Characterization of gizzards and grits of wild cranes found dead at Izumi Plain in Japan

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ABSTRACT. We analyzed the gizzards, and grits retained in the gizzards of 41 cranes that migrated to the Izumi Plain during the winter of 2015/2016 and died there, either due to accident or disease. These included 31 Hooded Cranes (Grus monacha) and 10 White-naped Cranes (G. vipio). We determined body weight, gizzard weight, total grit weight and number per gizzard, and size, shape, and surface roundness of the grits. Average gizzard weights were 92.4 g for Hooded Cranes and 97.1 g for White-naped Cranes, and gizzard weight positively correlated with body weight in both species. Average total grit weights per gizzard were 19.7 g in Hooded Cranes and 25.7 g in White-naped Cranes, and were significantly higher in the latter. Average percentages of body weight to grit weight were 0.8% in Hooded Cranes and 0.5% in White-naped Cranes. Average grit number per gizzard was 693.5 in Hooded Cranes and 924.2 in White-naped Cranes, and were significantly higher in the latter. The average grit size was 2.8 mm in both species. No differences were found in the shape and surface roundness of grits between the two species. To the best of our knowledge, this is the first study on the grits retained in the gizzards of Hooded and White-naped Cranes.

KEY WORDS: gizzard, grit, Hooded Crane, White-naped Crane

Each year, thousands of cranes migrate from Russia, Northeast China and Northern Mongolia to the Izumi Plain in the northwest of Kagoshima Prefecture, Japan. These cranes include 80–90% of the world’s population of Hooded Cranes (Grus monacha) and approximately half of the world’s population of White-naped Cranes (G. vipio). Their numbers in the Izumi Plane have increased in recent years; the presence of over 17,000 cranes (Hooded Cranes: 13,800, White-naped Cranes: 3,200) was confirmed in 2015 [6]. They start arriving in the Izumi Plane in October and overwinter for three to five months before returning to their northern breeding sites.

Both Hooded and White-naped Cranes are omnivorous, feed on small animals, such as loaches, crabs, mud snails, locusts, dragonfly larvae and moth larvae, and on various plants including rice and other cereals, Hemerocallis fulva var. disticha, Eleocharis kuroguwai, triangular clubrush, arrowheads and sweet potatoes [7]. Cranes have long beaks suitable for catching small aquatic animals that live underwater or in swamps. However, like other birds, they do not have teeth and cannot masticate their prey. In addition, they do not have a crop, where birds such as those belonging to the order Galliformes, as well as raptors, temporarily store food, and thus, the food they ingest is directly transported to the gizzard via the proventriculus. The gizzard, made of a thick muscular layer, physically breaks down food into small pieces. As in other avian species, the gizzard contains a large number of small stones called grits that are used to grind the ingested food.

Grits have been reported in the gizzards of a wide range of birds, and it is becoming clear that they have different characteristics depending on the species [1–3, 8]. Grit number, retention rates, and other qualities of grits vary depending on the feeding habits, age, body size, sex, and reproductive state of the birds as well as on other factors. Among these, feeding habit is the most influential factor. For example, grit retention rates and grit numbers are highest in herbivorous and granivorous birds, followed by those in insectivorous and frugivorous birds, and are lowest in carnivorous birds [3].

The cranes deliberately eat small stones to use them as grits [2, 5]. However, there have been few studies on the grits present in crane species. To obtain basic data and to learn more about the grits and gizzards of wild cranes, we conducted a study on the
Gizzards and grits found in 41 cranes that were found dead while they were wintering in the Izumi Plain in 2015/2016. To the best of our knowledge, this is the first study on gizzards and grits in Hooded and White-naped Cranes.

MATERIALS AND METHODS

Cranes
The 41 cranes that were studied included 31 Hooded Cranes (G. monacha) and 10 White-naped Cranes (G. vipio). Their details are shown in Table 1. The birds had migrated to the Izumi Plain between November 2015 and February 2016; they were found dead and were collected. A joint investigation was conducted at the Izumi City Crane Museum “Crane Park Izumi” and Joint Faculty of Veterinary Medicine, Kagoshima University to test the cranes for avian influenza, and all the birds tested negative. The birds were then sent to the Laboratory of Veterinary Microbiology of the Joint Faculty to determine the cause of their deaths. Various analyses were performed in that laboratory, including those of gizzards and grits.

Measurement of gizzards and grits
During the autopsy conducted on each bird, the gizzard was removed and fat tissues were scraped from the surface. Each gizzard was cut open and the contents were transferred to a beaker; the gizzard was then weighed. The contents of gizzard were washed under running water and classified into grits and non-grits. The stones were sorted using a commercially available drainer and those smaller than 2 mm in the major axis were classified as non-grits (soil or other components). The grits were dried overnight in an incubator set at 37°C. The weight, number, size, shape, and surface roundness of all grits in each gizzard were assessed, as described by Best et al. [1]. Specifically, the grit size was determined by adding the longest and shortest diameters of each grit (measured using a digital caliper), and then dividing the sum by 2. The number resulting from the division of the largest grit diameter by the smallest grit diameter was used as an index of grit shape, with a value of 1 indicating spherical shape and a larger value indicating an elliptical shape. The surface roundness of grit was assessed and grouped into one of the five categories with the following scores: 1=angular (sharp and irregular corners), 2=sub-angular (corners slightly rounded and inlets sharp), 3=sub-rounded (corners rounded and inlets more or less smooth), 4=rounded (corners well-rounded and only a few inlets) and 5=well-rounded (smoothly rounded with no corners or inlets).

Statistical processing
We used regression analysis to compare body weight and gizzard weight, body weight and grit weight, and body weight and grit number within each crane species. The inter-species comparisons were conducted using the two-sided t-test for grit weight, number of grits, grit size and grit shape, and Mann-Whitney Test was done for grit surface roundness. Significance was determined at the level of 5% or less.

RESULTS

Relationship between body weight and gizzard weight
Samples of the gizzards of Hooded and White-naped Cranes are shown in Fig. 1. Typical grits recovered from each species are shown in Fig. 2a and 2b, and the shell pieces and tuberous roots that were similar to grits but classified as non-grits are shown in Fig. 2c and 2d. Most of the grits were white, ivory, or pale gray; few black and brown grits were also present. The relationships between body weight and gizzard weight were assessed for birds that had not been partly eaten by crows or other wild animals. Twenty-eight Hooded Cranes and nine White-naped Cranes were assessed. Average body weight and average gizzard weight for each species are given in Table 2. Average body weight was significantly higher for White-naped Cranes than for Hooded Cranes (P<0.05); however, there was no significant difference in average gizzard weight between the two species. Average gizzard weights, expressed as percentages of average body weights, were 3.2% for Hooded Cranes and 2.1% for White-naped Cranes. The relationship between body weight and gizzard weight in the two species is shown in Fig. 3. In both species, gizzard weight increased linearly with body weight.

Table 1. Details of the examined cranes

| Species          | Age    | Sex | Total |
|------------------|--------|-----|-------|
|                  | Male   | Female | Unidentified | |
| Hooded Crane     | Juvenile | 12 | 10 | 1\(a) | 23 | 31 |
|                  | Adult   | 4 | 4 | - | 8 |
| White-naped Crane| Juvenile | 0 | 1 | - | 1 | 10 |
|                  | Adult   | 4 | 5 | - | 9 |
| Total            | 20 | 20 | 1 | 41 |

a) Unidentified, because the reproductive organ was not present.
Results of grit analysis

The data on grits were statistically analyzed for the comparisons, male vs. female of each crane species or juvenile vs. adult for Hooded Crane species; however no significant differences were obtained in either of the comparisons. Therefore, all the data for

![Fig. 1. Gizzards of Hooded Cranes (a; intact, b; open) and White-naped Cranes (c; intact, d; open). After cutting the gizzards open, the contents were removed and the gizzards were washed under running water.](image)

![Fig. 2. Examples of whole grits from a Hooded Crane (a) and a White-naped Crane (b); shell fragments (c) and bulbs (d) found in the grits from Hooded Cranes.](image)
subsequent measurements were collected for the comparison between Hooded and White-naped Cranes.

Average weight, number, size, shape and surface roundness of the grits in individual birds and their distribution are shown in Table 3 and Figs. 4–6. In total, 30,742 grits were examined.

**Grit weights:** Average grit weights per gizzard were 19.7 g in Hooded Cranes and 25.7 g in White-naped Cranes, with the latter having significantly heavier grits as shown in Table 3. An analysis of the correlations between body weight and grit weight in each species did not reveal significant correlations. Average grit weight per gizzard, expressed as a percentage of body weights, was 0.8% in Hooded Cranes and 0.5% in White-naped Cranes, with no significant difference between them. We also measured total weights of gizzard contents, including grits. Average grit weight per gizzard, expressed as a percentage of total weight of gizzard content, was 64.2% in Hooded Cranes and 62.8% in White-naped Cranes, and there was no significant difference between these averages.

**Number of grits:** As shown in Table 3, the average grit numbers per gizzard was 693.5 in Hooded Cranes and 924.2 in White-naped Cranes, and these averages were significantly different. The minimum number of grits in the Hooded and White-naped Cranes were 292 and 409, and the maximum numbers were 1,274 and 1,327, respectively. Thus, there was a wide individual variation in grit numbers in both species. There were no significant correlations between grit numbers and body weights.
Fig. 4. Size distributions of grits found in Hooded Cranes (top) and White-naped Cranes (bottom).

Fig. 5. Shape distributions of grits found in Hooded Cranes (gray) and White-naped Cranes (pink). The number resulting from the division of the largest grit diameter by the smallest grit diameter was used as an index of grit shape.

Fig. 6. Distribution of grit surface roundness in Hooded Cranes (gray) and White-naped Cranes (pink).
**Gizzards and Grits of Wild Cranes**

*Grit size:* As shown in Table 3 and Fig. 4, the most frequent grit size ranges were 2.2–2.4 mm in Hooded Cranes and 2.4–2.6 mm in White-naped Cranes. However, the average grit size for the two species was same (2.8 mm). The largest grit diameters in Hooded and White-naped Cranes were 14.0 and 14.9 mm, and the smallest diameters were 0.3 and 0.7 mm, respectively.

*Grit shapes:* As shown in Table 3 and Fig. 5, the average grit shape value was 1.9 in both the species, indicating an elliptical shape. The range and distribution of grit shapes were similar in each species, except that the maximum values were 11.95 and 4.88 in Hooded and White-naped Cranes, respectively.

*Grit surface roundness:* As shown in Table 3, the average roundness score was 2.9 for both species and distribution of each score was almost same as shown in Fig. 6. We found no significant differences in grit surface roundness between the two species. In both species, almost all the grits were sub-angular, sub-rounded, or rounded, and most of the grits were sub-rounded.

**DISCUSSION**

Capture of wild cranes is prohibited because they are designated by endangered species. However, at Izumi Plains, many dead cranes are found every year and autopsy is performed on them for the purpose of wild-life preservation. These dead cranes are precious materials and should be used effectively. They provide a lot of important and basic data about wild cranes. The present investigation provided important information about the gizzard and grit of wild Hooded and White-naped Cranes.

A previous study on Sandhill Cranes (G. canadensis) indicated that the cranes had well-developed gizzards with a large number of grits [2]; in addition, grit size varied between 2.36 and 4.75 mm in both greater and lesser Sandhill Cranes, and was similar to that observed for Hooded and White-naped Cranes (2.4–2.6 mm). On the other hand, average grit weights per gizzard for greater and lesser Sandhill Cranes were 22.8 and 16.6 g, which were lesser than those for White-naped (25.7 g) and Hooded Cranes (19.7 g). However, it remains unclear whether there was a statistically significant difference in the data for Sandhill and White-naped or Hooded Crane.

Franson et al. [2] reported on the risk of waterfowl mistakenly identifying illegally dumped lead fishing gear as grits, and ingesting them. We found no metal objects in the gizzards of birds in this study; however, in our previous studies, we occasionally found wave plate fixing brackets (unpublished). It is likely that if lead pieces of the right size occur in the environment, they will be ingested by cranes and could result in lead poisoning.

There have been few reports on the type and mineral content of grits for wild birds, including cranes. We did not identify the mineral contents of the grits in this study. Many of the grits observed were white, ivory or pale gray in color. We believe that many of the grits were quartz, which is resistant to abrasion and erosion from long-term exposure to gastric acid in the gizzard [8].

We did not observe any significant differences between gizzard weight and grit weight per gizzard in each crane. However, the per-gizzard grit weight, grit number, and body weight were all higher in the White-naped Cranes than in the Hooded Cranes. This finding is consistent with an earlier report indicating that there is a positive correlation between grit weight and body weight [5]. Wings and Sander [8] showed that in herbivorous birds, total grit weight was approximately 1% of body weight. In the present study, we found that total grit weight was 0.8% of body weight in Hooded Cranes and 0.5% in White-naped Cranes, although there was no significant difference between them. These lower percentages might be attributed to the fact that cranes are omnivorous rather than herbivorous.

For examine the reason for the difference in weight and number of grits per gizzard between Hooded and White-naped Cranes, an assessment of the foraging environment and habitats, including breeding area and wintering place is necessary.

We found no difference in the size, shape, and surface roundness of the grits in the gizzards of the birds of both species. Grit shape and surface roundness may depend on the environment where the cranes ingest the grits [3]. Therefore, different results might be obtained if the cranes are studied during the summer in Russia, Northeast China, and Northern Mongolia.

For this study, we used cranes that died in the Izumi Plain during the winter months of late 2015 and early 2016. An investigation of the causes of their deaths was outside the scope of this study. However, based on an earlier report [4], it is likely that there could be various causes, including infections and accidents. Deaths from chronic diseases may have influenced the number and weight of grits retained by some of the cranes in this study. Future studies should address this question and analyze the potential effects of sex and age on the grits retained in the gizzards of Hooded and White-naped Cranes.

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