1	3	0	10	3	44
2000	Fenced	40	36	46	6	0	6	4	138
	Unfenced	15	106	4	0	0	13	2	140
2001	Fenced	52	75	39	19	0	7	7	199
	Unfenced	48	70	3	0	0	7	2	130

In the moderately saline zone, the number of seedlings of each species recruited during 1998-2001 in the fenced and unfenced plots are shown in Table 2. Among those species *H. fomes*, *E. agallocha* and *B. sexangula* constituted the major part of the total seedlings in every year.

Table 2. Number of seedlings regeneration over an area of each 10 plots in the fenced and unfenced areas in the moderately saline zone.

Year	Treatment	No. of seedlings regeneration							
		Sundari	Gewa	Kankra	Passur	Baen	Goran	Amur	Total
1998	Fenced	190	61	38	1	10	0	1	301
	Unfenced	61	97	0	0	1	0	1	160
1999	Fenced	220	25	212	21	55	0	2	535
	Unfenced	73	35	43	0	3	0	5	159
2000	Fenced	28	386	29	2	37	0	0	482
	Unfenced	4	282	4	1	0	0	0	291
2001	Fenced	149	213	34	9	20	0	0	425
	Unfenced	110	237	14	0	1	0	2	364

The number of seedlings of each species recruited during 1998-2001 in the fenced and unfenced plots in the strongly saline zone are shown in Table 3. *H. fomes*, *X. mekongensis* and *A. officinalis* constituted the major part of the total seedlings in every year except 1998.

Table 3. Number of seedlings regeneration over an area of each 10 plots in the fenced and unfenced areas in the strongly saline zone.

Year	Treatment	No. of seedlings regeneration							
		Sundari	Gewa	Kankra	Passur	Baen	Goran	Amur	Total
1998	Fenced	3	3	0	3	0	12	0	21
	Unfenced	2	2	0	0	2	12	0	18
1999	Fenced	122	16	4	132	327	2	0	603
	Unfenced	35	0	0	41	153	3	0	232
2000	Fenced	33	4	2	90	30	6	0	165
	Unfenced	15	0	0	25	0	5	0	45
2001	Fenced	23	2	0	19	175	6	0	225
	Unfenced	8	6	0	12	29	2	0	57

The results of ANOVA for four-month-old seedlings between treatments (fenced and unfenced), between zones (less saline, moderately saline and strongly saline) and their interactions (treatments x zones) are shown in Table 4.

Table 4. Summary of ANOVA on the number of seedlings regeneration per 25 m² plot from 1998 to 2001.

Year	Species	Sources of variation		
		Between treatments	Between zones	Treatments x zones
1998	Sundari (*Heritiera fomes*)	**	***	**
	Gewa (*Excoecaria agallocha*)	n.s.	**	n.s.
	Kankra (*Bruguiera sexangula*)	***	***	***
	Passur (*Xylocarpus mekongensis*)	n.s.	n.s.	n.s.
	Baen (*Avicennia officinalis*)	n.s.	*	*
	Goran (*Ceriop decandra*)	n.s.	***	n.s.
	Amur (*Amoora cucullata*)	n.s.	**	n.s.
1999	Sundari (*H. fomes*)	**	***	n.s.
	Gewa (*E. agallocha*)	n.s.	**	n.s.
	Kankra (*B. sexangula*)	**	**	n.s.
	Passur (*X. mekongensis*)	***	***	*
	Baen (*A. officinalis*)	*	***	n.s.
	Goran (*C. decandra*)	n.s.	**	n.s.
	Amur (*A. cucullata*)	n.s.	n.s.	n.s.
2000	Sundari (*H. fomes*)	***	n.s.	n.s.
	Gewa (*E. agallocha*)	n.s.	***	n.s.
	Kankra (*B. sexangula*)	**	n.s.	n.s.
	Passur (*X. mekongensis*)	*	***	*
	Baen (*A. officinalis*)	**	n.s.	n.s.
	Goran (*C. decandra*)	n.s.	*	n.s.
	Amur (*A. cucullata*)	n.s.	***	n.s.

Table 4. Conted.

Year	Species	Sources of variation		
		Between treatments	Between zones	Treatmentsx zones
2001	Sundari (*H. fomes*)	n.s.	**	n.s.
	Gewa (*E. agallocha*)	n.s.	***	n.s.
	Kankra (*B. sexangula*)	*	*	*
	Passur (*X. mekongensis*)	***	*	n.s.
	Baen (*A. officinalis*)	*	**	*
	Goran (*C. decandra*)	n.s.	n.s.	n.s.
	Amur (*A. cucullata*)	n.s.	n.s.	n.s.

* Significant at P= <0.05, ** P= <0.01 and *** P= <0.001 level and n.s. = non-significant.

Sundari (*Heritiera fomes*) : The number of recruited seedlings regeneration showed significant differences between fenced and unfenced plots in 1998, 1999 and 2000, the difference was non-significant only in 2001 (Table 4, Fig. 1, 2, 3 & 4). This indicates that deer play a significant role to cause damage to newly emerging seedlings of *H. fomes*. Highly significant differences were found for the new seedlings between three salinity zones during 1998, 1999 and 2001 except 2000. The highest appearance was found in the moderately saline zone in almost all the years. According to Siddiqi (2001), the distribution of *H. fomes* is different in three salinity zones of the Sundarban.

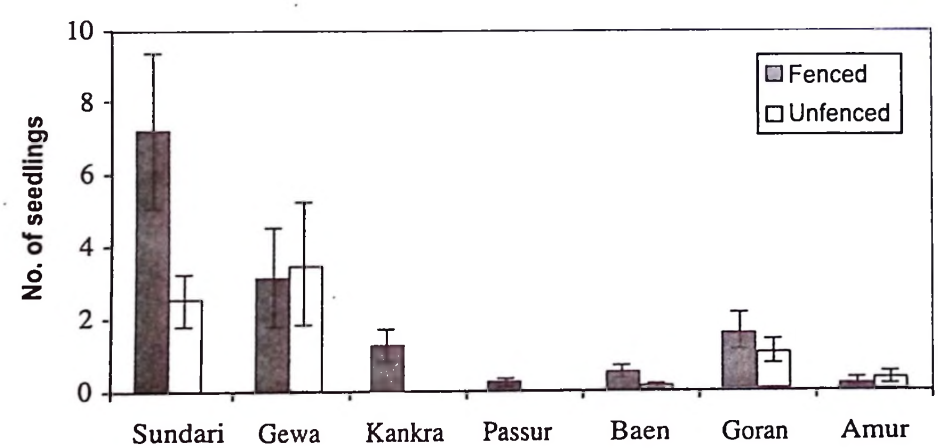

Figure 1. Average number of seedlings (± se) per 25 m^2 plot appeared in 1998.

Gewa (*Excoecaria agallocha*) : The results showed that no significant variation in seedlings regeneration was found in the fenced and unfenced plots during all the study years from 1998 to 2001 (Table 4). It means that deer did not feed or damage newly emerging *E. agallocha* seedlings in the Sundarban. Moreover, there were significant variations between three salinity zones. The highest appearance was found in the moderately saline zone and lowest in the strongly saline zone in each study year.

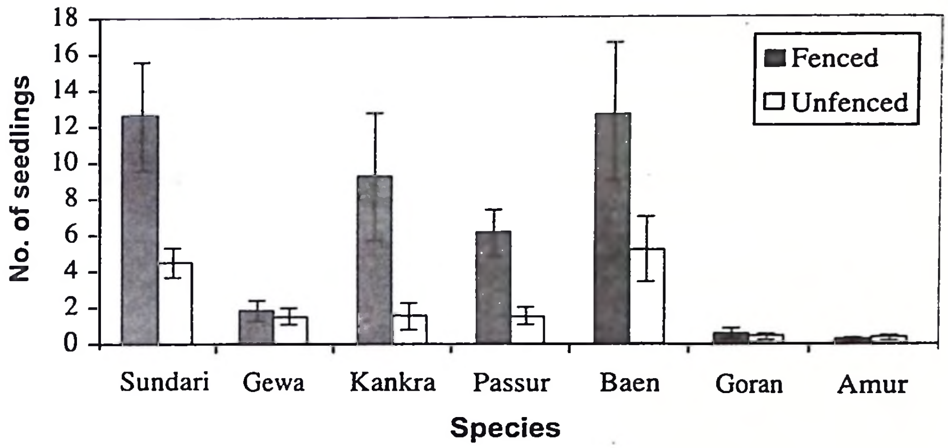

Figure 2. Average number of seedlings (± se) per 25 m^2 plot appeared in 1999.

Kankra (*Bruguiera sexangula*) : There were significant differences in seedling appearance between fenced and unfenced plots in all the study years from 1998 to 2001 (Table 4). This also indicates that the new seedlings of the species was browsed by deer. Significant variation in new seedlings were also found between three salinity zones in all the years except 2000. The highest appearance was found in the moderately saline zone and lowest in the strongly saline zone more or less every year.

Passur (*Xylocarpus mekongensis*) : The differences in the number of new seedlings in the fenced and unfenced plots were significant in the year of 1999 and highly significant in 2000 and 2001 (Table 4). Although a non-significant difference was found in 1998 but higher number of seedlings were also found in the fenced plot. The significantly highest appearance was found in the strongly saline zone in all the study years except 1998.

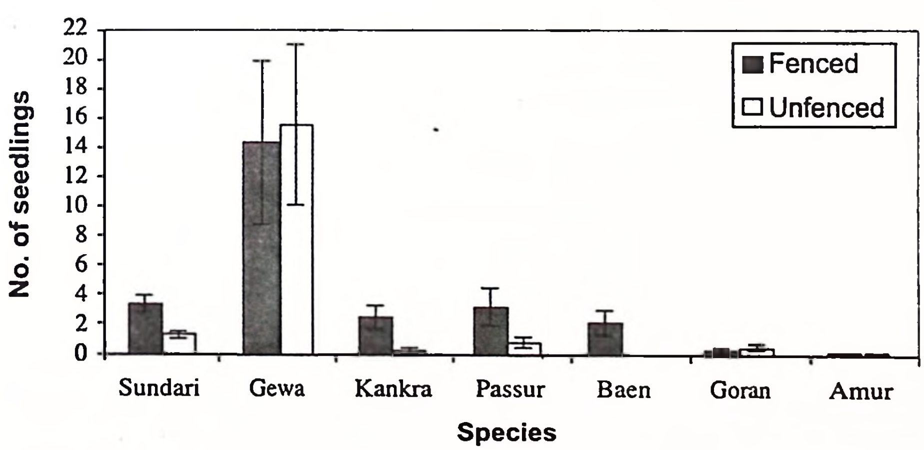

Figure 3. Average number of seedlings (± se) per 25 m^2 plot appeared in 2000.

Baen (*Avicennia officinalis*) : The significant variation in seedlings regeneration was found in the fenced and unfenced plots in all the study years except 1998 (Table 4) but a higher number of appearance was also found in the fenced plot. The significantly highest appearance was found in the strongly saline zone in all the study years except 2000 and no seedlings were found at all in the experimental plots of less saline zone.

Goran (*Ceriops decandra*) : No significant difference in the number of *C. decandra* seedlings regeneration was noticed in the fenced and unfenced plots in all the years from 1998 to 2001 (Table 4). The results indicated that deer did not cause damage to goran seedlings significantly in the forest floor. However, significant differences in the appearance of new seedlings were found in three salinity zones.

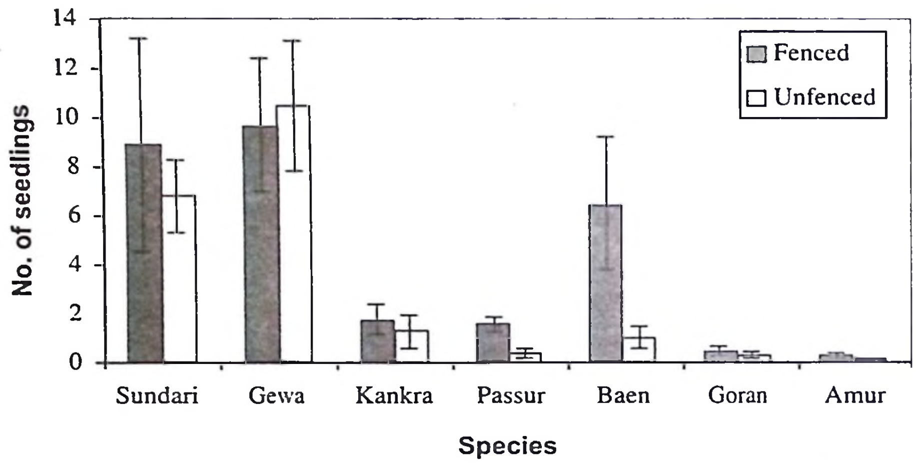

Figure 4. Average number of seedlings (± se) per 25 m^2 plot appeared in 2001.

Amur (*Amoora cucullata*) : A few new seedlings were found recruited in the plots of less and moderately saline zones but nothing was found in the plots of strongly saline zone. The results show that there was no significant difference in the appearance of new seedlings between fenced and unfenced plots throughout the study periods. But significant variations were found between three salinity zones in 1998 and 2000 (Table 4).

Analysis was made individually for different species to determine the yearly variation of seedlings recruitment in three salinity zones together (Table 5).

Table 5. Summary of ANOVA on the yearly appearance of seedlings during 1998 to 2001 in the fenced and unfenced areas.

Species	Source of variation (Between years)	
	Fenced areas	Unfenced areas
Sundari (*Heritiera fomes*)	*	***
Gewa (*Excoecaria agallocha*)	*	***
Kankra (*Bruguiera sexangula*)	**	**
Passur (*Xylocarpus mekongensis*)	***	***
Bean (*Avicennia officianlis*)	***	***
Goran (*Ceriop decandra*)	*	**
Amur (*Amoora cucullata*)	n.s.	n.s.

A significant yearly variation in seedlings recruitment of *H. fomes, E. agallocha, B. sexangula, X. mekongensis, A. officinalis* and *C. decandra* were found during the period from 1998 to 2001 both in the fenced and unfenced plots (Table 5, Fig. 5 and 6). It was non-significant only for *A. cuculata.* Seedling recruitment was highly irregular and no trends were observed in various years. Variation of yearly production of seeds for different mangrove species was observed in the Sundrabans due to periodicity or probably other environmental factors.

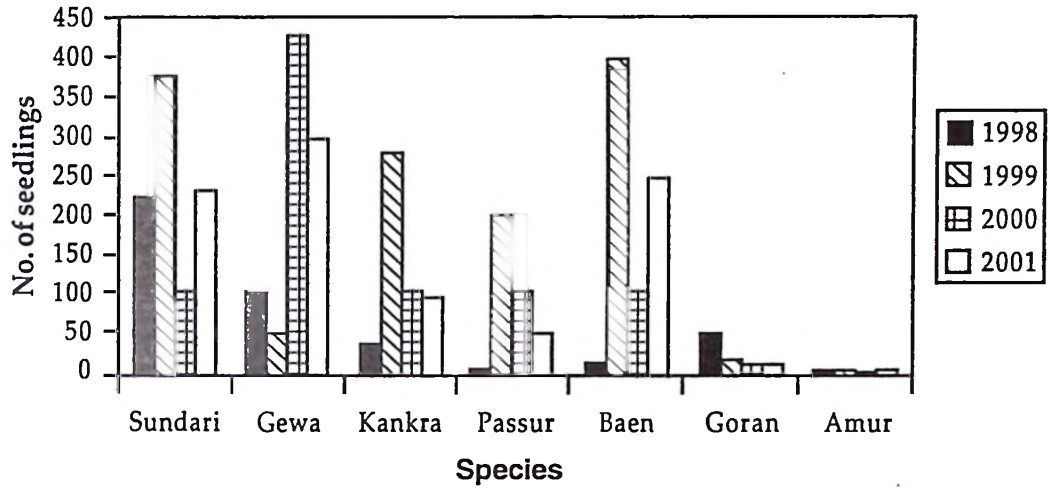

Figure 5. Total yearly appearance of seedlings of different species in 30 fenced plots.

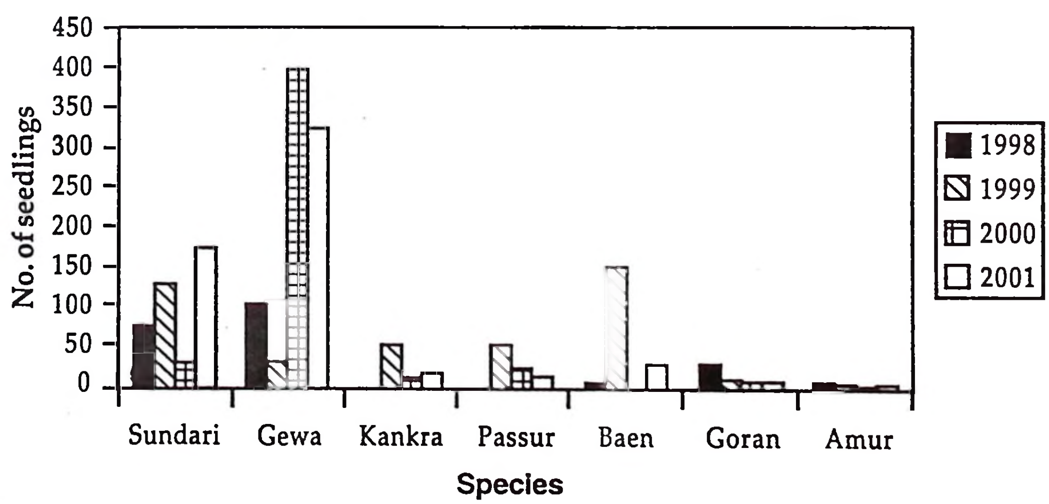

Figure 6. Total yearly appearance of seedlings of different species in 30 unfenced plots.

The population size of the spotted deer (*Axis axis*) in the Sundarbans is roughly 80,000 individuals (Hendrichs 1975). However the deer population may be higher at present. They were found in sufficient number all over the Sundarban but their density might vary in different parts of the forests (Siddiqi and Faizuddin 1981). The huge deer population is considered to cause damage to regeneration in the Sundarban due to their feeding (Faizuddin 2001; Siddiqi 2001). They play a vital role in controlling regeneration density of the forests by their preferential browsing habits (Champion *et al.* 1965; Choudhury 1968; Blasco 1977; Siddiqi and Husain 1994).

A significant browsing effect of deer on the newly recruited seedlings of *H. fomes, B. sexangula, X. mekongensis,* and *A. officinalis* was found in almost all the study years from 1998 to 2001 in the Sundarban. But a non-significant damage effect was observed in the seedlings of *E. agallocha, C. decandra* and *A. cucullata* in all the study years. Siddiqi and Husain (1994) found that deer was harmful to new seedlings of *A. officinalis, X. mekongensis, B. sexangula and Aegiceras corniculatum* but found a non-significant effect on the seedlings of *H. fomes*. Siddiqi (2001) also mentioned that the leaves of *X. mekongensis* and *A. officinalis* appeared to be highly palatable to deer and the seedlings of these species were heavily browsed upon all over the forests. Champion *et al.* (1965) reported that deer either killed or retarded natural regeneration of *E. agallocha, H. fomes* and *C. decandra.* But the present study showed that deer did not cause any significant damage to the new seedlings of *E. agallocha,* and *C. decandra* but caused significant damage to *H. fomes*. Choudhury (1968) noticed that deer caused serious damage to E. *agallocha*. He also observed that *Sonneratia apetala, Nypa fruticans, H. fomes and A. cucullata* were also consumed by deer. There were more supporting study by Blasco (1977) who found that deer was a problem for *Avicennia* sp. and *H. fomes* and *N. fruticans.*

Siddiqi (1996) reported that all the plated seedlings of *X. mekongensis, B. sexangula* and *A. officinalis* in the trial plantation died in the unfenced plots only within two months after out-planting because of severe browsing effect of deer. He also found a significant difference in seedling survival of *H. fomes, E. agallocha* and *C. decandra* between fenced and unfenced plots one year after planting.

The browsing effect of deer varies from species to species depending on their palatability. The feeding effect also depends on the occurrence of different species in the forest floor. According to Siddiqi and Husain (1994), deer do not appear to cause any significant damage to new seedlings of *H. fomes* but young leaves of *H. fomes* were found to browse by deer (Siddiqi 1996). In this study deer significantly damaged the seedlings of *H. fomes.* This may be possibly due to less or unavailability of seedlings of other species and thus young leaves of *H. fomes* were eaten by deer and ultimately the seedlings were disappeared. Although *H. fomes* is the dominant tree species in the Sundarban, decline in their stocking has been reported. So, it is likely that deer may help to suppress this species by damaging regeneration. Besides, *B. sexangula, X. mekongensis,* and *A. officinalis* were more preferred by the spotted deer. Thus, it adversely affects the regeneration density of those species. Further detailed studies on survival and establishment of the seedlings for several years are necessary to understand the effect of deer on regeneration. This could help to maintain natural regeneration and improve the stocking of mangrove species.

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