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**Original paper**

# Vocal repertoires of coypus (*Myocastor coypus*)

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**Abstract:** Although the caviomorph rodents have a variety of communication patterns, the vocalizations of coypus have not been studied at all. It is not certain whether they communicate vocally or not. In this study, we video recorded coypus in captivity, extracted their calls from the data, and analyzed the frequency and duration of their vocalizations. Their vocalizations were classified into four major types of patterns (fa, kyu, boo, and gaa). In addition, observations during capture and treatment revealed that nutria have two other vocal patterns. Individual differences in vocal quality and tonation were also observed even in the same type calls. These results suggested that coypus engage in a variety of vocal communication for individual identification under natural conditions.

## I. Introduction

Rodents have the most numerous species of mammals with a variety of habitats, survival strategies, and grouping patterns (e.g., Ebensperger & Cofré 2001, Ebensperger & Blumstein 2006). Therefore, communications within groups are also thought to be diverse. Freeberg et al. (2012) proposed "The Social Complexity Hypothesis for Communication (SCHC)," while Lima et al. (2018) considered that SCHC reflects phylogenetic relationships, as the evolution of the caviomorph rodents reflects the diversity of communication methods among species (e.g., Eisenberg 1974, Barros et al. 2011, Lacerda et al. 2013, Amaya et al. 2016, Francescoli 2017). The coypu (*Myocastor coypus*) which belongs to the same parvorder Caviomorpha (infraorder Hystricomorphi) is a well-known invasive alien species in many countries, and its social structure has been studied (e.g., Gosling 1979, Guichón et al. 2003, Mori et al. 2020). However, no studies on vocal communication necessary for understanding their social structure have been made.

The record of coypu's vocalizations is surprisingly old. In "The Naturalist in La Plata," Hudson (1895) noted that coypus engage in vocal communication between parents and juveniles, with both parents and juveniles calling each other. However, since his report, little has been known about coypu's vocalizations, with only Guichón et al. (2003) reporting that wild female coypus made alarm calls. Even Shelley & Blumstein (2005) who reviewed alarm calls made by rodents in general found no vocalization data for coypus.

Thus, although coypus have been observed to vocalize, vocal frequencies and vocalization patterns have not been determined. In this study, we collected and classified various vocalizations of coypus kept at the Department of Zoology, Faculty of Science, Okayama University of Science (OUS), for elucidating the vocalization patterns of coypus.

## II. Materials and Methods

### *1. Animals*

The subject animals were two adult female coypus (individual Nos. 5 and 6) and three adult males (Nos. 7, 8, and 9) kept in Department of Zoology, OUS. Nos. 5 and 6 were from Minami-ku, Okayama City, No. 7 from Kita-ku, Okayama City, and Nos. 8 and 9 from Wake Town, Wake County. Nos. 5, 6, 7, 8, and 9 weighed 5.25, 6.18, 8.06, 6.03, and 5.50 kg, respectively, all of which reached the standard weight of an adult animal at the time of this experiment.

### *2. Room environment*

The animals' room (W: 380 cm × D: 580 cm × H: 270 cm) had no windows, and the indoor room temperature was adjusted to 22-24°C in summer and 20°C in winter with 24-hour ventilation. The light-dark cycle was 12L:12D. Each animal was housed individually in a steel housing cage (W: 63.5 cm × D: 183 cm × H: 74 cm). Inside the housing cage, there were a plastic container for bathing (W: 50 cm × D: 35 cm × H: 36 cm for No.7 only, W: 40 cm × D: 28.5 cm × H: 24 cm for all other animals), and a wooden box.

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The wooden box (W: 31.6 cm × D: 42 cm × H: 31.6 cm) was sized the same as the wild coypu's burrow. Half of the cage was covered with black plastic corrugated cardboard (hereafter referred to as "plaCC") to prevent interference between individuals, and the other half of the cage was also partitioned with plaCC.

### *3. Audio acquisition*

Animals were observed to make a variety of calls during routine caretaking works. Digital video cameras HDR-PJ590 (Sony, Tokyo, Japan) and HDR-CX485 (Sony, Tokyo, Japan) were used for recording. The recordings were made from June 2018 to February 2019. All experiments were made following the Regulations for Animal Experiments of the OUS. Our experimental protocols, including those animals, were approved by the Animal Experiments Committee of the OUS (approval ID: Exp2018-12).

3-1. Steady-state recordings

Steady-state recordings were made for Nos. 5, 6, and 7. The recording time was 20 minutes before the start of caretaking, 20 minutes before feeding, and 20 minutes after feeding, for a total of 60 minutes. Recordings were made three times a day for each animal, from June 19 to September 17, 2018, for a total of three animals at the same time. Nos. 8 and 9 were not included in the data of steady-state recordings because their caretaking started after the end of this recording period. Video cameras were set up so that the inside of the housing cage could be clearly seen (Fig. 1). During recording, plastic containers for bathing, hutches and food dishes in the cage were removed to prevent hiding of animals and the ventilation fan was turned off to prevent noises. At the beginning of each session, the caretakers immediately moved out of the room and the animals were left unattended until the end of recording.

3-2. Continuous recordings

We made continuous recordings during the nighttime to investigate the calls and behaviors of coypus at night, i.e., regarded as their active period (e.g., Mori et al. 2020). Continuous recordings were made in the following two ways.

(1) A video camera was mounted on a tripod and placed in the center of the room to record the calls in the entire room (Fig. 2A). To urge expression of usual behavioral patterns of the animals, the containers for bathing and hutches in the cage were not removed and the ventilation fan was not turned off. Recordings were made on October 5, 2018.

(2) A video camera was set up so that the inside of the cage of No. 5 could be clearly observed (Fig. 2B). We used three supplementary lights (red bulbs 10W & 17W) to illuminate only the cage of No. 5, so that we could check the behavior of No.5 even after the room lights were turned off. The containers for bathing and hutches in the cage were not removed and the ventilation fans were not shut off. To prevent noises and other animals' calls, a sound insulation sheet (120 cm × 95 cm; PVC resin sheet laminated with non-woven fabric) was attached to a plaCC (W: 150 cm × H: 92.4 cm) and placed on both sides of the video camera. Recording was made on November 27, 2018.

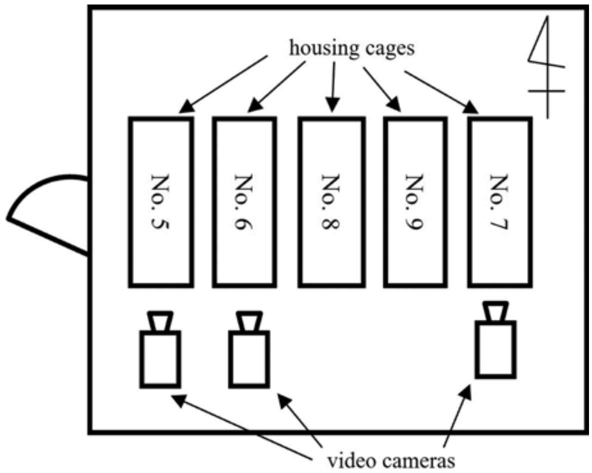


**Fig. 1. Location of the video camera and the housing cages in the animal's room during the steady-state recording.** Each animal was housed individually in a cage.

Recording was started after the end of caretaking and continued until the memory capacity of the camera was full or the battery ran out. The durations of continuous recording were 8 hours 14 minutes 42 seconds for continuous recording (1) and 9 hours 24 minutes 31 seconds for continuous recording (2).

3-3. Pattern recording

Pattern recordings were made for Nos. 5, 6, 7, 8 and 9. We used a video camera to record the sounds made by the animals when they approached each other, when the hutch was removed from the housing cage, or when the caretakers and the animals approached each other. Recordings were made on November 21, 2018, January 15 and 18, 2019 and February 3, 2019.

### *4. Analysis of vocalizations*

The recordings were played back using the video editing software "Movie Maker" (Microsoft, WA, USA). We extracted only the calls when there were few noises in all calls. The frequency, duration and sound pressure level of the calls were analyzed using the sound editing software "WavePad" (NCH Software, CO, USA).

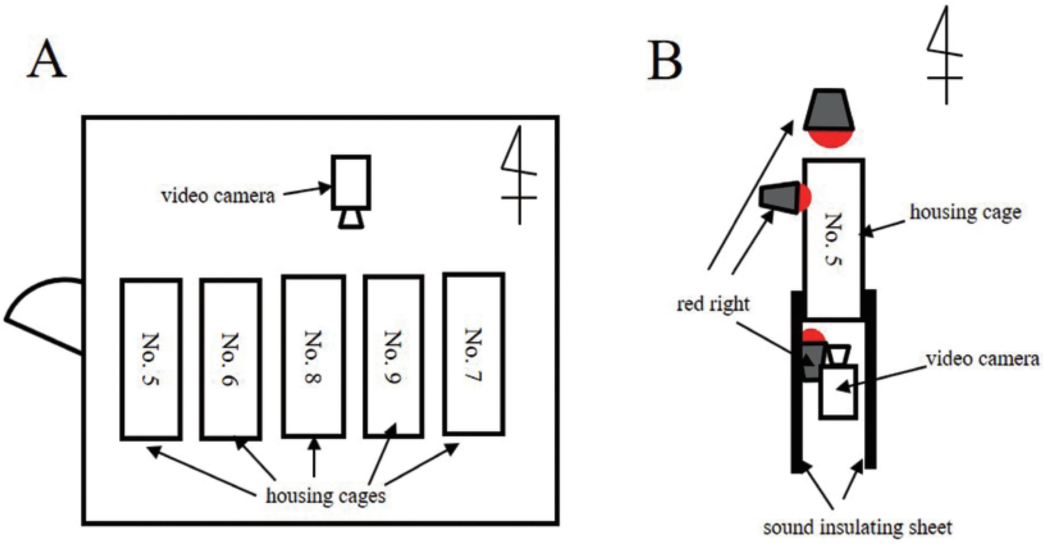


**Fig. 2. Methods of continuous recordings.** (A) Position of the video camera and the housing cages in the animal's room during continuous recording (1). (B) Position of video camera and red light during continuous recording (2). Three red bulbs illuminate only No. 5's cage.

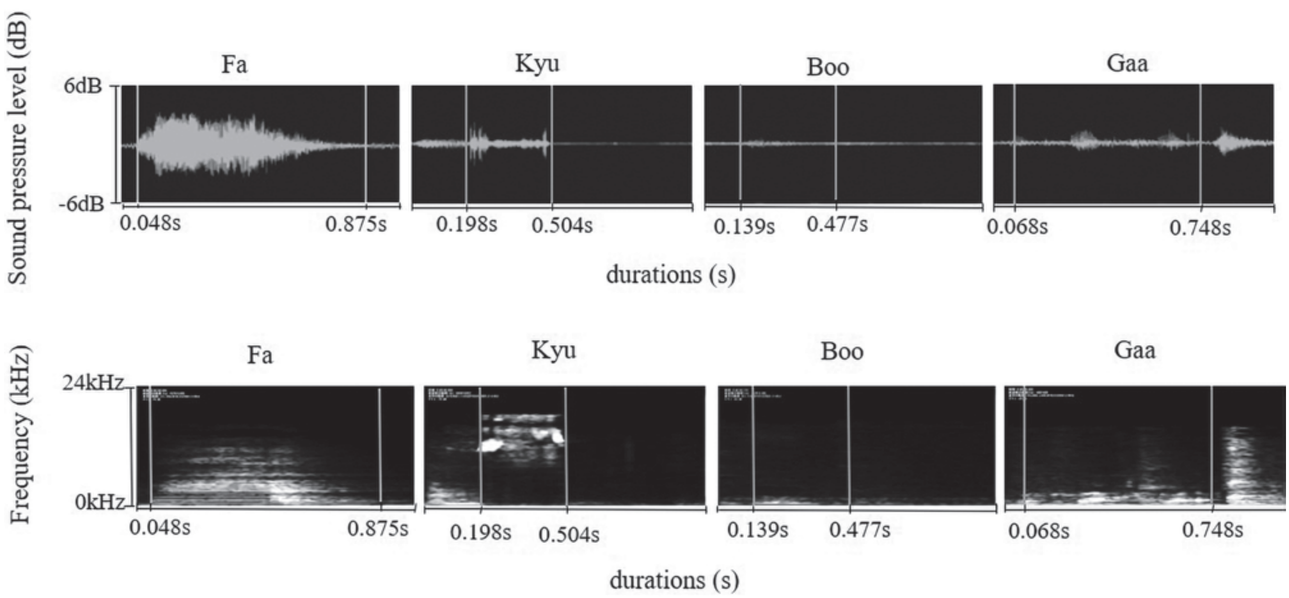


**Fig. 3. Changes in sound pressure level and frequency of all vocal patterns.**

The classified calls were named for each call pattern based on the pronunciation we heard. In all patterns, the highest level of frequency varied, and this was where we focused our attention and found that the frequency of the calls varied from one to another. We tabulated times of the maximum frequencies in vocalization patterns and animal's vocalizations. In case we could not identify which animals made the call, it was recorded as of an unidentified one.

## III. Results

### *1. Vocalization pattern of the calls*

A total of 411 calls were identified, which were classified as fa type (263 times), kyu type (123 times), boo type (21 times), and gaa type (4 times) (Fig. 3, Table 1). Of the calls excluding cases with many noises, 293 calls (fa 187, kyu 93, boo 10, gaa 3) were analyzed for frequency, and 344 calls (fa 243, kyu 91, boo 6, gaa 3) for average duration (Tables 2 & 3).

### *2. Steady-state recordings*

A total of 89 calls were confirmed in the steady-state recordings. The fa and boo calls were recorded. The number of calls confirmed was 0, 6, and 34 for Nos. 5, 6, and 7 before the start of caretaking, 1, 19, and 21 calls for Nos. 5, 6, and 7, respectively, before feeding, and 3, 2, and 7 calls for Nos. 5, 6, and 7 calls after feeding. No. 7 made 3 calls. In other words, No. 5 vocalized

**Table 1. Total number of vocal patterns of the calls (N = 411).**

| | | Number of vocal patterns | | | |
|---|---|---|---|---|---|
| Audio acquisition | Animal ID | Fa | Kyu | Boo | Gaa |
| Steady-state recording | No. 5 | 3 | 0 | 1 | 0 |
| | No. 6 | 24 | 0 | 3 | 0 |
| | No. 7 | 58 | 0 | 0 | 0 |
| Continuous recordings (1) | Unidentified | 79 | 88 | 13 | 0 |
| Continuous recordings (2) | No. 5 | 19 | 0 | 2 | 0 |
| | Unidentified | 80 | 33 | 1 | 0 |
| Pattern recording | No. 5 | 0 | 0 | 0 | 2 |
| | No. 8 | 0 | 0 | 0 | 2 |
| | No. 9 | 0 | 2 | 1 | 0 |
| Total | | 263 | 123 | 21 | 4 |

more after feeding, No. 6 most before feeding, and No. 7 most before the start of caretaking, indicating different times of day when they were most frequently vocalized.

The fa calls were recorded from all animals. They were made 85 times in total: 3 times for No. 5, 24 times for No. 6, and 58 times for No. 7 (Table 1). The maximum frequency ranged from 1.9 to 13.5 kHz (N = 35). The sound frequency of No. 5 ranged from 1.9 to 5.3 kHz (N = 2), that of No. 6 ranged from 6.7 to 9.8 kHz (N = 12), and that of No. 7 ranged from 8.8 to 13.5 kHz (N = 21), showing that the frequency range differed among animals (Table 2). The average duration was 0.807 seconds (N = 85). Comparing each animal, No. 5 vocalized for 0.717 seconds (N = 3), No. 6 for 0.779 seconds (N = 24), and No. 7 for 0.822 seconds (N = 58) (Table 3).

The boo calls were recorded from Nos. 5 and 6. In total, boo calls were made four times; once by No. 5, three times by No. 6 (Table 1). The maximum frequency of the calls ranged from 0.4 to 2.0 kHz (N = 3). The frequency of No. 5 was 2.0 kHz (N = 1), and frequency of No. 6 ranged from 0.4 kHz to 1.6 kHz (N = 2), showing little difference (Table 2). The average duration of the calls was 0.888 seconds (N = 4). The average duration was 2.322 seconds (N = 1) for No. 5 and 0.410 seconds (N = 3) for No. 6, i.e., with a considerable difference compared to the fa (Table 3).

### *3. Continuous recording*

The total number of all calls made in the recording series were 296 calls [180 in series (1) and 116 in (2)]. In both series (1) and (2), the patterns of fa, kyu, and boo calls were recorded. The numbers of vocalizations in series (1) and (2) were 178 times for fa, 121 times for kyu, and 16 times for boo calls (Table 1). The maximum frequency of fa calls ranged from 1.7 to 12.7 kHz (N = 152), with average duration 0.772 seconds (N = 158). The maximum frequency of the kyu calls ranged from 1.4 to 19.9 kHz (N = 152), with average duration 0.381 seconds (N = 89). The maximum frequency of the boo calls ranged from 1.1 to 2.1 kHz (N = 3), with average duration 1.246 seconds (N = 2).

3-1. Continuous recording (1)

As the continuous recording was made after the lights were turned off, it was difficult to identify animals based on the calls. The number of fa calls was 79 times (Table 1). The frequency of the fa call ranged from 2.8 to 11.5 kHz (N = 75), with average duration 0.834 seconds (N = 78) (Tables 2 & 3). The frequency of kyu calls was 88 times (Table 1). The frequency of the kyu ranged from 2.0 to 13.8 kHz (N = 60), with average duration 0.419 seconds (N = 62) (Tables 2 & 3). The number of boo calls was 13 (Table 1). The frequency of the boo ranged from 1.1 kHz to 1.8 kHz (N = 5), with average duration 2.021 seconds (N = 1) (Tables 2 & 3).

3-2. Continuous recording (2)

It was difficult to identify the calls other than those uttered by No. 5 in the dark. The number of fa calls was 19 for No. 5 and 80 for the unidentified animals (Table 1). The frequencies of fa calls ranged from 5.5 to 12.7 kHz (N = 15) for No. 5, and from 1.7 to 9.0 kHz (N = 62) for the unidentified (Table 2). The average duration of fa calls was 0.680 seconds (N = 17) for No. 5, and 0.720 seconds (N = 63) for the unidentified (Table 3). The number of kyu calls (unidentified) was 33 times (Table 1). The frequencies of kyu calls ranged from 1.4 to 19.9 kHz (N = 31), with average duration 0.292 seconds (N = 27) (Tables 2 & 3). No. 5 made two boo calls and an unidentified animal made one boo call (Table 1). The frequency of the boo call was 2.1 kHz (N = 1) for the unidentified, with average duration 0.470 seconds (N = 1) for No. 5 (Tables 2 & 3).

### *4. Pattern Recording*

The pattern recordings of kyu, boo, and gaa calls were made seven times in total (Table 1).

The kyu calls were twice (Table 1). The frequency of the call made by No. 9 on January 15 was 18.2 kHz with the duration of 0.333 seconds (Tables 2 & 3). On February 3, No. 9 emitted a call with a frequency of 12.4 kHz with the duration of 2.687 seconds (Tables 2 & 3). The call

**Table 2. Range of maximum frequency (kHz) of calls collected by all recording methods that were analyzable with few noises (N = 293).**

| | | Range of maximum frequency (kHz) of vocal patterns | | | |
|---|---|---|---|---|---|
| Audio acquisition | Animal ID | Fa (N = 187) | Kyu (N = 93) | Boo (N = 10) | Gaa (N = 3) |
| Steady-state recording | No. 5 | 1.9 - 5.3 (N = 2) | 0 | 2.0 (N=1) | 0 |
| | No. 6 | 6.7 - 9.8 (N = 12) | 0 | 0.4 - 1.6 (N=2) | 0 |
| | No. 7 | 8.8 - 13.5 (N = 21) | 0 | 0 | 0 |
| Continuous recordings (1) | Unidentified | 2.8 - 11.5 (N =7 5) | 2.0 - 13.8 (N=60) | 1.1 - 1.8 (N=5) | 0 |
| Continuous recordings (2) | No. 5 | 5.5 - 12.7 (N = 15) | 0 | 0 | 0 |
| | Unidentified | 1.7 - 9.0 (N = 62) | 1.4 - 19.9 (N=31) | 2.1 (N=1) | 0 |
| Pattern recording | No. 5 | 0 | 0 | 0 | 2.8 - 6.1 (N=2) |
| | No. 8 | 0 | 0 | 0 | 13.5 (N=1) |
| | No. 9 | 0 | 12.4 - 18.2 (N=2) | 4.7 (N=1) | 0 |

**Table 3. Durations (in seconds) of calls collected by all recording methods that were analyzable with few noises (N = 344).** For the steady-state and continuous recordings, it was expressed as the average duration. Only for the pattern recording, the duration was expressed for each day of recording. Durations and standard deviations were rounded off to the fourth decimal places.

| | | Durations (in seconds) of vocal patterns | | | |
|---|---|---|---|---|---|
| Audio acquisition | Animal ID | Fa (N = 243) | Kyu (N = 91) | Boo (N = 6) | Gaa (N = 3) |
| Steady-state recording | No. 5 | 0.717 ± 0.110 (N = 3) | 0 | 2.322 (N = 1) | 0 |
| | No. 6 | 0.779 ± 0.095 (N = 24) | 0 | 0.410 ± 0.117 (N = 3) | 0 |
| | No. 7 | 0.822 ± 0.069 (N = 58) | 0 | 0 | 0 |
| Continuous recordings (1) | Unidentified | 0.834 ± 0.149 (N = 78) | 0.419 ± 0.120 (N = 62) | 2.021 (N = 1) | 0 |
| Continuous recordings (2) | No. 5 | 0.680 ± 0.117 (N = 17) | 0 | 0.470 (N = 1) | 0 |
| | Unidentified | 0.720 ± 0.140 (N = 63) | 0.292 ± 0.120 (N = 27) | 0 | 0 |
| Pattern recording | No. 5 | 0 | 0 | 0 | (Nov. 21) ① 0.697, ② 0.804 |
| | No. 8 | 0 | 0 | 0 | (Jan. 15) 0.678 |
| | No. 9 | 0 | (Jan. 15) 0.333 (Feb. 3) 2.678 | 0 | 0 |

made by No. 9 on January 15 was confirmed when it approached No. 5 in the adjacent cage after the removal of plaCC for cleaning the room. Immediately before that, a boo call was made.

The boo call was once (Table 1). The frequency of the call made by No. 9 on January 15 was 4.7 kHz (Tables 2 & 3). The call made by No. 9 on January 15 was confirmed when it approached

No. 5 after the removal of the plaCC between the two animals. No. 9 made a kyu call immediately after the boo call.

The gaa calls were 4 times (Table 1). The calls were confirmed for Nos. 5 and 8. No. 5 made two calls [(1) and (2)] on November 21 (Table 1). The frequency of the gaa (1) was 2.8 kHz with duration 0.697 seconds (Tables 2 & 3). The frequency of the gaa (2) was 6.1 kHz with duration 0.804 seconds (Tables 2 & 3). Both kyu (1) and (2) were confirmed when the caretaker attempted to feed the animals through the cage. No. 8 made two gaa calls. The duration of the gaa call on January 15 was 0.678 seconds (N = 1) (Table 3). This call was confirmed when the hutch in the housing cage was moved. The frequency of the gaa call made on January 18 was 13.5 kHz (N = 1) (Table 2). This call was confirmed when the caretaker touched the rostrum of No. 8 before feeding.

## IV. Discussion

The present study allowed us to record four call patterns of coypus for the first time. Furthermore, in a series of attempts to capture coypus and keep them in captivity for life, we observed that the animals clicked their teeth when approached by their captors and emitted a roar-like sound when they were treated for wounds. Therefore, if we add these to their vocal repertoires, coypus can use at least six different types of vocal sounds. Barros et al. (2011) recorded seven repertoires of sounds made by capybaras (*Hydrochoerus hydrochaeris*), another semiaquatic rodent from South America, and classified them into five functional categories: isolation call, contact call, alarm call, distress call, and agonistic call, based on their behavioral context. Although based on data from animals separately housed indoors, the behavioral context was not clear in many cases. It is nevertheless possible to analyze functions with respect to some patterns of coypu's vocalizations.

The boo calls were made infrequently and only when the animals were approaching each other. When No. 9 (male) approached No. 5 (female) in the adjacent cage in pattern recording, No. 9 produced this boo call and switched to the kyu when it recognized the presence of No. 5. It suggests that the boo call may have the function of maintaining an appropriate distance from neighboring animals during foraging. This inference can be well explained by the following episode. When Kobayashi, one of the authors, was doing fieldwork in reed thickets with little visibility in the Kinkai Salt Field in Setouchi City, Okayama Prefecture, where many coypus live, this boo call approached from behind the thicket. He imitated the call, the caller stopped approaching and left the area. The coypu's eye structure is adapted to recognizing large shadows of distant predators rather than viewing objects in detail (Miyazaki et al. 2022). Thus, for example, if they move through a grassland, it would be difficult for them to identify other individuals approaching by sight alone. These suggest that the boo call was likely a contact call. The gaa call was uttered only when the caretaker approached Nos. 5 and 8. Both were in an agitated state at the time, suggesting that it was most likely an alarm call with a threatening nature.

The fa call was frequently recorded without the approach of other animals or caretakers, and it accounted for most of the total number of calls compared to the other calls (Table 1). In Table 1, this call was recorded quite a few times by several animals during steady-state recordings. We are not sure if it is whistle, cry or whine. Fa call was frequently made in both conditions of steady-state recording and continuous recording. It was not emitted in the context of direct interaction between animals. It is appropriate to regard them as isolation calls, i.e., a vocalization to convey individuals' location while they are spread and invisible from each other. Rather, the fa call seems like the "coo call" among Japanese macaques (*Macaca fuscata*), a primate species. This call is used to locate each individual in a group while foraging (Sugiura 2007). The large individual differences in frequency suggest that the fa call may convey information about callers. In any case, to elucidate the function of fa calls, it will be necessary to precisely record them under different conditions based on a finely defined behavioral context at the time of recording. In addition, if we apply the classification of Barros et al. (2011), we can consider the clicking of teeth by captive coypus in response to the approach of the captor as an agonistic call, and the roar-like calls made by wounded coypus when being treated as a distress call.

In conclusion, this study showed that coypus have practically six different vocal patterns, along with the identified patterns in the experiments. They use different patterns depending on the context, and these acoustic frequencies considerably differ among them. Our next tasks are to examine whether these six repertoires are also found under natural conditions, and to analyze the frequency with which each pattern is uttered in social situations to elucidate the nature of vocal communication among coypus.

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**八神未千弘・湯川梨沙子・竹ノ下祐二・小林秀司：ヌートリア*Myocastor coypus*の発声レパートリー**

**要約**

齧歯目テンジクネズミ形下目は，種ごとに多様なコミュニケーションをもつことが報告されているが，ヌートリアに関しては，その発声自体が全く研究されておらず，音声コミュニケーションを行うかどうか，はっきりしたことは分かっていない．そこで本研究では，飼育中のヌートリアを録画し，そのデータから鳴き声を抽出して，周波数や継続時間を解析した．その結果，ヌートリアの発声は，大きく分けて４種類（fa型，kyu型，boo型，gaa型）のパターンに分類された．さらに，捕獲や治療の際の観察で，ヌートリアには他に２つの発声パターンがあることが明らかになった．同じ鳴声でも声質やイントネーションに個体差が見られた．これらのことから，ヌートリアは，自然条件下では個体識別を伴う多様な音声コミュニケーションを行っていると推定された．

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