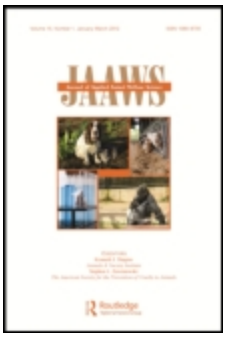

Play Behavior in Two Captive Bottlenose Dolphin Calves (Tursiops truncatus): Ethogram, Ontogeny, and Individual Differences

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ARTICLE

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ABSTRACT

This research focused on different aspects of play behavior including ethogram, ontogeny, and individual differences, in one male and one female captive bottlenose dolphin calves (*Tursiops truncatus*) from November 2003 to June 2004. We described the first peer-reviewed ethogram in bottlenose dolphin calves play behavior. These behaviors were grouped into three hierarchical levels: two categories -solitary and social play (intraspecific and interspecific play)-, three sub-categories -locomotor, object, and bubble play, and 35 play behaviors. This research was conducted in two phases: descriptive and quantitative. During the descriptive phase –from three to five months old-, we described 29 play behaviors. During the quantitative phase -from six to 10 months old – we described six new play behaviors. All social and solitary locomotor behaviors appeared when animals were three months old. Conversely, more complex behaviors concerning with play with objects, bubbles, and in the presence of humans were observed for six months old. There were not statistically significant intra-individual and inter-individual differences in the play behavioral diversity, in the time invested in play and in the Shannon's evenness index. However, we observed statistically significant inter-individual but not intra-individual differences for the Shannon's diversity index. The resulting ethogram offers a practical tool as a field guide or reference for quantitative research, for teaching of bottlenose dolphin behavior, and for facilitating the progress toward development of a complete ethogram in wild or captive bottlenose dolphin

and other cetaceans, due to play might be applied as a welfare indicator and a tool to improve welfare.

KEYWORDS

animal welfare; bottlenose dolphin; ethogram; individual differences; ontogeny; play

Many terrestrial mammals limit play to a short period of time of their life, whereas aquatic mammals appear to exhibit play during their whole life (Gewalt, 1989). Play is one of the most complicated forms of animal behavior and it is difficult to define (Kuczaj & Eskelinen, 2014). It is often hard to tell if an interaction may be playful, or agonistic. For instance, play can escalate or transform into an agonistic interaction. On the other hand, sexual interactions can also be playful. In addition, play in dolphins often takes the form of play fighting and therefore includes many behaviors that are also observed during agonistic interactions (Hill, Dietrich, & Cappiello, 2017).

In recent years, the term "play" has been more accurately defined and the literature explaining wild and captive cetacean play has increased (Paulos, Trone, & Kuczaj, 2010). Martin and Caro (1985) defined and classified play as all locomotor activity performed postnatally that appears to an observer to have no obvious immediate benefits for the player, and in which motor patterns resembling to those used in serious functional contexts may be displayed in modified forms. The motor acts constituting play possess some or all of the following structural features: exaggeration of movements, repetition of motor acts and fragmentation or disordering of sequences of motor acts. Social play refers to play with conspecifics; object play refers to play with inanimate objects; locomotor play refers to apparently spontaneous movements carried out by the individual in its environment and predatory play refers to play with living or dead prey. In other studies, the definition of play included situations in which dolphin activity is not directed towards satisfying hunger, migration or any other utilitarian need (Bel'kovich, Ivanova, Kazarovitsky, Novikova, & Kharitonov, 1991), motor and cognitive training, socialization, and pleasant activity (Bekoff & Byers, 1981), statements such as play is "fun", play is the antithesis of "work" or "serious" behavior, play is a generator of novelty, play sequences are "performed repeatedly (they may also be incomplete or exaggerated as compared to non-playful behavior in adults)", play is an

indicator of well-being (Burghardt, 2005) and, finally, the idea that play is accompanied by a particular positive mood state in which the individual is more prone to behave in a spontaneous and flexible way (Bateson, 2014).

The term ethogram refers to a catalogue of mutually exclusive and objective behaviors or actions exhibited by an animal, which avoids subjectivity and functional inference concerning their potential purpose. It is a key tool that helps to quantify species-specific behaviors by describing the discrete, basic motor patterns that form the behavioral repertoire of a given species (Martin & Bateson, 2007). The majority of cetacean ethograms focus on *Tursiops sp.* (e.g., Mann & Smuts, 1999; von Streit, Ganslosser, & von Fersen, 2011), including the one that is probably the most comprehensive marine mammal ethogram, developed by Müller, Boutière, Weaver, and Candelon (1998), built upon previous observations and describing over 100 behaviors of bottlenose dolphins observed along the San Diego coastline.

Play behavior ethograms, containing different classifications and play behaviors, have been described for wild and captive bottlenose dolphins. Definitions of motor play include jumps, complex turns, "chasing", "frontal attacks" and "free-style" (DeLong, 1999). Object play involves natural objects, such as jellyfish and food fish, as well as man-made objects, such as hoops, sprinklers, and balls (Bel'kovich et al., 1991; Denkinger & von Fersen, 1995). Dolphins can also play with their own toys by manipulating water thus producing bubbles (Tizzi, Castellano, & Pace, 2000; von Streit et al., 2011). Indeed, dolphins produce a variety of bubble formations with which they interact by biting them, swiping at them with flippers or flukes, swimming through them, catching and linking multiple rings as well as maneuvering around bubbles/rings without destroying them (McCowan, Marino, Vance, Walke, & Reiss, 2000). Social play refers to intraspecific and interspecific play, which can include humans (Kuczaj, Makecha, Trone, Paulos, & Ramos, 2006; Paulos et al., 2010).

Concerning play ontogeny, although bottlenose dolphins of all ages are known to participate in play, young dolphins usually engage in play more often than adults (Cappiello, Hill, & Bolton, 2018; Greene, Melillo-Sweeting, & Dudzinski, 2011; Kuczaj et al., 2006; Mann & Smuts, 1999). This age-related difference suggests that play is an important source of training for acquiring adult competences such as a hierarchical position, mate acquisition, hunting and predator avoidance (Bekoff & Byers, 1981; Fagen, 1981). According to different authors, the study of the ontogeny of play behavior in captive bottlenose dolphins suggests that social play appears two weeks after the birth (Tizzi et al., 2000) but it can start as early as the first week of life (von Streit, Ganslosser, & von Fersen, 2013); object play becomes visible only after two months of age (Tizzi et al., 2000), beginning at the 9th-13th week (von Streit et al., 2013); bubble play starts after one month of life (Tizzi et al., 2000) and locomotor play occurs from the 5th-7th week (von Streit et al., 2013). Although calves engage in both social and solitary play throughout their first year, play becomes increasingly social as they age. Calves also become more likely to initiate social play interactions as they mature. A calf's first social play partner is typically its mother, but other calves quickly replace her as the most common play partner (Mackey, Mackecha, & Kuczaj, 2014). Finally, the self-government and precision of fluke-made bubble formations appear during the 9th-10th month (Pace, 2000).

Sex differences in play behaviors have consistently been found, with males usually exhibiting rough-and-tumble forms of play and play fighting more often than females (Fagen, 1981; Pellis & Pellis, 2013). This male bias in social play seems to be mediated by hormone levels, specifically testosterone or other androgens. Locomotor play and object play are subjected to some sex differences, but these differences are not as consistent as those found for social play (Burghardt, 2005). In two groups of dolphins, sex differences were found concerning the frequency of object play, with captive male Atlantic bottlenose dolphins

exhibiting more object play than their female conspecifics but wild female Atlantic spotted dolphins (*Stenella frontalis*) exhibiting more object play than their male conspecifics (Greene et al., 2011). It is unclear if these sex differences were due to sampling protocols or habitat and species differences between each population. On the other hand, some studies on inter-individual differences in captive bottlenose dolphins did not find statistically significant differences between males and females in variables related to play behavior such as the time spent in play behavior (DeLong, 1999), the mean frequency of fluke-made bubble rings (Pace, 2000), the frequency of object play and social play (von Streit et al., 2013) and the proportion of enrichment participation (Eskelinen, Winship, & Borger-Turner, 2015).

In this paper, we present an ethogram of play behaviors in two captive dolphin calves from the Barcelona Zoo, observed from November 2003 to June 2004. Our aim was to develop an illustrated catalog of play behaviors observed in captivity, succinctly annotated with verbal description and reference to further published descriptions. Our emphasis was on simplicity and consolidation of information that would be useful as a practical field, rescue, or captive centers guide. This guide would also be useful for researchers, animal keepers, veterinarians, students, and others interested in play behavior or concerned with cetacean welfare. Play has long been identified as a potential welfare indicator because it often disappears when animals are under fitness challenge and because it is thought to be accompanied by a pleasurable emotional experience (Held & Spinka, 2011). We also focused on the ontogeny of bottlenose dolphin play behavior from third to 10th month old. Furthermore, we were interested in determining if there are intra and inter-individual differences in the diversity of play behaviors, the time invested in play as well as the Shannon's diversity index and its Shannon's evenness index from sixth to 10th month old.

Materials and methods

Animals and housing

This study focused on two bottlenose dolphin (*T. truncatus*) calves born at the Barcelona Zoo. During the observations, these two calves shared the exhibit with their respective mothers and an additional adult female (Table 1).

The exhibit was a cylindrical pool (6m depth, 22 m diameter) with a 9.119 m^3 capacity of seawater. The pool had five underwater observation windows through which the visitors and the researchers could observe these dolphins. The pool was filled with sea water pumped in from the sea and it was maintained at 13ºC, pH8 and a salinity of 26-28 g. liter $^{-1}$ (for more details, see Soriano, Tarascó, Vinyoles & Maté, 2015).

Captive management

The daily diet of adult dolphins consisted in 10-12 kg of frozen fish and vitamins distributed among five meals. The proportion of frozen fish was 30% mackerel, 50% sardine and 10 % capelin combined with sprat. Adult dolphins were fed at 11:00 a.m., 1:30 p.m., 2:00 p.m., 4:00 p.m. and 8:00 p.m. Calves were reared by their mothers. Every day at 1:00 p.m., the three adult female dolphins were trained to perform a show for the zoo visitors.

Data collection

This study focused on all aspects of the early development of play in bottlenose dolphin calves. The main aim of the descriptive phase (DP) was the description of play behaviors and its ontogeny in an observed or unobserved methodology. This phase was conducted between the third and the fifth month of life of the calves, which occurred from November 2003 to January 2004. Unfortunately, we did not observe the calves' play behavior during the first and the second months of life because they were in a breeding pool without underwater viewing. This circumstance did not allow us to observe play behavior details to describe it accurately.

Multifocal, all occurrences, sampling was conducted during 64 sessions lasting for 30-min, per subject and month (Altmann, 1974). The variables recorded during this phase were (a) the subject studied (male and female calf), (b) the daily period: morning (9 a.m. to 1p.m.), midday (1 p.m. to 3 p.m.) and afternoon (3 p.m. to 5 p.m.), which were balanced to obtain the daily play pattern, and c) the description of play behaviors including their definitions, illustrations and classifications.

The aim of the quantitative phase (QP) was to complete the ethogram with the description of new play behaviors which were not described during the DP and to quantify the play behaviors in order to determine the ontogeny and intra and inter-individual differences. This phase was comprised between the sixth and the 10th month, from February to June 2004. Focal, all occurrences, sampling was conducted during 64 sessions lasting for 30-min per subject in February, 72 sessions in March, 76 sessions in April, and 80 sessions in both May and June in relation to seasonal variation of Barcelona Zoo opening hours. The variables recorded during this phase were (a) the subject studied (male and female calf), (b) the daily period: morning (9 a.m. to 1 p.m.), midday (1 p.m. to 3 p.m.) and afternoon (3 p.m. to -5 p.m. in February; 4 p.m. to 6 p.m. in March; 4 p.m. to 6:30 p.m. in April; ; 4 p.m. to 7 p.m. in May and June), which were balanced to obtain the daily play pattern, c) the description of new play behaviors including their definitions, illustrations and classifications, and d) the duration (sec) of play behaviors, defined as the amount of time the calves engaged in play behaviors. Inter-observer reliability tests between two independent observers were calculated with the concordance index once a week and it ranged from 0.99 to 1.0 (Martin & Bateson, 2007).

Ethogram description

During the original observations, the play behaviors of this ethogram were observed in playful contexts although some of them could also be observed in other contexts. We took into

account all five criteria developed by P.K. Smith (1997) in order to distinguish play behaviors from other kinds of behaviors: (1) a resource, such as an object, leaf or stone was not gained or protected; (2) there were no combat-induced injuries; (3) there were frequent role reversals between a pair, with partners alternating between the attacker and the defender roles; (4) even if chasing ensued contact, further affiliation was likely; and (5) presence of play signals as exaggerated, reordered, incomplete, brief, varied in sequence, and inhibited forms of the typical behavior. Sexual aggression was never observed among these calves.

The hierarchical classification of this ethogram in three levels: category, subcategory, and behaviors followed those used in the unpublished thesis in mangabeys (*Cercocebus atys lunulatus*) (Maté, 1999). This play behavior ethogram was defined to be mutually exclusive, concise, and complete. The definition, illustration, and classification of all play behavioral behaviors used a structural criterion by referring to the posture and movements of the calves (Lehner, 1998). Body part composition used during play consisted on rostrum, head, blowhole, pectoral fin, side, ventral part, dorsal part, peduncle, and fluke (Delfour, Faulkner, & Carter, 2017; Müller et al., 1998). To describe this ethogram, we used three sources of information: review of existing cetacean behavior literature (English language) in wild and captive conditions, our original observations during the DP and QP phases and collaborative anonymous reviewers.

The ethogram presented here was amended and compiled into table format followed those used in published ethograms for equids. It includes: an English name for each play behavior (generally the most commonly used English term in the modern literature, and not necessarily the first name used in the literature), a line drawing depiction of the play behavior, a text description, examples of other terminology used, and the cetacean species in which we had found descriptions of similar behavior among cetaceans. Finally, for some categories or sub-categories, we included comments clarifying certain aspects of the behavior. Behaviors

were listed in chronological order of appearance starting by solitary and continuing by social behaviors (McDonnell & Haviland, 1995; McDonnell & Poulin, 2002).

Statistical analysis

The two following indexes were calculated for each calf separately by using the duration of play behaviors recorded during the QP.

In order to analyze the heterogeneity of play behavior we calculated the *Shannon's diversity index* (H) (Shannon & Weaver, 1949). The formula is

$$H= \sum p_i \log_2(1/p_i),$$

Where p_i is the proportion of time spent on the i_{th} play behavior. The value of the Shannon's diversity index partly depends on the number of behaviors in the sample and partly on the equality of the distribution of time among behaviors. Larger H values indicate higher behavioral diversity.

For the analysis of the degree of homogeneity of play we calculated *the Shannon's evenness index* (E) which analyzes how equal is the time invested in the different play behaviors by the calves. The formula is

$$E= H_{max}\text{-}H/ H_{max}$$

Where H is the Shannon's diversity index, H_{max} is the maximum heterogeneity calculated through H_{max}= Ln (N) (N is the number of play behaviors where all of them have different duration). The evenness index is constrained between 0 and 1. The values approach

1 indicate higher behavioral evenness where all play behavioral categories have the same duration (Begon, Townsend, & Harper, 2006; Maté, 1999).

All QP data analyses were performed with *SPSS* 25.0 for Windows (Statistical Package for Social Sciences, manufactured by *SPSS* Inc., Chicago, IL 60606, USA). A $p = 0.05$ rejection criterion was applied to all tests. The Lilliefors test verified the normal distribution of the results for each variable. The repeated measures ANOVA determined whether there were intra- and inter-individual significant differences per month for the following variables: (1) the percentage of the diversity of play (calculated by dividing the number of different play behaviors observed by the total number of play behaviors described in the ethogram); (2) the percentage of the time invested in play behavior (calculated by dividing the time invested in play by the rest of the time invested in non-play behavior); (3) the Shannon's diversity index (H); and (4) the Shannon's evenness index (E) (Lehner, 1998).

Results

This is the first peer-reviewed play ethogram in captive bottlenose dolphin calves which illustrates, defines, and classifies play into three hierarchical levels: categories, sub-categories, and behaviors. The defined play behaviors were recorded under broader categories and sub-categories of play behavior which allowed functional inference.

Figure 1 and Table 2 represent our resulting play ethogram in bottlenose dolphin calves. The ethogram was catalogued in 35 behaviors which were illustrated, defined, and classified. We distinguished the play between two categories: solitary and social play. Solitary play category with 17 behaviors was divided into three subcategories: locomotor play (six behaviors), object play (seven behaviors), and bubble play (four behaviors). Social play category with 18 behaviors was subdivided into two types and four subcategories: 1) intraspecific play –including locomotor play (comprising eight behaviors), play with object

(two behaviors), and play with bubbles (four behaviors) and 2) interspecific play – in the presence of humans- (four behaviors). Twenty-nine state play behaviors and six complex sequences of behaviors (*solitary* and *social follow of bubbles*, *push of bubbles*, and *burst of bubbles*) were catalogued. These sequenced behaviors always started with the behavior *make of bubbles*.

Most of the behaviors catalogued had been found in the English literature reviewed. The references to literature were chosen as readily available sources of further information. We did not attempt to provide an exhaustive inventory of all citations nor did we attempt to find earliest description of the behavior.

In terms related to ontogeny, thirty-two out of the 35 play behaviors were described during the DP and the remaining seven during the QP. The behaviors observed in both phases for both calves and in each month were: *swim, solitary jump, self-rub*, *exploration*, *push and pull, solitary throw and catch, solitary follow of bubbles, parallel swim, pursuit,* and *locomotion at the window*. All solitary and social locomotor sub-categories, as well as social bubble play sub-category, were described during the DP. *Social make of bubbles* and *social push of bubbles* were only observed during the DP but not during the QP for both calves. However, there were six behaviors observed in both subjects during the QP not previously seen: *throw, immersion, solitary make of bubbles, chase, bubbles at the window,* and *object at the window*. *Solitary sexual play* was only observed for the male in both phases. During the QP, *tongue play*, *rub*, and *propulsion* were only recorded for the male and *social throw and catch* were only recorded for the female. *Bubbles at the window* and *object at the window* were the two latest play behaviors which appeared at the eighth and ninth month for the female and the male, respectively (see Fig. 2 and Table 3).

There were no intra-individual significant differences in the percentage of play behavioral diversity (ANOVA repeated measures, $F = 1.96$, $df = 4$, $P = 0.39$), the percentage

of time invested in play ($F = 1.15$, $df = 4$, $P = 0.48$), the Shannon's diversity index ($F = 5.83$, $df = 4$, $P = 0.25$), and the Shannon's evenness index ($F = 5.85$, $df = 4$, $P = 0.25$) from sixth to 10th month old (Table 4).

There were inter-individual significant differences in the Shannon's diversity index ($F = 2296.62$, $df = 1$, $P = 0.01$) but not in the percentage of play behavioral diversity ($F = 178.38$, $df = 1$, $P = 0.05$), the percentage of time invested in play ($F = 62.87$, $df = 1$, $P = 0.08$) and the Shannon's evenness index ($F = 33.91$, $df = 1$, $P = 0.11$) from sixth to 10th month old (Table 4).

Discussion

Ethogram

This peer-reviewed play ethogram was the first in cataloguing play behavior in three hierarchical levels (categories, sub-categories, and behaviors) and illustrating in such a detailed manner all the play behaviors in bottlenose dolphin calves. Included in our final list of bottlenose dolphin calves play behaviors were what appeared in our original observations, in reports from the literature and the anonymous reviews to be the most common play behaviors of bottlenose dolphin calves. Some of our decisions concerning inclusion or exclusion from the ethogram may be questionable. Certainly, there could easily have been more play behaviors, further delineating specific elements within type of object, bubble, or humans. For example, objects such as leaves, buoy, stones could have been presented as several separate play behaviors, i.e. leaves circle, ball transport, buoy immersion. This distinction could be useful in future studies related to solitary or social object play or environmental enrichment evaluation (Delfour et al., 2017; Eskelinen et al., 2015). Another example would be in different bubble types. Bubble types such as ring, circle and column

could in other works be considered distinct play behaviors, especially in future studies related to the occurrence and function of bubble production (Moreno and Macgregor, 2004). Human types have been also considered distinct play behaviors, i.e. contact at the window in presence of researches, object at the window in presence of zoo visitors. This differentiation could be useful in future studies about visitors' effect on the cetacean welfare (Sherwen & Hemsworth, 2019).

Similarly, decisions were not always clear as to whether particular behaviors associated with play should be considered as elements of play. A related difficulty was deciding whether or not certain behaviors had a play form or were always serious behavior in young bottlenose dolphins. For example, some authors have considered ram and propulsion as play behavior (Denkinger & von Fersen, 1995). It is difficult to know whether or not these behaviors serve a serious social locomotor purpose as in adults or represents play forms of the behaviors. In this case, dolphin calves seem to mimic ram or propulsion behavior of adults in a playful manner. Solitary and social sexual play was often difficult to distinguish from sexual serious behavior but in this case, we consider it as play due to the sexual immaturity of the calves.

Previous literature which described ethograms in bottlenose dolphins focused on social play and play with objects (including bubbles), but did not mention the types of play involving social partners (intraspecific or interspecific) and objects (solitary or social) as we did in this study (Denkinger & von Fersen, 1995; Tizzi et al., 2000). The first level of the ethogram classification included solitary and social play. Solitary play is important and necessary because it helps dolphins to learn about their environment and to improve object-oriented skills before they develop the capacity of engaging in social play (Cappiello et al., 2018). Moreover, solitary play allows individuals to gain higher control over their movements, by allowing them to practice the orientation of their bodies in relation to different

objects and surfaces. These skills can then be translated into a social context under which individuals need to properly orient themselves in relation to their conspecifics during play (Pellis & Pellis, 2007). Solitary play behaviors in captive bottlenose dolphin calves have not been described before as much detail as in this study. Social play was also very important to bottlenose dolphin calves' development, including learning how to interact appropriately with the members of the group (e.g., hierarchical position, inter-individual recognition, cooperation), preparing themselves for adult activities (e.g., hunting, predator avoidance, and mate acquisition), and developing cultural competence (particularly through interaction with peers) (Mackey et al., 2014). In our ethogram, solitary locomotor play included less behaviors than solitary locomotor play as opposed to solitary object play which included more behaviors than their social versions. In the case of bubble play in both social and solitary sub-categories, the number of play behaviors were the same.

After determining if play was solitary or social, our ethogram allowed to catalogue different types of social play by answering the question: *with whom the dolphin is playing?* This level tried to distinguish between subjects of the same species –intraspecific- and different species –interspecific-human. This classification has not yet been observed in the literature related to bottlenose dolphin play. In captive bottlenose dolphins, intraspecific social play can occur as early as the first week of life. These interactions primarily occur between offspring and their mothers over the first two months (Kuczaj et al., 2006; Mackey et al., 2014). By learning a variety of behaviors through the observation of their mothers' activities, as well as by interacting with other calves, calves begin to show preferences for same-age peers rather than their mothers during play as they mature (Kuczaj & Eskelinen, 2014). Interspecific social play focused on calves' play behaviors in presence of humans independently if humans interacted or not with dolphins because it is known that e.g. zoo

visitors or staff have a neutral, positive, or negative effect on dolphin behavior (Trone, Kuczaj, & Solangi, 2005).

Once we established the distinction between solitary and social play categories on the one hand, and interspecific and intraspecific on the other, has been done, our ethogram allowed to catalogue different types of solitary and social play by answering to the question: *with what the dolphin is playing?* This level included locomotor play, object play and bubble play subcategories. This classification was not yet observed in any publication about bottlenose dolphin play. Locomotor play has been observed in species that show no other form of play, and locomotor-rotational play (body movements while the animal is otherwise stationary) is often the first play behavior exhibited by young animals (Burghardt, 2005). An example of this, found in the current study, was tongue play by calves which was observed more during the DP than the QP. Dolphins play with, or manipulate, animate or inanimate, organic, or inorganic objects of their environment, such as seaweed, non-prey animals and man-made objects. Although most dolphin individuals play with objects they can find, capture, or are provided with, dolphins in managed care can create their own objects with which to play, that is, bubbles (Hill et al., 2017). The capacity of making bubbles is almost exclusive to aquatic animals and it requires creativity, communication, and cultural transmission (e.g., Fertl & Wilson, 1997; Marten, Shariff, Psarakos, & White, 1996; Pace, 2000). Thus, we considered an important issue to differentiate between (1) non-self-produced objects (a) natural: leaves or stones and (b) man-made ones: balls, buoy, or plastic hoops and (2) the self-made object "bubbles". This differentiation allows us to test for the preference of these calves for natural or man-made objects (Greene et al., 2011). This last classification could be very useful in environmental enrichment studies, especially in studies related to object manipulation and its welfare implications in an effort to increase behavioral

opportunities to benefit the inhabitants of captive centers (e.g., Capiello et al., 2018; Delfour & Beyer, 2011; Delfour et al., 2017; Neto, Silveira, & dos Santos, 2016).

The use of a play ethogram, such as the one described in this study, could provide a valuable tool for the emerging field of conversation biology, which uses proximate and ultimate aspects of play behavior to aid in conservation decision-making and in reducing the loss of biodiversity (Buchholz, 2007).

Ontogeny

Hill et al. (2017) reviewed cetacean play under different developmental theories and perspectives. Most models of play development converge at the onset of play, anticipating that an animal's earliest play will take the simplest form: locomotor solitary play. Object and bubble play in dolphins developed as they matured whereas locomotor play was already present from birth as is the case for the results found in this study (Tizzi et al., 2000, Kuczaj et al., 2006). In our study, all social and solitary locomotor behaviors had already been described when both calves were three months old. During early development, one of the most important kinds of play behavior is locomotor play because it helps developing the sensorimotor skills (e.g., pursuit, swim, jump or rub) which are necessary to survive along this period (Mann & Smuts, 1999).

Conversely, some behaviors described in this study concerning play with objects –*chase*, *throw*, and *immersion*-, in the presence of humans –*bubbles at the window* and *object at the window*- and bubbles –*solitary make of bubbles*- were only observed during the QP. These behaviors are more complex than locomotor play and may require higher cognitive processes (e.g., self-monitoring, spatial positioning, and blowing bubbles) which are acquired as individuals mature (Kuczaj & Makecha, 2008; Spinka, Newberry, & Bekoff, 2001). Kuczaj et al. (2006) observed that spontaneous calf object play became more complex with increasing

age and Tizzi et al. (2000) found that object and bubble play developed in each animal individually as they mature, whereas social play seems to be present from birth coinciding with the results of our study.

In our case, only the male calf was observed engaging in socio-sexual bouts, in line with previous results showing that male bottlenose dolphins are the most involved in these kinds of behaviors (Connor, 2000).

Intra and inter-individual differences

During the QP, there were not statistically significant intra-individual differences between calves concerning the diversity of play, the time invested in play, the Shannon's diversity index, and the Shannon's evenness index.

During the QP, there were inter-individual differences between calves concerning the Shannon's diversity index but not in the time invested in play, the diversity of play, and the Shannon's evenness index. The female Shannon's diversity index was statistically significantly higher than in the male while the time invested in play, diversity of play, and Shannon's evenness index in both calves did not show differences from sixth to 10th month old. More studies about sexual differences are necessary because in this case there was only two subjects, so it is unclear if these findings were robust and hard to interpret in a broader sense. There were sexual differences in captive spotted dolphins, where males exhibited more object play than females (Greene et al., 2011) as well as in beluga males (*Delphinapterus leucas*) that preferred to engage in motor play while females preferred to engage in object play (Hill & Ramirez, 2014). Coinciding with the most of the results of our study, there were not inter-individual differences in some studies by Pace (2000), who revealed the absence of differences in fluke-made bubble rings between two calves, von Streit et al. (2013) who did not find significant differences in the amount of object play between two calves, and

Eskelinen et al., (2015) who did not observe differences in environmental enrichment participation between male and female calves. This absence of statistically significant inter-individual differences may be explained by the different forms of transmission mechanisms (trial and error, stimulus enhancement, exposure, contagion, imitation, demonstration, scaffolding, and teaching) at work for these dolphins. Play behaviors in this study could have been transmitted between mothers and calves (vertical transmission), between calves (horizontal transmission), and between older and younger dolphins (oblique transmission) (Hill et al., 2017). Among dolphins, comparable imitative tendencies are commonly seen in their games, or in their attraction towards an object being manipulated by another dolphin (Kuczaj & Yeater, 2006). In this study, *chase* and *solitary make of bubbles* appeared first for the female and later for the male. It is possible that the female calf or some other member of the group invented or mimed a novel play pattern never described before and the male imitated that play pattern during his display.

Finally, this study on the context of play was achieved in a single facility with two dolphins and limited by the small sample size but seems to reflect the similarity of play behaviors of the young dolphins. Other studies should be conducted with the same play ethogram in other facilities to compare the obtained results. Another limit of this study is a lack of data quantification from the birth to five months old. Moreover, no observations were conducted during the sessions nor at night. Further studies would benefit to focus on play but, for the welfare issue, a more inclusive studies would be needed to use this play ethogram to build a potential welfare indicator (Held & Spinka, 2011).

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FIGURE LEGEND

Fig. 1. Classification of play behavior in two bottlenose dolphin calves

Fig. 2. Occurrence of play behavior categories from 6th to 10th months old. (a) Female and (b) Male

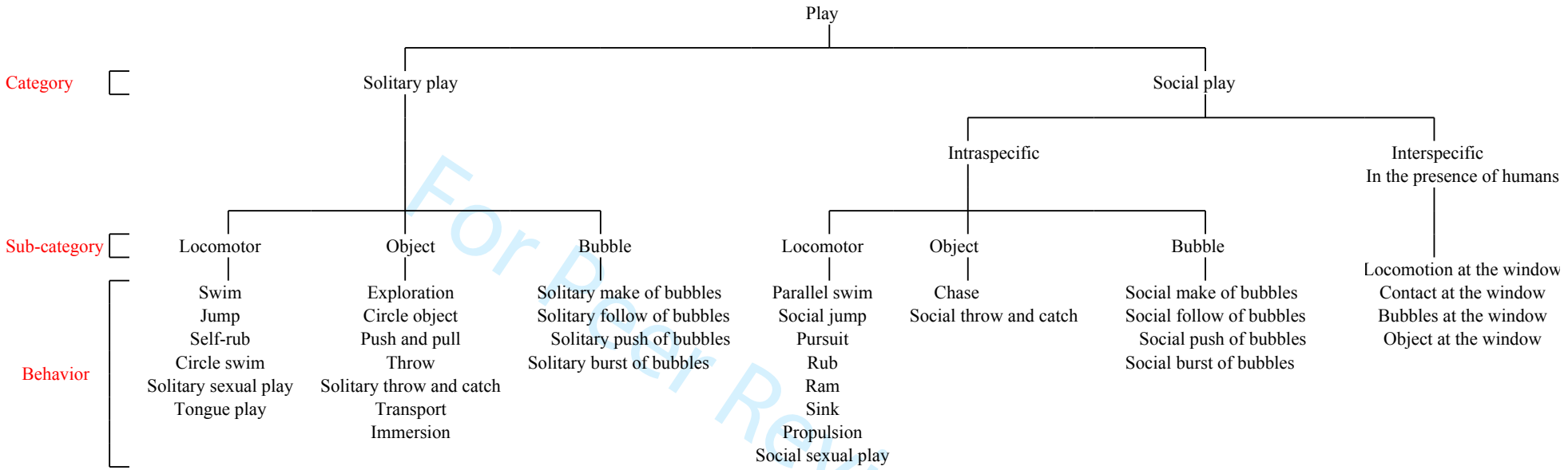
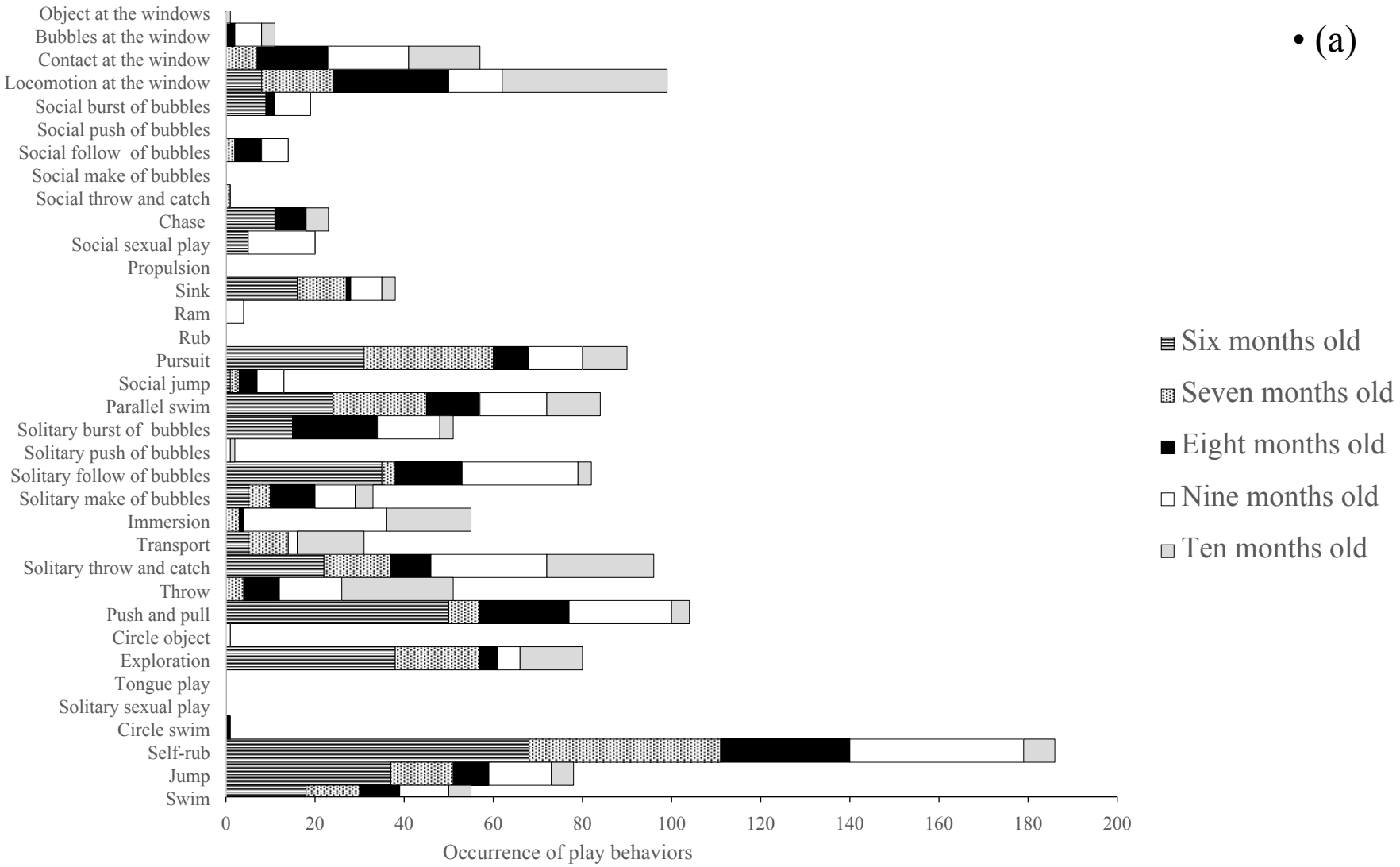


Fig. 1. Classification of play behavior for two bottlenose dolphin calves


Object at the windows
Bubbles at the window
Contact at the window
Locomotion at the window
Social burst of bubbles
Social push of bubbles
Social follow of bubbles
Social make of bubbles
Social throw and catch
Chase
Social sexual play
Propulsion
Sink
Ram
Rub
Pursuit
Social jump
Parallel swim
Solitary burst of bubbles
Solitary push of bubbles
Solitary follow of bubbles
Solitary make of bubbles
Immersion
Transport
Solitary throw and catch
Throw
Push and pull
Circle object
Exploration
Tongue play
Solitary sexual play
Circle swim
Self-rub
Jump
Swim
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20
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60
80
100
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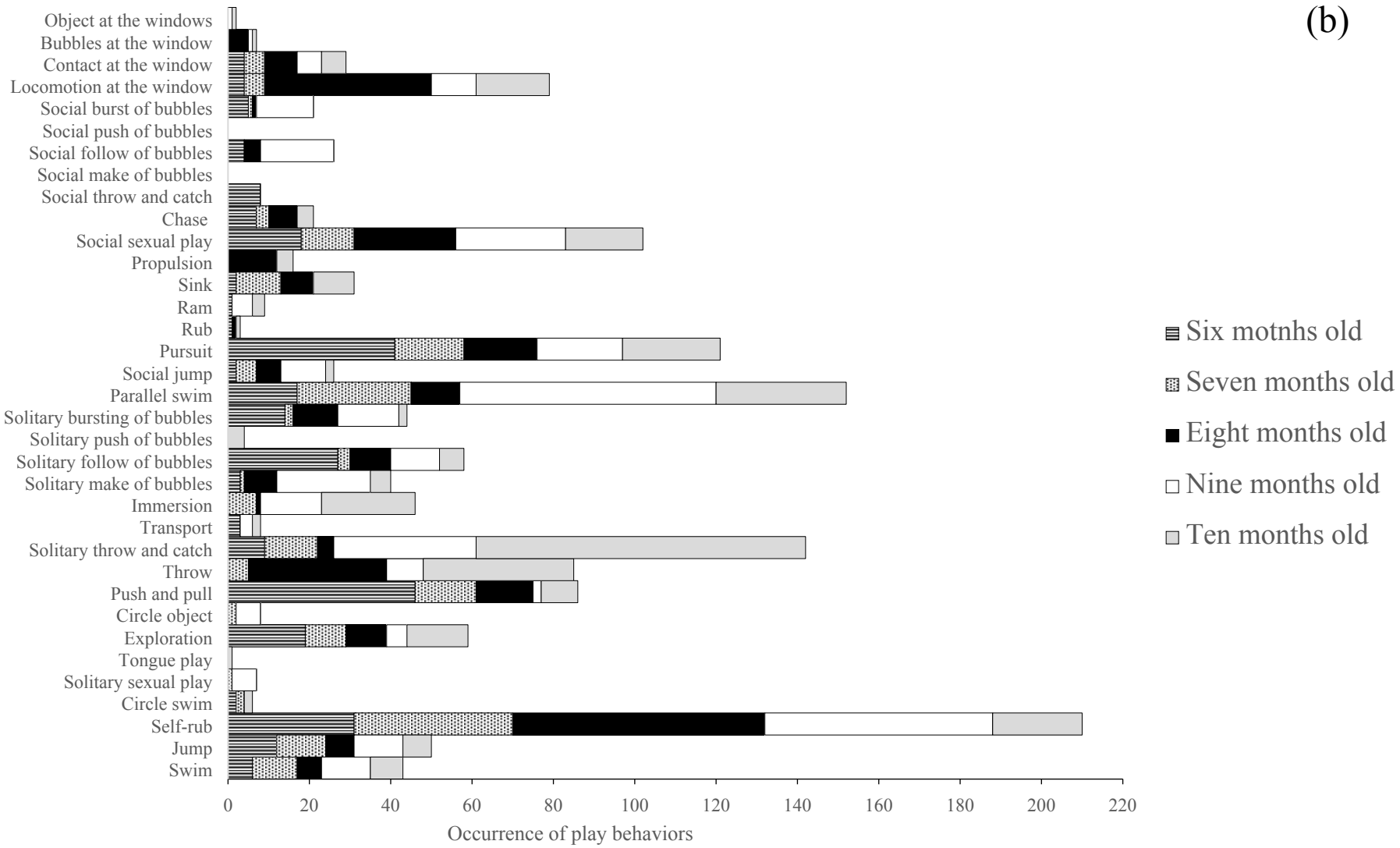
160
180
200
Occurrence of play behaviors
• (a)
Six months old
Seven months old
Eight months old
Nine months old
Ten months old


(b)
Object at the windows
Bubbles at the window
Contact at the window
Locomotion at the window
Social burst of bubbles
Social push of bubbles
Social follow of bubbles
Social make of bubbles
Social throw and catch
Chase
Social sexual play
Propulsion
Sink
Ram
Rub
Pursuit
Social jump
Parallel swim
Solitary bursting of bubbles
Solitary push of bubbles
Solitary follow of bubbles
Solitary make of bubbles
Immersion
Transport
Solitary throw and catch
Throw
Push and pull
Circle object
Exploration
Tongue play
Solitary sexual play
Circle swim
Self-rub
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Occurrence of play behaviors
Six motnhs old
Seven months old
Eight months old
Nine months old
Ten months old

Fig. 2. Occurrence of play behavior categories from 6th to 10th months old. (a) Female and (b) Male.

Table 1. Demographic information about the bottlenose dolphins.

Name	Sex	Age	Date of birth	Place of birth	Relationship
Neo	Male	Calf	24 August 2003	Born at Barcelona Zoo	Nereida's son
Leia	Female	Calf	25 August 2003	Born at Barcelona Zoo	Anak's daughter
Nereida	Female	Adult	Approx. 1980	Born in the wild	Neo's mother
Anak	Female	Adult	Approx. 1986	Born in the wild	Leia's mother
Nika	Female	Senior	Approx. 1964	Born in the wild	Unknown

Table 2. Play ethogram for both dolphin calves.

1. Solitary play: no other individuals are actively interacting with the focal individual (Cappiello et al., 2018, p. 456).

   1.1. Solitary locomotor play: consist on spontaneous movements carried out by the individual in its environment. It is also named motor play in bottlenose dolphins (Kuczaj et al., 2006).

Swim

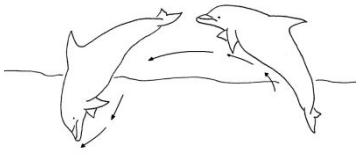
A dolphin zigzags with disordered sequences of motor acts around the pool.

Other names: serious travel (Baker, O'Brien, McHugh, & Berrow, 2017, p. 599; Miles and Herzing, 2003, p. 366), corkscrew swim (Müller et al., 1998, p. 98), and serious swim around, steady swim and speed swim (von Streit et al., 2011, p. 196).

Comments: in the literature, this play behavior has not been catalogued as play.

Species: bottlenose dolphin (Baker et al., 2017, p. 599; Müller et al., 1998, p. 98; von Streit et al., 2011, p. 196) and Atlantic spotted dolphin (Miles and Herzing, 2003, p. 366).

Jump



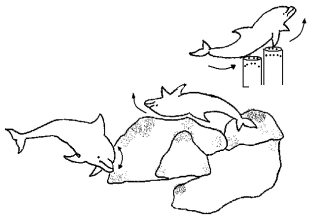
A dolphin breach and land on the back, the belly or on the side.

Other names: aerial behaviors: bow, lateral bow, breaching, back breaching, leap, inverted leap, and lateral leap (Müller et al., 1998, p. 92 and 94) and locomotor play (von Streit et al., 2011, p. 196).

Comments: normally dolphins jump separately, one by one, but on several occasions, a group of dolphins jumped simultaneously (see social jump) (Bel'kovich et al., 1991, p. 201).

Species: bottlenose dolphin (Bel'kovich et al., 1991, p. 201; Denkinger and von Fersen, 1995, p. 201; Müller et al., 1998, p. 92 and 94; von Streit et al., 2011, p. 196), dusky dolphin (*Lagenorhynchus obscurus*) (Würsig & Würsig, 1989, p. 879), and tucuxi (*Sotalia fluviatilis*) (Spinelli, Nascimiento, & Yamamoto, 2002, p. 168).

Self-rub



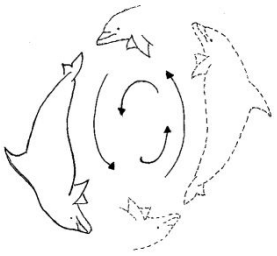
A dolphin with circular and up-and-down repeated movement presses against furniture with one of its body parts.

Other names: tactile play (Bel'kovich et al., 1991, p. 71), rubbing (Denkinger and von Fersen, 1995, p. 201), and rub (von Streit et al., 2011, p. 196).

Comments: Tizzi and cols. (2000, p. 156) described object rub when dolphin rubs head, side, or other areas of the body on objects, but it has not been observed in our ethogram.

Species: bottlenose dolphin (Denkinger and von Fersen, 1995, p. 201; Tizzi et al., 2000, p. 156; von Streit et al., 2011, p. 196) and Commerson's dolphin (*Cephalorhynchus commersonii*) (Sakai, Morisaka, Iwasaki, Yoshida, Wakabayashi, Seko, et al., 2013, p. 307).

Circle swim



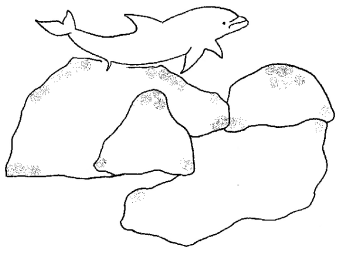
A dolphin swims in a repetitive circle.

Other names: erratic swim (Serres & Delfour, 2017, p.103) and steady swim (von Streit et al., 2011, p. 196).

Comments: steady swim behavior was classified as non-play solitary behavior (von Streit et al., 2011, p. 196).

Species: bottlenose dolphin (Serres & Delfour, 2017, p.103; von Streit et al., 2011, p. 196).

Solitary sexual play



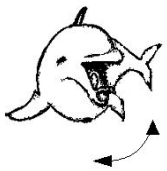
A dolphin has tactile interactions involving genital contact with objects. It includes genital slit/genitals which was defined as pink genital area or erect penis (Baker et al., 2017, p. 601).

Other names: tactile play (Bel'kovich et al., 1991, p.70) and rubs genital on tank objects (Defran & Pryor, 1980, p. 337).

Comments: rubs genital on tank objects was catalogued as serious sexual behavior (Defran & Pryor, 1980, p. 337).

Species: bottlenose dolphin (Bel'kovich et al., 1991, p.70) and Amazon river dolphin (*Inia geoffrensis*), killer whale (*Orcinus orca*), and spinner dolphin (*Stenella longirostris*) (Defran & Pryor, 1980, p. 337).

Tongue play

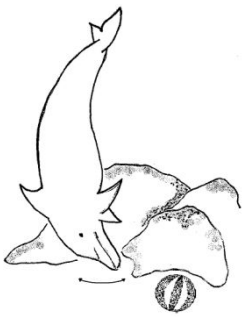


A dolphin repeatedly moves his tongue from one side to the other side of its mouth.

Species: bottlenose dolphin calves of this study (no specific reference found to this behavior in other species).

1.2. Solitary object play: the individual directs play behavior at an object for a minimum 1 sec (Cappiello et al., 2018, p. 456). It includes natural objects such as leaves or stones and man-made objects such as balls, buoys, or plastic hoops. There are publications which also differentiated between object play (solitary) and object play together (social) in bottlenose dolphins and Atlantic spotted dolphin (Greene et al., 2011; Kuczaj et al., 2006; Mackey et al., 2014).

Exploration



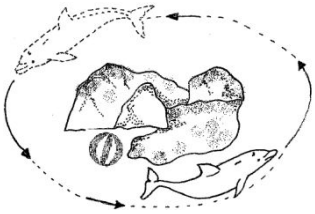
A dolphin swims around furniture and then it stops near to it moving its head while it is observing object below furniture.

Other names: tactile play (Bel'kovich et al., 1991, p.70), approaches new objects (Defran & Pryor, 1980, p. 337), object investigation (Morris & Lockyer, 1988, p. 53), and exploratory behavior (von Streit et al., 2011, p. 196).

Comments: exploratory behavior was catalogued as a serious solitary behavior instead of play (von Streit et al., 2011, p. 196).

Species: bottlenose dolphin (Bel'kovich et al., 1991, p.70; Morris & Lockyer, 1988, p. 53; von Streit et al., 2011, p.196), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), and rough-toothed dolphin (*Steno bredanensis*) (Defran & Pryor, 1980, p. 337), and Indo-Pacific bottlenose dolphin *(Tursiops aduncus*) (Tayler & Saayman, 1972, p. 26).

Circle object

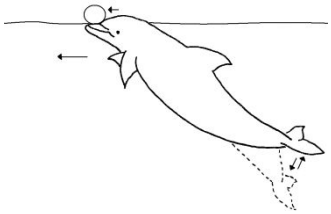


A dolphin swims around an object in circles.

Other names: circle (Tizzi et al., 2000).

Species: bottlenose dolphin (Tizzi et al., 2000).

Push and pull



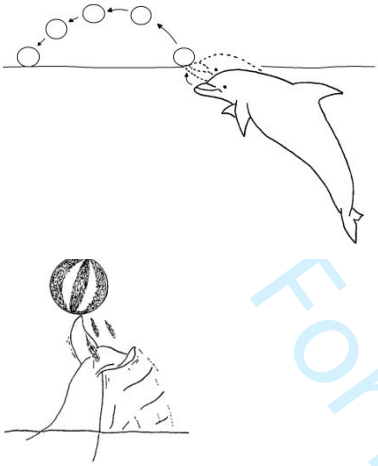
A dolphin uses one of its body parts to push or pull an object.

Other names: pushing (Denkinger & von Fersen, 1995 p. 201) and push (Tizzi et al., 2000, p. 156).

Comments: the both last behaviors include pulling in its definitions (Denkinger & von Fersen, 1995, p. 201; Tizzi et al., 2000, p. 156).

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; Tizzi et al., 2000, p. 156; Mackey et al., 2014, p. 35; von Streit et al., 2011, p. 196).

Throw



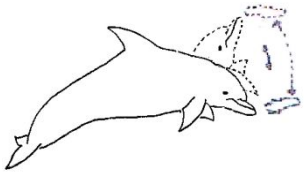
A dolphin hits an object above the surface of the water with one of its body parts.

Other names: throwing (Delfour et al., 2017, p. 6), object toss (Müller et al., 1998, p. 93), and throw out an object (von Streit et al., 2006, p. 196).

Comments: we have not been differentiated between toss and throw behaviors. However, manipulation of jellyfish and food fish were defined as dolphins tossing jellyfish or food fish in all directions with the rostrums and tails (Bel'kovich et al., 1991, p. 71).

Species: bottlenose dolphin (Bel'kovich et al., 1991, p. 71; Bloom, 1991, p. 104; Delfour et al., 2017, p. 6; Mackey et al., 2014, p. 35; Müller et al., 1998, p. 93; Tizzi et al., 2000, p. 156), Amazon river dolphin (Sylvestre, 1985, p. 63), and Amazon river dolphin and baiji (*Lipotes vexillifer*) (Martin, da Silva, & Rothery, 2008, p. 243; Renjun, 1994, p. 40).

Solitary throw and catch

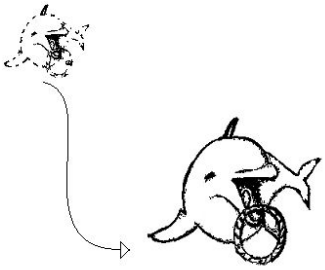


A dolphin holds an object with one of its body parts throws it to catch it back.

Other names: throwing and catching (Denkinger & von Fersen, 1995, p. 201).

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; McBride & Hebb, 1948, p. 116), spinner dolphin (Johnson & Norris, 1994, p.272), and Indo-Pacific bottlenose dolphin (Tayler & Saayman, 1972, p. 28).

Transport



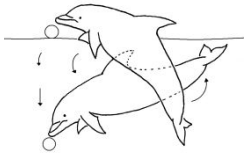
A dolphin holds an object with one of its body parts to carry it around the pool.

Other names: carry (Delfour et al., 2017, p. 6; Gewalt, 1989, p. 74; Mackey et al., 2014, p. 35), transporting (Denkinger & von Fersen, 1995, p. 201), carry object (Miles & Herzing, 2003, p. 370) and mouth (Tizzi et al., 2000, p. 156).

Comments: in the wild, bottlenose dolphins carry seagrass or weed in his mouth (Mann & Smuts, 1999, p. 551).

Species: bottlenose dolphin (Allen, Bejder, Krützen, 2010, p. 449; Delfour et al., 2017, p. 6; Denkinger & von Fersen, 1995, p. 201; Mackey et al., 2014, p. 35; Mann & Smuts, 1999, p. 551; McBride & Hebb, 1948, p. 116; Tizzi et al., 2000, p. 156; von Streit et al., 2011, p. 196), beluga whale (Gewalt, 1989, p. 74), spinner dolphin (Johnson & Norris, 1994, p.272), Amazon river dolphin (Kuczaj & Yeater, 2007, p. 416; Sylvestre, 1985, p. 63), Atlantic spotted dolphin (Miles & Herzing, 2003, p. 370), Indo-pacific humpback dolphin (*Sousa chinensis)* (Parra, 2007, p. 147), Amazon river dolphin and baiji (*Lipotes vexillifer*) (Renjun, 1994, p. 40), and Delphinidae (*Tursiops sp.*) (Smolker, Richards, Connor, Mann, & Berggren, 1997, p. 455).

Immersion



A dolphin presses with one of its body parts a floating object under the water.

Other names: pressing (Denkinger & von Fersen, 1995, p. 201).

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201) and bowhead whale (*Balaena mysticetus*) (Würsig, Dorsey, Richardson, & Wells, 1989, p. 33).

1.3. Solitary bubble play: the individual directs play behavior at a bubble or bubbles for a minimum of 1 sec (Cappiello et al., 2018, p. 456). Bubbles showed two shapes: ring or spherical.

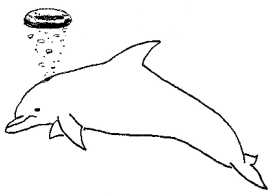
Solitary make of bubbles

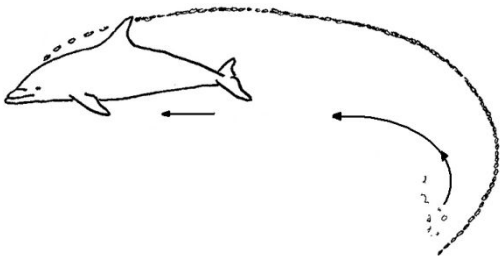
A dolphin makes a large singular bubble, a clouded circle of bubbles or a streamed of a column of bubbles and afterwards there is not any interaction with them (Moreno & Macgregor, 2019).

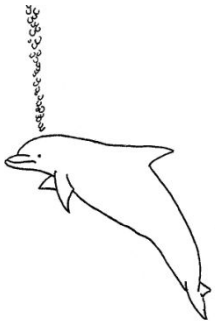
Other names: self-made air bubble rings (Gewalt, 1989, p. 73), whistle trail (Miles & Herzing, 2003, p. 370), and one large bubble (Müller et al., 1998, p. 95).

Comments: whistle trail consist on dolphin emits a trail of bubbles from its blowhole, usually performed while emitting a signature whistle or excitement vocalization. In our study, we have not included vocalizations because we could not hear them throughout the underwater windows.

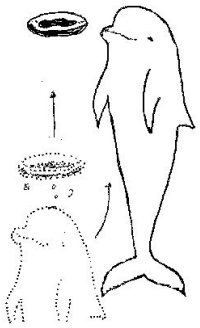
Species: bottlenose dolphin (Kuczaj II & Walker, 2006, p. 594; Marten et al., 1996, p. 93; McCowan et al., 2000, p. 100; Miles & Herzing, 2003, p. 370; Müller et al., 1998, p. 98), Amazon river dolphin (Gewalt, 1989, p. 73), and Atlantic spotted dolphin (Miles and Herzing, 2003, p. 366).

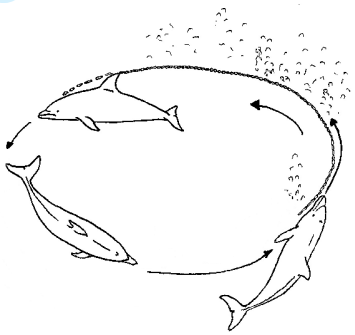


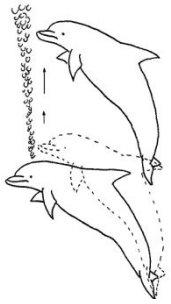




Solitary follow of bubbles	A dolphin chases a large singular bubble, a clouded circle of bubbles or a streamed of a column of bubbles closely without touching them. *Other names*: bubble interest/follow (Pace, 2000, p. 59) and interest (Tizzi et al., 2000, p. 156). *Species*: bottlenose dolphin (Marten et al., 1996, p. 93; McCowan et al., 2000, p. 100; Pace, 2000, p. 59; Serres and Delfour, 2017, p. 103; Tizzi et al., 2000, p. 156) and beluga whale (Delfour & Aulagnier, 1997).





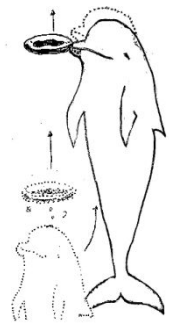


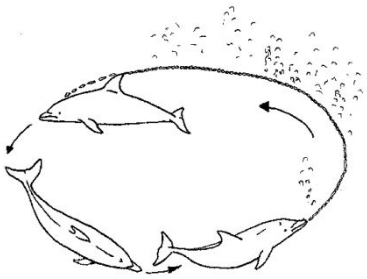
Solitary push of bubbles

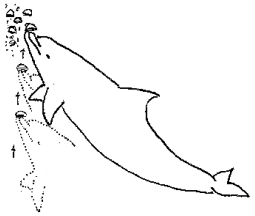
A dolphin follows a large singular bubble, a clouded circle of bubbles or a stream of a column of bubbles closely while raising them up with its rostrum.

Other names: ring push (Pace, 2000, p. 59) and push (Tizzi et al., 2000, p. 156).

Species: bottlenose dolphin (McCowan et al., 2000, p. 100; Pace, 2000, p. 59; Serres and Delfour, 2017, p. 103; Tizzi et al., 2000, p. 156).







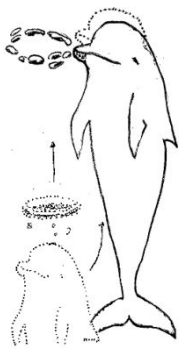
Solitary burst of bubbles

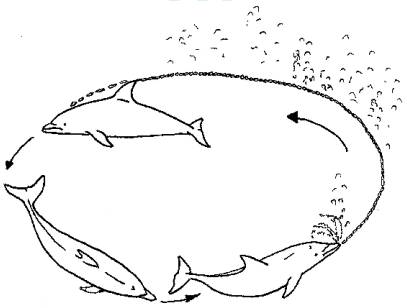
A dolphin follows a large singular bubble, a clouded circle of bubbles or a streamed of a column of bubbles closely while breaking them off with bites.

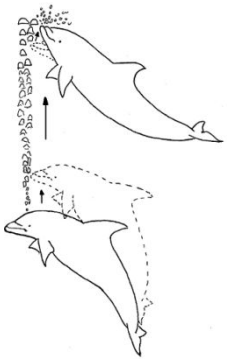
Other names: ring bite (Pace, 2000, p. 59) and bite (Tizzi et al., 2000, p. 156).

Comments: belugas burst bubble kicking it with their flukes (Delfour & Aulagnier, 1997, p. 184) and Amazon river dolphins burst bubbles swimming through them (Gewalt, 1989, p. 75).

Species: bottlenose dolphin (Mackey et al., 2014, p. 35; McCowan et al., 2000, p. 100; Pace, 2000, p. 59; Serres and Delfour, 2017, p. 103; Tizzi et al., 2000, p. 156), beluga whale (Delfour & Aulagnier, 1997, p. 184), and Amazon river dolphin (Gewalt, 1989, p. 75).







2. Social Play

2.1 Intraspecific

2.1.1 Social locomotor play: the individual is interacting with a conspecific(s) within one body lengths distance of each other for a minimum period of 1 sec (Cappiello et al., 2018, p. 456). It was also named motor play in bottlenose dolphins (Kuczaj et al., 2006).

Parallel swim

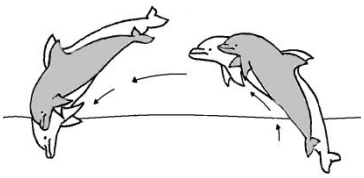
Two dolphins swim in the same direction and speed parallelly. The dolphins can change their direction with a zigzag movement.

Other names: cross swimming and speedy swimming (Denkinger & von Fersen, 1995, p. 201), locomotor play (von Streit et al., 2011, p. 196), synchronous swimming and synchronous veer (Serres & Delfour, 2017, p. 103), and swim (fast) (Tizzi et al., 2000, p. 156),

Comments: in the reviewed literature, it has been classified as social play.

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; Serres & Delfour, 2017, p. 103; von Streit et al., 2011, p. 196; Tizzi et al., 2000, p.156) and spinner dolphin (Johnson & Norris, 1994, p. 274).

Social jump



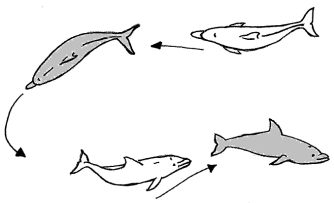
Two dolphins breach and land synchronously on the back, on the belly, or on the side.

Other names: jump (Bel'kovich et al., 1991, p. 201; Denkinger and von Fersen, 1995, p. 201), locomotor play (von Streit et al., 2013, p. 179; von Streit et al., 2011, p. 196), leap and slap (Tizzi et al., 2000, p. 156), and synchronous jumping and jump against (Serres & Delfour, 2017, p. 103).

Comments: Jump against was also defined as two dolphins jump synchronously and one dolphin hits the other with its body (Serres & Delfour, 2017, p. 103). Complex turns were also included in social jump and it was defined as rotations without separating the body from the water (Bel'kovich et al., 1991, p. 70). Some literature includes jump into a more general category such as locomotor play which also includes dolphin frolics on its side or on its back (von Streit et al., 2013, p. 179; von Streit et al., 2011, p. 196).

Species: bottlenose dolphin (Bel'kovich et al., 1991, p. 201; Denkinger and von Fersen, 1995, p. 201; Serres & Delfour, 2017, p. 103, Tizzi et al., 2000, p. 156; von Streit et al., 2013, p. 179; von Streit et al., 2011, p. 196) and, tucuxi (Spinelli et al., 2002, p. 168).

Pursuit



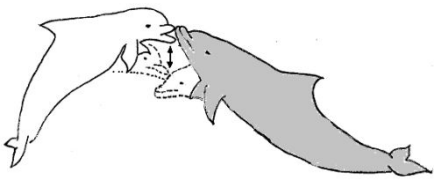
One dolphin swim behind another dolphin. When the pursued dolphin changes direction and speed, the pursuer dolphin also does so. The pursued dolphin can become the pursuer dolphin.

Other names: chasing (Bel'kovich et al., 1991, p. 71; DeLong, 1999, p. 219; Denkinger & von Fersen, 1995, p. 201), chase (Baker et al., 2017, p. 601; Mackey et al., 2014, p. 35), reciprocal chasing (Mann & Smuts, 1999, p. 550), and pursuit behaviors (Serres & Delfour, 2017, p. 103),

Comments: our pursuit behavior includes chasing, charge, follow, U turn, approach-leave-approach, jumping, escape, avoid, and turn around (Serres & Delfour, 2017, p. 103).

Species: bottlenose dolphin (Baker et al., 2017, p. 601; Bel'kovich et al., 1991, p. 71; DeLong, 1999, p. 219; Denkinger & von Fersen, 1995, p. 201; Mackey et al., 2014, p. 35; Mann & Smuts, 1999, p. 550; McBride & Hebb, 1948, p. 116; Serres & Delfour, 2017, p. 103) and Indo-Pacific bottlenose dolphin (Tayler & Saayman, 1972, p. 28).

Rub



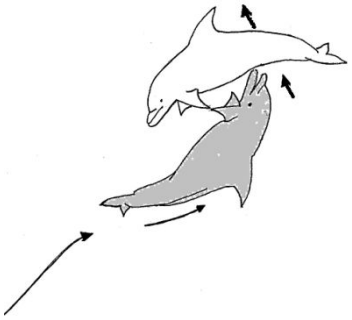
A dolphin uses one of its body parts to touch another dolphin repeatedly.

Other names: pec rub (Baker et al., 2017, p. 601), rubbing and beak to beak (Denkinger & von Fersen, 1995, p. 201), pectoral rubbing and caudal rubbing (Serres & Delfour, 2017, p. 102), and rubbing (Müller et al., 1998, p. 93).

Comments: pec rub detailed as one dolphin rubs along another's pectoral fin (Baker et al., 2017, p. 601). Rubbing bodies in adults was classified as sexual behavior (Bel'kovich et al., 1991, p. 71).

Species: bottlenose dolphin (Baker et al., 2017, p. 601; Denkinger & von Fersen, 1995, p. 201; Müller, et al., 1998, p. 93; Serres & Delfour, 2017, p. 102).

Ram



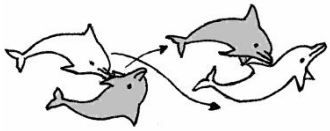
A dolphin charges with one of its body parts against another dolphin and it may involve biting or mouthing.

Other names: strokes another animal (Defran & Pryor, 1980, p. 335), ramming (Denkinger & von Fersen, 1995, p. 201), and rostral nudge (Müller et al., 1998, p. 93).

Comments: sideswipe was a variation of our ram behavior and it was detailed as momentary violent body contact resulting from one dolphin rapidly approaching another and rebounding off of its conspecific's body (Serres & Delfour, 2017, p. 102).

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; Müller et al., 1998, p. 93; Serres & Delfour, 2017, p. 102) and short-beaked common dolphin (*Delphinus delphis*), killer whale, false killer whale, spinner dolphin and rough-toothed dolphin (Defran & Pryor, 1980, p. 335).

Sink



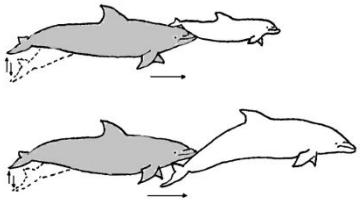
A dolphin uses one part of its body to push another dolphin down and it may involve biting or mouthing.

Other names: pushing an animal (Denkinger & von Fersen, 1995, p. 201) and fall one (Serres & Delfour, 2017, p. 102).

Comments: fall one is a variation of sink and it was defined as one dolphin falls on another animal or its body part at or above the surface (Serres & Delfour, 2017, p. 102).

Species: bottlenose dolphin (Serres & Delfour, 2017, p. 102; von Streit et al., 2011, p. 196).

Propulsion



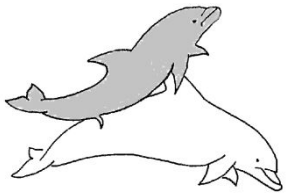
A dolphin pushes with the rostrum or head another dolphin by its fluke thus provoking the displacement of the pushed dolphin, who stays immobile, ahead.

Other names: pushing an animal (Denkinger & von Fersen, 1995, p. 201), pushing (Serres & Delfour, 2017, p. 102) and push (Tizzi et al., 2000, p. 156).

Comments: it is important to distinguish propulsion from *goose* which was defined as one dolphin contacts another's genital slit with its rostrum but there was not propulsion (Baker et al., 2017, p. 601).

Species: bottlenose dolphin (Baker et al., 2017, p. 601; Denkinger & von Fersen, 1995, p. 201; Serres & Delfour, 2017, p. 102; Tizzi et al., 2000, p. 156).

Social sexual play



A dolphin calf has a tactile interaction involving genital contact with another dolphin. It includes genital slit/genitals which has been defined as pink genital area or erect penis (Baker et al., 2017, p. 601).

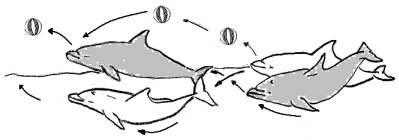
Other names: sexual behavior (Denkinger & von Fersen, 1995, p. 201). and mouth (von Streit et al., 2011, p. 196).

Comments: Serres and Delfour (2017, p. 103) catalogued socio-sexual behaviors and included side mount, mounting, erection, genital inspection, genital to head, melon to genitals and intromission. All of them have been observed in these dolphin calves and catalogued as social sexual play.

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; Serres & Delfour, 2017, p. 103).

2.1.2. Social object play: two or more individuals direct play behavior at an object for a minimum 1 sec (Cappiello et al., 2018, p. 456). It includes natural objects such as leaves or stones and man-made objects such as balls, buoys, or plastic hoops. There are publications which also differentiated between object play (solitary) and object play together (social) in bottlenose dolphins and Atlantic spotted dolphin (Greene et al., 2011; Kuczaj et al., 2006; Mackey et al., 2014) like in this study.

Chase



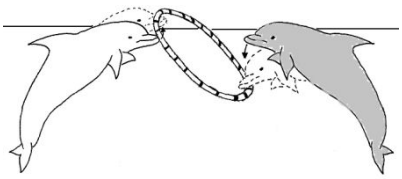
A dolphin carries an object on with one part of its body while another dolphin tries to grab it.

Other names: following, chasing and tailcatching with object (Denkinger and von Fersen, 1995, p. 201).

Comments: the three last behaviors defined by Denkinger and von Fersen (1995, p. 201) were defined as following, chasing, or tailcaching another animal with an object in the beak.

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; McBride & Hebb, 1948, p. 116).

Social throw and catch



A dolphin holds an object with one part of its body and throws it to another dolphin, who throws it back in the same direction. This behaviour is repeated either stationary or while animals are swimming around the pool.

Other names: throwing and catching (Denkinger and von Fersen, 19995, p. 201), sharing an object (Mackey et al., 2014, p. 35), and social object play together (von Streit et al., 2011, p. 196).

Comments: social object play together was defined as two dolphins take object into the mouth alternately (von Streit et al., 2011, p. 196).

Species: bottlenose dolphin (Denkinger & von Fersen, 1995, p. 201; Mackey et al., 2014, p. 35; von Streit et al., 2011, p. 196) and spinner dolphin (Johnson & Norris, 1994, p. 273).

2.1.3. Social bubble play: two or more individuals direct play behavior at a bubble or bubbles for a minimum of 1 sec (Cappiello et al., 2018, p. 456). Bubbles showed two shapes: ring or spherical.

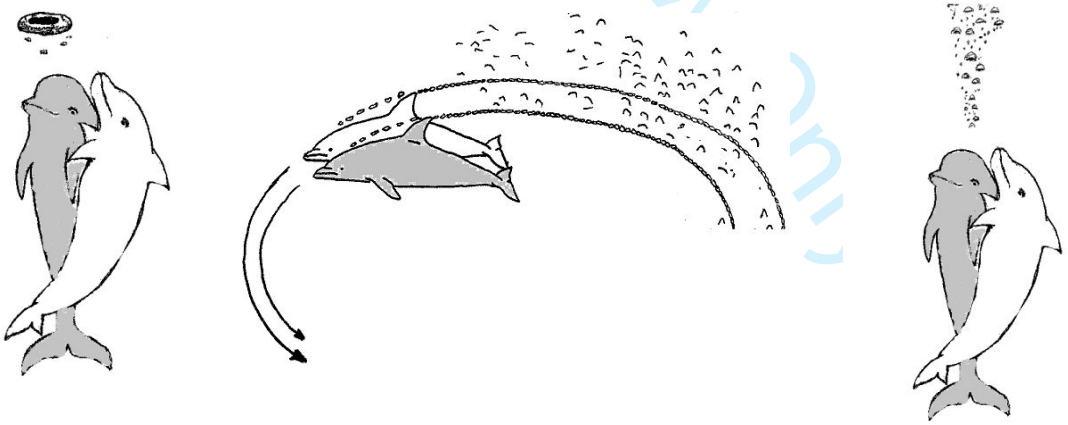
Social make of bubbles

Two nearby dolphins make a large singular bubble, a clouded circle of bubbles or a streamed of a column of bubbles without touching them.

Other names: whistle trail (Miles & Herzing, 2003, p. 370).

Comments: whistle trail consist on dolphin emits a trail of bubbles from its blowhole, usually performed while emitting a signature whistle or excitement vocalization. In our study, we have not included vocalizations because we could not hear them throughout the underwater windows (Miles & Herzing, 2003, p. 370).

Species: bottlenose dolphin (Miles & Herzing, 2003, p. 370) and Amazon river dolphin and baiji (*Lipotes vexillifer*) (Renjun, 1994, p. 40).

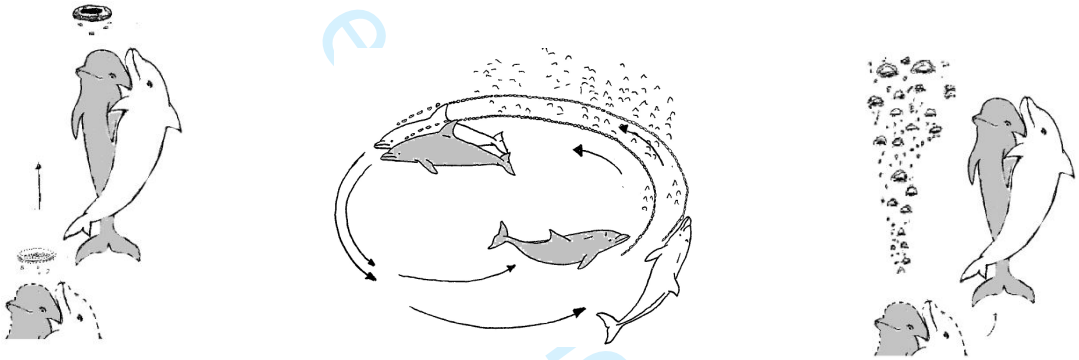


Social follow of bubbles

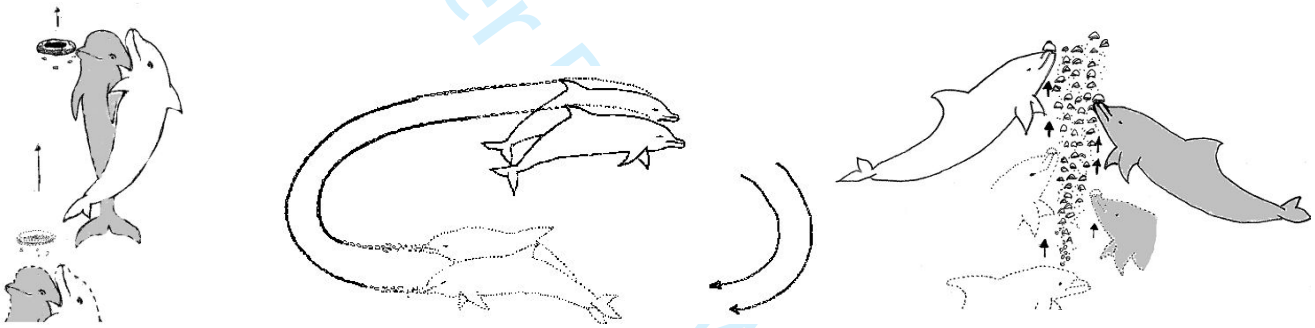
Two nearby dolphins follow a large singular bubble, a clouded circle of bubbles or a stream of column of bubbles without touching them.

Other names: bubble interest/follow (Pace, 2000, p. 59) and interest (Tizzi et al., 2000, p. 156).

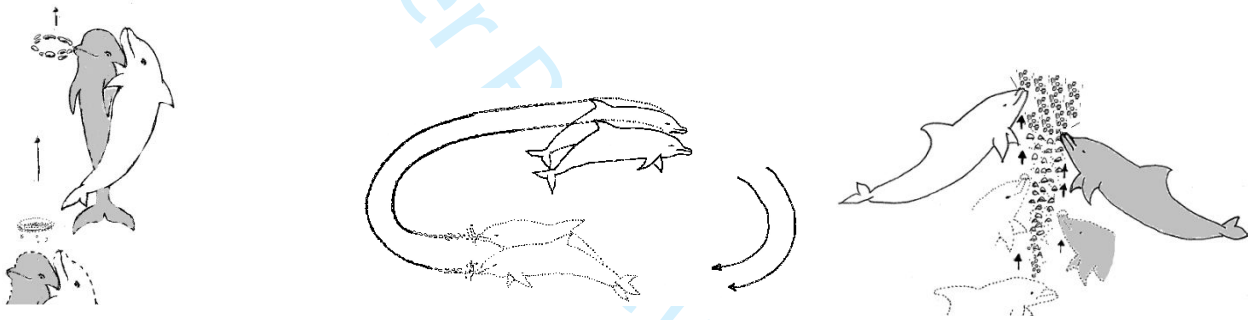
Species: bottlenose dolphin (Pace, 2000, p. 59; Serres and Delfour, 2017, p. 103; Tizzi et al., 2000, p. 156).



Social push of bubbles	Two nearby dolphins follow a large singular bubble, a clouded circle of bubble or a stream of a column of bubbles while raising them up with their rostrum. *Other names*: ring push (Pace, 2000, p. 59) and push (Tizzi et al., 2000, p. 156). *Species*: bottlenose dolphin (Pace, 2000, p. 59; Serres and Delfour, 2017, p. 103; Tizzi et al., 2000, p. 156).



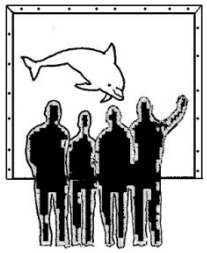
Social burst of bubbles	Two nearby dolphins follow a large singular bubble, a clouded circle of bubbles or a stream of a column of bubbles while breaking them off when they bite them. *Other names*: ring bite (Pace, 2000, p. 59) and bite (Tizzi et al., 2000, p. 156). *Species*: bottlenose dolphin (Kuczaj II & Walker, 2006, p. 594; Mackey et al., 2014, p. 35; Pace, 2000, p. 59; Serres and Delfour, 2017, p. 103; Tizzi et al., 2000, p. 156).



2.2. Interspecific

2.2.1 In the presence of humans: was only focused when there were humans at the underwater windows independently if they interacted or not with dolphins. Humans comprised zoo staff (keepers, vets, maintenance, or administrative workers), students, researchers, and visitors (Kuczaj et al., 2006, p. 227).

Locomotion at the window

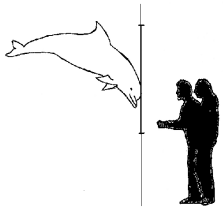


The dolphin imitates the movements of humans such as moving the head up and down or following people across the windows while they move from one place to another.

Other names: human imitation (Kuczaj & Yeater, 2006, p. 416).

Species: dolphin (Kuczaj & Yeater, 2006, p. 416).

Contact at the window

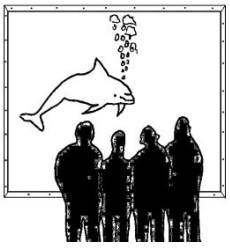


A dolphin repeatedly touches the underwater viewing windows with one part of its body.

Comments: this behavior was also catalogued as a stereotypy and observed in three sub-adult isolated bottlenose dolphins when placed in relatively close confinement. This stereotyped behavior was named head-pressing behavior and it was frequently observed when dolphin presses its forehead against the Perspex side of the tank (Greenwood, 1982, p. 15).

Species: bottlenose dolphin calves, this study.

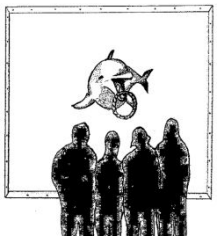
Bubble at the window



A dolphin makes bubbles in front of the window.

Species: bottlenose dolphin calves, this study.

Object at the window



A dolphin holds an object with one of its body parts in front of the window.

Species: bottlenose dolphin (Herzing, Delfour, & Pack, 2012).

Table 3. Observed and unobserved play behaviors during the PP and duration (sec) of play behaviors during the QP in both bottlenose dolphin calves.

Play behavioral classification				DP						QP									
				Three months old		Four months old		Five months old		Six months old		Seven months old		Eight months old		Nine months old		Ten months old	
				Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Solitary play		Locomotor	Swim	√	√	√	√	√	√	810	394	453	475	935	794	434	326	91	239
			Jump	√	√	√	√	√	√	813	180	100	112	102	30	165	116	46	87
			Self-rub	√	√	√	√	√	√	2100	1172	1001	1906	554	1752	801	2444	295	662
			Circle swim	√	√	√	√	√	√	0	29	0	32	16	0	0	0	0	27
			Solitary sexual play	x	√	x	√	x	√	0	0	0	84	0	0	0	204	0	0
			Tongue play	√	√	√	√	√	√	0	0	0	0	0	0	0	0	0	12
		Objects	Exploration	√	√	√	√	√	√	1566	1080	1183	290	296	989	157	239	799	801
			Circle object	√	x	x	√	x	√	0	0	0	225	0	0	11	170	0	0
			Push and pull	√	√	√	√	√	√	3231	2789	258	901	537	489	531	62	102	574
			Throw	x	x	x	x	x	x	0	0	18	516	449	1354	416	303	1220	1404
			Solitary throw and catch	√	√	√	√	√	√	1852	639	1017	535	695	175	1175	2062	1457	5942
			Transport	√	√	x	√	x	√	312	78	264	0	0	0	18	100	935	20
			Immersion	x	x	x	x	x	x	0	0	131	847	121	78	2198	863	1103	1234
		Bubbles	Solitary make of bubbles	x	x	x	x	x	x	804	62	816	13	172	98	161	478	26	51
			Solitary follow of bubbles	√	√	√	√	√	√	1127	874	44	67	131	194	318	259	28	48
			Solitary push of bubbles	√	√	√	√	x	√	0	0	0	0	0	0	35	0	17	15
			Solitary burst of bubbles	√	√	√	√	√	√	466	610	0	16	340	211	148	156	12	15
Social play	Intraspecific	Locomotor	Parallel swim	√	√	√	√	√	√	721	1611	1197	2457	582	1176	1152	3999	1461	3924
			Social jump	√	√	√	√	√	√	15	54	3	48	63	10	76	121	0	61
			Pursuit	√	√	√	√	√	√	1431	1726	1159	486	211	543	449	694	270	970
			Rub	√	√	√	√	√	x	0	68	0	0	0	19	0	0	0	21
			Ram	√	√	√	√	√	√	0	8	0	0	0	0	177	194	0	230
			Sink	√	√	√	√	√	x	822	126	684	695	26	870	395	0	105	940
			Propulsion	√	√	√	√	√	√	0	0	0	0	0	318	0	0	0	265
			Social sexual play	x	√	x	√	√	√	371	216	0	1071	0	1931	1564	1480	0	1227
		Objects	Chase	x	x	x	x	x	x	245	245	0	138	212	212	0	0	455	181
			Social throw and catch	√	√	√	√	x	√	0	0	33	0	0	0	0	0	0	0
		Bubbles	Social make of bubbles	√	√	√	√	√	√	0	0	0	0	0	0	0	0	0	0
			Social follow of bubbles	√	√	√	√	√	x	0	95	44	0	51	34	200	270	0	0
			Social push of bubbles	√	√	√	√	√	x	0	0	0	0	0	0	0	0	0	0
			Social burst of bubbles	√	√	√	√	√	x	330	148	0	18	40	6	594	697	0	0
	Interspecific	In the presence of humans	Locomotion at the window	√	√	√	√	√	√	148	98	385	176	678	1209	268	255	1104	325
			Contact at the window	√	√	x	√	√	√	0	171	372	868	362	475	416	150	216	98
			Bubbles at the window	x	x	x	x	x	x	0	0	0	0	12	185	77	3	35	3
			Object at the windows	x	x	x	x	x	x	0	0	0	0	0	0	0	27	100	20

√ : Observed
x : Unobserved

Observed and unobserved pair

Table 4. Values of the quantitative variables in both bottlenose dolphin calves during the QP.

	Six months old		Seven months old		Eight months old		Nine months old		Ten months old		Mean	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Diversity of play behavior (%)	51.43	65.71	54.28	65.71	62.86	65.71	71.43	71.43	60.00	80.00	60.00	69.71
Time invested in play behavior (%)	14.90	10.83	7.07	9.24	4.81	9.6	8.29	10.88	6.85	13.47	8.39	10.64
Shannon's diversity index (H)	2.49	2.44	2.45	2.47	2.67	2.59	2.70	2.47	2.41	2.23	2.54	2.44
Shannon's evenness index (E)	0.14	0.22	0.17	0.21	0.14	0.17	0.16	0.23	0.21	0.33	0.16	0.23