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Yawning in wild Indo-Pacific bottlenose dolphins (*Tursiops aduncus*)

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Abstract. Yawning is defined as an involuntary behavior with breathing, characterized by a slow opening of the mouth with inhalation, followed by a maximum gaping phase, and ending with a short exhalation and closing of the mouth. Recent reports on yawning in marine mammals (common bottlenose dolphins and a dugong) have challenged this definition because these marine mammals yawn underwater without breathing. However, yawning in marine mammals has only been studied in captive conditions, which indicates the possibility that yawning is an abnormal behavior in captive animals. Here, we report yawning in free-ranging wild Indo-Pacific bottlenose dolphins off Mikura Island, Japan. Five yawns that occurred between 8:00 am and 10:30 am were identified from 1816 hours of video data. The dolphins in this population may exhibit more resting behaviors in the morning, which implies that yawning in this population occurred in resting states that required arousal. This is the first reported observation of yawning in Indo-Pacific bottlenose dolphins. The occurrence of yawning in a wild population suggests that it is an innate behavior, rather than abnormal behavior, in dolphins.

Key words: involuntary action, open-mouth behavior, resting.

Yawning is an involuntary action that can be divided into three phases: Phase 1 starts with the opening of the mouth with inhalation; Phase 2 involves maximum mouth opening, which is maintained for a short period; and Phase 3 ends with the quick closing of the mouth with exhalation (Barbizet 1958). Yawning is considered to serve physiological functions, such as promoting arousal (in African elephants, *Loxodonta africana*, and humans, *Homo sapiens*) (Guggisberg et al. 2010; Rossman et al. 2017), drowsiness (in gray-cheeked mangabeys, *Cercocebus albigena*; crab-eating macaques, *Macaca fascicularis*; and American sea lions, *Otaria flavescens*) (Deputte 1994; Palagi et al. 2019), state change (e.g., wakefulness to sleep, sleep to wakefulness, alertness to boredom), and changing temperature or ear pressure (in humans) (Guggisberg et al. 2010; Massen et al. 2014), as well as social functions, such as communication and inter-group coordination (in humans; and wild geladas, *Theropithecus gelada*) (Guggisberg et al. 2010; Gallo et al. 2021). We found that captive common bottlenose dolphins, *Tursiops truncatus*, and dugongs, *Dugong dugon*, which are fully aquatic mammals, exhibit yawn-

ing (Enokizu et al. 2021, 2022). Yawning in these aquatic mammals occurs during their resting states, requiring arousal, and it has been suggested that yawning in fully aquatic mammals is the same behavior as that in terrestrial mammals such as humans. However, previous yawns in these fully aquatic mammals were observed in captive animals; therefore, the possibility of observing a specific behavior, such as stereotypic or repetitive behavior, in captive animals could not be excluded. The observation of yawning in wild fully aquatic mammals will exclude the possibility of captive-specific behavior and confirm the presence of yawning in fully aquatic mammals. In this study, we report five cases of yawning in free-ranging Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) off Mikura Island using video recordings over six years.

Materials and methods

The present study was conducted on a population of free-ranging wild Indo-Pacific bottlenose dolphins that live year-round in shallow coastal areas (2–30 m in depth)

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off Mikura Island (33°52'N, 139°36'E; shoreline approximately 16.8 km, area 20.58 km²). An individual identification study (ID study), organized mainly by the Mikurashima Tourism Association, using underwater video has been conducted on this population using swim-with-dolphin boats since 1994 from spring to early autumn (Kogi 2013), and the video data from 2012 to 2017 were used in this study. Boats were used to search for dolphins in a 300 m offshore area at depths of approximately 2–45 m. Once the dolphins were found, one to several videographers and other underwater observers skin-dived to record the dolphins for individual identification using various cameras (e.g., SONY HDR-CX430, HDR-SR12, HDR-CX590, and HDR-XR550) with underwater housing. One trip was conducted three times per day between 6:00 am to 5:00 pm. The total number of individuals identified in each year was 115 in 2012, 118 in 2013, 123 in 2014, 131 in 2015, 140 in 2016, and 143 in 2017.

To identify yawning, we used the method developed by Enokizu et al. (2021) to select yawning in aquatic mammals. For the data from 2014 to 2016, we checked the timing of the occurrence of open-mouth behaviors using ID sheets, in which the ID study from 2014 to 2016 noted the time of open-mouth behaviors. For the data from 2012 to 2013, we visually searched for open-mouth behaviors in the videos. After obtaining a video of open-mouth behaviors, we differentiated yawning from other behaviors using the method proposed for common

bottlenose dolphins (Enokizu et al. 2021) as follows: 1) open-mouth behaviors with three clear phases were selected; 2) in the three phases, phase 1 had a longer duration than phase 3; and 3) maximum mouth opening was reached in phase 2. The duration of each phase was measured on a millisecond timescale using video management software (SONY PlayMemories Home ver. 6.0, Tokyo Japan). The frame rate of the recorded data was 29.97 fps.

Results

We identified 94 instances of open-mouth behaviors from 1816 hours of video data (six cases in 2012, 34 in 2013, 37 in 2014, one in 2015, 10 in 2016, and six in 2017). We selected five out of the 94 open-mouth behaviors as yawning (Supplementary Video). The remaining 89 open-mouth behaviors were purposeful behaviors (e.g., threat behavior toward another individual, feeding behavior when biting fish, or social behavior such as play-biting with another individual). These five yawnings were observed in four individuals (with ages ranging from a one-year-old neonate to an over 18-year-old adult; three females and one male; Table 1). Yawning was infrequent and the average duration with standard deviation of the five yawnings was 1.87 ± 0.75 s (Phase 1: 0.84 ± 0.70 s; Phase 2: 0.80 ± 1.06 s; Phase 3: 0.23 ± 0.30 s; Fig. 1, Table 1) and all five yawn-like behaviors occurred between 8:00 am and 10:30 am.

Table 1. Information of the five cases of yawning including date and time, individual ID and sex, and yawning durations

Case	Date	Time (h:m:s)	ID	Sex	Duration (s)			
					Total	Phase1	Phase2	Phase3
1	2012/8/23	10:04:51	#033FA	F	3.09	0.14	2.84	0.11
2	2012/8/23	10:06:06	#033FA	F	1.03	0.11	0.84	0.08
3	2013/7/29	8:59:13	#636FN	F	1.17	1.00	0.11	0.06
4	2014/7/24	9:27:48	#601FS	F	1.85	0.92	0.10	0.83
5	2016/8/18	9:27:18	#408MA	M	2.19	2.02	0.10	0.07
Average					1.87	0.84	0.80	0.23
Standard deviation					0.75	0.70	1.06	0.30

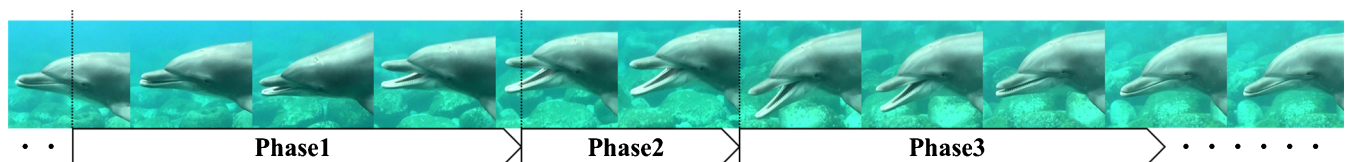


Fig. 1. Sequence of yawning in wild Indo-Pacific bottlenose dolphins: phase 1, slow mouth opening; phase 2, maintaining maximum mouth opening; phase 3, quick closure. The photos were taken by T.M. outside the study period.

Discussion

In this study, we confirmed the presence of yawning in wild Indo-Pacific bottlenose dolphins, suggesting that yawning in dolphins occurs irrespective of their condition (captive or wild). Yawning is therefore not a specific behavior of captive dolphins but an innate behavior. This is the first report of yawning in this species.

The behavioral states of the individuals and groups during yawning could not be studied because of the short duration of the video footage before and after yawning and the scarcity of this behavior. All the yawns reported here occurred in the mid-morning (from 8:00 am to 10:30 am). Hasegawa (2003) reported that 60% of dolphin groups in this population exhibited a resting state in the mid-morning, implying that yawning in the wild Indo-Pacific bottlenose dolphins off Mikura Island occurred during the resting states. Yawning in mammals, including common bottlenose dolphins, mainly occurs during drowsy or resting states, which require arousal (e.g., Deputte 1994; Palagi et al. 2019; Enokizu et al. 2021). Further research is needed to elucidate the function of yawning in wild Indo-Pacific bottlenose dolphins by examining the behavioral states of the individuals that exhibit yawning and discuss whether the yawning observed in this study is the same behavior as that observed in terrestrial mammals.

Supplementary data

Supplementary data are available at *Mammal Study* online.

Supplementary Video. Five cases of yawn-like behaviors in wild Indo-Pacific bottlenose dolphins off Mikura Island.

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