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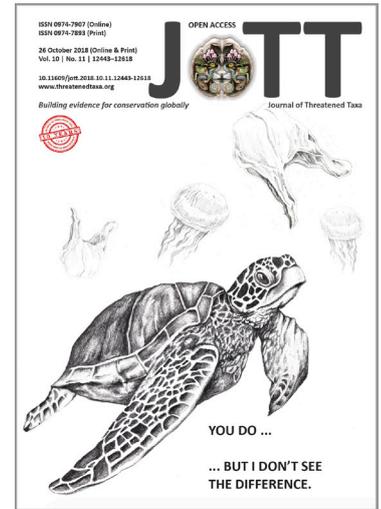
## SHORT COMMUNICATION

### A NEW REPORT ON THE CLASPER MOVEMENTS OF A CAPTIVE SAND TIGER SHARK *CARCHARIAS TAURUS* (LAMNIFORMES: ODONTASPIDIDAE) AND A POSSIBLE REASON FOR THE BEHAVIOUR

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## A NEW REPORT ON THE CLASPER MOVEMENTS OF A CAPTIVE SAND TIGER SHARK *CARCHARIAS TAURUS* (LAMNIFORMES: ODONTASPIDIDAE) AND A POSSIBLE REASON FOR THE BEHAVIOUR

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**Abstract:** Elasmobranchs present four clasper movements, which can be seen in different contexts from mating to no obvious reason. Three movements have been reported in *Carcharias taurus* and here the first occurrence of clasper flaring in this species is described. Clasper flaring was observed while other species were in a reproductive state and their aggressive behaviour towards the subject of this study was also observed.

**Keywords:** Agonistic behavior, *Carcharias taurus*, elasmobranch, Grey Nurse Shark, reproduction, reproductive behaviour.

Elasmobranchs have an external structure used to copulate, known as a clasper. This structure has the ability of movement by itself in order to facilitate copulation (Gilbert & Heath 1972). Four clasper movements have been described, as follows: flexion (movement of individual claspers backwards and forwards); splaying (the male contorting itself and opening his claspers up to 90° to the body axis); crossing (claspers crossed with

tips posterolateral); and flaring (clasper flexed and bent forward with their distal ends spread) (Gordon 1993; Compagno 2001; Ritter & Compagno 2013).

In lamnoid sharks, the clasper skeleton is constituted of the clasper shaft on the anterior region and the clasper glans on the posterior part. This second region presents a structure called a clasper hook, which helps the male to anchor itself to the female during copulation (Gilbert & Heath 1972; Compagno 2001). Specifically in the Grey Nurse Shark *Carcharias taurus*, just the first three clasper movements have been reported (Gordon 1993; Compagno 2001); and it is believed that clasper flexion occurs in different contexts, from mating to without an obvious reason (Myrberg & Gruber 1974; Gordon 1993).

There are two hypotheses for the causation of these movements in elasmobranchs: an agonistic cause (Martin 2007) and a pre-/post-copulation behaviour related to sperm transportation (Gilbert & Heath 1972;

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Ritter & Compagno 2013). Although these theories could explain some of the reports, they are not applicable to all the circumstances. Therefore, here we report the first occurrence of clasper flaring in *Carcharias taurus* and present a new hypothesis for its causation, which would also explain why these two hypotheses have been made.

## MATERIALS AND METHODS

### The subject of study

Our subject was an adult male *Carcharias taurus* that was 1.9m length, 80kg in weight and between 20-23 years old. This individual was housed in the Oceanarium tank at Aquário de São Paulo, São Paulo, Brazil, which is a 1,000m<sup>3</sup> enclosure with depths varying from 1.4m in the superior area to 5m in the lateral areas.

Besides this specimen, the tank was inhabited by eight Nurse Sharks *Ginglymostoma cirratum*, two Brownbanded Bamboo Sharks *Chiloscyllium punctatum*, five Southern Stingrays *Hypanus americanus* and 10 bony fishes.

This was an opportunistic data collection, since the main objective of the research was to better understand the behavior of the subject. After the first observation of the clasper movements, a new focus has been given to the study. So, a focal all-occurrences sampling protocol was used due to the low frequency of the observed movements (Altmann 1974; Lehner 1996). We recorded the type of clasper movements, time of occurrence, duration and additional observations (such as other inhabitants' reproductive and aggressive behaviors).

Observations were made for 72 hours between

January and April 2015; 36 hours of this total were realized between 09:00 and 10:00 hr and the remainder, between 21:00 and 22:00 hr. At night time, the tank's light was turned off since the aquarium does not work at this period. So, the observation was made with the aid of a flashlight. However, considering that unexpected changes in the lighting intensity can cause stress in elasmobranchs (Powell et al. 2004), the lights were turned on for 30 minutes before all nocturnal observations. Since this study was purely observational, it was not considered necessary to ask for an ethical permission.

## RESULTS

Clasper flexion and splaying were not performed by the subject in this study. We, however, observed two clasper movements: clasper crossing (CC) (clasper crossed with tips posterolateral) and clasper flaring (CF). This last movement consists of the clasper crossed at 90° to the body axis while their tips bent downward and spread itself, showing up its clasper hook (Fig. 1) (supporting information), that has never been reported on this species before.

Clasper crossing was observed on four nights, counting a total of seven occurrences in this work, while clasper flaring was observed on six days, adding up to seven occurrences (Table 1). These movements were observed while two other species (*Ginglymostoma cirratum* and *Hypanus americanus*) were at a reproductive stage, and so, some aggressive behaviour of these inhabitants toward the subject of this study (Table 1) was observed.

**Table 1.** Description on occurrences of clasper movements in a captive *Carcharias taurus*. Additional observations are given on the context in which the behaviour has been performed.

Day	Hour	Clasper movements	Duration (seconds)	Additional observations
07.i.2015	21:44	CC	50	-The subject was contorting itself while doing these behaviours -The nurse sharks of the tank were stalking the subject at 21:53
	21:56	CC	60	
	21:59	CC	20	
09.ii.2015	21:21	CF	60	
	21:22	CC	480	
05.iii.2015	21:04	CF	60	-Male nurse sharks were active and one of them performed CC at 21:01
	21:45	CF	45	
09.iii.2015	21:40	CF	30	-After the clasper movements, the subject contorted itself for 20 seconds
16.iii.2015	21:53	CC	20	
14.iv.2015	21:33	CF	35	
15.iv.2015	21:47	CC	10	-Before the clasper movements, the nurse sharks stalked the subject -One male Southern Stingray performed clasper crossing at 21:11
	21:47	CF	15	
	21:48	CC	25	
24.iv.2015	21:53	CF	90	-One female Southern Stingray released one egg capsule at 21:17

CC - clasper crossing (clasper crossed with tips posterolateral); CF - clasper flaring (clasper crossed at ninety degrees to the body axis while their tips bent downward and spread itself, showing up its clasper hook).

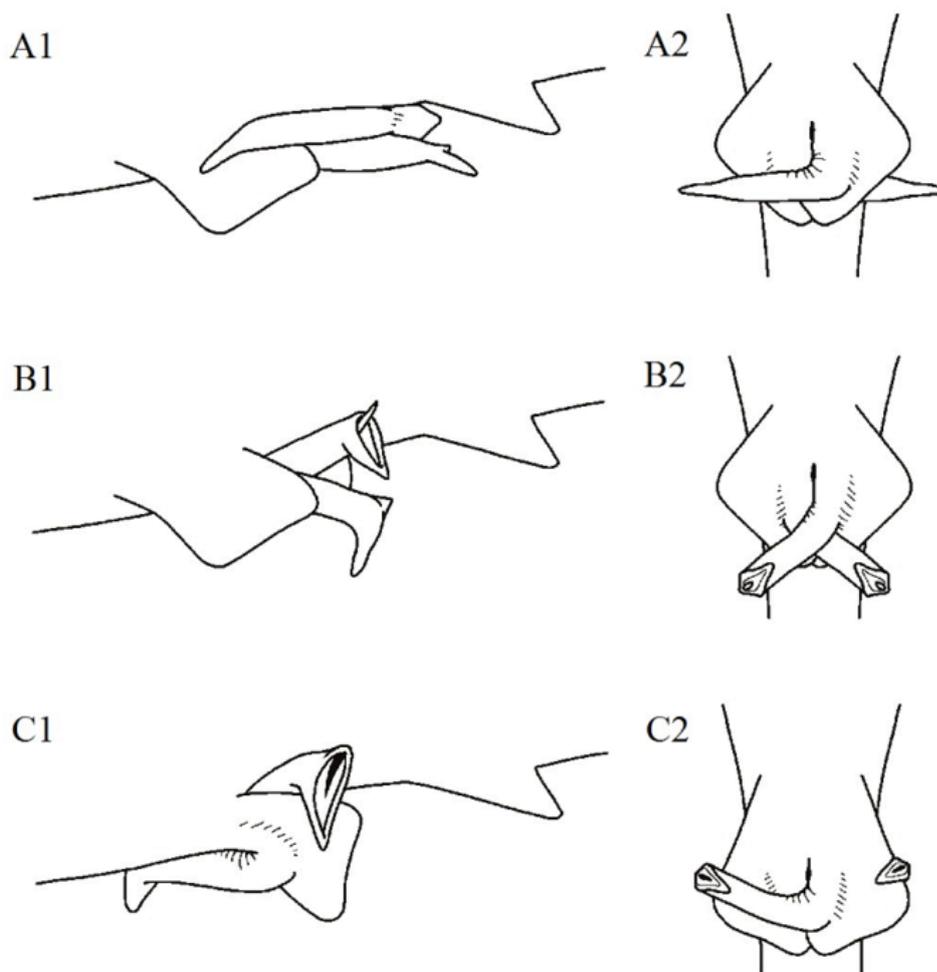


Figure 1. *Carcharias taurus* clasper movements: A1 - crossing claspers (lateral view); A2 - crossing claspers (ventral view); B1 - clasper flaring showing up its hook (lateral view); B2 - clasper flaring showing up its hook (ventral view); C1 - clasper flaring at ninety degrees to the body axis while their tips bent downward and spread itself (lateral view); C2 - clasper flaring at ninety degrees to the body axis while their tips bent downward and spread itself (ventral view).

## DISCUSSION

Clasper movements have been reported for various elasmobranch species: Bullhead Shark *Heterodontus francisci*, *Ginglymostoma cirratum*, *Carcharias taurus*, Gray Reef Shark *Carcharhinus amblyrhynchos*, Silky Shark *Carcharhinus falciformis*, Chain Catshark *Scyliorhinus rotifer*, Bonnethead Shark *Sphyrna tiburo*, Cape Shark *Squalus acanthias*, Whitetip Reef Shark *Triaenodon obesus*, Clearnose Skate *Raja eglanteria*, *Hypanus americanus*, Giant Manta Ray *Manta birostris* and Bat Ray *Myliobatis californica* (Myrberg & Gruber 1974; Klimley 1980; Tricas 1980; Gilbert 1984; Luer & Gilbert 1985; McKibben & Nelson 1986; Uchida et al. 1990; Gordon 1993; Carrier et al. 1994; Yano et al. 1999; Pratt & Carrier 2001; Chapman et al. 2003; Galván-Tirado et al. 2014). Most of these movements correspond to clasper flexion and, in some cases, clasper crossing.

During copulation, some species are known to expand and spread the tip of the inserted clasper to anchor the male securely to the female (Gilbert 1984; Luer & Gilbert 1985). Moreover, a *Triaenodon obesus* and a Flapnose Ray *Rhinoptera javanica* performed this behavior for a few minutes exactly after mating as witnessed by Uchida et al. (1990) in a captive environment. The expanded and spreading tip's condition observed on those studies are similar to those found in this work, besides the fact that our subject did not exhibit the behavior in a reproductive context.

In general, movements of claspers occur as a pre-copulatory behavior (Myrberg & Gruber 1974; Gordon 1993). Nevertheless, studies on *Sphyrna tiburo* and Grey Bamboo Shark *Chiloscyllium griseum* have reported these movements outside of mating events without being able to identify a cause for their occurrences (Myrberg &

Gruber 1974; Pratt & Carrier 2001). Martin (2007) has analysed agonistic behaviors in elasmobranchs and has pointed out that clasper flexion can be included in this classification despite its uncommon frequency.

During the mating season, agonistic behaviors are carried out as sexual conflict and may be directed toward conspecifics and other species which inhabit the same habitat (Gordon 1993; Martin 2007). In *Ginglymostoma cirratum*, aggressive behaviors are required to acquire and mate with females (Pratt & Carrier 2001) and can also be addressed in interspecific interactions (Henningsen et al. 2004).

The clasper movements here reported occurred at night, which agree with the nocturnal activity of the species (Compagno 2001; Hannon & Crook 2004; Barker et al. 2011). The manifestation of these movements occurred at the same time of pre-copulatory and aggressive behaviors of *Ginglymostoma cirratum*'s and *Hypanus americanus*'s specimens of the tank.

The Sand Tiger Sharks have been studied in captivity by Henningsen et al. (2004). These studies have reported that intrasexual conflicts can occur in a tank with only males of this species; they have also observed interspecific sexual conflicts of *Ginglymostoma cirratum* towards *Carcharias taurus*, which agrees with the findings of the present study.

Gordon (1993) stated that clasper flexion occurs in an elevated frequency when males start to perform pre-copulatory behaviors and, based on the study of Myrberg & Gruber (1974) with *Sphyrna tiburo*, stated the hypothesis that they might occur in different times of the year as well. Thus, this work presents not only the first evidence of clasper movements in grey nurse sharks in a different context from mating, but also as a new movement type.

In addition, our observations permit us to hypothesize that the claspers' displays are correlated with interspecific sexual conflicts, especially as a response to aggressive behaviors performed by the cohabitants, such as stalking, snapping and tailing. Probably, environmental stimuli present in the tank initiate physiological responses such as clasper movements. Additional research on clasper movements, however, is still needed. Studies in different facilities and with bigger captive populations should be carried out to permit a better understanding on this topic.

Another important question to consider is if there are any steroid hormones influencing these behaviors, since it is known that sexual conflicts are influenced by hormones, such as testosterone and progesterone (Henningsen et al. 2008). Attention should be paid to

the restricted area in which such captive mature animals inhabit, which could affect the hormones' effects, since the most common tank has a semi-closed system (Mohan & Aiken 2004) that may result in a concentration of these hormones.

## CONCLUSIONS

*Carcharias taurus* can perform at least four clasper movements. Besides clasper flexion, splaying and crossing, already described in the literature, this species can achieve a new mode, clasper flaring. Although this behaviour has already been seen in other species, this is the first report analyzing its occurrence without a reproductive context.

The results suggest that clasper movements are related to environmental stimuli, in a context different from mating. We believe that the convergence of reproductive behaviours of other species from the tank could have resulted in a physiological response in the subject that affected its behaviour. This would explain not only why the clasper movements are frequently seen in a captive context (since it normally has a closed system), but also why the movements here described occurred together with agonistic displays.

These results suggest the need to explore water sample analyses to better understand the stimuli that are released and that could affect the physiology behind behaviours and interspecific relationships in natural and artificial environments. These analyses would also improve captive husbandry techniques, since it could give us information on the need for keeping species apart at certain periods to avoid interspecific conflicts in confined environments.

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**Article**

**The terrestrial life of sea kraits: insights from a long-term study on two *Laticauda* species (Reptilia: Squamata: Elapidae) in the Andaman Islands, India**  
-- Zoya Tyabji, Nitya Prakash Mohanty, Erina Young & Tasneem Khan, Pp. 12443–12450

**Communications**

**Fishing Cat *Prionailurus viverrinus* Bennett, 1833 (Carnivora: Felidae) distribution and habitat characteristics in Chitwan National Park, Nepal**  
-- Rama Mishra, Khadga Basnet, Rajan Amin & Babu Ram Lamichhane, Pp. 12451–12458

**Status distribution and feeding habit of Wild Boar *Sus scrofa* (Mammalia: Artiodactyla: Suidae) in Pench Tiger Reserve, Madhya Pradesh, India**  
-- Shaheer Khan & Orus Ilyas, Pp. 12459–12463

**The composition and status of waterbirds of Perur Lake in Tamil Nadu, India**  
-- G. Parameswaran & R. Sivashankar, Pp. 12464–12488

**The herpetofauna of Jigme Singye Wangchuck National Park in central Bhutan: status, distribution and new records**  
-- Sangay Tshewang & Letro Letro, Pp. 12489–12498

**The Odonata (Insecta) of Dhofar, southern Oman**  
-- Elaine M. Cowan & Peter J. Cowan, Pp. 12499–12514

**New kissing bug (Hemiptera: Reduviidae: Triatominae) records from Napo and Morona-Santiago provinces with distribution updates in Ecuador**  
-- Ana Soto-Vivas, Sandra Enríquez, Ernesto Villacrés, Jazmin Arrivillaga, Martín Hinojosa & Jonathan Liria, Pp. 12515–12522

**Orchid diversity in two community forests of Makawanpur District, central Nepal**  
-- Bijaya Pant, Mukti Ram Paudel, Mukesh Babu Chand, Shreeti Pradhan, Bijaya Bahadur Malla & Bhakta Bahadur Raskoti, Pp. 12523–12530

**Habitat distribution modeling for reintroduction and conservation of *Aristolochia indica* L. - a threatened medicinal plant in Assam, India**  
-- Bhaskar Sarma, Prantik Sharma Baruah & Bhaben Tanti, Pp. 12531–12537

**Pollination ecology of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae)**  
-- B. Usharani & A.J. Solomon Raju, Pp. 12538–12551

**Review**

**Status of studies on zooplankton fauna of Arunachal Pradesh, India**  
-- Bikramjit Sinha, Pp. 12552–12560

**Short Communications**

**First record of the endangered Arabian Tahr *Arabitragus jayakari* (Thomas, 1894) in the Hatta Mountain Conservation Area, Dubai, United Arab Emirates**  
-- Jeruel Cabadonga Aguhob, Junid N. Shah, Esmat Elfaki Mohammed Elhassan, Aisha Almurr Al Muhery, Mohamed Mustafa Eltayeb Mohamed, Juma Abdulla Saeed Mohammad Al Omairi, Hamad Hashim Mohammed Khalaf Albedwawi, Obaid Mohammed Salem Mohammed Al Bedwawi, Hassan Zain Alsharif & Afra Mahmood Mohammad Ali Haji, Pp. 12561–12565

**Partners**



**A winter roost count of the Short-eared Owl *Asio flammeus* (Aves: Strigiformes: Strigidae) at Porbandar, Gujarat, India**  
-- Dhavalkumar Varagiya & Anita Chakraborty, Pp. 12566–12570

**Crocodiles of river Krishna: impact on agriculture, economy, and the sociology of human population in Sangli, Maharashtra, India**  
-- Rajaram Hindurao Atigre, Pp. 12571–12576

**A new report on the clasper movements of a captive Sand Tiger Shark *Carcharias taurus* (Lamniformes: Odontaspidae) and a possible reason for the behaviour**  
-- Helen Colbachini, Rafael Caprioli Gutierrez, Cristiane Schilbach Pizzutto & Otto Bismarck Fazzano Gadig, Pp. 12577–12581

**New species of termite *Pericapritermes travancorensis* sp. nov. (Isoptera: Termitidae: Termitinae) from India**  
-- Jobin Mathew & Chinnu Ipe, Pp. 12582–12588

**A checklist of vascular epiphytes of El Cometa Lagoon, Pantanos de Centla Biosphere Reserve, Mexico**  
-- Derio Antonio Jiménez-López, Candelario Peralta-Carreta, Jonathan V. Solórzano, Gerardo Luis Cervantes-Jiménez & Marco Antonio Domínguez-Vázquez, Pp. 12589–12597

**Notes**

**Two moth species of Lasiocampidae (Lepidoptera: Lasiocampoidea) recorded for the first time in Bhutan**  
Jatishwor Singh Irungham & Meenakshi Jatishwor Irungham, Pp. 12598–12601

**New nymphalid butterfly records from Jammu & Kashmir, India**  
-- Shakha Sharma & Neeraj Sharma, Pp. 12602–12606

***Argostemma khasianum* C.B. Clarke (Rubiaceae): a new record of a genus and species of flowering plant for the state of Arunachal Pradesh (India) and its lectotypification**  
-- Umeshkumar L. Tiwari & V.K. Rawat, Pp. 12607–12609

***Amorphophallus longiconnectivus* and *A. margaritifera*: additional aroids from Maharashtra with notes on the floral variations**  
-- Avinash R. Gholave, Ravikiran S. Govekar, Vasanta I. Kahalkar, Milind M. Sardesai & Shirang R. Yadav, Pp. 12610–12613

**Cultivation of the Himalayan seasoning *Allium* in a remote village of Uttarakhand, India**  
-- Chandra Prakash Kuniyal & Bir Singh Negi, Pp. 12614–12617

**Miscellaneous**

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