Roosting of Ducks on Open Water: Resting Site Selection in Relation to Safety.

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Roost site selection of ducks in relation to safety was investigated at 26 ponds from December 1992 to February 1993 and from December 1993 to January 1994 in northern Chiba Prefecture, central Japan. The degree of safety was evaluated as the size of the safe range. The escape distance (D) between the first individual escaping and the observer was estimated, based on five experiments on the Spot-billed Duck Anas poecilorhyncha the most common species in the study area. I subtracted an area of periphery (unsafe area: width D: 29.2 m from the accessible waterside) from the total area of each pond. The remaining water surface was defined as the safe range. Ten species, including eight dabbling ducks and two diving ducks, were observed at 17 ponds. The total areas and the safe ranges at the 17 ponds with dabbling ducks were significantly larger than at those nine ponds without them. A similar tendency was detected between the seven ponds with diving ducks and the 19 ponds without them. The number of dabbling ducks was positively correlated with the size of the safe range; however no such relationship was detected between the number of dabbling or diving ducks and the total area, or between the number of diving ducks and the size of the safe range. These differences seem to be related to the utilization patterns of the ponds between ducks with different foraging habits. The dabbling ducks utilized the ponds only for resting, while the diving ducks used them as resting and foraging sites. The safe range is a useful index for representing the safety of a roost.

Key Words: Dabbling ducks, Diving ducks, Escape distance, Roosting site, Safe range

Birds roost in various ecological environments (Skutch 1989). Some roost directly on the ground (e.g. Spotted Sandpiper Actitis macularia, Gochfeld 1971; Horned Lark Eremophila alpestris, Trost 1972; Sage Grouse Centrocercus urophasianus, Back et al. 1987), and others in trees or bushes (e.g. European Starling Sturnus vulgaris and Common Grackles Quiscalus quiscula, Caccamise et al. 1983; Cliff Swallow Hirundo pyrrhronota, Brown 1986; American Crow Corvus brachyrhynchos, Gorenzel & Salmon 1995). Such roosts are presumed to be formed at sites safe from predators (Lack 1968). Few studies, however, have assessed the actual safety of roost sites, and this is made difficult because most birds roost at night.

Because many species of waterfowl roost on open water during the daytime (e.g. Fredrickson 1971; Craig 1980; Thomas 1986), they make good subjects for an examination of roost safety. Among waterfowl, two groups are recognized in terms of their

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utilization of roosts. Dabbling ducks commonly roost during the daytime and forage at nearby rice fields at night (Haneda 1954; Sugimori et al. 1989). In contrast, diving ducks frequently forage in the daytime (Oka & Sekiya 1997).

Several studies have dealt with roost site selection by ducks (e.g. Higuchi et al. 1988; Takeda 1990). More ducks are found in areas where hunting is prohibited and where they are artificially provisioned than in areas where hunting occurs and where there is no provisioning (Higuchi et al. 1988). The abundance of ducks is not related to the form of ponds available, but it is affected by human activities, even in areas free from hunting (Takeda 1990). The studies of Higuchi et al. (1988) and Takeda (1990) indicate that the extent of human disturbance is an important factor affecting roost site selection by ducks. The effects of human disturbance would be expected to be higher in suburban areas inhabited by many people compared with rural areas, however, so far studies have mainly been conducted in rural areas.

I examined the effect of the size of the safe area in relation to human disturbance on roost site selection of dabbling and diving ducks in suburban areas.

METHODS

1) Study area and duck counts

The study was carried out at 26 ponds in suburban areas in northern Chiba Prefecture, central Japan (around 35° 47' N, 140° 00' E; 0-20 m a.s.l.). Neither hunting nor food provisioning were conducted at the ponds. The ponds ranged in size from 0.2 ha to 4.5 ha (1.3±1.2 ha, mean±SD). Of the 26 ponds, 18 (69%) were smaller than 1.0 ha (Table 1). The shorelines of all the ponds were mostly or partly modified for agricultural use.

Duck counts were conducted five to eight times (n=26; 5.2 times/pond on average) at each pond every four or five days from December 1992 to February 1993 and from December 1993 to January 1994. The ducks were observed between 10:00 and 16:00 to count the number after or before moving between the ponds and foraging fields. Observations were made from a single point with good visibility, using a 10 x 35 binocular, a 30 x 67 telescope, and several hand-counters.

2) Measurement of the degree of safety

The suburban study area was intensely affected by human activities such as walking, jogging and fishing, but no potential predators, such as eagles, falcons, hawks or small carnivores were observed. Therefore the degree of safety for ducks at the 26 ponds was evaluated based on the size of a safe range, an area excluding part of the unsafe water surface, against human approach.

The safe range was calculated based on experiments during which an observer approached the ducks and their escape distance was estimated. Because the Spot-billed Duck Anas poecilorhyncha was the most common species in the study area (Table 1), it was used as a representative dabbling duck. Two non-provisioned ponds were selected for measurements of the escape distance of Spot-billed Ducks from human approach. One pond was 1.0 ha (No. 12 in Table 1) and the other was 12.0 ha (not included in the following analysis). Residential areas surrounded both ponds. At the smaller pond, ducks other than Spot-billed Ducks, mainly Green-winged Teal A. crecca, were observed simultaneously, while Spot-billed Ducks were the only species observed at the larger pond.

Experiments were conducted at the smaller pond between 10:00 and 12:00 on 19, 23 and 25 February 1993 and at the
Table 1. Species composition and occurrence (%) of ducks observed at 26 ponds

<table>
<thead>
<tr>
<th>Pond No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12*</th>
<th>13</th>
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<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
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</thead>
<tbody>
<tr>
<td>Total area (ha)</td>
<td>4.48</td>
<td>3.97</td>
<td>2.88</td>
<td>2.30</td>
<td>2.27</td>
<td>2.05</td>
<td>1.78</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.98</td>
<td>0.88</td>
<td>0.75</td>
<td>0.66</td>
<td>0.63</td>
<td>0.53</td>
<td>0.52</td>
<td>0.41</td>
<td>0.39</td>
<td>0.39</td>
<td>0.28</td>
<td>0.27</td>
<td>0.23</td>
<td>0.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe range (ha)</td>
<td>3.27</td>
<td>2.90</td>
<td>0.74</td>
<td>0.18</td>
<td>0.53</td>
<td>1.57</td>
<td>1.67</td>
<td>1.00</td>
<td>0.67</td>
<td>0.53</td>
<td>0.53</td>
<td>0.56</td>
<td>0.03</td>
<td>0.56</td>
<td>0.57</td>
<td>0.00</td>
<td>0.00</td>
<td>0.23</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
<td>Counts</td>
<td>5</td>
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<td>5</td>
<td>5</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Dabbling ducks</th>
<th>Mallard</th>
<th><em>Anas platyrhynchos</em></th>
<th>0.2</th>
<th>16.0</th>
<th>2.9</th>
<th>49.7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spot-billed Duck</td>
<td><em>A. poecilorhyncha</em></td>
<td>36.0</td>
<td>27.8</td>
<td>41.3</td>
<td>66.3</td>
</tr>
<tr>
<td></td>
<td>Green-winged Teal</td>
<td><em>A. crecca</em></td>
<td>19.6</td>
<td>37.3</td>
<td>100.0</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>Falcated Teal</td>
<td><em>A. falcata</em></td>
<td>2.9</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Gadwall</td>
<td><em>A. strepera</em></td>
<td>1.3</td>
<td>7.6</td>
<td>58.3</td>
<td>92.3</td>
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<tr>
<td></td>
<td>Eurasian Wigeon</td>
<td><em>A. penelope</em></td>
<td>16.8</td>
<td></td>
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<tr>
<td></td>
<td>Northern Pintail</td>
<td><em>A. acuta</em></td>
<td>2.8</td>
<td>0.5</td>
<td>24.5</td>
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<td></td>
<td>Northern Shoveler</td>
<td><em>A. clypeata</em></td>
<td>7.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diving ducks</td>
<td>Common Pochard</td>
<td><em>Aythya ferina</em></td>
<td>39.9</td>
<td>41.7</td>
<td>7.7</td>
<td>23.9</td>
</tr>
<tr>
<td>Tufted Duck</td>
<td><em>A. fuligula</em></td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. species</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>No. individuals</td>
<td>93.8</td>
<td>83.5</td>
<td>72</td>
<td>52</td>
<td>10.8</td>
<td>36.8</td>
</tr>
</tbody>
</table>

* = The pond where the approaching experiments were conducted.
larger pond on 29 December 1993 and on 2 January 1994. The number of ducks roosting at the smaller pond was 37.7 (n=3; range 29-55) and at the larger one 153.0 (n=2; 122 and 184). Ducks were approached on each occasion from a point more than 80 m from the nearest duck, and on each occasion the approach was made in the same clothes, in the same manner, and at the same speed (ca. 3 km/h), because the escape behavior of waterfowl varies according to types of disturbance (Burger 1981). The escape distance (D) between the first individual escaping and the observer was measured.

The mean escape distance of Spot-billed Ducks was found to be 29.2 m (+1.1 SD, n=5). Takeda (1990) previously reported that the shortest distance observed between people and ducks was 30 m for ducks wintering at 252 suburban ponds, a value very similar to that found in this study.

The shorelines of all 26 ponds were visited and checked to see whether access by people to the waterside was possible or not. Stands of trees, and dense reedbeds were apparent barriers preventing people approaching the water's edge. Shorelines with such barriers were presumed to offer safer roosting sites for ducks, than those accessible to people. The unsafe area (width D from the human accessible waterside) was subtracted from the total area of each pond. The remaining water surface was defined as the safe range (Fig. 1).

3) Statistical analysis

Duck counts were averaged for each pond. The total areas and the safe ranges of ponds used by dabbling Anas spp. or diving Aythya spp. ducks were compared using the Mann-Whitney U-test. Kendall's rank correla-

Fig. 1. A schematic representation of the safe range. The safe range (stippled area) is the total pond area minus an area of width D (the escape distance) from the pond circumference where the shoreline is accessible to people.
tion was used to test for any relationship between the total area or the safe range and the mean numbers of dabbling and diving ducks.

RESULTS

Ten species of ducks (eight dabbling and two diving duck species) were observed during 135 counts at 17 of the 26 ponds (Table 1). The two most common species were the Spot-billed Duck and the Green-winged Teal (42.3%), while the least common were the Falcated Teal *A. falcata* and the Tufted Duck *Aythya fuligula* (7.7%).

Ponds where dabbling ducks were present were significantly larger total areas than those from which they were absent (present *n=17*, 1.6±1.2 ha; absent *n=9*, 0.5±0.3 ha, mean±SD, *U=18.5*, *P=0.002*; Fig. 2). Ponds where dabbling ducks were present also had significantly larger safe ranges than those from which they were absent (present *n=17*, 0.8±1.0 ha; absent *n=9*, 0.1±0.2 ha, *U=28.0*, *P=0.008*). Similarly, ponds where diving ducks were present were significantly larger than those where they were absent (present, total area *n=7*, 2.0±1.3 ha; absent total area; *n=19*, 0.9±0.9 ha, *U=23.0*, *P=0.012*), with significantly larger safe ranges (present, safe range *n=7*, 1.1±1.1 ha; absent safe range *n=19*, 0.4±0.7 ha, *U=22.5*, *P=0.009*).

The number of dabbling ducks was positively correlated with the size of the safe range (*n=17*, *r=0.51*, *P=0.004*), but was not correlated with the total area (*n=17*, *r=0.19*, n.s., Fig. 3). The relationships between the numbers of diving ducks and the total area and the safe range were not sig-

![Fig. 2.](image-url)
significant (total area $n=7$, $\tau=0.39$, n.s.; safe range $n=7$, $\tau=0.35$, n.s.).

DISCUSSION

Dabbling and diving ducks selected ponds with large total areas and large safe ranges (Fig. 2). Several previous studies have shown that the number of ducks was positively correlated with total pond area (e.g. Higuchi et al. 1988). In this study, however, only the number of dabbling ducks was correlated with the safe range (Fig. 3). Dabbling ducks roost during the daytime (Haneda 1954; Sugimori et al. 1989), and none were observed foraging at the ponds during the study period. Therefore, the number of resting dabbling ducks was likely to have been affected by the size of the areas where they could roost undisturbed. If the shapes of ponds are similar, then the sizes of safe ranges are positively correlated with the total area, however, the safe ranges of some medium-sized ponds (e.g. ponds 3, 4 and 5 in Table 1) were much smaller than their total area. Furthermore, in these ponds very few dabbling ducks were found roosting, hence significant correlations would not be detected between total area and dabbling duck numbers, whereas safe range size did

Fig. 3. Relationships between the total pond areas and safe range sizes and the number of dabbling ($n=17$) and diving ducks ($n=7$). Significant correlations were detected between safe range size and the number of dabbling ducks (Kendall's rank correlation).
affect the number of dabbling ducks.

The conclusions would be supported by the lack of a correlation between the number of diving ducks and both the size of total area and safe range (Fig. 3). Diving ducks frequently forage in the daytime (Oka & Sekiya 1997), and some diving ducks were observed diving in search of food in the center of the study ponds. Consequently, the number of diving ducks might be related to the size of safe range, and also to the food abundance in the ponds. Food abundance is not necessarily correlated with pond size. This might explain why there was no correlation between the number of diving ducks and either total pond area or safe range size. Nevertheless, diving ducks did not select the extremely small ponds, indicating that a certain extent of open water is required even by diving ducks to ensure their safety.

Previous studies have mainly analyzed the relationship between total pond area and total duck numbers or the number of each duck species, without considering the dabbling and diving ducks as two separate groups (e.g. Takeda 1990). The behavioral patterns of dabbling and diving ducks differ markedly, and in this study the relationship between duck numbers and safe range size differed between the two groups (Fig. 3). It is suggested that it is important to divide ducks into dabbling and diving groups in order to analyze their roost site selection.

Mahaulpatha et al. (2000) reported that ducks select ponds in residential areas where hunting is prohibited, despite there being more natural and human disturbance in such areas compared with ponds in forests. Although the relationship between the number of ducks and the extent of disturbance was not investigated during the present study, the data provide some insights. The extent of disturbance was not estimated in this study; however, the size of the safe range in effect represents a measure of the degree of disturbance at the ponds. The presence or absence of hunting is an important factor for ducks when they are selecting ponds as roosts, and the number of ducks, especially dabbling ducks, relates to the safe area size of those ponds.

In addition to safe range size, other factors may also influence the safety of a roost site. Roost safety may, for example, vary with differing extents of human or predator activities, and considering these variables when assessing the safety of roosts is recommended for any future research on this subject.

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LITERATURE CITED


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水面のねぐら: 安全性に関連したカモ類の休息場所選択

(Roosting of Ducks on Open Water: Resting Site Selection in Relation to Safety. 50: 167-174)

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鳥類は安全な場所にねぐらを作るといわれる。しかしこの安全性を実際に定量的に評価した研究はない。この論文では、千葉県北西部の市街地にある26ヶ所の池でみられたカモ類を対象に、安全範囲という概念に基づいて池の安全性を定量し、カモ類の休息場所選択との関連について調べた。カモ類のカウントは1992年12月〜1993年2月と1993年12月〜1994年1月にかけて計135回（5.2回／池）行った。調査地域で優占種であったカルガモへの接近実験を2ヶ所の池で5回行い、それぞれもとづいて安全範囲を評価した。すなわち、調査者がカルガモに近づいたとき逃げ始めた最初の個体と調査者との距離を計測し、池の全面積から、池の周囲で人間の侵入可能な部分から池に向けてその距離分で形成される面積を除いた範囲である。カルガモの逃げ開始距離の平均は29.2mであった。

17池で10種のカモ類（水面採食性カモ類：8種、潜水採食性カモ類：2種）を記録した。カモ類が水面採食性カモ類と潜水採食性カモ類の2つのグループに分け、各グループが出現した池としなかった池の間で、池の全面積、安全範囲の面積を比較した。どちらのグループのカモ類でも、出現した池の方が全面積、安全範囲の面積ともに有意に大きかった。個体数と面積の関係をみると、水面採食性カモ類の個体数と安全範囲の面積との間でのみ有意な正の相関が認められた。しかし水面採食性カモ類の個体数と全面積、潜水採食性カモ類の個体数と全面積、安全範囲の面積には有意な相関は認められなかった。水面採食性カモ類は池を休息場所としてのみ利用するが、潜水採食性カモ類は採食場所としても利用する。そのため潜水採食性カモ類の個体数には池内での食物量が大きく影響している可能性がある。

安全範囲はカモ類の休息場所の安全性を示す有効な指標になりうると考えられる。今回、安全範囲の算出には面積だけを用いた。今後、実際に生じる人為的擾乱の程度や捕食者の影響などを考慮することによって、さらに精度の高いねぐらの安全性の評価ができると考えられる。

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