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The Study of Activity Pattern, the Use of Space, Animal Proximity and Visitors' Actions to Determine the Individual Differences in Two Bottlenose Dolphin (*Tursiops truncatus*) Adult Females

by Ana I. Soriano, Iván Tarascó, Dolors Vinyoles and Carmen Maté

Introduction

The psychologists have long been interested in the role of individual differences in the behaviour of many species, particularly in consistent differences that might reflect the temperament or the personality – these two last terms are often used interchangeably in animal personality literature. Nowadays, animal personality has become an important and credible topic in animal behaviour research (Carere & Maestripieri, 2013; Highfill & Kuczaj, 2007).

Methods to determine individual differences within the species have been the use of ethological variables such as the daily activity pattern, the use of space, the proximity and the visitors' attitude.

There have been studies which only used the activity pattern, such as Forkman et al. (1995), who discussed the personality trait of "exploration" in piglets (*Sus scrofa*), or Gosling (2001) who used the term "curiosity" in his study of a group of Spotted hyenas (*Crocuta crocuta*).

A combination of activity patterns and the use of space was used to determine individual differences in many studies as, for example, in a Sitatunga (*Tragelaphus spekii*) group (Rose & Robert, 2013), during the application of a structural enrichment in Brown bears (*Ursus arctos*) (Soriano et al., 2006a), during the death of an alpha male in a pack of Iberian wolves (*Canis lupus signatus*) (Soriano et al., 2006b), and in the determination of maternal styles in California sea lions (*Zalophus californianus*) (Soriano et al., 2009).

Another ethological variable studied was the proximity that provides information in relation to animal bonding. Thus, there have also been publications in captivity that combined the activity or/and the use of space with the proximity in different species of primates in order to study social relationships such as, for example, the description of the social network - through dominance, proximity, and grooming relationships - in a colony of Hamadryas baboons (*Papio hamadryas*) (Leinfelder et al., 2003), the proximity patterns of Western lowland gorillas (*Gorilla gorilla gorilla*)

after parturition (Stoinski et al., 2003), the social relationships in a group of Diana monkeys (*Cercophitecus diana*) (Zucker et al., 1988) and playing interactions in a group of orangutans (*Pongo pygmaeus*) through the use of proximity and the contact between animals (Zucker & Thibaut, 1995).

The last variable used for determining individual differences has been visitors' influence. Each animal has a different capacity to adapt to visitors' presence and has a change in their attitude to them; visitors often have a great influence on animal welfare in captivity (Davey, 2007; Hosey, 2000). In zoos, there have been a lot of studies which determined individual animal responses towards visitors, as for example, in comparison between Brown bears (*U. arctos*) and Giant pandas (*Ailuropoda melanoleuca*) (Soriano et al., 2013), gorillas (*G. g. gorilla*) (Carder & Sample, 2008), mangabeys (*Cercocebus* spp.) (Mitchell et al., 1991) and cheetahs (*Acinonyx jubatus*) (O'Donovan et al., 1993).

On the one hand, some research on different species of dolphins has indicated consistent and individual differences in relation to different factors such as the behavioural development in wild Bottlenose dolphin new-borns (Mann, 1997; Mann & Smuts, 1999), the different types of bubbles (Marten et al., 1996; McCowan et al., 2000; Pace, 2000), the behavioural responses towards dead conspecifics (Dudzinski et al., 2003; Fertl & Schiro, 1994), the different captive parenting styles (Hill et al., 2007; Tizzi & Pace, 2003), the feeding behaviour in two groups of Bottlenose dolphins in the wild (Gazda et al., 2005), the group movements and the positional leadership in wild Bottlenose dolphins (Lewis et al., 2005), the dolphins' problem-solving strategies and the exploratory behaviours (Delfour & Marten, 2005; Kuczaj & Yeater, 2006), the social bonds in association with other animals (Connor et al., 2000; Wells, 1991) and the different types of social behaviours (Herzing et al., 2003; Kuczaj & Highfill, 2005).

On the other hand, the listed examples demonstrated that all the dolphins were not of the same charismatic quality. Differences in behaviour among dolphins may reflect the dolphins' individual personality (Highfill & Kuczaj, 2007). The knowledge of individual differences was seen as being very useful to improve captivity conditions and develop captivity conservation programmes more successfully as well (Weiss et al., 2006).

The aim of this study was to determine if there were individual differences between two adult female Bottlenose dolphins (*T. truncatus*) through the study of their daily activity pattern, their use of space, their proximity and their attitude to visitors in captivity.

Methods

Subjects

The subjects of this study were the old female (Nereida) and the young female (Anak). These two adult female Bottlenose dolphins (*T. truncatus*) lived at Barcelona Zoo and shared the enclosure with other subjects - not included in this study - of the same species and described in Table 1.

Table 1. Demographic information for the Bottlenose dolphins.

Name	Sex	Date of birth	Type of birth	Additional information
Nereida	Old Female	Approx. 1980	Born in the wild	Mother of Neo
Anak	Young Female	Approx. 1986	Born in the wild	Mother of Leia
Neo	Calf Male	24 August 2003	Born at Barcelona Zoo	Son of Nereida
Leia	Calf Female	25 August 2003	Born at Barcelona Zoo	Daughter of Anak
Nika	Senior Female	Approx. 1964	Born in the wild	_

Both females were multiparous; the first calf of the old female was a female which was born in 2001, but died a few days later while the first calf of the young female was a female which was born in 1998 and had a normal development.

Anak, Neo, Leia and, Nereida. Photo by Angela Martín

Anak and Nereida. Photo by Rafa González

Enclosure

The tank was the name of the enclosure in which the focussed individuals lived. It had a cylindrical construction of 22m diameter, 6m deep and with a capacity of 9,119 m^3 of sea water. The tank had five underwater observation windows through which the visitors and the researchers could look through to see the animals and to make their ethological observations respectively (Fig. 1A). At the top of the tank, there were outdoor bleachers where the visitors could sit during the shows' time (Fig. 1B). The water in the tank was sea water brought from the sea to the zoo using a pup system and it was maintained at *c.* 13ºC, pH 8 and a salinity of 26-28g $litre^{-1}$.

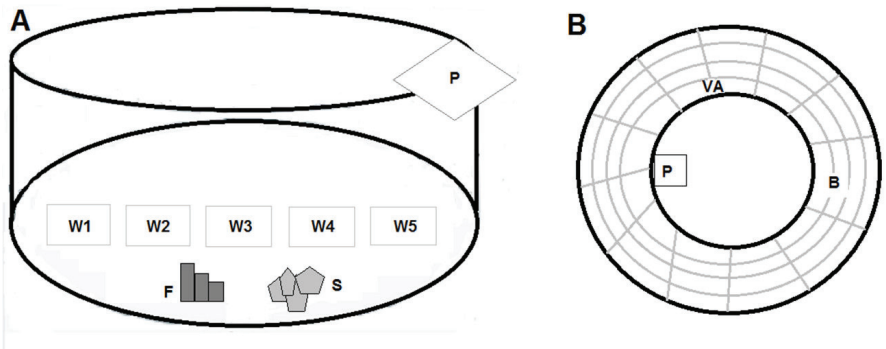


Figure 1. Diagram of the bottlenose dolphins' pool. A. Front vision of the enclosure: F= Filters; P= Platform for exhibitions; S= Stones, W1 to W5= public and researchers viewing windows. B. Apical vision of the enclosure: B= Bleachers for the visitors; P= Platform for show; VA= visitors' access.

Captive Management

The diet of these lactating females was frozen fish introduced in five shots. The old female ate 10 kg and the young female 12 kg. The proportion of frozen fish was 30% of mackerel, 50% of sardine and 10% of capelin combined with sprat. The dolphins were fed at the following hours: 11a.m., 1:30p.m., - coinciding with the show -, 2:00p.m., 4:00p.m. and at 8:00p.m. - mixed with vitamins -.

Sampling

The study was focused on the daily activity pattern, the use of space, the proximity, and the attitude to visitor in both Bottlenose dolphin females during December 2004 and January 2005 with a total of 22 hours recorded per individual.

Focal sampling and instantaneous scan methods were made at 1 minute intervals (Altmann, 1974) during 88 fifteen minute sessions for each subject (N = 1320). The variables studied were: 1) the time of the day which was studied in order to balance the observations through the three daily periods (morning (10a.m.-1p.m.), midday (1-2 p.m.) and afternoon (2-5 p.m.)); 2) the daily activity categories were described in the Table 2; 3) the use of space was studied using two criteria: a) Front division, which presented three categories: (i) *Surface Location*, upper middle area of the tank, (ii) *Deep Location*, lower middle area of the tank and, (iii) *Undetermined Location,* which was recorded when animals' location was not observed because the water had not transparency (Fig. 2A). b) Apical division with four categories: (i) *Front Location*, front area of the tank; (ii) *Middle Location*, intermediate area of the tank, and (iii) *Back Location*: back area of the tank and, (iv) *Undetermined Location* was recorded when animals' location was not observed because the water had not transparency (Fig. 2B); 4) The proximity was observed when the distance between two animals was less than 2 m. Also, it was studied using two criteria: a) number of animals in proximity: (i) *One Subject,* (ii) *Two Subjects,* (iii) *Three Subjects,* (iv) *Four Subjects* and (v) *Not Visible* - was recorded when the proximity could not be determined due to lack of water transparency - and b) The age class of animals in proximity: (i) *Solitary* - was registered when the distance between two animals was higher than 2m -, (ii) *Adult* - from 2 to 40 years -, (iii) *Calf* - since 2 years -, (iv) *All* – that included adults and calves - and (v) *Not Visible* - was recorded when the proximity could not be determined due to the lack of water transparency; 5) The visitors' actions were studied using four categories: 1) *Flash Photograph*: public took photos with flash when animals were near the visitor's viewing windows, 2) *Capturing the Animal Attention*: visitors hit the underwater windows, people made gestures and they shouted to attract the attention of dolphins when the animals were near of the window, 3) *Touching the Glass*: visitor's put their hands on the viewing windows when dolphins were near it and 4) *No Interaction*: visitor's only observing the animals through viewing windows.

Table 2. Ethogram of the captive bottlenose dolphins in this study.

ACTIVITY

Solitary behaviours

Exploration: the animal fixed her attention in a determined area of the tank (floor, window or furniture) and it could be tracked with her snout.

Vigilance: the dolphin was static in a vertical position fixing her attention on the visitors, another things or another animals.

Swimming: movements related to tour the enclosure.

Feeding: a dolphin caught the food into her mouth and swallowed it.

Maintenance: set of behaviours involved in the physiological well-being of the animal (scratching, urinating, or defecating).

Respiration: a dolphin placed her spiracle on the surface of the pool where she opened and closed it in order to capture air.

Solitary play: a dolphin carried out exaggerated, well-known movements with her own body or with some object.

Social behaviours

Aggression: a dolphin showed agonistic behaviour towards another subjects (biting, aggressiveness, or persecution).

Affiliation: an animal showed an affectionate attitude towards another dolphin (swimming close to other subject or contact).

Play: a subject showed a playful attitude towards another animal (playful persecution or social playing with objects).

Sexual: set of behaviours concerned with the reproduction (courting or mating).

Maternal: group of behaviours involved in caring of calves (lactation or maternal persecution).

Human interaction: a dolphin set her gaze on visitors, keepers or researchers and tried to attract their attention through body movements and/or air bubbles.

INACTIVITY

A dolphin was resting with her muscle tone relaxed and one eye closed.

NOT VISIBLE

The animal or her behaviour could not be identified.

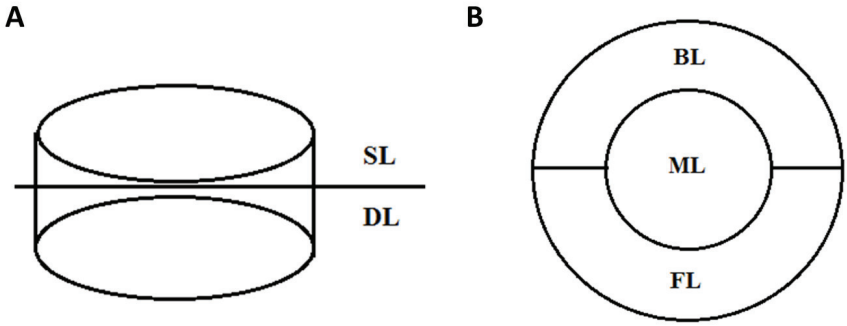


Figure 2. The division of the bottlenose dolphins' pool. A. Front division of the enclosure: SL= Surface Location; DL= Deep Location. B. Apical division of the enclosure: BL= Back Location; ML= Middle Location; FL= Front Location.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) version 21.0 for Windows was used to analyse the data. Using contingency tables, the categorical data for the daily activity pattern, the use of space, the proximity, and the visitor's action were analysed. These tables determined whether there were statistically significant differences in the two subjects for the four dependent variables through Pearson's X^2. This test was used to determine exactly which categories of the dependent variables showed statistically significant differences. This statistic had an absolute value of 1.96 for a normal distribution assuming that the significance level is .05 (Haberman, 1978).

In order to study the homogeneous use of space, the SPI index (spread-of-participation index) was used in each of the animals and in each of the two criteria to divide the dolphin's enclosure. A value of 1 indicated a minimum use of the enclosure and a value of 0 showed that the use of the space was homogeneous for each division of the tank (Dickens, 1974; Shepherdson et al., 1993).

Results

Daily Activity Patterns

There were statistically significant differences between two bottlenose dolphin's females in relation to daily activity pattern ($X^2_{(14)} = 98.68$, $P<0.05$). The old female spent more time engaged in the following activities: "swimming", "affiliation", and "maternal behaviours" whereas, the young female spent more time engaged in "exploration", "vigilance", "human interaction", and "inactivity". The detailed activity pattern categories which showed statistical significant differences were shown in Figure 3.

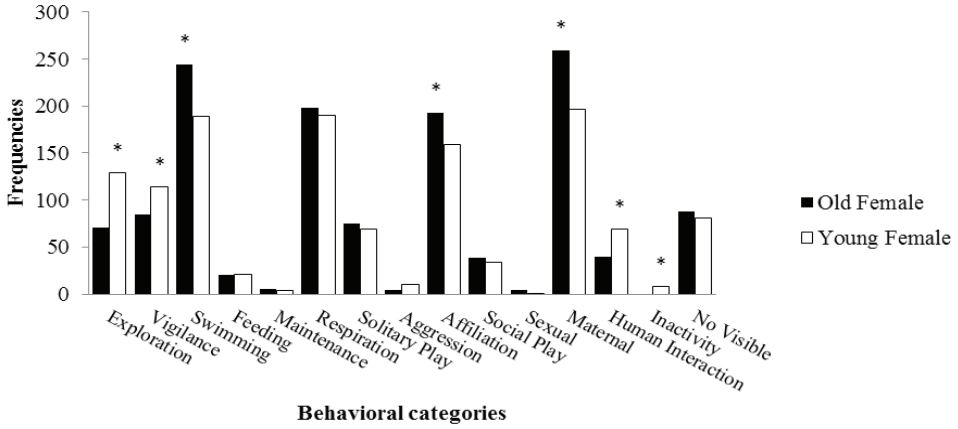
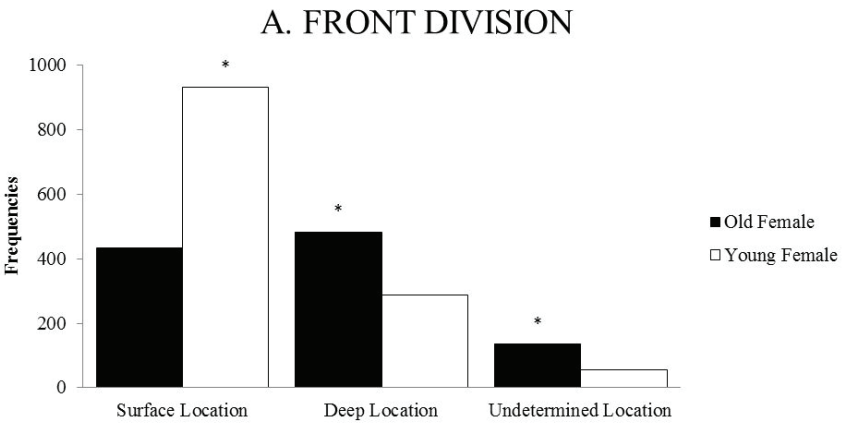


Figure 3. Activity patterns for both bottlenose dolphins.

Use of Space

There were statistically significant differences between the two female Bottlenose dolphins in relation to two criteria for use of space. On the one hand, in relation to front division, the old female spent more time significantly in "deep location" and "undetermined location" than the young female who spent more time significantly in "surface location" ($X^2_{(2)} = 21.45$, $P<0.05$) (Fig. 4A). On the other hand, in relation to apical division, the old female spent more time significantly in "middle location", "back location", and "undetermined location" than the young female who used the "front location" of the tank more frequently ($X^2_{(3)} = 69.35$, $P<0.05$) (Fig. 4B).



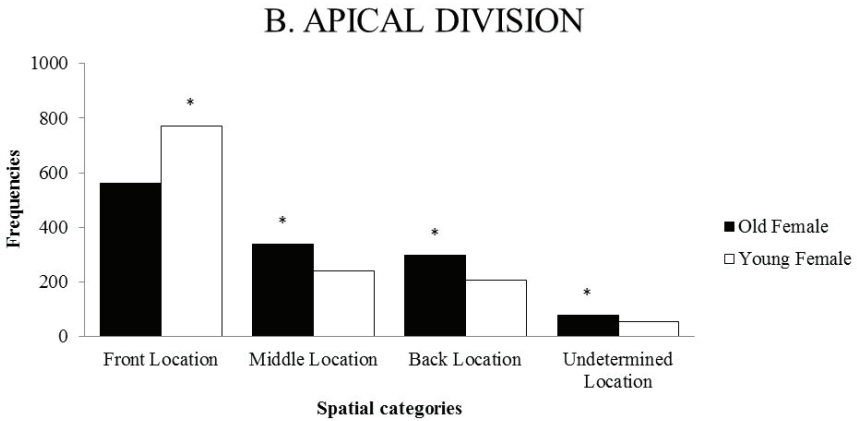


Figure 4. Bottlenose dolphin females' use of space: A. Front division of the tank and B. Apical division of the tank.

Table 3 shows the SPI index used for two criteria of the use of space in the two bottlenose females. Both females used more homogeneously the vertical plane of the tank than the horizontal plane which was used more homogeneously for the young female than for the old female.

Table 3. The values of the SPI index for two criteria of space use.

	Front Division	**Apical Division**
Old Female	0.80	0.27
Young Female	0.57	0.30

Proximity

There were statistically significant differences between the two Bottlenose dolphin females in relation to two criteria of proximity. On the one hand, in relation to the number of animals in proximity, the old female showed greater statistically significant differences with "one" and "two subjects" than the young female who showed more preference for "solitary" condition and with "three subjects" ($X2(6)= 34.01$, $P<0.05$) (Fig. 5A). On the other hand, in relation to the age class of animals in proximity, the old female showed greater statistically significant differences with "calf" than the young female who showed more preference for "solitary" conditions ($X2(4) = 23.70$, $P<0.05$) (Fig. 5B).

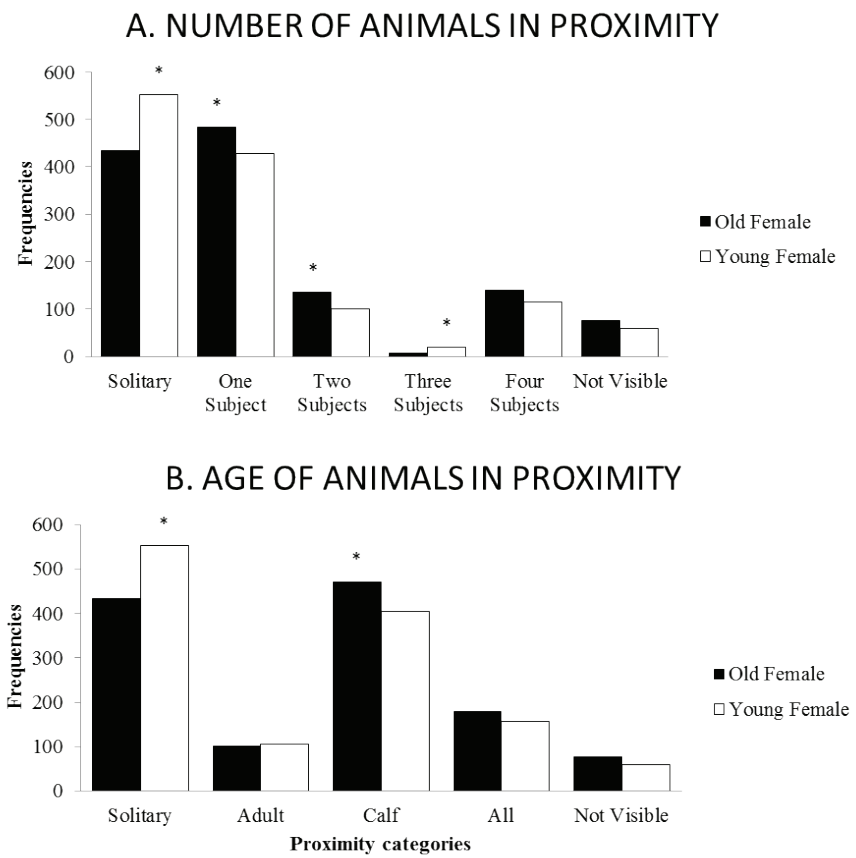


Figure 5. Bottlenose dolphin females' proximity: A. Number of animals in proximity and B. Age class of animals in proximity.

Visitors' actions

When data was collected for the young female it was more common to see the public showing "capturing the animals' attention" and "touching the glass" with statistically significant differences ($X2(3) = 14.83$, $P<0.05$). In contrast, "flash photograph" and "no interaction" was recorded independently of whether the focal animal studied was the old female or the young female (Fig. 6).

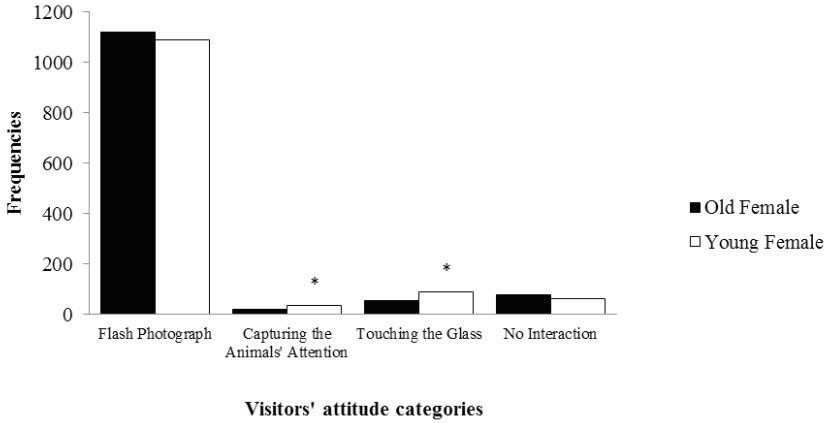


Figure 6. Attitude of both female Bottlenose dolphins to the actions of visitors during data collection.

Discussion

The comparison - made between these two adult female Bottlenose dolphins for each ethological variable studied - showed notable individual differences and, as a consequence, two possible different personalities to take into account in their management (Carere & Maestripieri, 2013).

Therefore, the individual differences and the animal personalities could be explained using the concept of the phenotype or individual that is the sum of the genotype – the genetic or the heritable factor - and the environmental factors – the external factor - resulting in a large variety of forms (Carere & Maestripieri, 2013).

The two Bottlenose dolphins showed individual differences which were studied through the ethological variables and this offered a blueprint for the implementation of welfare measures and an objective rationale for their widespread use (Maple & Perdue, 2013). The old female Bottlenose dolphin seemed to develop more intraspecific social skills showing more activities, such as affiliation and maternal relationships, and she was also more frequently accompanied by one or two individuals and calf; whereas the young female Bottlenose dolphin seemed to develop more interspecific social skills towards visitors or humans and with more solitary tendencies. Also, the individual differences were also determined with the use of these ethological variables in other species like Brown bears (Soriano et al., 2006a), Sitatunga (Rose & Robert, 2013), and Iberian wolves (Soriano et al., 2006b).

These results also showed that in relation to these individual variations it could distinguish two different maternal styles as described by Hill et al. (2007) and Tizzi and Pace (2003). These differences could depend on primiparous or multiparous female conditions as in California sea lion (Soriano et al., 2009) or it could depend on birth and raising experiences as in this study because the Bottlenose dolphins' offspring were the second calves for the both females, although one of them had a neonate death. Thus, the old female seemed to develop more protector maternal style than the young one, perhaps due to the premature death of her first calf (Hill et al., 2007). This point was especially interesting regarding the development of conservation programmes in order to determine the most efficient mother to rear and breed endangered captive calves (Fa et al., 2011).

The studies that used ethological variables - activity patterns, use of space, proximity and visitors' attitude - must be applied to improve the zoo biology, the animal welfare and the management of programmes as Rose and Robert (2013) in Sitatungas and Soriano et al. (2006a; 2006b) in Brown bears suggested.

On the one hand, the study of animal individual differences has both practical and theoretical benefits (Highfill & Kuczaj 2007). So the information about the individual differences of animals could be used by zoo staff (managers, keepers, students, veterinarians, researchers, volunteers and educators) in order to design individual plans in relation to (Hosey et al., 2009; Kleiman et al., 1996, 2010; Rees, 2011):

1) Enclosure design, taking into account intraspecific requirements and also individual needs to maintain behavioural diversity. The natural selection acts in different directions in heterogeneous environments (Frankham et al., 2002) which is the basis for some hypothesis explaining individual variations (Dall et al., 2004; Wolf et al., 2007).

2) Diet composition, depending on the age, the activity's level or reproductive phase.

3) Changes in animal group formation for breeding and conservation purposes. Each animal could develop more attraction for one animal than another.

4) Environmental enrichment programs, designed through the knowledge of individual preferences in relation to food, scents and social skills with animals of the same or different species.

5) Training sessions with three aims: exhibition, medical or predator training before reintroductions. The animals also have a different capacity to learn different preferences for one trainer or another, not showing the same results in each condition (Wilson, 1998).

6) Veterinary care; the animals could suffer diseases or syndromes individually whose correct diagnosis and treatment must improve the quality of life of the animals significantly.

7) Animal movements to another zoos; during the exchange of animals between zoos, account must be taken of the individual needs of the subjects and changes must not compromise the animal's welfare. It will be positive to attach any research or publication made about the animal together with other reports (i.e. taxon report,

veterinarian information, genetic studies, etc.) in order to maximize the amount of information about animals in captivity.

8) Visitors' influence; publications about visitors' behaviour show that they could not only have a negative effect on animal welfare, but could have a positive or neutral effect (Soriano et al., 2013). All these management techniques must facilitate the work with individuals that showed boldness and/or aggression in rehabilitation programs (Carere & Maestripieri, 2013).

On the other hand, there are animals, such as the young female of this study, which had a positive effect on their status through human or visitor presence (Davey 2007; Hosey 2000). This positive effect of the public could depend on their type of breeding (maternal or human), the origin (captivity or wild) and the early experience with humans among others (Hosey, 2008). It is very important to avoid human interaction or influence in reintroductions or rehabilitation programs in order to achieve their objectives successfully (Fa et al., 2011).

Additional researches as this one will be necessary to obtain further information about the effects of captive activity on shaping and changing individual traits. Periodical research of individual differences will allow zoo managers to monitor the effects of reintroduction in the wild and incorporate individual characteristics into captive studbooks in order to track the breeding success rate in relation to the individual variations (Carere & Mestripieri, 2013).

Although it is clear that not all dolphins have the same behavioural pattern it is also clear that there is much more to learn about dolphin individual differences and personalities (Highfill & Kuczaj, 2007).

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Correspondence: Dr. Ana I. Soriano, Negrell Street 14 First Floor, 08038 Barcelona, Spain
Email: anaisabel_soriano@yahoo.es
Correspondence: Iván Tarascó, Mossèn Ribes i Ferrer 3 First Floor 1, Sant Antoni de Portmany 07820, Eivissa, Spain
Email: dooraemonsoc@hotmail.com
Correspondence: Dr. Dolors Vinyoles, Biology Animal Department, Barcelona University, Diagonal Avenue 643, 08028 Barcelona, Spain
Email: dvinyoles@ub.edu
Correspondence: Dr. Carme Maté, BCASA, Acer Street 16, 08038 Barcelona, Spain
Email: carmenmategarcia@gmail.com