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Population status of mangrove species in estuarine regions of Orissa coast, India

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Abstract: The mangrove ecosystems are store-house of economically important resources like trees, fishes and prawns and other marine organisms. The present study highlights the effect of natural and man induced stresses on regeneration and population status of mangroves of Bhitarkanika National Park, Orissa. The species such as *Cynometra ramiflora*, *Rhizophora mucronata* and *Sonneratia apetala* had lesser number of juveniles compared to other species of Bhitarkanika. The juvenile population across all sites and species ranged between 6 and 18% and individuals of mature/reproducing category ranged between 70 and 94. Among factors responsible for tree death, harvesting and cutting are the most important followed by old age mortality. The large gap in numbers of juvenile and mature population in the study sites suggests that a conservation and management plan is needed to define and develop regeneration strategies.

Resumen: Los ecosistemas de manglar son almacenes de recursos de importancia económica, como árboles, peces, camarones y otros organismos marinos. El presente estudio destaca el efecto del estrés natural y el inducido por el hombre sobre la regeneración y el estatus poblacional de los manglares del Parque Nacional Bhitarkanika, Orissa. Especies como *Cynometra ramiflora*, *Rhizophora mucronata* y *Sonneratia apetala* tuvieron números de juveniles menors en comparación con las otras especies de Bhitarkanika. La población joven para todas las especies y en todos los sitios varió entre 6 y 18%, y los individuos de la categoría maduros/reproductivos variaron entre 70 y 94. Entre los factores responsables por la muerte de los árboles, los más importantes son la recolección y el corte, seguidos de la mortalidad por edad avanzada. La gran diferencia en los números de juveniles y las poblaciones maduras en el sitio de estudio sugiere que hace falta un plan de conservación y manejo para definir y desarrollar estrategias de regeneración.

Resumo: O ecossistema mangal é um manancial de importantes recursos económicos como árvores, peixes, camarões e outros organismos marinhos. O presente estudo realça o efeito de stresses induzidos pela natureza e o homem na regeneração e no status populacional dos mangais do Parque Nacional de Bhitarkanika, Orissa. Espécies como a *ramiflora*, *Rhizophora mucronata* e *Sonneratia apetala* apresentam menor numero de juvenis quando comparado com outras espécies no Bhitarkanika. A população juvenil através de todos os sites e espécies oscilou entre os 6 e os 18% e os indivíduos na categoria de maduros/reprodutores oscilou entre os 70 e os 94. Entre os factores responsáveis pela mortalidade das árvores, a extracção e o abate foram os mais importantes, seguidos pela mortalidade por envelhecimento. O grande intervalo em números da população juvenil e adulta nas estações estudadas sugere que é necessário um plano de conservação e gestão para definir e desenvolver estratégias de regeneração.

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Key words: Bhitarkanika National Park, mangrove, mangrove population status, mangrove regeneration.

Introduction

The coastal and estuarine habitats have been under tremendous human induced stresses due to their immense economic, recreational and transport services. Increase in human population in estuarine areas will further increase the pressure on mangroves. Thus, these habitats need better management and legal enforcement of protection rules. The population study helps us to understand the regeneration and recruitment patterns of different species and, therefore, is an important conservation tool for sustainable management of natural resources.

Assessment of the population status of mangroves is important from conservation point of view. Management issues such as clear felling activities causing poor regeneration of species (Ahmed 1937; Chengappa 1918), selective tree felling by leaving seed bearing trees, and increasing the felling cycle in Indian mangrove ecosystem have been studied earlier by several workers (Venkatesan 1966). Density-diameter distribution has often been used to represent the population structure of forests. Even and all aged stands differ in density-diameter distribution. Similarly, early successional and mature forests differ in the distribution of stems in different diameter classes (Goff & West 1975). Several studies on mangrove forests of the world have been performed to find out the ecological status of these fragile ecosystems (Ashton & Macintosh 2002; Ellison & Farnsworth 2001; Lugo & Snedaker 1974). Floristic and ecological studies on Indian mangrove forests at Pichavaram and Muthupet (Kathiresan *et al*. 1994; Muniyandi 1986), in Andaman Islands (Dagar 1987; Mall *et al*. 1991) and in Sunderbans (Chaudhuri & Chakrabarti 1989; Mukherjee & Mukherjee 1970) are noteworthy. However, no information on the population status of mangroves of Bhitarkanika is available. The present study was, therefore, carried out to assess the population status of major mangrove species of Bhitarkanika which is facing recurrent anthropogenic pressure in addition to cyclones and tsunami type disturbances.

Materials and methods

Study sites and vegetation

The state of Orissa has a geographical area of 155707 sq. km., with an actual forest cover of 47107 sq. km. (30.3%). Out of this, mangrove forests constitute 195 sq. km. Thus, the percentage of mangrove forests to geographical and actual forest cover comes to 0.125% and 0.414%, respectively (FSI 1997, 1999). The Bhitarkanika mangrove forest is located at 20^0 4' - 20^0 8' N Latitude and 86^0 45' - 87^0 5' E Longitude, in the north-eastern coastal plain of Kendrapara district in Orissa, India. Total area of Bhitarkanika Wildlife Sanctuary is 672 sq. km., of which mangrove forests constitute approximately 130 sq. km.; the remaining areas are covered by water bodies, villages, uninhabited private and other revenue lands. The area is located in the combined delta of the rivers Mahanadi, Brahmani and Baitarani, which are interconnected. Distributaries of the Mahanadi and Brahmani join together near the coast and have a common estuarine region. Similarly, the Baitarani at its lower reaches drains into the river Brahmani, and these two rivers have a common mouth near Dhamra (Sinha 1999). Bhitarkanika is located in the estuarine environment created by Brahmani and Baitarani. A separate wildlife division with headquarters at Chandbali (Bhadrak district) was created during February 1980 for better management of the sanctuary. The same division was renamed as Mangrove Forest Division (wildlife) and shifted to Rajnagar (Kendrapara district) since November 1990. In addition to Bhitarkanika Wildlife Sanctuary, this division also looks after the adjacent mangrove forests of Bhadrak. The mangroves in several areas have shown marked decrease in quality and quantity of the vegetation cover due to shoreline changes, settlements, conversion for agriculture and aqua

culture (Upadhyay *et al.* 2002). Four forest blocks in the Bhitarkanika Wildlife Sanctuary were selected for carrying out vegetation survey. The total area of Bhitarkanika forest block is 1712 ha, Dangmal is 636 ha, Kakranasi is 310 ha, and Thakurdia is 272 ha. The Thakurdia and Kakranasi are situated closer to the Ekakula Nasi at Maipura river mouth region. Both the blocks are situated opposite to each other on both the banks of the river Baunsagada which flows nearly parallel to the sea before falling into the sea again at 'Pentha'. The Dangmal and Bhitarkanika blocks are situated at a distance of about 15 km from the Maipura river mouth. These blocks constitute the core area of the sanctuary.

The soil sediments are divided into two categories, recent or sub-recent forms named as 'newer alluvium' and Pleistocene forms named as 'older alluvium' (GSI 1974). The recent sediments are composed of sand, silt, and clay with assorted boulders and pebbles. They are dark and loosely compacted with high moisture content. The Pleistocene deposits comprise clay, sand, silt, and 'kankar', with locally cemented pebbles and gravels. They are reddish brown due to high degree of oxidation (Banerjee & Rao 1990).

Methods

Phytosociological data for tree and juvenile layers were collected by quadrat method for two years (1997 and 1998) for dominant and major mangrove species at Bhitarkanika, Thakurdia, Kakranasi and Dangmal sites located in Bhitarkanika mangroves forest ecosystem in Orissa. At each of the above sites, 30 random quadrats, each of 10 m x 10 m size, were sampled. Trees having height of ≥ 1m were measured for their girth to nearest cm at breast height. In the case of *Rhizophora*, the girth was measured just above the top prop root. Individuals having diameter ≥ 2.5 cm (dbh) were considered as trees (Amarasinghe & Balasubramaniam 1992). Height measurement of the trees was done during phytosociological analysis in each quadrat. Individuals having ≥ 1 m height were grouped into three categories:

(1) dead trees - cut and broken trees; (2) mature trees - undergoing flowering and fruiting; and (3) juveniles - individuals of trees below reproductive stage.

The population of dead trees was further classified into three categories on the basis of factors causing the death of the trees. Those trees which were subjected to cutting were considered as 'cut ', those dead due to age as 'dead' and those suffered from wind injury or river bank erosion were considered as affected due to 'other reasons'.

Results and discussion

Population status of species

The Bhittarkanika block had the highest percentage of trees in the 'mature/ reproducing category' followed by Dangmal, Kakranasi, and Thakurdia blocks (Table 1). Thakurdia forest block had the highest percentage of juveniles followed by Dangmal, Kakranasi and Bhitarkanika blocks. Maximum number of dead/harvested trees (8-10%) was found in Thakurdia and Kakranasi Forest Blocks. Access to these forest blocks by the surrounding villagers is easy compared to Dangmal and Bhitarkanika which had only < 4% dead/ harvested trees.

Numbers of individuals in mature and juvenile categories were enumerated separately for a few dominant mangrove species in the Bhittarkanika Wildlife Sanctuary (Table 2). *Excoecaria agallocha* had the highest percentage of plants under 'mature/ reproducing' category in Bhitarkanika block followed by Dangmal, Kakranasi and Thakurdia. *Heritiera fomes* had 83% individuals in 'mature/ reproducing' category at Bhitarkanika block. Nearly all the trees of *Ceriops decandra* were of reproductive age in Dangmal and

Table 1. Population of mangroves (number of stems ha^{-1}) in four forest blocks in Bhitarkanika Forests. Values in parenthesis are per cent of total number of stems.

Block	Mature/Reproducing	Juveniles	Dead remains	Total number of stems ha^{-1}
Dangmal	5810 (77.2)	1386 (18.2)	253 (3.4)	7450
Bhitarkanika	6301 (84.5)	1407 (11.3)	312 (4.2)	7653
Thakurdia	11616 (64.7)	4493 (25.0)	1834 (10.2)	17943
Kakranasi	10909 (73.4)	2640 (18.0)	1314 (8.8)	14863

Table 2. Population of 8 mangrove species as per cent of total stems, juvenile (J) and mature (M), and total number of stems ha^{-1} in mangrove communities of Bhitarkanika Forests.

Species	Dangmal			Bhitarkanika			Thakurdia			Kakranasi		
	J (%)	M (%)	Total stems ha^{-1}	J (%)	M (%)	Total stems ha^{-1}	J (%)	M (%)	Total stems ha^{-1}	J (%)	M (%)	Total stems ha^{-1}
E. agallocha	13	87	1568	10	90	1772	24	76	5814	14	86	5188
H. fomes	27	73	3266	17	83	3080	28	72	832	23	77	866
C. ramiflora	13	87	1199	6	94	759	0	0	0	0	0	0
A. officinalis	13	87	80	0	100	197	0	100	50	37	63	1209
S. apetala	7	93	50	8	92	236	0	100	13	20	80	17
R. mucronata	0	100	40	0	100	63	33	67	30	17	83	40
A. corniculatum	32	68	177	5	95	363	24	76	1868	24	76	150
C. decandra	0	100	30	3	97	103	27	73	4222	10	90	3750

Bhitarkanika blocks, whereas 73% individuals were under 'mature/ reproducing' category and 27% under the 'juvenile' category in Thakurdia block. *Cynometra ramiflora*, available only in the Bhitarkanika and Dangmal blocks, respectively, had 94% and 87% individuals in 'mature/ reproducing' category. All the trees of *Avicennia officinalis* were in 'mature/ reproducing' category in the Bhitarkanika and Thakurdia blocks. Only 63% trees of this species in Kakranasi block were in mature stage. *Aegiceras corniculatum* had 95% trees in Bhitarkanika and only 68% in the adjacent Dangmal block as 'mature/reproducing'. All the trees of *Rhizophora mucronata* in Dangmal and Bhitarkanika and *Sonneratia apetala* in Thakurdia block were 'mature/reproducing'. Kakranasi block had 80% mature individuals of the same species.

Near absence of juvenile plants of *C. decandra, C. ramiflora, E. agallocha* in Bhitarkanika, *A. officinalis, S. apetala* in Bhitarkanika, Dangmal and Thakurdia, and *R. mucronata* in Bhitarkanika and Dangmal blocks indicate that these species may become locally extinct, if regeneration is not stepped up at right time. Data pooled across species and sites also reveal only (i) 4.75 to 10% juveniles for *C. ramiflora*, *S. apetala* and *C. decandra*, (ii) > 10% but < 12.5% juveniles for *A. officinalis* and *R. mucronata,* and > 15.25 to 23.75% juveniles for *E. agallocha, H. fomes* and *A. corniculatum*. The group (i) species may be completely replaced by those of (ii) and (iii), if management measures are not explored at this stage.

Research on plant animal interaction has not been done in the Indian mangrove ecosystems. The invertebrates like grapsid crabs consume propagules, leaf, flower and fruits directly off the tree (Farnsworth & Ellison 1991). Other mammals like monkeys and deer eat mangrove leaf and forage shoots, respectively. Similarly, fungal pathogens which are causative agents of mass die back of some species (Weir *et al.* 2000) need to be studied. Regeneration ecology of Bhitarkanika mangroves need be studied, especially with reference to canopy gaps.

Tree mortality

An analysis of factors responsible for tree mortality in the forest blocks is shown in Table 3. It is observed that harvesting through cutting is the predominant reason for tree mortality in all the four forest blocks with above 84% of tree

Table 3. Tree loss due to different factors at different sites in Bhitarkanika Forests. Values in parenthesis are per cent of total stems lost.

Forest Block	Number of stems lost ha^{-1}			Total stems lost ha^{-1}
	Cut	Old age	Other reasons	
Dangmal	221 (88.2)	10 (3.9)	20 (7.9)	251
Bhitarkanika	271 (85.4)	26 (8.3)	20 (6.2)	317
Thakurdia	1588 (83.6)	241 (13.3)	56 (3.1)	1885
Kakranasi	1112 (85.5)	155 (11.9)	33 (2.5)	1300

mortality occurring due to this factor. Mortality due to old age is the second important factor for tree death. Thakurdia had the highest number of trees that are dead due to old age (13.3%) and Dangmal the least (3.9%). Other factors for tree mortality are riverbank erosion, wind injury, and pest infestation. These factors caused maximum tree death (7.9%) in the Dangmal forest block. Studies have revealed that seedlings in gaps grow significantly faster than those under canopy (Ellison & Farnsworth 1993, 1996). This present study is significant in the light of increased biotic pressure. Sagar & Singh (2004) observed biotic disturbances to be responsible for local depletion of species population in tropical dry deciduous forests of northern India, and advocated strong regulatory measures and protection for the re-establishment of depleted population. With sound forest management principles, planting nursery-raised or wild-collected seedlings in the canopy gaps will also generate timber and meet the requirements of the people on a controlled and scientific basis. Meeting the fuel wood demand of the local human population by raising such plantations in buffer areas and in villages will reduce anthropogenic pressure on mangroves and will help natural regeneration and recovery (Upadhyay *et al.* 2002). Mangrove associations are adapted to events of natural mortality, and recovery after disturbance in mangrove areas is faster (Jimenez & Lugo 1985). Lugo (1980) observed that mangroves are resilient to disturbances caused due to cyclones and storm surges and recover successfully from these natural events. Our study shows that more than 80% of death and damages of mangrove trees have been due to anthropogenic (human induced) disturbances. Unlike natural disturbances, the human interference changes the ecological conditions that do not allow regeneration of mangrove species. In the Muthupet mangrove forests in Tamil Nadu (Ahmed 1937), the harvest through clear felling in a 12 year rotation cycle resulted in poor regeneration of mangrove species. The felling was done with the assumption that all mangrove species could regenerate from rootstock (Chengappa 1918), however, only species such as *Excoecaria* and *Avicennia* could regenerate from the rootstock (Blasco 1975). The felling by leaving seed bearing trees for regeneration and increasing the felling cycle to 20 years is a viable option (Venkatesan 1966).

For expanding population, the number of juveniles should be higher than that of 'mature/ reproducing' individuals, and for stability, both should be almost equal to permit one to one replacement. Thus, observations on the predominant species of Bhitarkanika, as discussed above, show that regeneration of these species (and the ecosystem as a whole) has to be stepped up. Total absence of seedlings of *A. officinalis* in Bhitarkanika and Thakurdia, *R. mucronata* in Bhitarkanika and Dangmal, *S. apetala* in Thakurdia and *C. decandra* in Dangmal warrants immediate intervention. There is a great need to study damaged Mangrove ecosystems for developing guidelines for ecosystem restoration (Lugo 1998). The catchments of rivers Brahmani and Baitarini which discharge the water in the Bhitarkanika estuary, are being heavily concentrated with new steel and power industries and iron and chromite mines. Research ought to be initiated to assess the discharges of pollutants in the estuary area and their impact on the ecology of mangroves. The increase in human population around estuarine areas may also affect the ecology of mangroves. Such impacts will deteriorate the mangrove ecosystem including shrinkage in area. Continuous monitoring is necessary to maintain the mangrove ecosystem of Orissa.

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