Whistle Production Pre- and Post-Partum in Bottlenose Dolphins (*Tursiops truncatus*) in Human Care

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Abstract

The bottlenose dolphin (*Tursiops truncatus*) has a highly variable acoustic repertoire of whistles, clicks, and pulse burst sounds. Whistles are used to express individuality (signature whistle) and emotional state, and to initiate and maintain contact within a group. This study investigated the whistle production pre- and post-partum of three female bottlenose dolphins and their calves at the Kolmården Djurpark, Sweden. Gestation lasts approximately 12 months, and with the approach of delivery, the behaviour of the female changed in several ways. Observations of the behaviour and sound production were done for up to seven months prior to birth and for up to the first 22 months of the calves' lives. The results showed that whistle production increased significantly for all three females in the seven months pre-partum, with an accelerating increase in the days prior to birth. The whistles, therefore, might be used as an indicator that delivery is imminent. After birth, the mother-calf pair whistled more often when separated (66%) than when together (34%), and significantly more often when the calf returned to its mother than when she retrieved the calf.

Key Words: bottlenose dolphin, *Tursiops truncatus*, whistle production, pre-partum, post-partum, Kolmårdens Djurpark

Introduction

The bottlenose dolphin (*Tursiops truncatus)* has a highly variable repertoire of whistles, clicks, and burst pulse sounds (Popper, 1980). Whistles are suggested to be used to express identity (signature whistle) and emotional state, and to initiate and maintain contact within a group (Tyack, 1986, 1993); this is also important between a mother and her neonate. Gestation lasts approximately 12 months (McBride & Kritzler, 1951), and with the approach of delivery, the female changes her

behaviour in several ways. She may rub her belly on the bottom of the pool more often (Dudok van Heel, 1974; Joseph et al., 1999), and she generally becomes less social prior to parturition, spending a large portion of her time alone. Her food intake usually decreases drastically or stops completely 6 to 24 h prior to parturition (Joseph et al., 1987, 1999; Tavolga & Essapian, 1957). The female's general activities decrease in vigor, and an increasing frequency of body flexing is considered a characteristic behaviour in the latter months of pregnancy (Joseph et al., 1999; Sweeney et al., 1999; Tavolga & Essapian, 1957). Several weeks before birth, the pregnant female also may change her respiration pattern (Tavolga & Essapian, 1957; Tizzi et al., 2001).

Mothers and calves typically travel continuously, and if separated, it is important that they can determine each other's positions for a quick reunion even at night or in murky waters. The omnidirectional, frequency-modulated, and repetitively produced signature whistle (Caldwell & Caldwell, 1965, 1968), with newly discovered partly directional, high-frequency harmonics (Lammers & Au, 2003), may be well-suited for localization and will help the mother and calf to establish contact (McBride & Kritzler, 1951).

This study investigated the production of signature whistles, pre- and post-partum, by three female bottlenose dolphins, and the whistles produced by their calves. All of the study participants are kept for public display at the Kolmården Djurpark in Sweden.

Materials and Methods

Facility
The pool complex at the Kolmården Djurpark holds 6,400 m^3 of artificial seawater in seven, interconnected pools (Figure 1). A 900 m^2, 3- to 6-m deep public display pool, called the "Lagoon," was used as the breeding pool. Another pool, 800 m^2 and 4 m deep, was used for the main public

presentations. Between these display pools, there are five, 4-m deep holding pools varying in size from 16 m² to 117 m² (totaling 250 m²). These pools are connected to the "Lagoon" via a 1.8 m x 2.5 m gate, and to the show pool via a 1.4 m wide, 2 m deep, and 8 m long channel. The "Lagoon" is fitted with transparent underwater acrylic panels at two levels, offering underwater viewing to the visitor. The observation station was set up at one of the upper-level panels, which was fitted with an air-filled Plexiglas cupola, giving the observer a wide-angle view of the whole pool.

Animals
At the end of this study, the dolphinarium had 16 Atlantic bottlenose dolphins (*Tursiops truncatus*): one adult and two subadult males, seven adult and three subadult females, and one juvenile female. The three pregnant females swam together with the rest of the group until one to several days prior to each one's delivery, when the pregnant female that was ready to have her calf was separated into the "Lagoon" (see Table 1). Each female was kept

there alone with its calf for one to three weeks, whereupon selected females were gradually introduced to her as company. The time of the introduction and the animals that would be introduced were decided by the trainers. During the separation, the female and her calf were able to maintain visual and acoustic contact with the others through the netted gate to the holding pools.

Data Collection and Statistical Analysis
The study was carried out from February 2001 to October 2002. Direct observations were made, using a Toshiba laptop computer operating *The Observer, Version 3.0* software (Noldus Information Technology; courtesy of Linköping University). This software has been especially developed for behavioural studies and breaks the observations down into a predefined series of keystrokes, each representing an animal subject and behaviours from a detailed ethogram. Each observation was automatically given a time stamp, with a resolution of 0.01 s. All observations were conducted by use of focal and *ad libitum* sampling
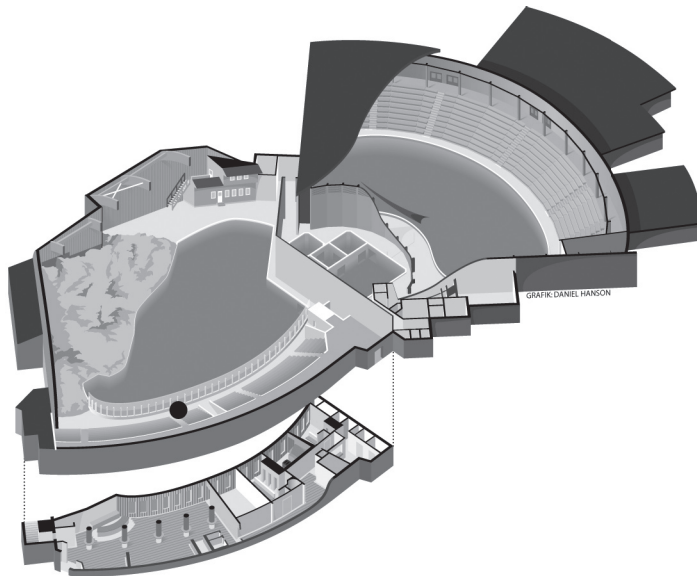

Figure 1. Drawing of the pool system at the Kolmården Djurpark; note the researcher's location on the diagram (•).

Table 1. Date of birth and separation time for each pregnant female

	Date of birth	Date of separation	Group composition
Sharky	27 September 2001	26 September 2001	28 September-2 October: Daphne & Sharky/calf
Daphne	7 October 2001*	28 September 2001	2-7 October: Lotty, Daphne, & Sharky/calf
Lotty	21 October 2001	2 October 2001	7-14 October: Lotty, Daphne/calf, & Sharky/calf
			from 14 October: Lotty/calf & Sharky/calf

*Calf died on 14 October 2001.

(Altmann, 1974). Concurrent sounds in the pool were picked up with a 25-mm HS/70 ball hydrophone (Sonar Research and Development, Ltd, Beverley, East Yorkshire, UK), which was connected via an Etec preamplifier (Etec, Albertslund, Denmark) to a Sony TCD-D8 DAT Recorder. This system was flat from 100 Hz to 22 kHz (± 2 dB).

Whistles were identified and classified by visual inspection of spectrograms, using *WSpecGram, Version 1.0*, software for real-time spectrograms (developed by G. Pavan, Università degli Studi di Pavia, Italy). The whistles of the neonates were determined by bubble stream emissions by the neonates. ANOVAs were done to investigate these data. The statistical analysis was performed with *JMP, Version 4.0* (SAS Institute Inc., Cary, NC, USA).

Results

Pre-Partum Whistling
A total of 8,786 signature whistles, which were assigned to the three pregnant females, were recorded during the seven months prior to each delivery. Of these, 1,085 were produced by Lotty, 3,032 by Sharky, and 4,669 by Daphne (Figure 2).

The pregnant females had a statistically significant increase in their number of signature whistles as they approached partum (Figures 3 & 4). This trend was observed throughout the studied seven-month pre-partum period ($F = 7.13$, $p = 0.0081$), but in addition, there was a significant increase in the whistling frequency in the females ($F = 6.22$, $p = 0.0002$) during the last 27 days pre-partum.

The primiparous female, Daphne, had an overall higher whistle production than the other two females, which were both multiparous. As can be seen in Figure 4, Daphne also reached a very high whistling frequency peak in the days before, and on the day of, parturition.

Post-Partum Whistling
A total of 28,957 whistles were recorded within the three calves' first year of life (22 months for one of the calves), of which 19,207 were produced during spontaneous mother-calf separations and 9,750 after reunions (Figure 5). There was a significantly higher production of whistles/min when the mother and calf were apart than when together ($F = 101.26$, $p < 0.0001$). During the separation, mothers and calves produced the same amount of whistles ($F = 0.38$, $p = 0.5334$). When reunited, the mother produced significantly more whistles/min than the calf ($F = 76.22$, $p < 0.0001$).

Three mother-calf pairs were studied. In the first pair, the mother (Vicky) whistled significantly more often per min both during separations and during reunions than her calf (Luna) ($F = 5.72$, $p = 0.0173$ and $F = 25.22$,
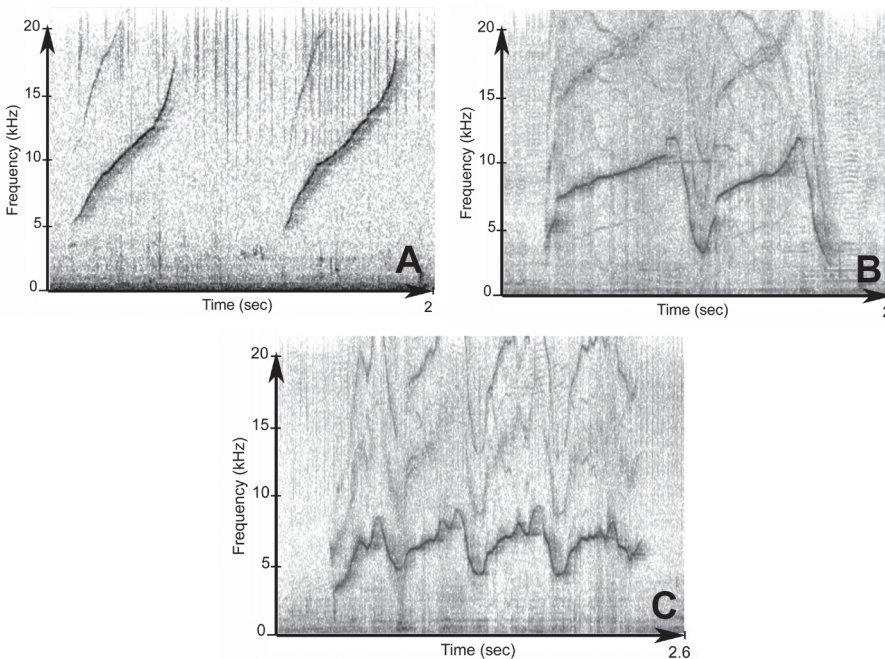

Figure 2. Spectrograms of the signature whistles of the three pregnant females: (A) Lotty, (B) Daphne, and (C) Sharky
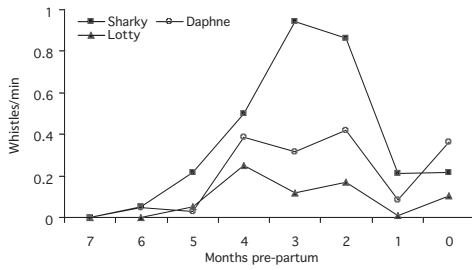
Figure 3. Variations in the whistle production/min during the months pre-partum in Lotty (F = 4.47, *p* = 0.0146), Sharky (F = 4.75, *p* = 0.0324), and Daphne (F = 4.3340, *p* = 0.0407)
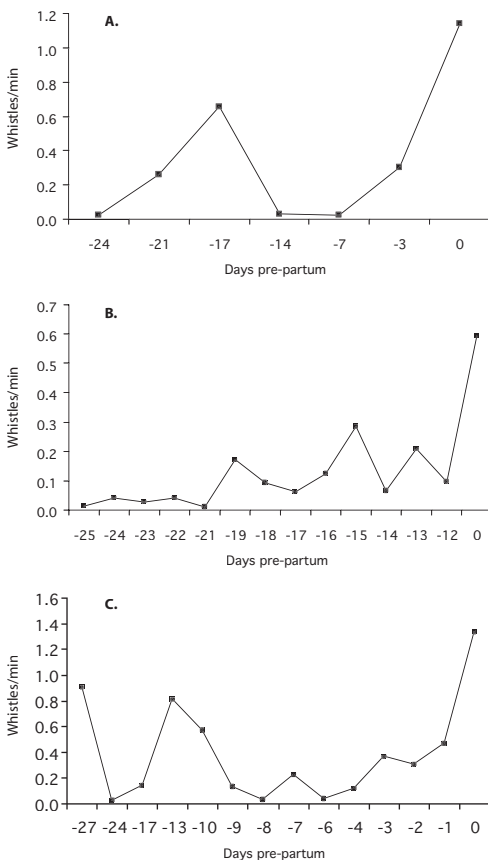

Figure 4. Variations in the whistle production/min during the last 27 days pre-partum in (A) Lotty (F = 34.25, *p* < 0.0001), (B) Sharky (F = 7.36, *p* = 0.0676), and (C) Daphne (F = 10.80, *p* = 0.0017); note the different X- and Y-axis scales.

p < 0.0001, respectively). In the second pair, during separations, both mother (Sharky) and calf (Max) whistled similarly (F = 2.90, *p* = 0.0901).
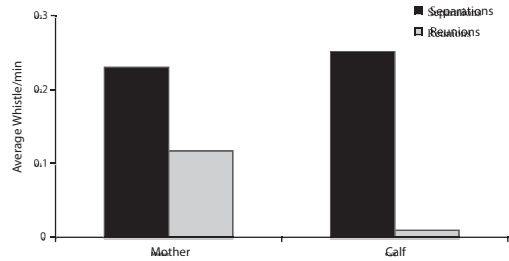

Figure 5. Whistle production/min by mother-calf pairs during separations and after reunions

During reunions, the mother whistled significantly more often per min than her calf (F = 48.83, *p* < 0.0001). Finally, in the third mother-calf pair, the calf (Fenix) whistled significantly more often per min than his mother during separations (F = 11.57, *p* = 0.0008), but not during reunions where the mother produced significantly more whistles (F = 18.69, *p* < 0.0001).

In a significant majority of the separations, it was the calf that returned to its mother and not the mother that retrieved her calf (F = 33.28, *p* < 0.0001).

Discussion

Some changes in social behaviour are to be expected in a pregnant female since pregnancy is associated with marked fluctuations in hormones, such as oestrogen and progesterone, which have a well-known effect on behaviour (Maestripieri, 1999; Maestripieri & Megna, 2000).

In many gregarious mammals, the pregnant female becomes less social before parturition. Pregnant Mediterranean monk seals (*Monachus monachus)* were found withdrawing to isolated spots inside the colony caves, far from other seals (Layna et al., 1999). In primates, like the rhesus (*Macaca mulatta*), Japanese (*Macaca fuscata),* and pigtail macaques (*Macaca nemestrina)*, the pregnant female also withdraws from social contact when parturition is near (Bardi et al., 2001; Maestripieri & Megna, 2000; Maestripieri & Wallen, 1995). A near-term wild boar sow (*Sus scofra*) leaves the group on the day of delivery and builds a nest some considerable distance away from the rest of the group (Harris et al., 2001). In bottlenose dolphins, the pregnant female also becomes less social prior to parturition, spending a large portion of her time alone (Joseph et al., 1987; Tavolga & Essapian, 1957). The reduced participation in social activities may reflect the reduced mobility in the pregnant female due to her large body size and weight and may allow her to save energy in preparation for delivery (Maestripieri, 1999). Leaving the group may also

be a way to avoid the turmoil, including theft of the newborn, which has been observed to occur when the calf has been born in view of the group (Amundin, 1999).

Other behaviourial changes occur when a female is pregnant. In rhesus macaques, a high frequency of self-grooming was observed prior to parturition, which might be a functional way to improve the readiness of care toward an infant by simply shifting the care for oneself to the care of the infant (Bardi et al., 2001). In pregnant pigtail macaques, an increased interest in infants is seen during pregnancy, which also may be a preparation for impending motherhood, when most of her social attention will be directed to her own infant (Maestripieri, 1999; Maestripieri & Wallen, 1995).

The study presented here revealed that the signature whistle production in pregnant bottlenose dolphin females increased during the entire pregnancy, and this trend accelerated to a peak in the last few days pre-partum. A similar increased vocalization has also been seen in domestic goats (*Capra hircus*) in connection with an increasing restlessness when parturition approached (Lickliter, 1985).

Intense restlessness was observed more often in primiparous females than in multiparous ones in goats (Das & Tomer, 1997), and in Mexican mantled howler monkeys (*Alouatta palliata*) (Dias, 2005). The higher whistle production by the primiparous female in our study may be a reflection of this restlessness. In emperor tamarins (*Saguinus imperator*), the primiparous female also was restless and vocalized a great deal during labour (Windfelder, 2000).

Along with the loss of appetite, the increase in body flexing, and withdrawal from social contact (Espmark, 1971; Joseph et al., 1987; Ramírez et al., 1995; Tavolga & Essapian, 1957), our results indicated that the rate of signature whistling might be used as an additional indicator of an imminent delivery.

The function of the increased whistling of the mother pre-partum might be to prepare the calf so it can quickly learn to recognize the mother's signature whistle post-partum, a skill that would be crucial for survival. A foetus is developing in an environment that is rich with internal as well as external sounds (Gerhardt et al., 1990; Vince et al., 1982b). In dolphins, waterborne sounds may play an important role since they most likely penetrate into the womb with little attenuation, and the dolphin ear is adapted to hearing in water (McCormick et al., 1970; Purves, 1966; Reysenbach de Haan, 1966). Prior to birth, the foetus appears to be particularly sensitive to the amount of overall stimulation present in its environment, and the amount of prenatal stimulation influences the early perceptual development (DeCasper & Spence, 1986; Spence & DeCasper, 1987; Vince, 1979; Vince et al., 1982a). It also has been shown that the ability to respond differentially to emotional speech is based upon learning that occurs during the foetal period (Mastropieri & Turkewitz, 1999).

Whistling in the context of separations may benefit a calf in two ways. The first involves localisation. A calf may whistle to announce its position and to induce the mother to whistle, thereby revealing not only her position, but also her willingness to be rejoined. The second involves the inducement of other responses from the mother such as approaching or waiting for the infant (Smolker et al., 1993). The results shown here are consistent with the hypothesis of a localisation function of the signature whistles. The calf seems to have the primary responsibility for reinstating proximity after a separation, that is, calves approach their mothers rather than vice-versa (Chirighin, 1987; Smolker et al., 1993). This is supported by our results. In 77% of the separations, it was the calf approaching the mother. If the calf's success at returning to its mother typically depends on hearing its mother's whistle, the mother would be expected to whistle quite often during separations. This was not seen in our study, where the mother whistled more often when swimming together with her calf. Smolker et al. (1993) also found that the mothers did not whistle quite as often as expected during separation. On the other hand, it is possible that the mother monitored her calf's approach by its whistling and did not whistle in response unless the calf was distressed or off course. In addition, our study was carried out only in daylight hours and in perfectly clear artificial seawater, where visual cues may have affected the whistling frequency. If so, a higher whistling rate would be expected at night or in murky water. This hypothesis could not be tested in this study since it was not possible to detect separations at night.

Acknowledgments

Literature Cited

Altmann, J. (1974). Observational study of behavior: Sampling methods. *Behaviour*, *49*, 227-267.

Amundin, M. (1999). Effects of maternal/neonate behaviour on calf survival in the bottlenose dolphin, *Tursiops truncatus*. *Bottlenose Dolphin Reproduction Workshop* (pp. 319-327), San Diego, CA, USA.

Bardi, M., Shimizu, K., Fujita, S., Borgognini-Tarli, S., & Huffman, M. A. (2001). Social behavior and

hormonal correlates during the perinatal period in Japanese macaques. *Hormones and Behaviour*, *39*(3), 239-246. (doi: 10.1006/hbeh.2001.1651)

Caldwell, M. C., & Caldwell, D. K. (1965). Individualized whistle contours in bottlenosed dolphins (*Tursiops truncatus*). *Nature*, *207*, 434-435.

Caldwell, M. C., & Caldwell, D. K. (1968). Vocalization of naive captive dolphins in small groups. *Science*, *159*, 1121-1123.

Chirighin, L. (1987). Mother-calf relationships and calf development in the captive bottlenose dolphin (*Tursiops truncatus*). *Aquatic Mammals*, *13*(1), 5-15.

Das, N., & Tomer, O. S. (1997). Time pattern on parturition sequences in Beetal goats and crosses: Comparison between primiparous and multiparous does. *Small Ruminant Research*, *26*(1-2), 157-161. (doi: 10.1016/S0921-4488(96)00997-2)

DeCasper, A. J., & Spence, M. J. (1986). Prenatal maternal speech influences newborns' perception of speech sounds. *Infant Behavior and Development*, *9*(2), 133-150. (doi: 10.1016/0163-6383(86)90025-1)

Dias, P. A. D. (2005). Observation of parturition in the Mexican mantled howler monkeys (*Alouatta palliata*) on the Island of Agaltepec, Veracruz State, Mexico. *International Journal of Primatology*, *65*(1), 93-98. (doi: 10.1002/ajp.20100)

Dudok van Heel, W. H. (1974). Birth in dolphins (*Tursiops truncatus*, Mont.) in the Dophinarium Harderwijk, Netherlands. *Aquatic Mammals*, *2*(2), 11-22.

Espmark, Y. (1971). Individual recognition by voice in reindeer mother-young relationship: Field observations and playback experiments. *Behaviour*, *40*, 295-301.

Gerhardt, K. J., Abrams, R. M., & Oliver, C. C. (1990). Sound environment of the fetal sheep. *American Journal of Obstetrics and Gynecology*, *162*(1), 282-287.

Harris, M. J., Bergeron, R., & Gonyou, H. W. (2001). Parturient behaviour and offspring-directed aggression in farmed wild boar of three genetic lines. *Applied Animal Behaviour Science*, *74*(2), 153-163. (doi: 10.1016/S0168-1591(01)00160-5)

Joseph, B. E., Antrim, J. E., & Cornell, L. H. (1987). Commerson's dolphin (*Cephalorhynchus commersonii*): A discussion of the first live birth within a marine zoological park. *Zoo Biology*, *6*(1), 69-77.

Joseph, B., Duffield, D., & Robeck, T. (1999). Summary data on reproduction of bottlenose dolphins in controlled environments. *Bottlenose Dolphin Reproduction Workshop* (pp. 43-55), San Diego, CA, USA.

Lammers, M. O., & Au, W. W. L. (2003). Directionality in the whistles of Hawaiian spinner dolphins (*Stenella longirostris*): A signal feature to cue direction of movement? *Marine Mammal Science*, *19*(2), 249-264.

Layna, J. F., Cedenilla, M. A., Aparicio, F., & Gonzalez, L. M. (1999). Observations of parturition in the Mediterranean monk seal (*Monachus monachus*). *Marine Mammal Science*, *15*(3), 879-882.

Lickliter, R. (1985). Behavior associated with parturition in the domestic goat. *Applied Animal Behaviour Science*, *13*(4), 335-345. (doi: 10.1016/0168-1591(85)90013-9)

Maestripieri, D. (1999). Changes in social behavior and their hormonal correlates during pregnancy in pig-tailed macaques. *International Journal of Primatology*, *20*(5), 707-718.

Maestripieri, D., & Megna, N. L. (2000). Hormones and behavior in rhesus macaque abusive and nonabusive mothers. 1. Social interactions during late pregnancy and early lactation. *Physiology & Behavior*, *71*(1-2), 35-42.

Maestripieri, D., & Wallen, K. (1995). Interest in infants varies with reproductive condition in group-living female pigtail macaques (*Macaca nemestrina*). *Physiology & Behavior*, *57*(2), 353-358. (doi: 10.1016/0031-9384(94)00222-Q)

Mastropieri, D., & Turkewitz, G. (1999). Prenatal experience and neonatal responsiveness to vocal expressions of emotion. *Developmental Psychobiology*, *35*(3), 204-214.

McBride, A. F., & Kritzler, H. (1951). Observations on pregnancy, parturition and post-natal behavior in bottlenosed dolphin. *Journal of Mammalogy*, *32*, 251-266.

McCormick, J. G., Wever, E. G., Palin, J., & Ridgway, S. H. (1970). Sound conduction in the dolphin ear. *Journal of the Acoustical Society of America*, *48*(6, pt. 2), 1418-1428.

Popper, A. N. (1980). Sound emission and detection by delphinids. In L. M. Herman (Ed.), *Cetacean behaviour: Mechanisms and functions* (pp. 1-52). New York: John Wiley & Sons.

Purves, P. E. (1966). Anatomy and physiology of the outer and middle ear in cetaceans. In K. S. Norris, B. Würsig, R. S. Wells, & M. Würsig (Eds.), *Whales, dolphins and porpoises* (pp. 320-380). Berkeley: University of California Press.

Ramírez, A., Quiles, A., Hevia, M., & Sotillo, F. (1995). Behavior of the Murciano-Granadina goat in the hour before parturition. *Applied Animal Behaviour Science*, *44*(1), 29-35. (doi: 10.1016/0168-1591(95)00580-L)

Reysenbach de Haan, F. W. (1966). Listening underwater: Thoughts on sound and cetacean hearing. In K. S. Norris, B. Würsig, R. S. Wells, & M. Würsig (Eds.), *Whales, dolphins and porpoises* (pp. 583-596). Berkeley: University of California Press.

Smolker, R. A., Mann, J., & Smuts, B. B. (1993). Use of signature whistles during separations and reunions by wild bottlenose dolphin mothers and infants. *Behavioral Ecology and Sociobiology*, *33*, 393-402.

Spence, M. J., & DeCasper, A. J. (1987). Prenatal experience with low-frequency maternal-voice sounds influence neonatal perception of maternal voice samples. *Infant Behavior and Development*, *10*(2), 133-142. (doi: 10.1016/0163-6383(87)90028-2)

Sweeney, J. C., Krames, B., Krames, J., & Stone, L. R. (1999). Stages of parturition, normal early calf development, and food energy requirements of the cow.

Bottlenose Dolphin Reproduction Workshop (pp. 289-296)*,* San Diego, CA, USA.

Tavolga, M. C., & Essapian, F. S. (1957). The behavior of the bottlenose dolphin: Pregnancy, parturition and mother-infant behavior. *Zoologica*, *42*(2), 11-31.

Tizzi, R., Gabaldo, M., & Pace, D. S. (2001). Pregnancy in bottlenose dolphin (*Tursiops truncatus*): Behavioural and respiratory aspects. *Proceedings of the 15th International Conference of the European Cetacean Society* (p. 28)*,* Rome, Italy.

Tyack, P. L. (1986). Whistle repertoires of two bottlenosed dolphins, *Tursiops truncatus*: Mimicry of signature whistles? *Behavioral Ecology and Sociobiology*, *18*, 251-257.

Tyack, P. L. (1993). Animal language research needs a broader comparative and evolutionary framework. In H. L. Roitblat, L. M. Herman, & P. E. Nachtigall (Eds.), *Language and communication: Comparative perspectives (comparative cognition and neuroscience)* (pp. 115-152). Mahwah, NJ: Lawrence Erlbaum Associates.

Vince, M. A. (1979). Post natal effects of pre natal sound stimulation in the guinea pig *Cavia porcellus*. *Animal Behaviour*, *27*(3), 908-918.

Vince, M. A., Armitage, S. E., Walser, E. S., & Reader, M. (1982a). Post natal consequences of pre natal sound stimulation in the sheep. *Behaviour*, *81*(2-4), 128-139.

Vince, M. A., Armitage, S. E., Baldwin, B. A., Toner, J., & Moore, B. C. J. (1982b). The sound environment of the fetal sheep. *Behaviour*, *81*(2-4), 296-315.

Windfelder, T. L. (2000). Observations on the birth and subsequent care of twin offspring by a lone pair of wild emperor tamarins (*Saguinus imperator*). *American Journal of Primatology*, *52*(2), 107-113.