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Research article

Implications of human–animal interactions on mother-calf interactions in a bottlenose dolphin (*Tursiops truncatus*) dyad

Thomas Welsh[1,2] and Samantha J Ward[2]

[1]*University Centre Askham Bryan, Askham Bryan College, UK*
[2]*School of Animal, Rural and Environmental Sciences, Nottingham Trent University, UK*

Correspondence: Thomas Welsh; thomas.welsh@askham-bryan.ac.uk

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Abstract

Most research on human–animal interactions (HAIs) in zoos focuses on the influence of unfamiliar humans (visitors) on the animals. Limited research focusses on the influence of familiar (keepers/trainers) HAI and there has been no research investigating the impact of familiar HAIs on mother–offspring interactions. The bottlenose dolphin (*Tursiops truncatus*) has been bred and trained in captivity for decades and is the most common cetacean in captivity. This provides scope to investigate the impact that familiar HAIs can have on mother–calf interactions. This study aimed to compare the dolphin-dyadic interactions before, during and after a HAI with a trainer. A single mother–calf dyad was observed for 50 hours at Mundomar dolphinarium, Spain. Instantaneous focal sampling recorded the mother–calf interactions exhibited before, during and after HAI. The HAI category (medical, training, gating, separation and presentation) was also recorded. A Friedman Two-Way ANOVA and Related-Samples Wilcoxon Signed Rank Test showed no significant decreases in mother–calf interactions post HAI, with 'suckling' observed significantly more after HAI and 'not-interacting' seen significantly less. HAI category found that dolphin interactions were seen more after medical interactions than other categories. Results suggest that the HAIs are encouraging increased interactions between the mother–offspring dyad and therefore there is an effect of HAI on interactions; yet, due to data constraints it is difficult to conclude whether these are positive or negative. However, an increase in affiliative behaviour promotes social bonding between mother and calf. This study has provided a first step in assessing the impacts of familiar HAI on the development of the mother–calf relationship and given scope for further research in this area.

Introduction

More than 700 million people visit zoos and aquariums worldwide each year (Gusset and Dick 2011) with 250 dolphins in EAZA accredited facilities (Clegg et al. 2017) and 444 individuals in US and Canadian aquaria (Cetabase 2011). This highlights the large numbers of individuals that may be affected by research to establish advancing management techniques suitable for their welfare. With the large number of zoo visitors, human–animal interactions (HAIs) are growing, and this is a growing area of research due to the importance of the impacts that humans can have on animal behaviour (Hosey 2008). Most current HAI research focuses on the impact that visitors have on the animals with an array of results, most being negative (Stevens et al. 2013; Wells et al. 2005) or neutral (Ozella et al. 2015; Sherwen et al. 2014). Research focusing on familiar HAI (i.e. keepers), however, does indicate that positive interactions (including positive reinforcement training) lead to positive behavioural responses (Ward and Melfi 2013) and that these can develop into position human–animal relationships (HARs) with positive welfare implications (Ward and Melfi 2015). However, within familiar HAI research, there have as yet been no studies focusing on their impact on the mother–offspring relationship. Bottlenose dolphins (*Tursiops truncatus*; here after referred to as dolphins) have been known to exhibit anticipatory behaviour prior to positive reinforcement and food-based training sessions with trainers (Jensen et al. 2013; Clegg et al. 2018). Anticipatory behaviour has been recognised as a real time measure of an animal's perception of what it wants from its environment (Watters 2014). It has also been used to measure preference between training sessions and enrichment (Clegg et al. 2018) which indicated that dolphins perceive HAIs as rewarding and preferred them over enrichment.

Studies of dolphins indicate they are a highly social species living in fission–fusion societies, having strong social interactions with much of their time budget spent forming bonds with conspecifics (Rogers et al. 2004). Of those conspecifics, the mother-calf dyad shares the highest degree of association (Harvey et al. 2017) with studies indicating that the first year of parental care is critical for the physical and social development of the offspring (Cockcroft and Ross 1990; Gubbins et al. 1999). Data on calf development and survival from the world's longest running study of a wild dolphin population in Sarasota Bay, Florida (Wells 2009) has influenced the management and husbandry protocols for captive mother-calf dyads (Brando 2010). Infant development is one of the pivotal stages in an animal's life and there are differences between captive facilities and the wild; therefore, it is important to investigate the possible impacts that captive factors may have on the development of the mother-calf relationship, for example day to day contact with familiar humans.

Gubbins et al. (1999) discussed the spatial relationship between mother and calf dolphins during the first 12 months. Their results were consistent with similar captive (McCowan and Reiss 1997; Chirighin 1987) and wild (Mann 1997) studies; showing that calf independence increases as the calf ages, which is commonplace among mammals. Cockcroft and Ross (1990) and Reid et al. (1995) reported a significant decrease in the amount of time infants spend with their mothers as they aged. These studies indicate that there is an ontogenetic pattern across distinct social groups of increasing calf independence as age increases, so it is to be expected and may not be a result of interaction with a trainer.

Research on the interactive behaviour between mother and calf was summarised by von Streit et al. (2011) who compared the field ethograms of Mann and Smutts (1999) and Miles and Herzing (2003) to their own captive ethogram. They defined 51 behavioural patterns of which 26 were described in either one, or both, field ethograms, most behaviours seen solely in the captive ethogram were due to being in captivity, for example rubbing against a wall, or due to methodological differences (von Streit et al. 2011). The behaviours that were seen in all three of the studies were the affiliative, tactile behaviours such as suckling, echelon and mother–calf position, swimming together, flipper and body rubs, rostrum to genital region and social play (von Streit et al. 2011). This similar behavioural repertoire shows that regardless of whether the dyad is captive or wild, the interactive behaviours, mother–calf relationship and its development will be the same. Observations between both captive and wild mother and calf dolphins have shown two specific spatial states of importance; the 'echelon position' and what Gubbins et al. (1999) named the 'infant position', but which is later referred to by von Streit et al. (2011) as the 'mother calf position'. It is thought that these spatial states have adaptive significance and contribute to infant survival (Gubbins et al. 1999); as the calf ages, time spent in the echelon position decreases while the mother calf position increases.

This research investigated the implications of HAI on mother–calf interactions and therefore the mother–calf relationship, which has not yet been studied in any species. More specifically, to analyse the interactive behaviour exhibited by a dolphin mother and calf due to the HAI, to evaluate the overall effect of the HAI on the mother–calf dyad and to determine if the type of HAI; which were divided into medical contact, training sessions and presentations, affects the mother-calf dyad.

Methods

Subjects, housing and husbandry

Data collection was carried out at Mundomar Exotic Animal Park, C/ Sierra Helada, s/n, 03503 Benidorm, Alicante, Spain from 06/03/2017–26/04/2017. The mother–calf dyad that were the subjects of the study were part of a group of 11 individuals (Table 1), housed in a dolphinarium (Figure 1). All individuals were present in the main pool most of the time, with the exception of training sessions or presentations, where a maximum of two individuals were separated for the session and reintroduced afterwards. The mother and calf remained in the main pool and were not separated for the duration of the study and in line with EAAM management guidelines and positive reinforcement training, the mothers' participation in each HAI was voluntary, with no repercussions for refusing to participate. Observations were carried out from a public viewing area that allowed for underwater viewing of the group.

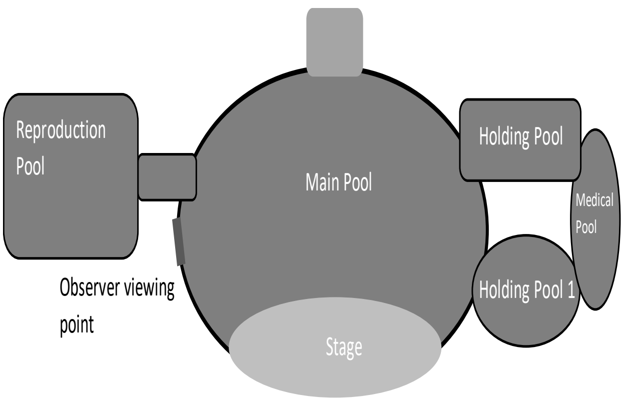

Figure 1. Diagram of Mundomar dolphinarium facility, showing the observer viewing point (not to scale).

Table 1. Details of the animals housed in the Mundomar dolphinarium, D4 and D11 formed the mother-calf dyad (* Approximate age).

Name	Age	Sex
D1	30*	M
D2	30*	F
D3	45*	F
D4	20	F
D5	20	F
D6	11	M
D7	7	M
D8	8	F
D9	9	F
D10	3	M
D11	9 months	M

Table 2. Ethogram of dolphin mother-calf interactions, adapted from Gubbins et al.,(1999) and von Streit et al. (2011).

Behaviour Category	Definition
Suckling behaviour	
Suckling	Calf swims under the mother and holds its rostrum to her mammary slit. It lies on its side, the fluke slightly bent towards the belly. Usually performed as 2 or 3 suckling events in quick succession.
Side Presentation	Mother stops her swimming movements, rolls onto her side and turns her mammary region towards the calf.
Swimming positions	
Echelon position	Mother and calf swim very close together. The calf's head is next to the mother's fin and its body slightly above the mother, touching or nearly touching the mother's body. The mother's swimming movements are strong; the calf's are weak or absent.
Mother-calf position	Calf swims under the mother, its head touching her mammary region.
Mother swims under calf	Mother-calf position with reversed roles
Mother-calf interactions	
Push up	Calf sinks to the bottom and mother gently pushes the calf to the surface with her rostrum or head.
Lift	Mother swims on her back under the calf so that it lies on her chin. She lifts it out the water.
Push away	Mother pushes calf away from the tank wall, a net or an object.
Mother brings calf to her side	Mother passes the calf closely, thus bringing it to her side in her wake.
Mother follows calf	When the calf leaves, the mother turns on her side, uttering loud whistles and snarling sounds. First, she stays in one spot always turning her rostrum towards the calf. Then she chases the calf and brings it to her side.
Swim together	Two dolphins swim in steady circles around the tank, the distance between them is less than one body-length.
Rest together	Two dolphins lie at a spot within a distance of a maximum of one body-length.
Play Together	Mother and calf both engage in using an enrichment device, such as an ice toy, ropes or floating devices.
Flipper rub	While swimming together, the calf rubs part or its whole body on its mother's pectoral fins. It turns different parts of its body towards the mother's pectoral fins, swimming sometimes on its side or back. The mother remains horizontal. She sometimes sticks her pectoral fins towards the calf and moves them up and down.
Body rub	Calf rubs part of its body on its mother's head or body.
Calf observes mother	Calf is less than two body-lengths away from its mother and orientates its rostrum towards the mother. Sometimes it circles the mother slowly and moves its head up and down.
Mother observes calf	Mother is less than two body-lengths away from its calf and orientates its rostrum towards the calf. Sometimes it circles the calf slowly and moves its head up and down.
Calf twirls around mother	While the mother rests or swims slowly, the calf crosses or leaps in front of her, lies on its side in front of her, nudges her, glides over her head, leaps onto her head, slaps its tail towards her, or jumps and falls onto her with its back.
Calf nibbles at mother	Calf nibbles at mother's fluke or very rarely at her head or body.
Mother moves calf	Mother moves calf with her rostrum. The calf lies motionless on its side. The mother's rostrum is placed at the calf's fluke, genital region or belly.
Belly to belly	Two dolphins swim belly to belly.
Sexual Behaviour	Calf exhibits sexual behaviour towards its mother. The penis will be visible and the calf may rub it on the mother's genital region.
Non-interactive	
Not interacting	Both dolphins are carrying out individual solitary behaviours such as swimming individually, playing on their own or inspecting an object without the other being present. Dolphins are more than two body lengths apart and not interacting.
Interacting with others	Calf is interacting with another dolphin, other than the mother.
Not in view	The calf cannot be seen from the observers' viewpoint.

Data collection

Instantaneous focal sampling was used to record the interactions between mother and calf every 30 seconds, following a behavioural ethogram (Altmann 1974). Non-interactive behaviours were grouped into 'Not Interacting', 'Interacting with others' and 'Not in view' (Table 2). Data were collected across three treatment groups: before, during and after a HAI where the human was familiar to the animal and was an established trainer. An 'interaction' was defined as the trainer on the stage or in the main pool in visual or physical contact with the animal, whilst food was used as primary reinforcement during the interaction. Trainer interactions were classified into five mutually exclusive interaction categories (Table

Table 3. Types of HAI categories

Interaction	Definition	No. of sessions observed
Gating	The animals are given stationing cues with the aim of the session to move an individual(s) to another pool and the gates closed.	4
Separation	The animals are given stationing cues with the aim of the session to move an individual(s) to another pool temporarily, with them returned to the rest of the group by the end of the session. The mother and calf were never separated during the study.	4
Medical	The interaction is primarily training for a medical or husbandry behaviour such as voluntary blood draw, ultrasound, hydration, measurements, blowhole sampling, faecal sampling, gastric sampling. It could also be an actual medical examination for an injury.	37
Training	The aim of the interaction is to train a new behaviour or practice and refine learned behaviours not associated with medical or husbandry needs. Behaviours cued in this interaction may be high energy such as jumping, low energy such as a pectoral wave or water work with the trainer.	12
Presentation	The interaction forms part of a display of behaviours to the public at designated times during the day. Several different behaviours are asked during the interaction. This is the only interaction where public are present.	43

3). Other variables recorded included weather, temperature and time of day (Margulis and Westhus 2008).

Each behavioural observation was 10 minutes per treatment group: immediately before the HAI (before), during the HAI (during) and immediately post HAI (after). Three HAI sessions were chosen randomly per day, all of which were part of the daily husbandry routine. Where the interaction was longer than 10 minutes, recording was stopped and restarted after the trainer interaction had finished. When a timeout was used during the interaction, recording was stopped as the trainers left the area for 1–5 minutes; recording restarted when the interaction resumed. One hundred observations were carried out totalling 50 hours of behaviour recorded.

Data analysis

Data were analysed using IBM SPSS Statistics Version 23. A Friedman Two-Way ANOVA determined whether the HAI had a significant effect on dolphin interactions over the three treatment groups. Where significant differences were found, a Related-Samples Wilcoxon Signed Rank Test was used as a post hoc pairwise test to determine where the differences fell between the treatment groups (before, during and after HAI). A Bonferroni correction was applied to identify differences between before–during, before–after and during–after.

A Two-Way ANOVA was used to analyse possible effects of each type of HAI (Table 3) on mother-calf interactions. A Related-Samples Wilcoxon Signed Rank Test, with a Bonferroni correction

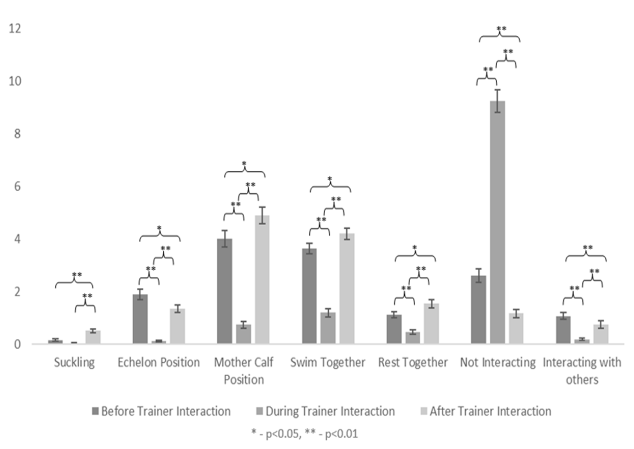

Figure 2. The mean frequency ± S.E of significant behaviours before, during and after trainer interaction.

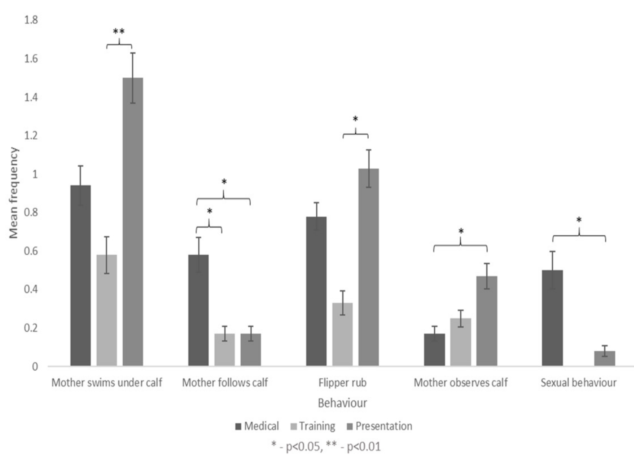

Figure 3. The mean frequency ± S.E of significant behaviours between medical, training and presentations HAIs.

Table 4. Results of the Friedman's Two-Way ANOVA and post hoc Wilcoxon Signed Rank Tests for behaviour before, during and after HAI.

Related-Samples Wilcoxon Signed Rank Test				
Behaviour	Friedman's Two-Way ANOVA	Before - During	Before - After	During - After
Suckling	F_2 = 40.663, P < 0.01	W_{100} = -2.132, P > 0.05	W_{100} = 4.053, P < 0.01	W_{100} = 5.352, P < 0.01
Side Presentation	F_2 = 9.867, P < 0.01	W_{100} = -1.325, P > 0.05	W_{100} = 1.304, P > 0.05	W_{100} = 2.831, P < 0.01
Echelon position	F_2 = 68.834 , P < 0.01	W_{100} -7.133= , P < 0.01	W_{100} = -2.398, P > 0.05	W_{100} = 6.255, P < 0.01
Mother-calf position	F_2 = 83.006, P < 0.01	W_{100} = -7.108, P < 0.01	W_{100} = 2.007, P > 0.05	W_{100} = 7.681, P < 0.01
Mother swims under calf	F_2 = 35.077, P < 0.01	W_{100} = -4.911, P < 0.01	W_{100} = -1.488, P > 0.05	W_{100} = 4.657, P < 0.01
Push up	F_2 = 2, P > 0.05	W_{100} = -1, P > 0.05	W_{100} = NaN, P > 0.05	W_{100} = 1, P > 0.05
Lift	F_2 = 0, P > 0.05	W_{100} = NaN, P > 0.05	W_{100} = NaN, P > 0.05	W_{100} = NaN, P > 0.05
Push away	F_2 = 1.333, P > 0.05	W_{100} = 1, P > 0.05	W_{100} = 0, P > 0.05	W_{100} = 1, P > 0.05
Mother brings calf to her side	$F_{2 =}$ 2.778 , P > 0.05	W_{100} = 1.573, P > 0.05	W_{100} = 1.307, P > 0.05	W_{100} = -0.493, P > 0.05
Mother follows calf	F_2 = 0.538, P > 0.05	W_{100} = 0.421, P > 0.05	W_{100} = 0.92, P > 0.05	W_{100} = 0.645, P > 0.05
Swim together	F_2 = 94.237, P < 0.01	W_{100} = -7.186, P < 0.01	W_{100} = 2.217, P > 0.05	W_{100} = 7.718, P < 0.01
Rest together	F_2 = 35.605, P < 0.01	W_{100} = -4.485, P < 0.01	W_{100} = 2.092, P > 0.05	W_{100} = 5.139, P < 0.01
Play Together	F_2 = 27.733, P < 0.01	W_{100} = -4.917, P < 0.01	W_{100} = 0.059, P > 0.05	W_{100} = 4.473, P < 0.01
Flipper rub	F_2 = 17.344, P < 0.01	W_{100} = -2.913, P < 0.01	W_{100} = 0.651, P > 0.05	W_{100} = 3.341, P < 0.01
Body rub	F_2 = 55.685, P < 0.01	W_{100} = 5.890, P < 0.01	W_{100} = -0.2652, P > 0.05	W_{100} = 5.851, P < 0.01
Calf observes mother	F_2 = 3.188, P > 0.05	W_{100} = -1.667, P > 0.05	W_{100} = -1.414, P > 0.05	W_{100} = .0447, P > 0.05
Mother observes calf	F_2 = 7.923, P = 0.019	W_{100} = -2.546, P = 0.011	W_{100} = -0.218, P > 0.05	W_{100} = 2.668, P < 0.01
Calf twirls around mother	F_2 = 14.456, P < 0.01	W_{100} = -3.66, P < 0.01	W_{100} = -1.696, P > 0.05	W_{100} = 2.683, P < 0.01
Calf nibbles at mother	F_2 = 8, P <=0.018	W_{100} = -2.652, P < 0.01	W_{100} = 0.017, P > 0.05	W_{100} = 1.119, P > 0.05
Mother moves calf	F_2 = 0.529, P > 0.05	W_{100} = -1.1, P > 0.05	W_{100} = 0.302, P > 0.05	W_{100} = 2.5, P = 0.012
Belly to belly	F_2 = 5.84, P > 0.05	W_{100} = -2.138, P = 0.033	W_{100} = 0.392, P < 0.01	W_{100} = 2.401, P = 0.016
Sexual Behaviour	F_2 = 6.186, P = 0.045	W_{100} = 8.134, P < 0.01	W_{100} = 4.739, P < 0.01	W_{100} = -8.55, P < 0.01
Not interacting	F_2 = 138.697, P < 0.01	W_{100} = 6.162, P < 0.01	W_{100} = NaN, P > 0.05	W_{100} = -6.162, P < 0.01
Interacting with others	F_2 = 37.481, P < 0.01	W_{100} = -5.709, P < 0.01	W_{100} = -2.383, P < 0.01	W_{100} = 3.640, P < 0.01
Not in view	F_2 = 0.394, P > 0.05	W_{100} = 1.66, P > 0.05	W_{100} = -0.422, P > 0.05	W_{100} = -2.025, P = 0.043

was used as a posthoc pairwise test to identify differences between the HAI types.

Ethics

Ethical approval was sought and approved via Nottingham Trent University prior to data collection with full approval from Mundomar Dolphinarium. This manuscript was produced in accordance with the ARRIVE Guidelines where applicable.

Results

Analysis of interactive behaviour

Table 4 shows the results of the Friedman's Two-Way ANOVA and Related Samples Wilcoxon Signed Rank Test. Figure 2 shows the comparison before–after HAI found that 'suckling', 'mother–calf position', 'swim together' and 'rest together', respectively, were significantly higher after HAIs than before (W100=4.053, P<0.01; W100=2.007, P<0.05; W100=2.217, P<0.05; W100=2.092, P<0.05). 'Echelon position' was observed significantly more before HAIs than after (W100=−2.398, P<0.05). For non-interactive behaviours, both 'not interacting' and 'interacting with others' were significantly lower after HAIs than before respectively (W100=−4.739, P<0.01; W100=−2.383, P<0.01). All other behaviours (side presentation, mother swims under calf, push up, lift, push away, mother brings calf to her side, mother follows calf, play together, flipper rub, body rub, calf observes mother, mother observes calf, calf twirls around mother, calf nibbles at mother, mother moves calf, belly to belly, sexual behaviour, not in view) showed no significant difference between before and after a HAI.

Table 5. Results of the Friedmans Two-Way ANOVA and post hoc Wilcoxon Signed Rank Tests for behaviour between HAI categories.

	Related-Samples Wilcoxon Signed Rank Test			
Behaviour	Friedman's Two-Way ANOVA	Medical - Training	Medical - Presentation	Training - Presentation
Suckling	F_2 = 0.941, P>0.05	W_{12} = -0.905, P>0.05	W_{36} = 0.114, P>0.05	W_{12} = 0.159, P>0.05
Side Presentation	F_2 = 2.529, P>0.05	W_{12} = 1.414, P>0.05	W_{36} = -0.451, P>0.05	W_{12} = 1.218, P>0.05
Echelon position	F_2 = 2.048, P>0.05	W_{12} = -0.31, P>0.05	W_{36} = -0.876, P>0.05	W_{12} = 0.537, P>0.05
Mother-calf position	F_2 = 5.167, P>0.05	W_{12} = 1.767, P>0.05	W_{36} = 1.831, P>0.05	W_{12} = 0.989, P>0.05
Mother swims under calf	F_2 = 12.4, P<0.01	W_{12} = 0.552, P>0.05	W_{36} = 1.845, P>0.05	W_{12} = 2.701, P<0.01
Push up	F_2 = 2, P>0.05	W_{12} = -1, P>0.05	W_{36} = 1, P>0.05	W_{12} = NaN, P>0.05
Lift	F_2 =0 , P>0.05	W_{12} = NaN, P>0.05	W_{36} = NaN, P>0.05	W_{12} = NaN, P>0.05
Push away	F_2 = 2, P>0.05	W_{12} = 1, P>0.05	W_{36} = 1, P>0.05	W_{12} = NaN, P>0.05
Mother brings calf to her side	F_2 = 0.65, P>0.05	W_{12} = 0.702, P>0.05	W_{36} = -1.054, P>0.05	W_{12} = -0.66, P>0.05
Mother follows calf	F_2 = 9.8, P<0.01	W_{12} = -2.326, P>0.05	W_{36} = -2.433, P>0.05	W_{12} = 0, P>0.05
Swim together	F_2 = 4.739, P>0.05	W_{12} = -0.355, P>0.05	W_{36} = -2.493, P>0.05	W_{12} = -2.41, P>0.05
Rest together	F_2 = 0.333, P>0.05	W_{12} = 0.678, P>0.05	W_{36} = -1.593, P>0.05	W_{12} = 0.07, P>0.05
Play Together	F_2 = 4.769, P>0.05	W_{12} = -1.407, P>0.05	W_{36} = -0.156, P>0.05	W_{12} = 1.539, P>0.05
Flipper rub	F_2 = 3.722, P>0.05	W_{12} = -0.127, P>0.05	W_{36} = 1.184, P>0.05	W_{12} = 1.983, P>0.05
Body rub	F_2 = 0.529, P>0.05	W_{12} = 0.18, P>0.05	W_{36} = -0.977, P>0.05	W_{12} = -0.21, P>0.05
Calf observes mother	F_2 = 0.5, P>0.05	W_{12} = 0, P>0.05	W_{36} = -0.277, P>0.05	W_{12} = 0.577, P>0.05
Mother observes calf	F_2 = 2.8, P>0.05	W_{12} = 1.732, P>0.05	W_{36} = 2.399, P>0.05	W_{12} = -0.447, P>0.05
Calf twirls around mother	F_2 = 0.25, P>0.05	W_{12} = -0.447, P>0.05	W_{36} = 0.395, P>0.05	W_{12} = 0.707, P>0.05
Calf nibbles at mother	F_2 = 0.286, P>0.05	W_{12} = -0.736, P>0.05	W_{36} = -1.667, P>0.05	W_{12} = 0.966, P>0.05
Mother moves calf	F_2 = 3.583, P>0.05	W_{12} = -1.156, P>0.05	W_{36} = -1.892, P>0.05	W_{12} = -1.625, P>0.05
Belly to belly	F_2 = 0.75, P>0.05	W_{12} = -1.134, P>0.05	W_{36} = 0.44, P>0.05	W_{12} = 0.707, P>0.05
Sexual Behaviour	F_2 = 2, P>0.05	W_{12} = -1, P>0.05	W_{36} = -2.539, P>0.05	W_{12} = 1, P>0.05
Not interacting	F_2 = 6.5, P>0.05	W_{12} = 0.905, P>0.05	W_{36} = 0.794, P>0.05	W_{12} = 1.689, P>0.05
Interacting with others	F_2 = 3.15, P>0.05	W_{12} = 1.334, P>0.05	W_{36} = 0.708, P>0.05	W_{12} = -1.811, P>0.05
Not in view	F_2 = 17.783, P<0.001	W_{12} = -1.601, P>0.05	W_{36} = -3.026, P<0.01	W_{12} = -2.937, P<0.01

Analysis of HAI category

Table 5 shows results of the Friedmans Two-Way ANOVA and post hoc Related-Samples Wilcoxon Signed Rank Test. 'Gating' and 'separation' were omitted due to lack of data for analysis. A Related-Samples Wilcoxon Signed Rank Test found significant differences in dolphin interactions between HAI categories (Figure 3). 'Mother swims under calf' was significantly higher in presentations than in training (W12=−2.701, P<0.01), 'mother follows calf' was significantly higher in medical HAIs than both training and presentations respectively (W12=−2.326, P<0.05; W36=−2.433, P<0.05). 'Flipper rub' was seen more in presentations than training sessions (W12=1.983, P<0.05), 'mother observes calf' was significantly higher in presentations than medical (W36=2.399, P<0.05) and 'sexual behaviour' was significantly higher in medical than presentations (W36=−2.539, P<0.05).

Non-interactive behaviours (not interacting and interacting with others) showed no significance; however, 'not in view' was seen significantly more in training than presentations (W12=−2.937, P<0.01) and seen more in medical than presentations (W36=−3.026, P<0.01) but there was no significant difference between training and medical sessions for 'not in view'.

Discussion

The aim for this study was to analyse the interactive behaviour exhibited by a dolphin mother and calf as a result of HAI. The mother–calf interactions, including 'suckling', 'mother calf position', 'swim together' and 'rest together', were seen significantly more after trainer interaction than before. These results regarding the degree of association are consistent with Harvey et al. (2017), who concluded that mother–calf dyads shared the highest coefficients of association. Clegg et al. (2015) discussed how 'suckling' and 'mother calf position' are highly affiliative bonding behaviours, and they are known to be important in the development of the mother–calf relationship (Harvey et al. 2017). The observed increase in these behaviours due to trainer interactions suggests that the trainer is influencing the mother–calf dyad, which could in turn be interpreted as a positive effect because of the increase in social behaviour. Additionally, 'interacting with others' and 'not interacting' significantly decreased after trainer interaction, thus suggesting that the trainer interaction increases the degree of association between mother and calf. Harvey et al. (2017) suggests this is important for the development of social relationships in dolphins. Alternatively, although not supported in the literature, the increase in interactive behaviour after HAI may be interpreted as a negative effect on the mother–calf relationship. The familiar human may be diverting the attention of the mother away from its calf during HAI and encouraging its independence before it would naturally occur in the wild (Wells 1993; 2009). Therefore, more interactive behaviour post-HAI could be interpreted as consolatory; however, due to the sample size being restricted to one mother–calf pair, further research is needed to substantiate either interpretation.

Non-interactive behaviours significantly decreased after HAI, whilst 'not in view' had a similar mean before and after (1.37±0.23769 and 1.21±0.16654, respectively), therefore, the dyad was exhibiting more interactive behaviours. These results are consistent with other studies that report an increase or no change in social behaviours within a social dolphin group after HAI with a familiar human, such as Samuels and Spradlin (1995) and Trone et al. (2005).

Another aim of this study was to determine if the category of HAI affects the mother–calf dyad. The results showed that medical and presentation HAIs increased dolphin interactions after HAI significantly more than training HAIs. This may be because learning new behaviours during training HAIs is more strenuous than repeating learnt behaviours in medical and presentation HAIs. However, further research is needed to corroborate this. This may also have been due to the individual mother–calf rather than a trend across dyads (Mann 1997), as it was noted during anecdotal conversations with trainers that the mother is known to be protective (Perlado-Campos, pers. comm). This scenario has also been reported by Reid et al. (1995) where the personality of the mother influenced the impact of the HAIs. Medical HAIs involve the most tactile contact between animal and trainer, due to health checks and routine veterinary procedures (Brando 2010); therefore, it may be that the mother discourages the calf from interacting with the trainers but being more attentive to the calf and ignoring the trainer. However due to the lack of literature in this area, this cannot be substantiated, and we recommend further work.

The results show that with these individuals, interacting with the trainer increased mother–calf interactions and thus provided opportunities to strengthen the mother–calf relationship. Positive HAIs may form the foundations of a positive HAI between the calf and trainer, which will improve husbandry, welfare and management in both the short and long term (Brando 2010; Clegg et al. 2015). Research with other individuals is encouraged to identify if these findings are representative of captive dolphin mother–calves. From a wider perspective, the trainer may serve a 'fission' role within a captive dolphin society (Trone et al. 2005) but more research would provide additional evidence to support or disprove this theory.

As already mentioned, it is important to acknowledge that the results of this study have come from observations of one mother–calf dyad and the differences in interactive behaviour from familiar HAIs could be due to the personalities and individual life histories rather than being representative of dolphin responses generally. However, this study is novel and shows that this area needs further investigation and to involve other species, as there has been limited research investigating the impacts of HAIs on social groups including mother–offspring dyads and animals living in different types of societies.

Conclusion

This study is the first investigation of the impact of familiar HAIs on dolphin mother–calf behaviour; and it is an important area of captive cetacean husbandry. The study aimed to analyse the interactive behaviour exhibited by a dolphin mother and calf as a result of an HAI and to evaluate the overall effect of the HAI on the mother–calf dyad. The authors conclude that, in this case study, interacting with the trainer encourages mother–calf interactions, as affiliative behaviours were seen more after a HAI had taken place, therefore promoting a positive mother–calf relationship. However, it must be noted that the increased interactions post-HAI could be interpreted many ways. It was additionally found that mother–calf interactions increased more after medical and presentation HAIs compared to training HAIs, which may have been due to the repetition of learnt behaviours in these HAIs as compared to the learning of new behaviours in training HAIs.

This novel study, although currently only representing one mother–calf dyad, has provided scope for further research into possible implications of HAIs, specifically positive reinforcement training, on the development of the mother–calf interactions and therefore the mother–calf relationship. Once expanded, this research area can potentially influence the development of husbandry practices for mother–calf pairs and wider dolphin social groups in captive-training environments and gives scope to investigate this in other species.

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