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Nursing Behavior of Bottlenose Dolphin (*Tursiops truncatus*) Calves from 1990-2014 at Brookfield Zoo Chicago, USA

Margaret Ramont*, Johanna Sholar, Rita Stacey, Mark Gonka, and Lance J. Miller

Animal Welfare Research, Chicago Zoological Society-Brookfield Zoo Chicago, Brookfield, IL

*Corresponding author (Email: margaret.ramont@czs.org)

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Abstract – While the common bottlenose dolphin (*Tursiops truncatus*) population under managed care in North American zoos and aquariums is self-sustaining, understanding normal nursing behavior can help management make informed care decisions for neonates and future births. This study examined behavioral data from the first 30 days of life collected from 14 dolphin calves born between 1990-2014 at Brookfield Zoo Chicago in Brookfield, IL. We hypothesized that surviving calves showed significantly different patterns of nursing than those that did not survive. There were no significant differences in average nursing rates or average nursing frequency between calves that did and did not survive up to 17 days old. Surviving calves up to eight days old had significantly longer average nursing performance (s/hr), and significantly longer average nursing durations (s/bout) than non-surviving calves. Shorter nursing duration early in the life of the calf may be indicative of developmental problems and may be a useful metric to inform staff when supplemental care may be needed. Calf survival improved from the first half to the second half of the study period by 150%, most likely due to improvements in animal care, medical intervention, and experience of the dams. Understanding normal nursing behavior is essential to learning when human intervention is necessary to help survival and can help guide future care and management of dolphin births under professional care.

Keywords – Bottlenose dolphin, *Tursiops truncatus*, Nursing behavior, Neonate

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Bottlenose dolphins (*Tursiops truncatus*) are one of the most common species of marine mammals housed in zoological institutions (Couquiaud, 2005). Advances in animal care and husbandry in the last 40 years have improved life expectancy and overall health at all stages of development (Venn-Watson et al., 2011, 2015; von Streit et al., 2011). A recent analysis of historical improvements in marine mammal life expectancies in managed care demonstrated that the average life expectancy for bottlenose dolphins has more than tripled in the last century from approximately nine years from 1947-1989 to approximately 30 years from 2005-2020 (Tidière et al., 2023). Average life expectancy in the wild in a similar time frame (1986-2003) was calculated as 9.48 years (Mattson et al., 2006). However, in both managed care and in the wild dolphin calves under one year of age have the highest mortality rate due to a variety of factors. Between 2005-2020, 26% of female calves and 18% of male calves in managed care did not survive past the first year of life (Tidière et al., 2023). Similarly, in one wild population calf mortality during the first year of life was calculated as 24.10% for data collected between 1993-2020 (Lacy et al., 2021). Consequently, there is a high priority to help ensure the highest survivorship possible through understanding the typical behavior of dolphin calves both in the wild and in zoological institutions (Wells, 2009). As an important behavioral indicator of calf condition, nursing behavior is a non-invasive measure that can be observed from the critical period after birth to weaning.

While nursing behavior can be recorded and described in wild populations (such as in sperm whales (*Physeter macrocephalus*; Sarano et al., 2023), it is difficult to accurately record nursing behavior to gather enough continuous data to investigate the ontogenesis of nursing in wild populations. Nursing behavior can be roughly estimated in wild environments (Mann & Smuts, 1999), but common limitations of behavioral research, such as reduced visibility above water and the difficulty of tracking and monitoring calves consistently over a 24 hr period, make it difficult to accurately record all nursing behavior in these settings. Consequently, most developmental studies of nursing behavior have been focused on observations recorded in zoological institutions, and managed care facilities with underwater viewing areas are especially valuable for this type of research. These facilities allow for more accurate observations of nursing behavior by providing observers with up close, unobstructed views both above and below the water. Measures of developmentally normal nursing behavior can inform animal care staff to make critical care decisions in a timely manner. In addition, nursing behavior changes as the calf grows and develops; deviations from the species' general nursing trends can be monitored over time to alert staff to any sudden changes in calf health or condition before they otherwise would have been noticeable (Sweeney et al., 2010).

In bottlenose dolphins, each nursing bout is very brief, lasting anywhere from 3-10 s (including estimates in wild populations, Mann & Smuts, 1999), and usually occurs in groups of multiple nursing bouts in quick succession (Eastcott & Dickinson, 1987; Kastleien et al., 1990; Peddemors et al., 1992; Thurman et al., 1986). Nursing frequency, as a measure of bouts over time, is another useful measure of calf intake and can help researchers more accurately visualize trends in calf nursing behavior. Nursing during the first week to ten days of life follows a general pattern of 3-5 nursing bouts occurring approximately every 20 min (Sweeney et al., 2010). Other studies have measured total number of nursing bouts per day (Peddemors et al., 1992), number of bouts per hr (Cockcroft & Ross, 1990), and inter-bout intervals (Jacobsen et al., 2003), with each measurement highlighting a similar trend of decreased nursing frequency as the calf ages. At around two weeks old the calf nurses much less often, with nursing performance as low as 8 s of total nursing time per hour (Sweeney et al., 2010). It is unclear whether changes in nursing performance is related to the nutritional content of the mother's milk. While milk composition changes over longer time scales (West et al., 2007), no research has explicitly investigated the changes in milk composition over the course of the first month of nursing. Instead, the reduction in frequency of nursing is believed to be due to the calf's increased nursing efficiency as it becomes stronger, more coordinated, and receives more milk per bout (Peddemors et al., 1992). A calf that has not demonstrated this change in suckling behavior within a zoo or aquarium habitat may need feeding intervention or supplementation. Therefore, it is critical to monitor the nursing behavior of calves in the first month postpartum to ensure they receive adequate nutrition for healthy growth.

In the current study, we analyzed the nursing patterns of 14 calves born at Brookfield Zoo Chicago, USA, between 1990-2014. The goal of this study was to compare these trends to those seen in previously published literature, and to determine whether any significant differences in nursing behavior exist between calves that survived past 30 days and those that did not. We hypothesize that surviving calves have an overall higher nursing performance, a higher frequency of nursing bouts, and longer duration of nursing per bout than those that did not survive. This information can act as a tool to inform animal care decisions for future births under managed care and help reduce calf mortality during the first 30 days after birth.

Methods

Ethics Statement

All data collected for this study was purely observational and did not require any changes to the care and husbandry of the dolphins. Observations were part of a routine monitoring protocol as part of management best practices for dolphin births, and Institutional Animal Care and Use Committee (IACUC) approval was not necessary.

Subjects and Housing

The Seven Seas complex at Brookfield Zoo Chicago, USA, consists of four connected indoor dolphin habitats: the largest main habitat with dimensions approximately 33.5m x 12.2m x 7.6m, two smaller habitats connected behind the north and south ends of the main habitat by gated channels, and a medical habitat connecting the north and south habitats (Figures 1 and 2). Overall capacity of the complex is approximately 3,918,000 L of water. Public viewing is accessible from the main habitat only, both above water during dolphin education programs, and below water in the underwater viewing area.

Figure 1

Diagram of the Seven Seas Habitat Complex at Brookfield Zoo Chicago

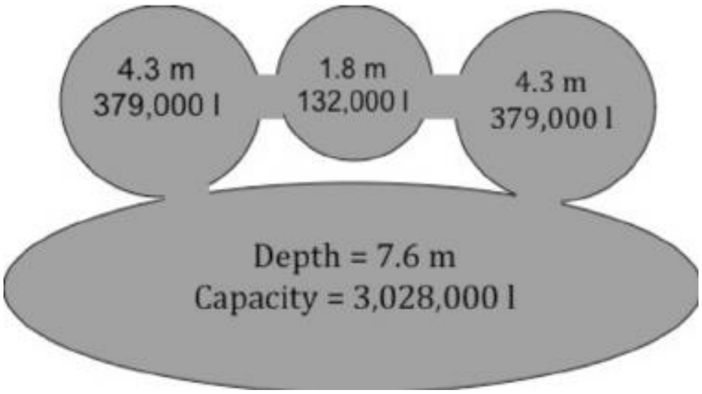
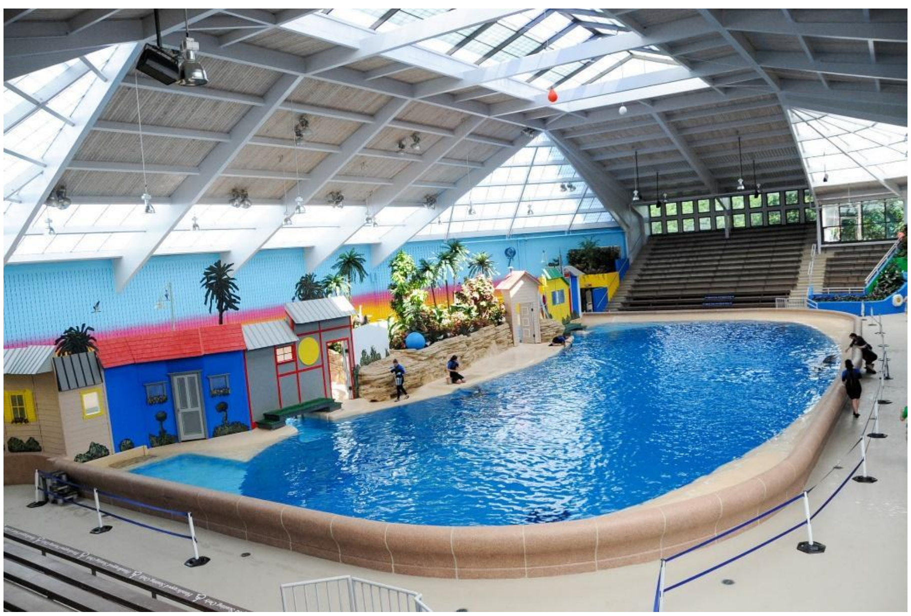


Figure 2

Photograph of the Main Habitat of the Seven Seas Complex at Brookfield Zoo Chicago



The 14 calves in this study were born from a total of five individual dams and six different sires and housed at Seven Seas between 1990-2014 (Table 1). Seven calves were born between 1990-2000, and seven were born between 2001-2014. All calves were nursed by their dams except for C8, which was nursed exclusively by D2 when his dam did not nurse him herself.

Table 1

Bottlenose Dolphin Calves Born at Brookfield Zoo Chicago from 1990-2014

Calf	Sex	DOB	Number of days survived	Sire	Dam	Age of dam at birth	Number of prior births	Social exposure to other dam-calf pairs?
C1	M	8/30/1990	8	S1	D1	14	0	No
C2	M	10/5/1991	17	S1	D1	15	1	No
C3	M	4/28/1992	6	S1	D2	10	0	Yes
C4	M	9/3/1993	3	S1	D1	17	2	No
C5	F	9/17/1993	>30	S2	D2	11	1	Yes
C6	M	10/11/1994	>30	S1	D1	18	3	Yes
C7	F	2/1/2000	11	S2	D2	18	2	Yes
C8	M	10/19/2001	>30	S3	D3	8	0	No
C9	F	10/30/2003	>30	S4	D2	21	3	Yes
C10	F	11/3/2005	>30	S5	D2	23	4	Yes
C11	F	8/2/2013	7	S6	D4	26	3	Yes
C12	M	10/16/2013	>30	S3	D2	31	5	Yes
C13	M	12/12/2014	8	S3	D5	9	0	Yes
C14	F	12/16/2014	>30	S3	D4	27	4	Yes

Data collection

After the birth of each calf, behavioral data were collected for the calf's first 30 days of life, or until the calf's death, on a near-continuous schedule, depending on staff and volunteer availability. Observations consisted of all-occurrence continuous sampling of both successful and unsuccessful nursing attempts, but only successful nursing bouts are included in this dataset. An unsuccessful nursing attempt was defined as each instance the calf made contact with its rostrum within six inches of the mammary slit but not in the correct location to nurse. A successful nursing bout was defined as each instance the calf made contact with its rostrum to its mother's mammary slit and remained in contact while suckling until they released.

To ensure data were collected as close to continuously as possible, observations occurred for seven days per week during the first 30 days of the calf's life, and total observation time was as close to 24 hr a day as possible, but varied depending on staff needs. Each day was split into four 6 hr shifts per day, with multiple observers splitting a given shift depending on staff needs. While interobserver reliability was never formally calculated, every observer was an experienced member of the animal care team and extensively trained using an established training protocol with both a classroom and practical training period in which observers were not allowed to collect data until senior staff members ensured the observer was accurate. Over the course of this study period, approximately 20 Brookfield Zoo Chicago staff members were trained using this protocol, and various platforms were utilized to record observational data. From 1990-2000, data were collected on handwritten observation sheets notating the time each observed nursing bout occurred and the duration of each bout. The duration of each successful nursing bout was recorded using a stopwatch. From 2000-2012, data were collected on the same handwritten sheets, but a PalmPilot personal digital assistant was utilized to time the nursing bouts. From 2012-2015, data were collected using NursingObs, a platform developed for iPad at Brookfield Zoo Chicago (not available commercially). NursingObs allowed the observer to select a button when the calf began a nursing bout and again when the calf terminated the behavior, recording the date and time the nursing bout occurred and the overall duration of the nursing bout.

Data from all platforms were then transferred into Microsoft Excel and converted into the same format for analysis.

Statistical Analysis

Three measures of nursing behavior were calculated from the dataset per day for each calf, following Sweeney et al. (2010): 1) overall average nursing performance per day was calculated in seconds nursed per hour, 2) average frequency of nursing behavior was calculated in number of nursing bouts per hour, and 3) average nursing bout duration was calculated in number of seconds nursed per bout. To account for differences in total observation time, means were calculated using the total seconds of observation time per day for each calf. Daily means were averaged together to record each calf's overall nursing behavior. Based on visual analysis of the data for calves that did not survive, we found two peaks in length of survival at around eight and 17 days. To see whether the length of survival had any impact on nursing behavior, we grouped non-surviving calves into two age groups: calves that survived up to eight days old (n = 5), and calves that survived up to 17 days old (n = 2). For calves up to eight days old, daily means for days 1-8 or until day of death were averaged to create an overall nursing measure for both surviving and non-surviving calves. For calves up to 17 days old, daily means for days 1-17 or until day of death were averaged to create an overall nursing measure for both surviving and non-surviving calves. To test for differences in nursing behavior between surviving and non-surviving calves, Wilcoxon rank sum tests were conducted in R (Version 4.2.1., R Core Team, 2022), with α set to .05.

Results

In the current study, seven of the 14 calves lived past the first 30 days of life. Comparing calves born between 1990-2000 and those born between 2001-2014, there was a 150% increase in the number of surviving calves in the latter period as compared to the first period.

Over the course of the first 30 days of life for surviving calves, average nursing performance was 40.17 s/h (SD = 31.58) (Figure 3), average nursing frequency was 7.17 bouts/hr (SD = 5.87) (Figure 4), and average nursing duration was 6.19 s/bout (SD = 1.72) (Figure 5). To summarize the differences between calves that survive and calves that did not, mean values for nursing behaviors on days 1-8 or days 1-17 were calculated for each group of calves, and can be seen in Tables 2, 3, and 4.

Average nursing performance was significantly different between calves that did and did not survive up to eight days old (W = 5, p = .05), with surviving calves nursing for significantly more s/hr than those that did not. There was no significant difference in average nursing performance, however, between calves that survived up to 17 days old and those that did not (W = 0, p = .06). Average nursing frequency was not significantly different between surviving calves up to eight days old and those that did not (W = 12, p = .43), or between calves up to 17 days old and those that did not (W = 7 , p = 1.0). Average nursing duration during the first eight days was significantly longer in surviving calves compared to non-surviving calves (W = 3, p = .018), but not between surviving and non-surviving calves up to 17 days old (W = 4, p = .5).

Figure 3

Daily Average Nursing Performance (s/hr) for the 7 Calves that Survived the First 30 Days of Life

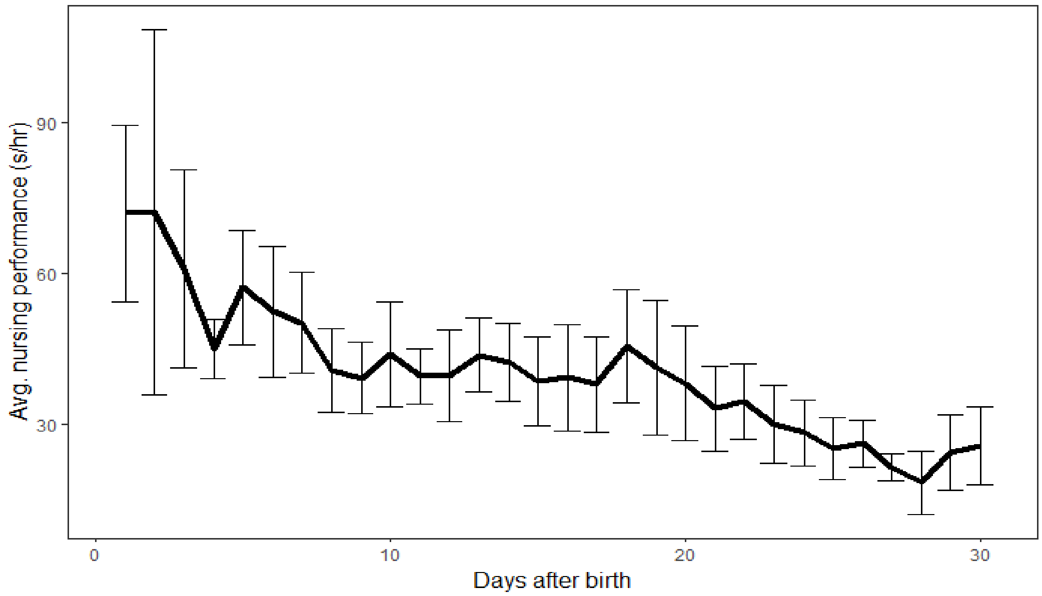


Figure 4

Daily Average Nursing Frequency (bouts/hr) for the 7 Calves that Survived the First 30 Days of Life

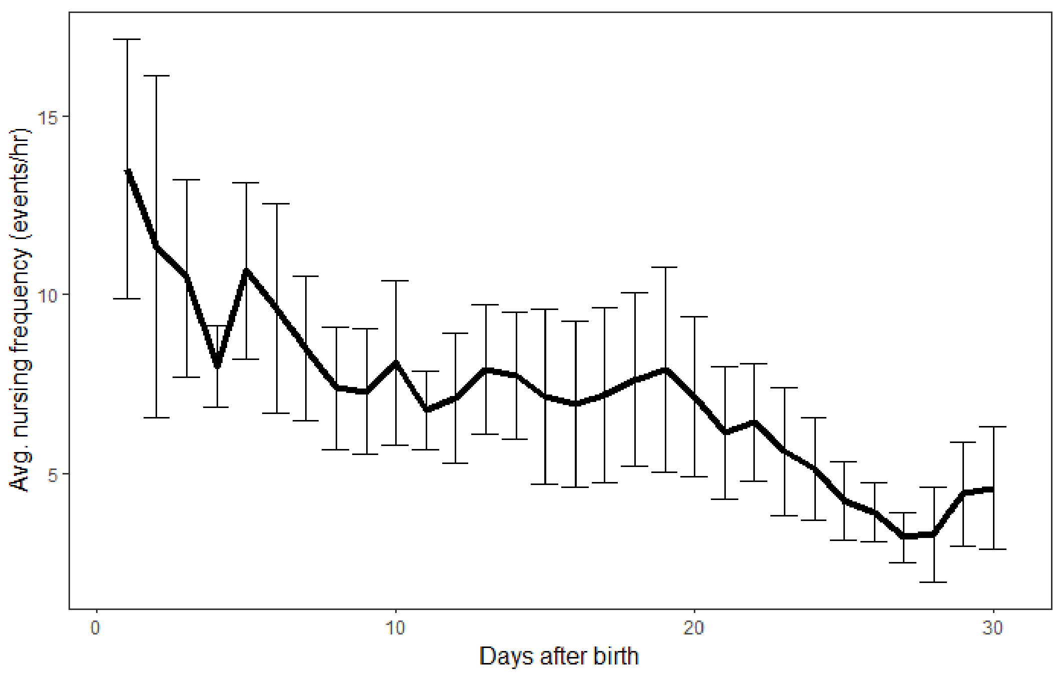


Figure 5

Daily Average Nursing Duration (s/bout) for the 7 Calves that Survived the First 30 Days of Life

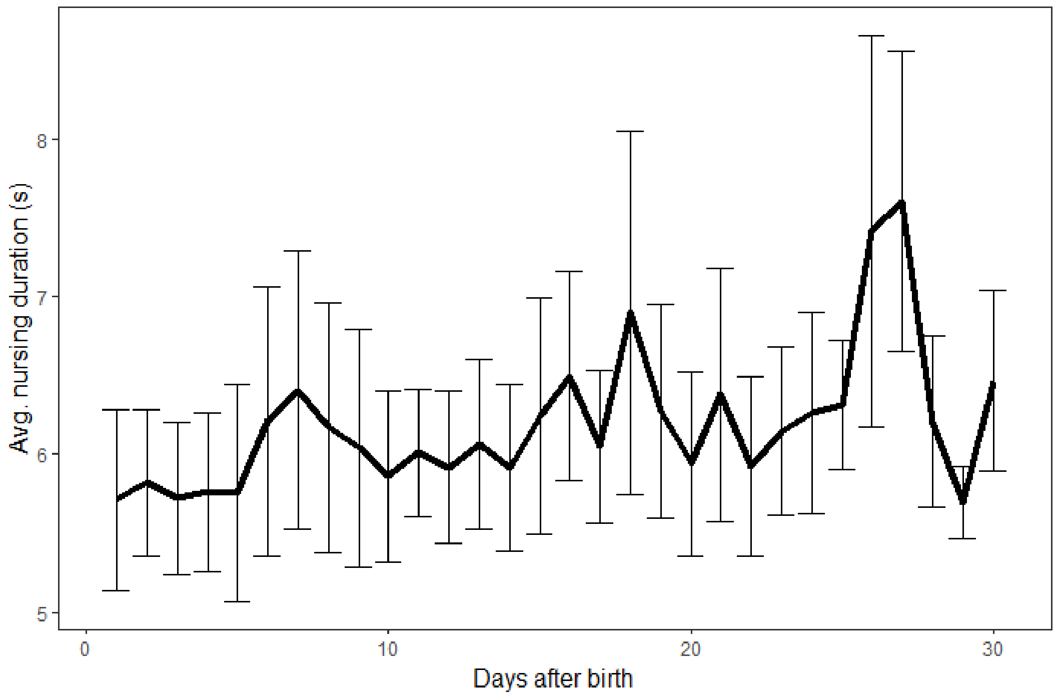


Table 2

Comparison of the Mean Values for Nursing Performance (s/hr) by Calf Survival at Two Separate Age Classes

Calf Survival	First Eight Days	First 17 Days
Successful	56.30 (45.35)	47.89 (35.55)
Unsuccessful	30.47 (18.16)	28.90 (14.47)

Note. SD shown in parentheses.

Table 3

Comparison of the Mean Values for Nursing Frequency (bouts/hr) by Calf Survival at Two Separate Age Classes

Calf Survival	First Eight Days	First 17 Days
Successful	9.93 (7.41)	8.56 (6.36)
Unsuccessful	7.82 (4.99)	7.58 (3.67)

Note. SD shown in parentheses.

Table 4

Comparison of the Mean Values for Nursing Duration (bouts/hr) by Calf Survival at Two Separate Age Classes

Calf Survival	First Eight Days	First 17 Days
Successful	5.94 (1.68)	6.01 (1.56)
Unsuccessful	3.93 (1.17)	3.99 (1.69)

Note. SD shown in parentheses.

Discussion

The values from our dataset fall within the range of those previously published in the literature (e.g., Biancani et al., 2021; Cockcroft and Ross, 1990; Sweeney et al., 2010), and are useful as a reference for developmentally normal patterns of nursing. There were no significant differences in nursing behavior between calves that did and did not survive up to 17 days old, suggesting that these calves followed a relatively normal pattern of nursing. In contrast, surviving calves up to eight days old had significantly longer average nursing performance than those that did not survive. This is most likely due to several calves in our dataset that nursed as low as 8 s/hr on average during the first several days of life, suggesting that these calves struggled to develop appropriate patterns of nursing from birth. Research has suggested that some individuals may need more time to establish typical nursing patterns (Von Streit et al., 2013). Consequently, low overall nursing performance in the first few days of life can alert animal care staff to take action against potential causes of low nursing performance and provide supplemental care.

Average duration of nursing was significantly different between calves that did and did not survive up to eight days old, with surviving calves nursing longer per bout on average than those that did not. While definitions of nursing bouts vary depending on the study and its methodology, our findings are similar to those previously reported (Eastcott & Dickinson, 1987; Kastelein et al., 1990; Peddemors et al., 1992). Thurman et al. (1986) reported an average nursing duration of 3-5 s for two calves that did not survive 30 days past birth; in the current study non-surviving calves had similar average nursing durations. The data presented in this study suggest that nursing duration may be a useful behavioral indicator of calf health.

Since average nursing duration was significantly longer for surviving calves than non-surviving calves in the first eight days of life, an average duration of approximately 5-6 seconds may be an indicator of normal health and development. Nursing duration is especially important to monitor during the first three to five days after parturition, as this period is the riskiest for calf survival; calves need this time after birth to gain the strength and coordination to become proficient in nursing and begin to put on weight (Sweeney et al., 2010; Venn-Watson et al., 2011). Starting around day 5, the calf should begin to nurse for slightly longer durations as it gains competency; by two weeks old the calf should nurse more frequently but efficiently, receiving more milk in shorter nursing bouts (Triossi et al., 1998). A consistently short nursing duration and/or sudden drops in nursing duration may occur because the calf leaves the nipple too early, which may be indicative of developmental problems (Eastcott & Dickinson, 1987). Nursing duration can be a tool to evaluate the calf's development and should be monitored throughout the first 30 days after birth.

Nursing duration may also provide information about the calf's respiratory health. Particularly in the first few days of life, the calf's ability to hold its breath is not fully developed. Younger calves must surface to breathe more often, which may constrain the length of each nursing bout (Kastelein et al., 1990). As the calf grows and develops normally, it can hold its breath for longer and can nurse for longer periods at a time. Additionally, calves 8-30 days old seem particularly vulnerable to infection (Sweeney et al., 2010; Venn-Watson et al., 2011). If a calf suddenly decreases its nursing bout duration, it may be a sign that it is increasing its respiratory rate to compensate for illness. While the current study did not measure respiratory rate, Biancani et al. (2021) measured apnea (the time between breaths) and did not find a significant correlation with nursing duration. However, the study did not include nursing events shorter than three seconds in their dataset, which may have influenced their results. Therefore, future research should explore if any potential relationships between nursing bout duration and respiratory rate/respiratory illness exist in nursing dolphin calves. If such a relationship is present, lower nursing duration may be an early warning sign of illness and could alert animal care staff prior to the development of serious symptoms.

Overall, this study's results are consistent with those previously published and are a suitable reference for the average values of bottlenose dolphin calf nursing behavior in a managed setting for the first 30 days after birth. While our small sample size precludes us from making overarching conclusions about differences in nursing behavior between calves that survived and calves that did not survive up to both 8 days and 17 days old, our findings suggest that nursing bout duration may be a useful tool for assessing and managing calf health.

There was a 150% increase in surviving calves in the second half of this study period (i.e., 2001-2014 vs. 1990-2000), which can likely be attributed to improvements in husbandry and veterinary knowledge, management techniques, and in the maternal experience of the dams (Brando et al., 2018; Miller et al., 2015). Maternal experience is an important factor in the development of proper nursing behavior. In this dataset, calves between 1990-2000 were mostly born to primiparous mothers and/or mothers with no social exposure to calves, while those born between 2001-2014 were mostly born to multiparous mothers and/or mothers with social exposure to calves. In a behavioral study with two mother-calf dyads as subjects, the primiparous pair needed more time to establish typical suckling and swimming routines than the calf of the multiparous pair (von Streit et al., 2013). Knowledge of the maternal experience of the dam can be another vital data point for animal care staff to consider when a calf is born. Not included in our dataset was the birth of one calf in 2013 at Brookfield Zoo Chicago to a primiparous mother. With this information in mind, when the mother did not display appropriate maternal behavior shortly after birth and the calf was not suckling, animal care and veterinary staff made the decision to first attempt to introduce the calf to a surrogate mother; when insufficient milk was produced, staff instead hand-reared the calf through to weaning. This was Brookfield Zoo Chicago's first instance of a successful hand-rearing and re-integration of a dolphin calf to its social group (for full case study, see Flower et al., 2018). Both the careful records of the dam's previous experience and improved husbandry and management techniques based on data such as the current dataset contributed to quick and efficient decision-making in this instance by animal care staff that ensured proper timing for intervention and care that increased the health and survival of this calf.

The current study further contributes to a model of evidence-based care for the dolphins at Brookfield Zoo Chicago and can serve as a guideline for future births. Nursing bout duration is a useful measure that staff can quickly analyze day-by-day or even hour-by-hour to monitor calf health and development. An average nursing bout duration of approximately five to six seconds can be an indicator of normal health and development in a calf. An average nursing bout duration of approximately four seconds or shorter may be an early alert to underlying problems and can help animal care managers make critical care decisions. Calves with lower average nursing durations should be evaluated along with other data to determine whether the calf is nursing sufficiently on its own, or whether to provide additional support such as supplemental feeding or medication to increase calf health and welfare.

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Data availability: Data access restrictions apply; the data are available upon request to researchers who meet facility criteria for access to confidential data. Requests can be sent to the corresponding author.

Conflict of Interest: We have no known conflicts of interest to disclose.

References

Biancani, B., Sanchez-Contreras, G. J., Furlati, S., Benaglia, F., Arija, C. M., & Gili, C. (2021). Physiological parameters monitored on bottlenose dolphin neonates (*Tursiops truncatus*, Montagu 1821) over the first 30 days of life. *Animals*, *11*(4), 1066.

Brando, S., Broom, D. M., Acasuso-Rivero, C., & Clark, F. (2018). Optimal marine mammal welfare under human care: Current efforts and future directions. *Behavioural Processes*, *156*, 16– 36.

Cockcroft, V. G., & Ross, G. J. B. (1989). Age, growth and reproduction in bottlenose dolphins from the east coast of southern Africa [PhD Thesis]. In *Fishery Bulletin* (Vol. 88, Issue 2). University of Natal.

Couquiaud, L. (2005). Survey of international cetacean facilities. *Aquatic Mammals*, *31*, 311– 9.

Eastcott, A., & Dickinson, T. (1987). Underwater observations of the suckling and social behavior of a newborn bottlenosed dolphin (Tursiops truncatus). *Aquatic Mammals*, *13*(2), 51–56.

Jacobsen, T. B., Mayntz, M., & Amundin, M. (2003). Splitting suckling data of bottlenose dolphin (*Tursiops truncatus*) neonates in human care into suckling bouts. *Zoo Biology*, *22*(5), 477–488.

Kastelein, R. A., Dokter, T., & Zwart, P. (1990). The suckling of a bottlenose dolphin calf (*Tursiops truncatus*) by a foster mother, and information on transverse birth bands. *Aquatic Mammals*, *16*(3), 134–138.

Mann, J., & Smuts, B. (1999). Behavioral development in wild bottlenose dolphin newborns (*Tursiops* sp.). *Behaviour*, *136*, 529–566.

Mattson, M. C., Mullin, K. D., Ingram Jr, G. W., & Hoggard, W. (2006). Age structure and growth of the bottlenose dolphin (*Tursiops truncatus*) from strandings in the Mississippi Sound region of the north-central Gulf of Mexico from 1986 to 2003. *Marine Mammal Science*, *22*(3), 654–666.

Miller, L. J., Wells, R. S., Stacey, R., Zeigler, F. W., Whitham, J. C., & Adkesson, M. (2015). Animal Welfare Management of Bottlenose Dolphins at the Chicago Zoological Society's Brookfield Zoo. WAZA Magazine.

Peddemors, V. M., Fothergill, M., & Cockcroft, V. G. (1992). Feeding and growth in a captive-born bottle-nosed dolphin *Tursiops truncatus*. *South African Journal of Zoology*, *27*(2), 74–80.

R Core Team (2022). R: A language and environment for statistical computing. *R Foundation for Statistical Computing*, Vienna, Austria. URL https://www.R-project.org/.

Sarano, F., Sarano, V., Tonietto, M.-L., Yernaux, A., Jung, J.-L., Arribart, M., Girardet, J., Preud'Homme, A., Heuzey, R., & Delfour, F. (2023). Nursing behavior in sperm whales (*Physeter macrocephalus*). *Animal Behavior and Cognition*, *10*(2), 105–131.

Sweeney, J. C., Stone, R., Campbell, M., McBain, J., St Leger, J., Xitco, M., Jensen, E., & Ridgway, S. (2010). Comparative survivability of *Tursiops* neonates from three U.S. institutions for the decades 1990-1999 and 2000-2009. *Aquatic Mammals*, *36*(3), 248–261.

Thurman, G. D., & Williams, M. C. (1986). Neonatal mortality in two Indian Ocean bottlenose dolphins bred in captivity. *Aquatic Mammals*, *12*(3), 83–86.

Tidière, M., Colchero, F., Staerk, J., Adkesson, M. J., Andersen, D. H., Bland, L., Böye, M., Brando, S., Clegg, I., Cubaynes, S., Cutting, A., De Man, D., Derocher, A. E., Dorsey, C., Elgar, W., Gaglione, E., Anderson Hansen, K., Jungheim, A., Kok, J., … Conde, D. A. (2023). Survival improvements of marine mammals in zoological institutions mirror historical advances in human longevity. *Proceedings of the Royal Society B: Biological Sciences*, *290*(2009), 20231895.

Triossi, F., Pace, D. S., Terranova, M. L., & Renzi, P. (1998). The development of suckling behavior in two captive-born calves of bottlenose dolphins (*Tursiops truncatus*). *Aquatic Mammals, 24,* 75–84.

Venn-Watson, S. K., Jensen, E. D., & Ridgway, S. H. (2011). Evaluation of population health among bottlenose dolphins (*Tursiops truncatus*) at the United States Navy Marine Mammal Program. *Journal of the American Veterinary Medical Association*, *238*(3), 356–360.

Venn-Watson, S. K., Jensen, E. D., Smith, C. R., Xitco, M., & Ridgway, S. H. (2015). Evaluation of annual survival and mortality rates and longevity of bottlenose dolphins (*Tursiops truncatus*) at the United States Navy Marine Mammal Program from 2004 through 2013. *Journal of the American Veterinary Medical Association*, *246*(8), 893–898.

von Streit, C., Ganslosser, U., & von Fersen, L. (2011). Ethogram of two captive mother-calf dyads of bottlenose dolphins (*Tursiops truncatus*): comparison with field ethograms. *Aquatic Mammals*, *37*(2), 193–197.

von Streit, C., Ganslosser, U., & von Fersen, L. (2013). Behavioral development of two captive mother-calf dyads of bottlenose dolphins (*Tursiops truncatus*) in the calves' first year. *International Journal of Comparative Psychology*, *26*(3), 176-196.

Wells, R. S. (2009). Learning from nature: bottlenose dolphin care and husbandry. *Zoo Biology*, *28*(6), 635–651.

West, K. L., Oftedal, O. T., Carpenter, J. R., Krames, B. J., Campbell, M., & Sweeney, J. C. (2007). Effect of lactation stage and concurrent pregnancy on milk composition in the bottlenose dolphin. *Journal of Zoology*, *273*(2), 148–160.