Are Carrion Crows that congregate in spring roosts juveniles or adults?

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Abstract Carrion Crows Corvus corone often establish spring roosts even during the breeding season. To examine whether the individuals roosting in spring are juveniles with immature reproductive organs, we compared the body size, sexual organs, and plumage of 150 roosting and 35 breeding individuals collected in the Joetsu region, Niigata, Japan, between 20 April and 9 May 1992. In both sexes, roosting individuals had significantly lighter bodies, and shorter wings and tails than breeding individuals. Roosting males had significantly lighter and shorter testes, and a lower testes/body percentage than breeding males. All 15 breeding males and 17 of 70 roosting males (24.3%) had mature testes, while 53 of 70 roosting males (75.7%) had immature testes. Roosting females had significantly lighter ovaries and a lower ovary/body percentage than breeding females. All 20 breeding females and 19 of 80 roosting females (23.8%) had long, enlarged oviducts, while 61 roosting females (76.2%) had undeveloped oviducts. Based on plumage characteristics, we estimated that 112 of the 150 roosting crows (74.7%) were juveniles. The reproductive organs of 108 of the 112 juveniles (96.4%) and 6 of 38 adults (15.8%) were immature. These results suggest that the spring roost consisted mainly of juveniles with immature reproductive organs. Thirty-six roosting individuals had mature reproductive organs. We considered them to be either territorial adults that had attempted to breed near the roost but failed, or sexually mature non-territorial males.

Key words Age, Carrion Crow, Reproductive organs, Roosting individual, Spring roost

Carrion Crows Corvus corone establish large roosts from autumn to winter, while they often form small roosts in spring, even during the breeding season (Kurata & Higuchi 1972; Koshio et al. 1996; Nakamura 2003; Yoshida 2003). Breeding adults remain on their territories and sleep near the nest at night (Haneda & Iida 1966; Nakamura 1998; Yoshida 2003). Therefore, many authors assume that individuals congregating in spring roosts are sexually immature juvenile birds (e.g. Goodwin 1986). However, there is no direct evidence for this.

The best way to identify roosting birds as sexually immature birds is to collect roosting birds and examine their internal reproductive organs. Carrion Crows were shot as pest birds in the spring of 1992 in the Joetsu region, Niigata, Japan and we obtained a total of 185 individuals. Carrion Crows can be aged by their plumage (Busse 1984). Our aim was to determine whether the individuals roosting in spring are juveniles with immature reproductive organs, based on the development of their reproductive organs, and examine the relationship between age and the development of reproductive organs.

STUDY AREA AND METHODS

Crows were shot around the campus of Joetsu University of Education (37°08′N, 138°14′E, 15–25 m elevation), Joetsu City, Niigata, and in an 8×4-km area (37°07′N, 138°19′E, 15–20 m elevation) at Sanwa-mura, Nakakubiki-gun, Niigata, between 20 April and 9 May 1992. The latter area was about 22 km from the university. A forest on the campus of the university has been used as a roost mainly by
Carrion Crows throughout the season for at least 25 years (Tanaka 1989; S Murayama unpubl.). Roosting individuals (those that congregate in the spring roost in the evening) were shot around the university and we obtained 150 specimens. To compare the body size, plumage characteristics, and reproductive organ development between roosting and breeding individuals, 35 breeding individuals were shot during the nestling period in the study area at Sanwa-mura. The shooting period corresponded to the nestling period in our study population. Members of the Japanese Hunting Association had authority to shoot the crows and we went along with them to collect specimens.

For each specimen, four measurements were recorded as body size: (1) body mass, measured to the nearest 0.1 g with an electronic balance; (2) wing length, the maximum distance from the carpal joint to the tip of the longest primary in the flattened and straightened right wing; (3) tail length; and (4) tarsus length. All linear measurements were made to the nearest 0.1 mm with vernier calipers.

Age determination using plumage characteristics followed Busse (1984). Juveniles have dark brown greater and median coverts, and the tips of the tail wing are worn and cut off conically, while adults have metallic black greater and median coverts, and the tips of the tail wing are not worn and are cut off perpendicularly.

Within two hours of collecting each specimen, we removed the entire reproductive tract and determined the sex. In males, each testis was removed and weighed to the nearest 0.01 g on an electronic balance. We measured the testes length (major and minor axes) with vernier calipers to the nearest 0.1 mm. The testes length (major axes) of Carrion Crows from central Hokkaido was found to increase from March to May (Tamada & Fujimaki 1993), however, in our study area no such increase was observed during the shorter period from 20 April to 9 May (roosting males, $F_{1,68} = 1.85$, $P = 0.18$; breeding males, $F_{1,13} = 3.90$, $P = 0.70$). Thus, the data were pooled for 20 days.

After we measured testes size, the testes were fixed in Bouin’s solution for 48 h and preserved in 70% ethanol. The testes were prepared for routine histology: 8-μm-thick paraffin sections were stained with Mayer’s hematoxylin-eosin and examined under a light microscope. The testes of all avian species undergo marked changes during the development of spermatogenesis. Immature testes are characterized by thin seminiferous tubules, which are largely full of spermatogonia and interstitial tissue. Mature testes show active spermatogenesis with thick seminiferous tubules and compressed interstitial tissue between adjacent tubules.

**Fig. 1.** Microscopic (a and b) and macroscopic (c) features of the gonads from male (a and b) and female (c) Carrion Crows. a: immature testis, characterized by thin seminiferous tubules (st) that are largely occupied by spermatogonia and by well-developed interstitial tissue (it). Scale indicates 50 μm. b: maturing or mature testis showing active spermatogenesis in thick seminiferous tubules (st) and compressed interstitial tissue (it) between adjacent tubules. Scale indicates 50 μm. c: a long, enlarged oviduct (od); arrow shows ovary. Scale indicates 30 mm.
spermatogonia, and by well-developed interstitial tissue, while mature testes show active spermatogenesis, the seminiferous tubules have expanded enormously, and the interstitial tissue between adjacent tubules is greatly compressed (Lofts & Murton 1973). Based on the condition of the seminiferous tubules and interstitial tissues, we distinguished immature (Fig. 1a) and mature (Fig. 1b) testes. In females, the ovary was removed and weighed to the nearest 0.01 g on an electronic balance. Breeding females, particularly females that have laid eggs, have long, enlarged oviducts, but the oviducts become thinner during the non-breeding season (Gilbert 1979). We regarded long, and enlarged oviducts (Fig. 1c) as developed oviducts.

**RESULTS**

1) **Males**

Roosting males had significantly lighter bodies, shorter wings and tails than breeding males; while tarsus length was marginally, but not significantly shorter in roosting males (Table 1). Roosting males had significantly lighter and shorter testes, and a lower testes/body percentage than breeding males. However, overlap in these values was evident (Table 1). The frequency distribution of testes mass also showed considerable overlap (Fig. 2). All 15 breeding males and 17 of 70 roosting males (24.3%) had mature testes, while the remaining 53 roosting males (75.7%) had immature testes (Fig. 2). Based on age determination using plumage characteristics, all 15 breeding males and 23 of 70 roosting males (32.9%) were adults. The testes of 47 juveniles were immature. Of 23 adult males, 17 males had mature testes, but six had immature testes.

2) **Females**

Roosting females had significantly lighter bodies, shorter wings and tails than breeding females, while tarsus length was marginally, but not significantly shorter in roosting females (Table 2). Roosting females had significantly lighter ovaries, and a lower ovary/body percentage than breeding females, although the values overlapped (Table 2). The frequency distribution of ovary mass showed considerable overlap between breeding and roosting females (Fig. 3). All 20 breeding females and 19 of 80 roosting females (23.8%) had long, enlarged oviducts, while 61 roosting females (76.2%) had undeveloped oviducts (Fig. 3). All 20 breeding females and 15 of 80 roosting females (18.8%) were identified as adults using plumage characteristics. All 15 adults had developed oviducts. Of 65 juvenile females, 61 had

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### Table 1. Comparison of body and testes size of roosting and breeding males. Figures are means±SD.

<table>
<thead>
<tr>
<th></th>
<th>Roosting individual</th>
<th>Breeding individual</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>70</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass (g)</td>
<td>631.1±49.2</td>
<td>680.0±50.7</td>
<td>3.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Wing length (mm)</td>
<td>32.8±1.4</td>
<td>34.8±0.8</td>
<td>5.47</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Tail length (mm)</td>
<td>19.8±2.7</td>
<td>21.5±0.7</td>
<td>2.41</td>
<td>&lt;0.05</td>
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<tr>
<td>Tarsus length (mm)</td>
<td>6.3±0.3</td>
<td>6.4±0.3</td>
<td>1.66</td>
<td>=0.101</td>
</tr>
<tr>
<td>Testes mass¹ (g)</td>
<td>0.70±0.81</td>
<td>1.75±0.75</td>
<td>4.64</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Testis length² (mm)</td>
<td>1.03±0.45</td>
<td>1.56±0.27</td>
<td>4.36</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Testes/body³ (%)</td>
<td>0.11±0.12</td>
<td>0.26±0.11</td>
<td>4.41</td>
<td>&lt;0.0001</td>
</tr>
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</table>

¹ Combined mass of both testes.  
² Major axis of the larger testis.  
³ Combined mass of both testes as a percentage of body mass.
DISCUSSION

It is clear that 114 of 150 roosting crows (76.0%) were non-breeders because they had immature reproductive organs. Based on plumage characteristics, we considered 112 of the 150 roosting crows (74.7%) to be juveniles. The reproductive organs of 108 of the 112 juveniles (96.4%) were immature. These results suggest that the spring roost was composed mainly of juveniles with immature reproductive organs. However, six roosting males estimated as adults had immature testes. Four roosting females had developed oviducts but were considered juveniles. Thus, plumage characteristics are not always consistent with sexual organ development.

Breeding adults likely roost near their nests to protect eggs and nestlings from predators. However, 17 males and 19 females with mature reproductive organs assembled in the spring roost. There are three possible explanations for this. First, individuals that bred near the spring roost assembled in the roost. Kurata and Higuchi (1972) observed that some breeding adults assembled in a spring roost that was 4 km from their nests. Second, individuals that failed in breeding assembled in the spring roost because they did not need to protect eggs and nestlings. The Carrion Crow has two distinct social types: territorial pairs, and flocks of non-territorial individuals (Yoshida 2003). Pairs breed in territories (Nakamura 1998; Yoshida 2003), thus, sexually mature individuals that bred near the spring roost and failed in breeding must have had territories. Third, non-territorial adults assembled in the spring roost. Yoshida (2003) found that non-territorial individuals live in flocks until they can acquire a breeding territory, and the flock is composed of juveniles and individuals over two years old. Only rarely are females with developed oviducts non-territorial. Therefore, the individuals congregating in the spring roost would be sexually mature non-territorial males.

We concluded that spring roosts were composed mainly of non-territorial juveniles with immature reproductive organs and some sexually mature territorial adults that had attempted to breed near the roost but failed, or sexually mature non-territorial males.

ACKNOWLEDGMENTS

We are indebted to Honorary Professor T. Nakamura of Joetsu University of Education for his encouragement and advice on our work. We thank Professor S. Daigobo of the university for his technical advice in making paraffin sections. Professor A. Chiba of Nippon Dental University School of Dentistry at Niigata kindly gave histological information on reproductive organs. We are grateful to members of the Laboratory of Animal Ecology of the university for helping with the field work. We also express our thanks to two anonymous reviewers for their many constructive comments and suggestions. We could not have carried out this work without the sup-

Table 2. Comparison of body and ovary size of roosting and breeding females. Figures are means±SD.

<table>
<thead>
<tr>
<th></th>
<th>Roosting individual</th>
<th>Breeding individual</th>
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<th>P</th>
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</thead>
<tbody>
<tr>
<td>N</td>
<td>80</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass (g)</td>
<td>537.9±43.0</td>
<td>602.6±39.7</td>
<td>6.10</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Wing length (mm)</td>
<td>31.3±1.4</td>
<td>32.7±0.7</td>
<td>4.46</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Tail length (mm)</td>
<td>19.1±1.9</td>
<td>20.3±0.6</td>
<td>2.82</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Tarsus length (mm)</td>
<td>6.0±0.2</td>
<td>6.1±0.2</td>
<td>1.81</td>
<td>=0.073</td>
</tr>
<tr>
<td>Ovary mass (g)</td>
<td>0.17±0.12</td>
<td>0.36±0.21</td>
<td>5.32</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ovary/body(%)</td>
<td>0.03±0.02</td>
<td>0.06±0.03</td>
<td>4.61</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

1 Mass of ovary as a percentage of body mass.

Fig. 3. Frequency distribution of ovary mass. Hatched bars are females with developed oviducts.

Undeveloped oviducts, while four had developed oviducts.
port of the members of the Joetsu branch of the Japanese Hunting Association (Dainippon Ryoyukai), K. Nozaki, Y. Hayashi, and staff members of the Environmental Planning Section in the Joetsu City Office.

REFERENCES