Short Note

First Record of Conspecific Aggression in Dugongs (*Dugong dugon*) in Thailand

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Conspecific aggression, an attempt to injure conspecifics or a display of intention to do so (Nelson, 2005), may have a substantial impact on relationships and interactions. It can entail several costs, such as risk of injury or death, physiological stress, energy expenditure, increased risk of attracting predators, and mother-juvenile separation, as well as time allocation trade-offs with other survival-related activities, such as feeding (Le Boeuf & Campagna, 1994; Ross & Wilson, 1996; Barnett et al., 2009; Cotter et al., 2011; Georgiev et al., 2013). Conspecific aggression, especially male-male aggression, is commonly driven by competition for resources such as food, territory, and mates (Le Boeuf, 1974; Kato, 1984; Neumann, 1999; Connor et al., 2005; Fitzpatrick et al., 2012; Honeywell & Maher, 2017). In this context, the function of aggression is to drive away the opponent from a resource. The expected context of female-male aggression includes apparent aggressive displays as a part of courtship, which demonstrate male quality and facilitate female mate choice (Clutton-Brock & McAuliffe, 2009) and attempts to retain females for copulation (Clutton-Brock & Parker, 1995). Conspecific aggression can also occur during social play in a variety of mammalian species (Blanchard et al., 2003; Hill et al., 2017), which can facilitate the acquisition of behaviors used in feeding, hunting, fleeing, courtship, mating, and fighting (Kuczaj & Eskelinen, 2014). In highly aggressive species, the benefits of aggression probably outweigh the costs (Enquist & Leimar, 1987; Georgiev et al., 2013). Most herbivores do not aggressively compete (i.e., attack and displace others) for plants that are typically low in nutrition, widely distributed,

and difficult to monopolize (van Schaik, 1989; Isbell, 1991; Georgiev et al., 2013).

Conspecific aggression has been documented in a wide variety of marine mammal species (cetaceans: Clapham, 1996; Connor et al., 2000, 2001; pinnipeds: Le Boeuf, 1974; Neumann, 1999; Honeywell & Maher, 2017; fissipeds: Taylor et al., 1985; Ivanov et al., 2020). Agonistic behavior is also present in sirenians (dugongs and manatees). Sirenians are herbivorous marine mammals. It has been suggested that the agonistic behavior of dugongs (Dugong dugon) is more intense compared to other sirenian species (Marsh et al., 2011). Dugongs exhibit sexual dimorphism of tusks, whereas manatees do not have tusks (Domning & Beatty, 2007). Most adult dugongs exhibit heavy scars and receive new scars each year (Lanyon et al., 2021), and the distance between paired parallel scars corresponds to the spacing between dugong tusks (Preen, 1989; Anderson, 1995). Male Florida manatees (Trichechus manatus latirostris) collide with each other for the nearest location to an estrous female. These collisions do not typically result in injury (Hartman, 1979). To our knowledge, only one report has documented agonistic behavior in other manatee species-namely, the ramming, pushing, and approaching of divers by Antillean manatees (Trichechus manatus manatus) participating in an estrous herd (Harms-Tuohy & Tuohy, 2018).

Despite the indirect evidence suggesting the aggressiveness of dugongs, agonistic behavior of this species has been minimally described owing to the limits of direct observation imposed by their short surfacing intervals and use of frequently turbid inshore waters. In one rare observation, dugongs were observed remaining in one spot and engaging in a continuous bout of violent clashes characterized by explosive splashes, tail thrashing, body rolls, and body lunges (Preen, 1989). Anderson (1997) reported that dugongs charged and rammed against each other at high speed, rolling below and at the water surface. Such agonistic encounters have often been explained as a behavior that occurs in a reproductive context (Anderson & Birtles, 1978; Preen, 1989). Mature adults in subtropical areas acquire the greatest number of fresh tusk wounds during the mating season, which suggests that their tusks aid in aggressive male–male competition for access to mates and/ or in mating with females (Lanyon et al., 2021).

Drones are increasingly utilized for behavioral studies of wild aquatic mammals (Torres et al., 2018; Fiori et al., 2020; Hartman et al., 2020), a trend that will likely continue. Drone surveys possess distinct advantages over manned aerial- and boat-based surveys, including cost efficiency and enhanced maneuverability. Consequently, drone use enhances the quantifications of animal behavior using objective indicators, including velocity and location, thereby facilitating comparative analysis of behavioral traits. Given these circumstances, it is important to accumulate knowledge regarding behaviors and associated parameters, particularly when the behavior can play a crucial role in life history; however, these aspects still need to be thoroughly explored.

This short note presents the first documentation of the agonistic behavior of dugongs in a tropical Asian region. A relatively comprehensive report of agonistic interactions can help provide a baseline for future behavioral research on this species.

Agonistic behaviors were opportunistically observed twice on 2 and 4 May 2022 (hereinafter referred to as event 1 and event 2, respectively) as a part of a study on feeding ground utilization by dugongs at Talibong Island, Thailand (Figure 1). Previous surveys have estimated a population of 120 dugongs around this island, representing the largest population in Thailand (Hines et al., 2005). The occurrence of a mating season in this area is unknown. Both events occurred in an intertidal seagrass bed (7° 13' 05" N, 99° 23' 50" E; tidal range: 0 to 3 m) when the tide was coming in. This area is mostly utilized by solitary adults (Ichikawa et al., 2012). Both events involved two pairs of different individuals (hereinafter referred to as initiator and opponent), both of which were solitary before and after the events. Considering that dugong calves usually accompany adults (Anderson, 1981, 1998; Adulyanukosol et al., 2007), all the individuals involved were presumably adults or subadults. Both events were recorded on video footage using a commercial drone (Mavic 3; Da-Jiang Innovations Science and Technology Co., Ltd., Shenzhen, China) at an altitude of 40 to 100 m (the supplemental video for this short note is available on the



Figure 1. Talibong Island in Thailand, with locations where events were initiated indicated. Created using data provided by Natural Earth (https://www.naturalearthdata.com/downloads/10m-physical-vectors).

Aquatic Mammals website). We did not observe apparent behavioral responses to the drone (i.e., changes in behavior or possible fleeing). The mutual interactions apparently ended in separation, wherein both individuals swam in opposite directions. Continuous observations were performed for approximately 3 min until the observer was unable to keep the individuals within the field of view. After 5 to 18 min of interruption, the locations and behaviors of each individual were recorded by photography and videography using the drone. Each individual was identified by matching its body scarring pattern (Anderson, 1995).

The tracks of individuals responsible for the events were reconstructed from the videos. Photoshop, Version 24.1.1 (Adobe Systems Inc., San Jose, CA, USA), was used for image analysis. Frames at 1-s intervals were extracted for 191 s in each event. As each image frame was captured at different altitudes and positions, its spatial scale and position were standardized using a georeferenced aerial image (orthophoto) of the study area generated as a part of the feeding ground survey. Each frame was manually transformed by rotating, rescaling, and translating, and then they were overlaid on the orthophoto so that seagrass patches in the frame matched those in the orthophoto. We then marked the snout of the dugong in each frame overlaid on the orthophoto. A track is defined as a line connecting the time series of the snout positions. Each event was broken down into stages; the timing of both events (m:ss) was defined as the time elapsing since we started to observe the first behavioral stage (event 1) or the second stage (event 2). The start time of event 2 was set to the second stage because it was not clear when the observation of the first stage started. The snout position at 1-s intervals was unavailable for some periods (0:02 to 0:16, 0:20 to 0:22, 0:41 to 0:45, and 0:54 to 0:58 in event 2), either because (1) the observer failed to keep the dugong within the field of view or (2) the dugong was hidden in the cloud of gray sediments raised by the other dugong. Tracks during these periods were estimated by tracing sediment clouds. The swimming speed was calculated by dividing the length of the track by the time interval of the frames.

The body length ratio between the individuals involved was measured using a video of each event. We extracted frames from the videos (five frames for each event) in which the bodies of both individuals were straight. The body length (snout to fluke notch length) ratio of the two individuals was calculated. The body lengths of the initiators were 1.08 ± 0.04 (n = 5) and 1.21 ± 0.04 (n = 5) times larger than those of the opponent in events 1 and 2, respectively.

The absolute body length of the initiator in each event was estimated when it was photographed opportunistically with objects of known sizes. Additional video footage of the initiator of event 1 was obtained on 7 December 2022, and that of the initiator of event 2 was collected on 1, 2, and 6 May 2022. The drone was flown over the animal for 1 to 7 min with the camera positioned in a downward orientation at an altitude of 40 m. Frames in which the animal's body was at and in parallel with the water surface were extracted from the videos. Body length was scaled using reference objects in the frames, such as seagrass patches and feeding trails, which were also present in the orthophoto. The absolute body lengths of the initiators were approximately 2.5 m for the initiator of event 1 and 2.2 m, 2.3 m, and 2.4 m for the initiator of event 2 on three distinct occasions.

Event 1 on 2 May included four distinct behavioral stages: (1) approaching, (2) pursuing, (3) agonistic collision, and (4) separating (Figure 2). They swam at a velocity of 2 to 23 km/h, covering a distance of 400 m (Figure 3). A description of the behavioral sequence for the first event is as follows:

- Approaching A dugong (initiator) initiated its approach from more than 30 m away from a feeding dugong (opponent) at 3 to 5 km/h (4.3 ± 0.5 km/h; observation duration:14 s). The opponent stopped feeding and swam away when the initiator was within 20 m from the opponent.
- 2. Pursuing The initiator intensely chased the opponent at 5 to 23 km/h (11.4 ± 5.9 km/h) for 140 m. The initiator attempted to drive its snout (and possibly its tusks if this is a male) across the lower back of the other. When swimming at speeds greater than 17 km/h, the initiator stroked its fluke approximately 2.5 times per second (27 times for 11 s; 2:38 to 2:50).
- 3. Agonistic collision The opponent turned to face the initiator. They rammed into each other in such a way that the opponent rode over the belly of the initiator (Figure 2c) or they used their jaws on each other (Figure 2e). They then remained in one spot and engaged in a continuous bout of violent clashes characterized by splashes and rolls (as stated by Preen, 1989) for several seconds (13 or 9 s in the first and second agonistic collision, respectively; Figure 2c & e). Their bodies were briefly visible in positions such that the upper jaw of one individual was used on the other's upper jaw (Figure 2c) or the ventral side of its body.



Figure 2. Behavioral sequences of event 1. Start time of each stage (m:ss) is defined as an elapsed time since the observation of the first stage ("approaching") was started. (Photos taken from drone footage)



Figure 3. Initiator's track in event 1, colored by swimming speed. The gray solid line shows the opponent's track after separating. Black circles represent where each behavioral stage was initiated. The black square shows positions of the initiator and opponent when they were resigned 5 or 6 min after separating.

- 4. Pursuing The opponent swam away from the site of the collision and was intensely chased by the initiator at 5 to 23 km/h ($13.2 \pm$ 4.6 km/h) for 140 m.
- Agonistic collision They rammed into each other and engaged in another bout of agonistic clashes.
- 6. Pursuing The opponent swam away and was chased by the initiator in a less vigorous manner at 6 to 11 km/h (7.8 ± 1.6 km/h) for 70 m.
- 7. *Separating* The initiator breathed at the surface and slowed down. The dugongs swam in opposite directions.

From 5 to 6 min after separation, the initiator and opponent were seen swimming. The initiator was relatively closer to the shore than the opponent and was approximately 200 m away from the opponent (Figure 3). The initiator and opponent were approximately 100 and 200 m away from the approaching site, respectively.

Event 2 on 4 May included four behavioral stages: (1) approaching, (2) pursuing, (3) rushing and mounting, and (4) separating (Figure 4). Unlike event 1, it did not include an agonistic collision



Figure 4. Behavioral sequences of event 2. Start time of each stage (m:ss) is provided as an elapsed time since the second stage ("pursuing") was initiated. (Photos taken from drone footage)



Figure 5. Initiator's track in event 2, colored by swimming speed. The gray solid line shows the opponent's track after separating. Solid and dotted lines represent the tracks reconstructed at 1-s and 2- to 15-s intervals, respectively. Black circles represent where each behavioral stage was initiated. The black square shows position of the opponent when it was resignted 18 min after separating.

but included rushing and mounting instead. The two dugongs moved at 1 to 22 km/h for 350 m (Figure 5). A description of the behavioral sequence for the second event is as follows:

- Approaching A dugong (initiator) approached from behind a feeding dugong (opponent). The initiator attempted to drive its snout across the lower back of the opponent. The opponent swam away.
- Pursuing The initiator intensely pursued the opponent at 5 to 22 km/h for 340 m (mean and standard deviation were not provided here since the 1-s intervals track was not available during some periods in this stage). When

chasing from a distance (e.g., 48 m at 0:44 and 43 m at 0:54 in event 2), the initiator possibly followed the cloud of sediments raised after the opponent swam (i.e., not swimming straight towards the opponent; upper inset of Figure 4b). The initiator was swimming with its ventral side facing downwards (hereinafter called ventral swimming) throughout the observation, while the opponent was occasionally swimming on its side (tilted 90° with its lateral side facing downwards, hereinafter called side-ventral swimming; event 1: Figure 2d; event 2: middle inset of Figure 4b). The clouds of sediments were less visible after side-ventral swimming (middle and lower insets of Figure 4b).

- 3. *Rushing and mounting* While the opponent slowed down while breathing at the surface, the initiator accelerated and rode up over the opponent's back from behind. The opponent swam swiftly away from the initiator.
- 4. Pursuing The initiator chased the opponent less intensely at 4 to 8 km/h (5.9 ± 1.7 km/h) for 10 m.
- Separating The initiator slowed down and turned. The dugongs swam in opposite directions.

The opponent was observed swimming 500 m away in the offshore direction from the site of approaching after 18 min (Figure 5).

Both events met a narrow definition of aggression: an attempt to injure the other or a display of the intention to do so (Hinde, 1969; Nelson, 2005). Dugongs are not conspicuously sexually dimorphic, although tusks erupt in the upper jaws of adult males. While the tusks were not directly observed, the events included an attempt to drive the jaws and possibly the tusks, if present, across the other animal ("pursuing" and "agonistic collision" in event 1 and "approaching" in event 2). It may be possible to assume the sex of a dugong that applies its upper jaw to another animal (the initiator and opponent in event 1 and the initiator in event 2) is male. Consequently, event 1 could be a male-male competition, and event 2 could be a male-male or female-male competition.

The events were distinguishable from the successful mating behavior described in the two most reliable reports (Adulyanukosol et al., 2007; Infantes et al., 2020), primarily in the briefness of physical contact and swimming speed. Both researchers described that the mating behavior included an approaching and stimulating stage in which a male approached a female and "touched" the ventral or muzzle side (chest, belly, and especially the genital region) of females using his muzzle. Dugongs engaging in presumably approaching and stimulating behavior were swimming while maintaining body contact (embracing or touching) for more than 2 min (see video shared by Infantes et al., 2020). We did not observe prolonged bodily contact but, instead, brief and more violent contacts such as an attempt by the initiator to drive its snout across the lower back ("pursuing" in event 1 and "approaching" in event 2) or ventral side ("agonistic collision" in event 1) of the other, and rushing and riding up over the opponent's back from behind ("rushing and mounting" in event 2). Side-ventral swimming demonstrated by the opponents may be a sign of a serious escape attempt. This could be an attempt to prevent a

cloud of sediments from rising and to shake off the initiator that was presumably following the cloud. Furthermore, dugongs engaging in aggression swam faster throughout the event than those engaging in successful mating in other studies. For instance, the fluke-stroke rate of a male engaging in mating behavior was approximately 0.3 times per second (0:44 to 0:50 in the video shared by Infantes et al., 2020), which was much lower than that of the initiator engaging in pursuing.

There remains the possibility that event 2 was an unsuccessful attempt to mate. Riding on another animal's back, possibly using its tusk (in rushing and mounting), could be interpreted as an attempt to physically restrain a female to copulate, perhaps to increase the chances of the female mating with the individual (Clutton-Brock & Parker, 1995). Holding and riding on the backs of females is one of the features of suspected mating behavior. This is supported by the fact that adult females have considerably more tusk punctures than adult males, which are mostly distributed around the dorsal and lateral head regions (Lanyon et al., 2021).

Both events appeared to be non-playful rather than playful aggression. The criteria for play include (1) not being fully functional and, therefore, not contributing to the immediate purpose; (2) repetitive but not rigid, as in stereotypic behavior; and (3) occurring in a supportive or benign environment (not during other behavioral states such as feeding, breeding, or defense; Bekoff & Byers, 1981; Burghardt, 2006; Kuczaj et al., 2012; Hill et al., 2017). The events do not clearly meet these requirements and, further, the opponents were interrupted during feeding and were displaced from their original locations.

The opponent in event 2 did not exhibit aggressive behavior. This can be explained by the avoidance of unnecessary fights as observed in many animal species (Field et al., 2005). Differences in fighting ability (e.g., advantage conferred by larger size [Owen-Smith, 1993; Stamps et al., 1998] and prior occupancy [animals already occupying space tend to win; Honeywell & Maher, 2017]), individual differences, or sex differences could affect the opponent's response. Thus, event 1 was probably not mating; however, there is a possibility of event 2 being an unsuccessful attempt to mate.

The initiators engaged in energy-expending aggression, even in situations in which they could consume energy through feeding, as opponents were observed feeding on the intertidal seagrass bed when the events were initiated. Dugongs can feed on intertidal seagrass beds only at high tide; therefore, the cost of losing feeding opportunities in intertidal seagrass beds is greater than that in subtidal seagrass beds.

Further observation is needed to reveal the benefits of dugong aggression. Considering that the opponents of both events left the original feeding location, it could be reasonable to interpret these events as a male-male competition for territory. However, contrary to the prevailing notion that territory owners would occupy their territory (Hinsch & Komdeur, 2017), the initiator in event 1 moved to a point 100 m away from the original location several minutes after driving out the opponent. Consequently, event 1 partially deviated from the established criteria for male-male competition. We did not observe these behaviors in the reproductive context (i.e., male-male competition for mating or female-male aggression), and the focus area is not known as a mating ground. The nearest location where mating behavior was observed was more than 3 km away from our study site (7° 14' N, 99° 25' E; Adulyanukosol et al., 2007).

In this short note, we present the behavioral categories and indicators of dugong aggression. The use of drones can expand the possibilities for aerial observations of dugongs. The indicators described in this study can be utilized for future interspecies comparisons of aggression, and for the classification of dugong aggression and its discrimination from playful and reproductive behaviors. The present study also serves as a first-hand account of the aggressive behavior of dugongs in Tropical Asia.

Note: The supplemental video for this short note is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index. php?option=com_content&view=article&id=10&I temid=147.

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