CHAPTER 5

RESOURCE PARTITIONING

5.1 Introduction
Differential resource selection is one of the principal factors, which permit species coexistence (Schoner 1974; Rosenwig 1981). In studies of niche partitioning, nest site location has received much less attention than food or habitat, perhaps because suitable nest sites are presumed to be readily available for most species. However, when a species has specific nesting requirements, suitable nesting locations may be difficult to obtain (Weins 1989; Burger & Gochfield 1990). This may bring about the overlap of nest sites and consequently, predation costs for breeders because of the attraction of the predators due to the increase in cumulative nest density (Martin 1996). Factors commonly identified to explain aggregations are the spatial availability of food and defense against predators (Emlen & Demong 1975; Birkhead & Furness 1985; Brown, Stutchaburuy & Walsh 1990). Other studies suggest that ectoparasitism and abiotic factors (Ex. Precipitation) affect habitat quality and become a dominant force influencing aggregation behaviour in birds (Hill and Levin 1989, Boulinger & Gavin 1989, Weins 1992, Bouliner & Lemel 1996). Differential resource selection is one of the principal factors, which permit species coexistence (Schoner 1974; Rosenwig 1981). The response of wild populations to their resources is not always predictable because of the outcome of the number of interacting factors, which may go since a single until multiple factors (Parish 1995). Food scarcity often leads to foraging in distant areas, which may result in formation of small colonies (Arengo & Baldasare 1995). Strong seasonal peaks in food resources may limit breeding to a single season of the year and cause synchronized breeding of the population. In these cases large colonies are formed and intense competition occurs for food (Emlen and Demong 1975). Competition might be lessened by a strategy of fine scale temporal and spatial segregation in the use of habitats among species with similar feeding habits. (Murray 1971; Hill and Levin 1989). Anderson et al., 1979, suggested vertical stratification is
believed to partition resources and thereby reduce competition among co-existing species.

**Habitat selection and Nesting association:** The environment of most animal species is heterogeneous at different spatial and temporal scales for various characteristics that can directly affect components of fitness. The process of habitat selection is thus likely to be under strong selective pressures (Cody 1985; Martin 1993). Animals can use variety of physical cues to assess environmental suitability (Buckley and Buckley 1980; Cody 1985; Danchin and Wagner 1997). More parsimoniously, they can use some integrative cue such as the presence and activities of conspecifics (Keister 1979; Shields et al., 1988; Stamps 1991; Boulinier and Danchin 1997). Gulls and Terns breed colonially due to similar habitat preferences, mutual advantages provided by better predator avoidance, and the possibility of exchange of information for food acquisition (Erwin 1979; Burger & Gochfield 1990b; Oro 1996; Rolland et al., 1998). On the other hand, colonial birds may compete for resources, and colonies may attract predators (Wittenberger & Hunt 1985; Krebs & Davies 1987; Siegel – Causey & Kharitonov 1990). Multiple factors drive colony site dynamics in waterbirds, depending on habitat quality (Kharitonov and Siegel – Causey 1988; Fasola & Alieri 1992; Boulinier and Lemel 1996; Erwin et al., 1998). Habitat composition around nesting sites has been so far the most studied of those across (Fasola & Alieri 1992; Baxter & Fairweather 1998). Since reproduction is a time of high energy demand (Drent & Dann 1980, availability of suitable foraging sites ill directly influence colony location, colony size and reproductive parameters.

**Temporal segregation:** Custer and Osborn (1978) found asynchronous nest building phases in North Carolina. Maxwell and Kale (1977) found Florida Caerulea, started to breed later than other colony species. Frederick and Callopy (1989) showed a strong difference for the nesting chronology of four species (*Casmerodius albus, Egretta tricolour, Egretta caerulea, Eudocimus albus*) in Florida. Maxwell and Kale (1977) and Jenni (1969) found that nests of *Egretta thula* and *Bulbulcus ibis* showed an average nest height from 2.04
– 2.59 m. result of this work support the notion that species overlap temporally in breeding, also segregate vertically in nest placement within the colony.

**Central – periphery distribution of nests:** Breeding success may differ between centre and edge nests (Coulson 1968; Balda and Bateman 1972; Brown and Brown 1987), but it is not always attributable to predation (Coulson 1968; Bunin and Bates 1994). Nest defense against potential predators has long been suggested as an important force in the evolution of coloniality in birds (Lack 1968; Gotmark and Anderson 1984). Nests located in the more densely populated areas of the colonies are more sheltered from predation more than those at the periphery (Wittenberger and Hunt 1985). In the context of the relationship nest density and predation, the central – periphery distribution hypothesis was first proposed by Coulson (1968) in his study of colony of Kittiwakes (*Rissa tridactyla*), where he found birds breeding in the central area were of better quality and had higher reproductive success than those nesting in the periphery. Moreover subsequent studies showed that this population is regulated by the availability of central sites (Porter and Coulson 1987) and that birds breeding in the centre have a higher survival rate. (Aebischer and Coulson 1990). The variation in survival arises because central individuals are less accessible to predators (Hamilton 1971; Vine 1971). Central – Periphery distribution hypothesis is generally accepted explanation for nest dispersion patterns in sea bird colonies (Wittenberger and Hunt 1985; Furness and Monaghan 1987; Kharitonov and Sigel- Causey 1988). However there are some examples where this hypothesis is not fulfilled. Ryder and Ryder (1981) found a colony of ring billed gulls (*Larus delawarensis*) in which there was no variation in reproductive success between central and peripheral areas, while in another colony, Pugesek and Diem (1983) observed that reproductive success were determined by different spatial distributional of age groups. Scolaro et al (1996), in a study on a colony of the South American tern (*Sterna hirundinacea*), found that birds nest site selection is at first random and then uniform but not in the central – periphery pattern. In a study on behavior of Kittiwake recruits in a colony in North shields, Porter (1990) found that first time breeders prefer more densely populated sites, with poorer quality birds being regulated to peripheral zones.
Danchin et al (1991) reported that recruits are directly attracted by successful sites and they visit these sites during the prospecting season. It’s widely assumed that edge or fringe nesters should have a lower breeding success compared to central nesters (Wittenberger and Hunt 1985). Several authors have reported that edge or fringe nesters show higher levels of failure than more central nesters and that the centre advantage increases as colony size increases (Rukk 1968; Brown and Brown 1987, Spear 1983). Furthermore, several studies have shown preference by males for establishing territories with in the centre of colonies (Kittiwake, *Rissa tridactyla*, Coulson 1964; Least terns, Burger 1988).

The heronries play a vital role in the life cycle of the birds of family Ardeidae, Ciconiidae, Threskiornithidae and Phalacrocoracidae. In mixed species heronries, such diverse groups congregate in large numbers to breed and raise their progeny. Different species occupy certain space in the heronry at certain times. Strong site fidelity has been observed among birds as this is advantageous to them. As the birds become familiar with the area, it enhances their foraging success, predator avoidance, defense and other behaviours, which contribute to reproduction performance (Newton and Wyllie 1992). This chapter documents about the patterns of nest spacing and the factors that determine such patterns. Nest tree preference, species association and disassociation patterns, species preference of nest trees and vertical stratification of nesting species are dealt in detail in this chapter.

**5.2 Methods**

*Field methods:* With such a large congregation of breeding birds in a small area it would be interesting to learn how these birds share the available limited resources. Parameters such as type of materials used for nesting, nest height in a tree, type of branch in the tree used for nesting, direction of the nest, distance from the nearby foraging areas and food habits were collected to study the resource partitioning among breeding birds in the heronry. Nest constituents were visually identified and types of tree species used for nesting
were noted. Since the average height of the trees in the heronry are around 5-6 m (personal observation), nest height was approximately estimated using one meter graded pole (Datta and Pal 1993). In case of exceptionally tall trees the tree height was visually estimated. Nearest neighbour distance was measured both vertically and horizontally using a measuring tape for all the species. To study the species association dissociation patterns all species in the selected nest tree will be recorded. The heronry census was carried out in the last week of August, just after the hatching process of all the birds were over. Since the nests of different bird species are not uniformly distributed in this heronry, sample count of nests would give biased information on the total number of breeding birds. Hence, a total count of nest trees was carried out in the heronry. The entire nesting colony was subdivided into smaller subunits and based on the natural boundaries. All the trees in the subunits were then marked numerically in increasing order by paint. Parameters like, tree species, tree height, Girth at breast height (GBH), species nesting on the tree, no of nests, nest height were recorded. Nest height and tree height were visually estimated. GBH was measured with an inch tape. The nest of the bird species was identified by looking at the species guarding the nets and during the absence of both the parents, the nest design and nest materials were used to identify the species nesting. To determine the nest location in the trees, the entire tree height was divided in to five strata i.e., Upper canopy, upper middle, lower middle, lower and lowest canopy.

**Analytical methods:**

**Relationship between tree height & no. of nests:**

Since the scatter plot showed a non-linear association, non-linear regression was performed. The relationship was found to follow quadratic model. \( r = 0.54, \ F \text{ Significance} < 0.01 \).

**Species preference of nesting trees:**

We developed a simple and straightforward preference index (PI) for investigating the nesting tree preference by the water birds.

\[
\text{PI} = -1 \times [1 - \frac{F \text{ (observed)}}{F \text{ (expected)}}]
\]

Where
F (obs) = Observed number of nests on the given tree species
F (exp) = Expected number of nests calculated as the relative proportion of the number of tree species

The final value ranges from $-\infty$ to $+\infty$, where 0 refers to random selection. Increasing values on positive scale indicate preference while the negative scores point to avoidance. For the sake of clarity, we predefine the index value of 1 to $\geq 3$ as zone of preference and -1 to $\leq -3$ as zone of avoidance. The scores ranging between -1 to +1 are treated as evidence for the random choice of the nesting tree.

Spatial association / co-occurrence of nesting species in the Heronry:
Pearson’s Chi-square Statistic # P > 0.05 (indicating spatial independence of nests) was carried out to understand the association between nesting species in the heronry.

All statistical analysis was carried out using the statistical package SPSS 8.0.

5.3 Results

5.3.1. Nest tree usage: Birds used five species of mangrove trees; *Excoecaria agallocha* (Guan), *Heritiera fomes* (Bada Sundari), *Cynometra iripa* (Singada), *Hibiscus tiliaceus* (Bania), *Tamarix troupii* (Jagula) for nesting in the heronry. A total of 3843 nest trees were counted inside the heronry. A majority of 77.9% nest trees were *Excoecaria agallocha* followed by *Heritiera fomes* (18.7%), *Cynometra iripa* (2.8%), *Hibiscus tiliaceus* (0.9%) and only one tree of *Tamarix troupii* was used for nesting. Maximum numbers of 79.6% nests were recorded in *Excoecaria agallocha* followed by *Heritiera fomes* (17.4%), *Cynometra iripa* (2.2%), *Hibiscus tiliaceus* (0.9%) and only two nests were found on *Tamarix troupii* (Fig. 5.1).
Fig. 5.1. Number of nest w.r.t. to tree species. *Excoecaria agallocha* is the most abundant tree species in the heronry and maximum nets were recorded in this tree species.

![Bar chart showing the number of nests per tree species]

5.3.2. *Tree composition in the Heronry*: Although *E. agallocha* was the most numerous in the heronry, *H. fomes* was found to be the tallest and stoutest tree species in the heronry (Fig 5.2a & 5.2b). Asian Openbill nests extensively on *E. agallocha* trees and most of these trees are located in the centre of the heronry. Continued nesting of Openbill has damaged the top portions of the trees resulting in a stunted growth of *E. agallocha* in the heronry. This in turn has given a saucer shape to the heronry.
Fig 5.2(a) Relationship between tree species and GBH.

Fig 5.2(b) Relationship between tree species and tree height.
5.3.3. **Relationship between tree height/ GBH & no. of nests:** The relationship was found to follow the quadratic model which means that the number of nests increases with increasing GBH/tree height up to a certain value after which it starts to decline. This is because the tall and old growth trees occupy the periphery of the heronry but the water birds prefer the interior trees for nesting which are shorter and thinner compared to the peripheral ones (5.3a and 5.3b).

Fig 5.3 (a). Relationship between tree height and no of nests

![Graph showing the relationship between tree height (ft) and number of nests.](attachment:image.png)

$$r^2 = 0.3 \quad F = 4.9 \quad P < 0.05$$

Fig 5.3(b).

![Graph showing the relationship between GBH (cm) and number of nests.](attachment:image.png)

$$r^2 = 0.1 \quad F = 8.1 \quad P < 0.01$$
5.3.4. *Species wise nest height and nest location in the Heronry*: Oriental darter, Grey heron and Purple heron showed a higher nest height compared to other species since they preferred the tall *Heritiera fomes* to nest (Fig 5.4a). Asian Openbill storks showed affinity to nest in the top canopy and their mean nest height was 14 ft. They nest extensively on *Excoecaria agallocha*, which had a mean tree height of 14.5 ft. Most of the nesting species showed affinities to nest in the upper and upper middle canopy; however White ibis and Night herons showed preference for nesting in the lower middle canopy also (Fig 5.4b). None of the species showed evidence to nest in the lower and lowest canopy since the branching of the trees started only from the lower middle canopy.

Fig 5.4 (a). Mean nest height of nesting species
**5.3.5. Spatial association / co-occurrence of nesting species in the heronry:** White Ibis showed strong dissociation with other colonial species except for Large and Intermediate egrets and tends to nest forming sub colonies inside the heronry. Grey heron and Purple heron showed lesser evidence of nesting together and similar trend was also seen between Night heron and cattle egret. Darters also showed dissociation with Little cormorants, Intermediate, Little and Cattle egrets (Table 5.1).

**5.3.6. Species preference of nesting trees:** Asian Openbill, Little cormorant, White ibis, Little egret, Cattle egrets showed a preference to nest in *Excoecaria agallocha*, where as Darter, Grey heron, purple heron and night herons showed a preference to nest in *Heritiera fomes*. White Ibis, Little cormorant, Darter, Intermediate egret, little egret and cattle egret tends to avoid nesting in *Hibiscus tiliaceus*. (Fig 5.5 a, b and c)
Fig 5.5 (a). Nest tree preference of Openbill, Little cormorant, White ibis and Darter. Darter showed a strong preference to nest in *Heritiera fomes*.

Fig 5.5 (b). Nest tree preference of Large egret, Intermediate egret, Little egret, Cattle egret.
Fig 5.5 (c). Nest tree preference of Grey heron, Purple heron and Night heron. All the three species showed a strong preference of *Heritiera fomes*.

<table>
<thead>
<tr>
<th>Nest Trees</th>
<th>Preference Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. iripa</em></td>
<td>3.0</td>
</tr>
<tr>
<td><em>E. agallocha</em></td>
<td>2.0</td>
</tr>
<tr>
<td><em>H. formes</em></td>
<td>1.0</td>
</tr>
<tr>
<td><em>H. tiliaecius</em></td>
<td>0.0</td>
</tr>
<tr>
<td><em>Purple heron</em></td>
<td>-1.0</td>
</tr>
<tr>
<td><em>Night heron</em></td>
<td>-2.0</td>
</tr>
<tr>
<td><em>Grey heron</em></td>
<td>-3.0</td>
</tr>
</tbody>
</table>

Competition for space in waterbird colonies is known to be mitigated through habitat partitioning. Both vertical and horizontal associations among the nesting waterbirds in the heronry were studied. It was observed that Asian Openbill (*Anastomus oscitans*), Large egret (*Ardea alba*), Intermediate egret (*Egretta intermedia*), Little cormorant (*Phalacrocorax niger*), and Little egret (*Egretta garzetta*) were associated more frequently than they would be expected at random. There was a significant avoidance trend between Grey (*Ardea cinerea*) and Purple (*Ardea purpurea*) herons, and between Darter (*Anhinga melanogaster*) and Asian Openbill. Interestingly, Black-headed ibis (*Threskiornis melanocephalus*) was observed to nest away from most of the species within the heronry forming sub-colonies on its own.

Results of our analysis on vertical alignment of nests did not support the body mass-nest height hypothesis which postulated a direct positive correlation between body weight and nest height among colonial waterbirds (Fig.5.6). There was a significant radial zonation of species in the heronry with Asian Openbill storks preferring the central portion of the heronry (KW $\chi^2=8.54$, $P<0.05$) whereas Darter and Grey heron nests were observed more towards
the periphery of the heronry (KW $\chi^2=6.40$, $P<0.05$) (Fig.5.7). On the other hand, nests of Little egret (KW $\chi^2=11.11$, $P<0.05$), Purple heron (KW $\chi^2=11.53$, $P<0.05$) and Night heron *Nycticorax nycticorax* (KW $\chi^2=10.61$, $P<0.05$) were found to have clumped distribution being restricted to select blocks of the heronry (Fig.5.8).

![Fig.5.6 Body mass Vs Nest height:](image-url)
Fig. 5.7. Radial distribution of nests

Fig. 5.8 Sector wise distribution of nests
Table 5.1 Spatial association / co-occurrence of nesting species in the heronry: Pearson’s Chi-square Statistic # P > 0.05 (indicating spatial independence of nests)

<table>
<thead>
<tr>
<th>Species</th>
<th>Asian Openbill</th>
<th>Little Cormorant</th>
<th>White Ibis</th>
<th>Oriental Darter</th>
<th>Large Egret</th>
<th>Intermediate Egret</th>
<th>Little Egret</th>
<th>Cattle Egret</th>
<th>Grey Heron</th>
<th>Purple Heron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian Openbill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Cormorant</td>
<td>444.1</td>
<td>P&lt;0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>White Ibis</td>
<td>140.6</td>
<td>P= 0.753</td>
<td>182.1</td>
<td>P&lt;0.0001</td>
<td></td>
<td></td>
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<tr>
<td>Oriental Darter</td>
<td>204.4</td>
<td>P&lt;0.0001</td>
<td>57.8</td>
<td>P = 0.886</td>
<td>0.673</td>
<td>P &gt; 0.999</td>
<td></td>
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</tr>
<tr>
<td>Large Egret</td>
<td>1761.3</td>
<td>P&lt;0.0001</td>
<td>1236.3</td>
<td>P&lt;0.0001</td>
<td>378.8</td>
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<td>710.2</td>
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<td>Intermediate Egret</td>
<td>585.1</td>
<td>P&lt;0.0001</td>
<td>1441.2</td>
<td>P&lt;0.0001</td>
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<td>60</td>
<td>P = 0.114</td>
<td>197.8</td>
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<tr>
<td>Little Egret</td>
<td>56.8</td>
<td>P = 0.008</td>
<td>424.9</td>
<td>P&lt;0.0001</td>
<td>0.710</td>
<td>P &gt; 0.999</td>
<td>0.886</td>
<td>P&gt;0.999</td>
<td>199.7</td>
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<tr>
<td>Cattle Egret</td>
<td>240.5</td>
<td>P&lt;0.0001</td>
<td>921.3</td>
<td>P&lt;0.0001</td>
<td>11.6</td>
<td>P = 0.996</td>
<td>28.3</td>
<td>P = 0.24</td>
<td>239.1</td>
<td>P&lt; 0.0001</td>
</tr>
<tr>
<td>Grey Heron</td>
<td>723.9</td>
<td>P&lt;0.0001</td>
<td>81.8</td>
<td>P = 0.009</td>
<td>6.15</td>
<td>P &gt; 0.999</td>
<td>5417.6</td>
<td>P&lt;0.0001</td>
<td>267.4</td>
<td>P&lt; 0.0001</td>
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<tr>
<td>Purple Heron</td>
<td>628.0</td>
<td>P&lt;0.0001</td>
<td>987.9</td>
<td>P&lt;0.0001</td>
<td>5.47</td>
<td>P &gt; 0.999</td>
<td>157</td>
<td>P&lt; 0.0001</td>
<td>1108.5</td>
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<tr>
<td>Night Heron</td>
<td>278.3</td>
<td>P&lt;0.0001</td>
<td>648.1</td>
<td>P&lt;0.0001</td>
<td>10.5</td>
<td>P &gt; 0.999</td>
<td>4529.1</td>
<td>P&lt;0.0001</td>
<td>1052</td>
<td>P&lt; 0.0001</td>
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5.4 Discussion

Resource partitioning studies generally deal with food (Culver 1994 and Kaufmann 1974), but the partitioning of space to avoid competition. Actually aggression is the most precise mechanism for such partitioning. Since large species largely win over smaller species by occupying the preferred nest sites independent of their arrival and settlement patterns of the birds to the heronry (Schoener 1974). In heronries with mixed tree species, the larger species tend to select particular types of vegetation and while in homogenous vegetation heronries with no physical difference, species might divide the available space among themselves. The Darters and Grey herons were the first to arrive at the heronry and they chose to nest only in the peripheral tall *Heritiera fomes* trees and the Asian Openbill storks which are the dominant nesting birds in the heronry chose to nest only in the central location of the heronry. The Oriental white ibis, though arrives last in the heronry, they also tend to nest in the central location by displacing already established nests of small birds like large egrets, intermediate egrets and little egrets. One other major factor to partition the space is by nest tree preference. The oriental darters, Grey herons, Purple heron and Night herons showed a strong preference to the *Heritiera fomes* trees. Night herons also showed preference to the *Cynometra iripa* trees. Night herons are usually shy species and love to nest in thick canopy trees with plenty of shade and this might be the reason for them to choose the peripheral location of the heronry dominated by *Heritiera fomes* and *Cynometra iripa*. Species like White Ibis, Asian Openbill, little cormorant, Intermediate egret and Cattle egret showed a strong preference to nest in the *Excoecaria agallocha* trees. Asian Openbill stork have a propensity to clip the apical leaves while nest building and renovation, which is why Openbill prefer to nest in the small and tender *Excoecaria agallocha* trees whose apical leaves could be easily clipped by Openbill in comparison to the hard and sturdy *Heritiera fomes* and *Cynometra iripa* trees. White ibis tend to form subcolonies i.e. many individuals group together and occupy an entire tree and nest either vertically or horizontally with all the nests touching each other. *Excoecaria agallocha* trees structures are perfect for supporting these sub colonies and this would be the reason white ibis
showing preference to nest in *Excoecaria agallocha* trees. Certain species showed strong association patterns and whereas certain species tend to avoid each other, for example White Ibis showed strong dissociation with other colonial species except for Large and Intermediate egrets and tends to nest forming sub colonies inside the heronry. Grey heron and Purple heron showed lesser evidence of nesting together and similar trend was also seen between Night heron and cattle egret. Darters also showed dissociation with Little cormorants, Intermediate, Little and Cattle egrets. The relationship was found to follow the quadratic model which means that the number of nests increases with increasing GBH/tree height up to a certain value after which it starts to decline. This is because the tall and old growth trees occupy the periphery of the heronry but the water birds prefer the interior trees for nesting which are shorter and thinner compared to the peripheral ones. Oriental darter, Grey heron and Purple heron showed a higher nest height compared to other species since they preferred the tall *Heritiera fomes* to nest. Asian Openbill storks showed affinity to nest in the top canopy and their mean nest height was 14 ft. They nest extensively on *Excoecaria agallocha*, which had a mean tree height of 14.5 ft. Most of the nesting species showed affinities to nest in the upper and upper middle canopy; however White ibis and Night herons showed preference for nesting in the lower middle canopy also. None of the species showed evidence to nest in the lower and lowest canopy since the branching of the trees started only from the lower middle canopy. Both vertical and horizontal associations among the nesting waterbirds in the heronry were studied. It was observed that Asian openbill (*Anastomus oscitans*), Large egret (*Ardea alba*), Intermediate egret (*Egretta intermedia*), Little cormorant (*Phalacrocorax niger*), and Little egret (*Egretta garzetta*) were associated more frequently than they would be expected at random. There was a significant avoidance trend between Grey (*Ardea cinerea*) and Purple (*Ardea purpurea*) herons, and between Darter (*Anhinga malanogaster*) and Asian Openbill. Interestingly, Black-headed ibis (*Threskiornis melanocephalus*) was observed to nest away from most of the species within the heronry forming sub-colonies on its own.
It has been proposed that within homogenous vegetation, nesting herons align themselves vertically in direct relation to body length, with larger species at higher levels. This was attributed mainly to arrival times and to aggressive dominance by the larger species (Burger 1978, 1982). This pattern has been confirmed in some studies (McCrimmon 1978) but not in others (Burger and Gochfeld 1990), and a large variation exists between colonies, because herons adapt to the available vegetation (Beaver et al, 1980). However results of our analysis on vertical alignment of nests did not support the body mass-nest height hypothesis which postulated a direct positive correlation between body weight and nest height among colonial waterbirds. This observed pattern might be due to two reasons: 1. Occurrence of heterogeneous vegetation which makes different birds chooses different nest trees according to biological requirements and 2. Larger birds might tend to nest lower in the nest tree to conceal their large nests and attain greater protection from the aerial predators.

There was a significant radial zonation of species in the heronry with Asian openbill storks preferring the central portion of the heronry (KW $\chi^2=8.54$, $P<0.05$) whereas Darter and Grey heron nests were observed more towards the periphery of the heronry (KW $\chi^2=6.40$, $P<0.05$). On the other hand, nests of little egret (KW $\chi^2=11.11$, $P<0.05$), Purple heron (KW $\chi^2=11.53$, $P<0.05$) and Night heron Nycticorax nycticorax (KW $\chi^2=10.61$, $P<0.05$) were found to have clumped distribution being restricted to select blocks of the heronry.

5.5 Summary of findings

It was observed that Asian Openbill stork, Large egret, Intermediate egret, little cormorant and little egret were associated more frequently than they would be expected at random. There was a significant avoidance trend between Grey heron and Purple heron, and between Oriental Darter and Asian Openbill stork. Interestingly, White Ibis was observed to nest away from most of the species within the heronry forming sub-colonies on its own. Results of our analysis on vertical alignment of nests did not support the body
mass-nest height hypothesis which postulated a direct positive correlation between body weight and nest height among colonial waterbirds. There was a significant radial zonation of species in the heronry with Asian Openbill storks preferring the central portion of the heronry, whereas Oriental Darter and Grey heron nests were observed more towards the periphery of the heronry. On the other hand, nests of little egret, Purple heron and Night heron were found to have clumped distribution being restricted to select blocks of the heronry. These foretold patterns might have been responsible for reducing the interspecific aggression and thereby enhancing the interspecific resource partitioning.