Summary

Sound variation and function in Commerson's dolphin (*Cephalorhynchus commersonii*)

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Commerson's dolphin is the smallest dolphin inhabiting the Southern South America and Keruguelen Islands. Most of the small toothed whales produce both pulse sounds mainly for echolocation and whistle mainly for intra-specific communication. However, this species produces only narrow-band high-frequency (NBHF) pulse sounds, and no whistle. There are no reports of acoustic communication in Commerson's dolphin using NBHF pulse sounds. This study aimed to clarify sound variation of Commerson's dolphins and the relationship between the sound type and behaviour both in captive and wild conditions to infer the function of each sound type.

I defined a click-train as a group of sequential pulses separated from other pulses by an ICI > 100 ms. The recorded click-trains were categorised into the following four types based on the changing pattern of their ICI: Decreasing type, with continuously decreasing ICI during the last part of the train; Increasing type, with continuously increasing ICI during the last part; Fluctuating type, with fluctuating ICI; and Burst-pulse type, with very short and constant ICI. We have no previous reports on click trains corresponding to the Increasing type in Commerson's dolphin. From the changing pattern of ICI, functions of each click-train types were estimated.

I analysed the relationships between click-train types and dolphin behaviours, especially those during approaching behaviour to the newly introduced object or other dolphin to infer the function of each click-train type in the Toba Aquarium on December 27–28, 2007. During the approaching behaviour to the object, the frequency of the Decreasing type gradually increased and suddenly decreased after the dolphin passed by the object and the Burst-pulse type suddenly increased in front of the object when the dolphin directed its face to the object in many cases. During the approaching behaviour to the other dolphin, both the Increasing type and the Burst-pulse type increased. Based on these results, the functions of each types were suggested as follows, Burst-pulse type; the short-range echolocation rather than those for communication, Increasing type; some function as communication signal, possibly for initiating social behaviour, Decreasing type; the echolocation sound for the recognition of a particular target during the approach to the target, Fluctuating type; the echolocation sound for scanning a wide range of

space in front of the dolphin during their swim. So, I analysed the behavior observed during emissions of the 2 possible communication sounds estimated from previous study, the Burst-pulse type and Increasing type click-trains at the Marinepia Matsushima Aquarium, Japan. In the diel change in the frequencies of the behavioural state of the dolphins and the two types of click-train, the highest peak of the Increasing type corresponded to the highest peak of social swimming. The highest peak of the Burst-pulse type corresponded to that of solo play and the second highest peak of social swimming. During the emission of the Burst-pulse type and the Increasing type, approaching behaviour to other dolphins was observed more often than expected from the rate of this behavior in total observation time. The Burst-pulse type was suggested to have multiple functions, short-range echolocation and communication such as the calls for social swimming . The Increasing type was suggested to have the functions as communication signals related to the affiliative social behavior.

Sound and behavior records of wild Commerson's dolphins in Fitzroy Strait, Southern Chile were collected and analyzed. The study was conducted from March 1 to 25, 2011 and from March 1 to 28, 2012 during the daytime. I compared characteristics of the click-train types and relationship between the click-train types and behaviour with those in captive conditions to infer the function of each type of click-train. I could successfully identify the click-trains similar to those of captive Commerson's dolphins using the same method that I used for the analysis of captive dolphin sounds. I could also categorize all the identified click-trains into the 3 of 4 types I defined in the study on captive dolphins, though the Burst pulse type was not recorded, indicating that we can identify and analyze click-trains recorded from wild dolphins using this method.

The peak in ICIs distribution of the wild dolphin sifted toward longer side from that of the captive dolphins, suggesting that echolocation range in the wild was longer than in the captive. The mean ICI was longer than those of the captive dolphins in all 3 click-train types, suggesting that the Increasing type also have echolocation function. The relationship between the sound type and the behavior could be explained from the functions of each sound type estimated from my studies on captive dolphins.

I clarified the sound variation of Commerson's dolphins and estimated the functions of each sound types from the relationship between the sound type and behaviour both in captive and wild conditions. The results strongly suggested the acoustic communication in this species with pulse sounds.