

The following annotated bibliographies were organized based on themes from vague to specific, and oldest to youngest within each theme. The first bibliography corresponds to a review article that summarizes the patterns of nursing/lactating, followed by an article that introduces the other factors that determine the context of maternal behaviours (such as nursing/suckling) in cetaceans, next are multiple articles of observations of cetacean species in the wild followed by observations in captivity, and last are articles that explore allonursing in cetaceans.

Oftedal, O. T. (1997). Lactation in whales and dolphins: Evidence of divergence between baleen- and toothed-species. *Journal of Mammary Gland Biology and Neoplasia*, 2(3), 205–230. <https://doi.org/10.1023/A:1026328203526>

Summary

Literature on cetacean lactation was first published over a hundred years ago, but few studies have been completed to further the literature on these immense species. Much of the information available today is the result of measurements taken during the whaling industry with numerous biases. In this article, the author aimed to explore lactation patterns, milk composition and lactation performance of different cetacean species to interest lactation physiologists and cetacean biologist in exploring a neglected field. This was conducted as a systematic review and continuously compared the patterns seen in cetaceans to the recent evidence of lactation patterns found in pinnipeds. Two clear patterns were found in the cetaceans between baleen whales (mysticetes) and toothed whales (odontocetes). Baleen whales often found to have clear patterns of fasted lactating periods, for shorter lengths of time (5-7 months) than the toothed whales which do not fast during lactation and spend a longer length of time lactating (1-3 years). Some exceptions were found in each group: bowhead whales in the mysticetes with a longer lactation period and harbor porpoises in the odontocetes with a shorter lactation period. Additionally, mysticetes were found to produce milk high in fat (30-50%) and low in water (40-53%), while odontocetes produce milk higher in water (60-77%) and lower in fat (10-30%). The findings of this review are significant because it works to outline the patterns of lactation in cetaceans, as well as it compares the different strategies extensively. Additionally, the author identified the sources of biases and error in the different data available based on the methods they were obtained through. The authors point out all the gaps in their review where further research needs to be done, including the composition and production of cetacean milk through isotope techniques.

Contribution

I chose this article for my literature review because it provides a detailed summary of all the literature and data on the lactation and suckling behaviour observed in different cetacean species prior to the year 2000. This article advanced knowledge in this field as it clearly outlined the differences in lactation behaviour between mysticetes and odontocetes by describing the findings on each species. The author presents throughout the article where further research needs to be

conducted for species where data is not available and proposed better methods for determining the composition of cetacean milk (i.e., isotope techniques).

Burnham, R. E., & Duffus, D. A. (2020). Maternal behaviors of gray whales (*Eschrichtius robustus*) on a summer foraging site. *Marine Mammal Science*, 36(4), 1212–1230.

<https://doi.org/10.1111/mms.12710>

Summary

Grey whale (*Eschrichtius robustus*) calves have been found to have three critical periods: birth to initial post-partum period, leaving the breeding area, and their first summer in the foraging area where weaning occurs. In breeding lagoons, motherese calls (analogous to “baby talk”) have been observed between mother-calf pairs. It is unknown what the relationship is between the weaning location and the return rate of the calves. The study objectives of the researchers were the following: to examine how weaning location and residency time influence the return rate of the matured calves to the foraging site, as well as what protection/antipredator behaviours are displayed by mothers, and how mother-calf pairs compare to individual whales. The study was completed from a minimum of 30 transect surveys every year from 1998 to 2016 at Clayoquot Sound on the coast of Vancouver Island. An autonomous multichannel acoustic recorder was used for passive acoustic recording to accompany visual observations in the bay. The study found mother-calf pairs decreased towards the end of the summer as well as the number of motherese calls observed. They found a positive relationship between the residency time at the foraging area and the rate of return. It is suggested this return rate is the result of maternally inherited prey preference and site use behaviours. Lastly, the study found cow-calf pairs commonly used shallow waters and closer proximity to the shore, while single foraging whales were found throughout the transect. This study functions to add further knowledge to the life history of grey whales and can be used to further the understanding of measures necessary for protection of this species. This study introduces the question as to what the effect of noise pollution and increased predation would be on weaning conditions, which may need further assessment for conservation efforts.

Contribution

I chose this article because it outlines differences in behaviour between mother whales with their calves, and single whales. Particularly, differences in migration and foraging. This article effectively advances the knowledge of grey whales’ habitat use, acoustic behaviour, maternal inheritance of site use and prey preference, and recruitment arrangements into the Pacific Coastal Feeding Group (PCFG). The researchers support previous findings of the call-types used between mother-calf pairs (motherese) and adults, as well as the use of shallow waters by them. Due to the timeline of the study, it provides significant knowledge to the long-term behavior of grey whales.

Gero, S., & Whitehead, H. (2007). Suckling behavior in sperm whale calves: Observations and hypotheses. *Marine Mammal Science*, 23(2), 398–413.

<https://doi.org/10.1111/j.17487692.2007.00113.x>

Summary

Sperm whales form matrilineal units consisting of females and their offspring. The formation of these units has been found to increase protection for calves while mothers forage. However, most studies on sperm whale behaviours have focused on mother behaviour over calf behaviour. The objective of this study was to describe calf behaviour in detail and set a baseline from which to produce a more complete ethogram on infant sperm whale. The researchers collected data through photo-identification and focal follows of 11 calves from the Caribbean Sea and 11 from the Sargasso Sea. Individuals were identified using the shape of the dorsal fins and distinct marking on the fin/body. The study found peduncle diving (diving under the base of the caudal fin of the mother) by calves is laterally asymmetrical with a preference for the left side (69.8% of bouts). Additionally, calves rarely switched sides of the female during a suckling bout (10.8% of bouts). No difference in dive duration by the calf was found between left and right side of the female. From the underwater observations of peduncle diving, no attempts of oral contact to the mother's nipple were made by the calf, suggesting the possibility that suckling cannot be inferred to occur from peduncle dives as has been done by previous studies. The study suggests two possible explanations for the lack of suckling observations during peduncle diving: calves dive to position themselves under the female to reduce drag, and/or sperm whales do not suckle through the mouth and use the nasal passage instead as calves were observed pushing their blowhole against the genital area of the mother. The researchers suggest further research into the development of sperm whale calves and the function of the peduncle diving be explored to understand social units and suckling in this species.

Contribution

This article was chosen for my literature review for its contextual observations of what is usually a proxy for suckling (peduncle diving), in sperm whale calves. This study advanced knowledge of the field by being the first to describe sperm whale suckling behaviour with above and below surface observations. With their underwater observations, this study contradicts previous finding that describe peduncle diving as a proxy for suckling. They present a new line of inquiry in suggesting sperm whale calves possibly nursing through their nasal passage due to their differential jaw structure in comparison to other cetaceans.

Videsen, S. K. A., Bejder, L., Johnson, M., & Madsen, P. T. (2017). High suckling rates and acoustic crypsis of humpback whale neonates maximise potential for mother–calf energy transfer. *Functional Ecology*, 31(8), 1561–1573. <https://doi.org/10.1111/1365-2435.12871>

Summary

Humpback whales migrate long distances from breeding-grounds to foraging-grounds, with the females accompanied by their calves; a critical time in which the calves maximize energy intake through suckling to survive the migration precedes this. The objectives of the study were to quantify where and how often calves suckle to understand their resilience to disturbances, and to investigate how mother-calf pairs solve the need to maintain contact in low visibility environments while controlling for predation and detection by male humpbacks. Data was collected with multi-sensor tags on mother-calf pairs in the Exmouth Gulf, Western Australia, during August and September 2014. Pairs were tagged during slow travel and observed from >200 meters away with the boat engine off to avoid biased data. Additionally sound data was collected and examined with a spectrogram. The study found the calves to be in suckling position

20% of the time, while 50% of this suckling behaviour occurred while the mother was submerged. The study also found tactile cues to be more important to initiate sucking/nursing behaviour as opposed to vocal cues, although weak vocal calls were used between the pair during travelling. These findings suggest there may be avoidance of predation and benefits in thermoregulation to suckling at greater water depths. Similarly, using vocalizations in active diving as opposed to suckling dives, suggest the mother-calf pairs reduce risk of exposure to predators and male escorts by behaving inconspicuously. Lastly, the weak calls between the pair are suggested to be problematic for conservation of humpback whales as they could easily be concealed by ambient noise and result in mother-calf separation. The researchers question the consequences of increased noise-generating human activities on the fitness of humpback whales as they could be driven to separation or using louder calls that would increase predation risk.

Contribution

This article was chosen for my literature review for its observations of suckling behaviour in humpback whales in the wild and how it is affected by their environment. This study advances knowledge of communication that initiates suckling behaviour, as well as preferred depth for suckling. The study supports the findings of previous studies regarding the time spent by calves suckling and the diving behaviour observed. The researchers present a less biased form of observation with the use of tagging and decreased observation-platform disturbance. Lastly, the study introduces the effects of anthropogenic activity on calls between mother and calf.

Zoidis, A., & Lomac-MacNair, K. (2017). A note on suckling behavior and laterality in nursing humpback whale calves from underwater observations. *Animals*, 7(12), 51.
<https://doi.org/10.3390/ani7070051>

Summary

Suckling and nursing behaviour is not well documented in large baleen whale species (i.e., humpback whales) due to low accessibility. Most previous studies on nursing behaviour in whales have been conducted with surface observations. This study attempted to fill the gap on documentation in the literature. The researchers set four study objectives. First, obtain underwater observations with video documentation of suckling events in humpback whales. Second, to support and contribute to past research on humpback whale nursing/suckling. Third, to associate observations of milk in the water to suckling/nursing events. Lastly, explore the possible laterality patterns in mother-calf pairs during suckling. Underwater observations with a video camera and acoustic recordings with a hydrophone were collected for 199 focal groups chosen for their mother-calf pair presence in waters southwest of Maui, Hawaii from 2001 to 2015. The researchers observed nursing behaviour in five focal groups out of the 199 groups observed. Their main findings were nursing events were short in duration (mean of 30.6 seconds), and calves positioned themselves on the right side of the mother, suggesting right side laterality. This study is significant to the field as it provides information on this behaviour from an underwater point of view and the first documentation of cetacean milk in the water column during the observation of nursing behaviour. This documentation of milk in the water is the first concrete proof that the mother-calf position in other studies that is assumed to be nursing behaviour indeed has transference of milk from mother to calf. The study suggests further study on the laterality of nursing behaviour to explore whether lateral preference is determined by the mother or calf, whether the preference is socially or physiologically driven, and whether the right lateral preference seen here can be found at the population level.

Contribution

I chose this article for my literature review because it provides direct observations of suckling/nursing behaviour of cetaceans in their natural habitat. This study advances knowledge in the field as it provides visual documentation of nursing behaviour accompanied by milk in the water column providing confirmation to the position previously assumed to be nursing. This study corroborates previous studies that have attributed this mother-calf pair position to nursing and studies that have seen laterality in other cetaceans. The researchers use their finding to suggest further study into what causes the laterality seen in their study specimens.

Eastcott, A., & Dickinson, T. (1987). Underwater observations of the suckling and social behavior of a new-born bottlenosed dolphin (*Tursiops truncatus*). *Aquatic Mammals*, 13(2), 516–556.

Summary

A bottlenose dolphin born in the Brighton Aquarium, England in 1985, allowed for the study of the suckling and developmental behaviour of the calf, in the presence of two adult dolphins aside from the mother. The study objective was to make detailed observations of suckling and other behaviours by the calf in the aquarium environment, and document new findings that could contribute to successful rearing and husbandry of bottlenose dolphins. Postpartum of the calf, all shows were cancelled, making the aquarium inaccessible to the public. Data was collected via 24-hour watches from day one. The researchers monitored suckling, sightings of milk, calf faeces, and other behaviours. Nighttime observations were completed for two weeks, while daytime observations were completed for five weeks. Suckling was found to occur in a threecomponent pattern: a suckling bout, nipple lock-on time within a bout, and an interval phase between bouts (no suckling). The study found the calf suckled more at night and less frequently as the calf aged. Breathing rates of the calf could not be correlated to the suckling periods, and no milk loss into the pool was observed. Additionally, the researchers saw clear avoidance behaviour by the cow-calf pair to the other two adult dolphins in the pool. However, this behaviour also decreased as the calf aged. The significance of these findings is they show suckling to be continuous through any point in the 24-hour cycle and shows there to be a sequence of event in which calves suckle. Additionally, the researchers suggest the lack of milk loss in the water is a positive result of an undisturbed environment where the calve is not frightened away from the nipple. The study presents the question that nighttime preference for suckling could possibly be the result of minimized environmental interruptions at this time.

Contribution

This article was chosen for my literature review for its detailed observations of bottlenose dolphin suckling behaviour. This study advanced knowledge in the field as it was one of the first data collections of this behaviour in captive dolphins. They contradict findings of previous studies that had found shorter time lapses for the calf to find the mother's nipple. Similarly, they found frequent suckling at depth instead of at the surface as described in other reports. At the time of the study, they provided important information on the environment necessary for the successful development of dolphin calves in captivity.

Russell, J. M., Simonoff, J. S., & Nightingale, J. (1997). Nursing behaviors of beluga calves (*Delphinapterus leucas*) born in captivity. *Zoo Biology*, 16(3), 247–262.

[https://doi.org/10.1002/\(SICI\)1098-2361\(1997\)16:3<247::AID-ZOO5>3.0.CO;2-A](https://doi.org/10.1002/(SICI)1098-2361(1997)16:3<247::AID-ZOO5>3.0.CO;2-A)

Summary

At the time of this study, there was little research on beluga behaviour, specifically nursing/suckling behaviour. Study of this behaviour is of special interest to institutions of beluga captivity that want to ensure survival of the individuals held. The objective of this study was to fill the gap in the literature of beluga behaviour by exploring in detail the frequency of nursing bouts, and the amount of time spent nursing. Two beluga whale calves were observed for 55 days postpartum. The first mother-calf pair were initially placed in the same pool as a pregnant beluga female, but after the pregnant female was seen to strike the calf, she was moved to a separate pool where she would birth her own calf (second calf observed in the study). The sampling method used was focal-pair sampling where nursing activity was continuously observed during sampling periods. Three observers around the pool simultaneously collected data in 4-hr shifts. A total of 30 observers were used. The study found one calf to continuously nurse more than the other but saw similar patterns in both. Nursing was seen to peak at 7-10 days postpartum and slowly declined from there. More nursing was generally associated with a wider range of individual nursing time, with a nursing bout every 36 minutes on average. Lastly, no circadian rhythm was found in suckling activity. The significance of these findings is the variability in nursing between calves of the same species; suggested to be related to the receptiveness of the mothers to their calves. Additionally, this study found patterns in nursing activity that coincides with the patterns of other cetaceans (i.e., killer whales). Lastly, the study presents the idea that monitoring nursing behaviour can indicate illness in calves as was seen with one of the subjects of the study.

Contribution

This article was chosen for my literature review for its detailed data collection of nursing/suckling behaviour in beluga whales. This adds another species to the review of suckling in cetaceans. This article advances knowledge in the field by adding comparable data on suckling behaviour of a cetacean species and concluding the activity in one bout had a relationship with the next. The study supports previous findings regarding peak nursing period and nursing patterns (i.e., decreased activity with aging of calf). The study presents a new function to monitoring nursing behaviour in calves: indication of illness through lowered activity.

Xian, Y., Wang, K., Xiao, J., & Wang, D. (2012). Suckling behavior and its development in two Yangtze finless porpoise calves in captivity: Suckling behavior in porpoise calves. *Zoo Biology*, 31(2), 229–234. <https://doi.org/10.1002/zoo.20391>

Summary

The Yangtze finless porpoise (*Neophocaena phocaenoides*) is one of few freshwater cetaceans and faces extinction as victims of increasing human activity. With the first two calves to successfully be born in captivity in 2007, the researchers studied their suckling behaviour and development. The objective of this study was to contribute to solving the endangerment of this species by gaining information for their conservation. The researchers collected data on the calves every Wednesday and Sunday during the first year postpartum, and once a week in the second year for one calf. The calves were focally followed and recorded in 10.5-min sessions throughout the daytime. In reviewing the video data, they noted the swimming positions of the pair three seconds before suckling, the mother's position (i.e., turning sideways or not) during suckling, and the side of the mammary slit used. All suckling events were pooled to calculate mean duration, daily frequency, and daily proportion of time spent suckling. 40 days postpartum, one of the mothers died from a disease, which was closely followed by the death of her calf 51 days postpartum from nutritional deficiency despite being given milk from another source. The study found the first suckling bout to proceed after repeated stroking of the mother's body with their rostrum and swimming under the mother's genital region in later bouts. Suckling duration observed was 4.4 ± 0.8 seconds and 4.8 ± 0.4 seconds in the calves, with equal use of the two mammary slits. Additionally, the mother was found to predominantly turn sideways to facilitate suckling. The surviving calf was found to suckle continuously for 483 days postpartum. These findings are significant as they support nursing patterns seen in other toothed whales and suggest the importance of a minimum period mother-calf pairs should not be separated during to ensure successful development of the calf.

Contribution

This article was chosen for my literature review for its contextual observations of finless porpoises, adding another species to my review of suckling behaviour. This article advances knowledge in the field by supporting previous findings on the suckling patterns of toothed whales, while also contributing new data on the length of time a porpoise calf can suckle for. The study presents a new line of inquiry from some sociosexual behaviour seen from one male calf to the female of the second cow-calf pair, suggesting separation of cow-calf pairs from males of any age for undisturbed and successful suckling/nursing.

Leung, E. S., Vergara, V., & Barrett-Lennard, L. G. (2010). Allonursing in captive belugas (*Delphinapterus leucas*). *Zoo Biology*, 29(5), 633–637. <https://doi.org/10.1002/zoo.20295>

Summary

Alloparental care describes the parental care of non-offspring by individuals. Additionally, the nursing of non-offspring by adult females (allonursing) has been observed in most mammalian taxon, including cetaceans. Detailed underwater observations of nursing can be difficult to obtain from fast-moving species such as beluga whales. This adds value to observing these individuals in captivity. The objective of the study was to explore allonursing by two beluga whales in captivity. The researchers exposed the mother-calf pair to an unrelated female and a half-sister of the mother, when the calf was 2.5 and 3 months old and collected nursing/allonursing data throughout the day for 1-3 hours, two to four times a week as part of a larger study on beluga behaviour. Nursing/suckling was timed from when the calf locked onto the teat with its mouth for at least 2 seconds to the point when the calf released. Data was collected from when the calf was 3-13 months, 15-26 months, and 30-34 months. In period one, the calf was seen to nurse 147 times from the mother, seven times from the half-sister, and once from the unrelated female. In period two, the calf was seen to nurse 47 times from the mother, none from the half-sister, and 64 times from the unrelated female. In period three, the calf was seen to nurse nine times from the mother, five times from the half-sister, and none from the unrelated female. The significance of the findings is the documentation of spontaneous lactation by females due to the birth of a calf in their proximity, giving context to beluga social groups and the use of “helpers” for mother whales. The researchers suggested further research to explore the benefits of alloparental care in wild belugas and other cetaceans as there is likely energetic and reproductive benefits.

Contribution

This article was chosen for my literature review for its contextual evidence of nursing and suckling in beluga whales, as it adds more observations of this behaviour in a cetacean species. This study advances knowledge in its field by giving detailed documentation of nursing rates of belugas as the calf ages. The study supports previous studies that have found calves to decrease nursing bouts with aging. In presenting evidence of spontaneous lactation by neighbouring females, the study introduces the line of inquiry of the use of “helpers” in beluga social groups and the associated benefits of this evolutionary trait.

Best, P. B., Elwen, S. H., Palsbøll, P. J., Thornton, M., Austin, E., & Vinding, K. (2015). Possible non-offspring nursing in the southern right whale, *Eubalaena australis*. *Journal of Mammalogy*, 96(2), 405–416. <https://doi.org/10.1093/jmammal/gyv042>

Summary

Southern right whales (*Eubalaena australis*) have been observed to give birth over a 4-month period and raise their young for seven months to a year in the coastal waters of South Africa. During the same period, stranded calves have been observed in this region. In this article, the study objective was to explore three occasions of female whales accompanied by two calves (one non-offspring), and one occasion of an adult female interacting with an apparently abandoned calf. Observations in the form of photo-identification were collected through annual aerial surveys along the south coast of South Africa between Muizenberg and Plettenberg Bay from 1979 to 2012, annually in mid-October. Additionally, from 1995 to 1997 biopsy sampling was done annually between July and November from Lamberts Bay to Wilderness. The biopsy data along with photographs of the whales sampled was compared with the catalogue of right whale photographs collected by the Mammal Research Institute (MRI). Since 2005, more photographs of right whales were obtained by the pilots and passengers of whale-watching flights over Walker Bay and Pearly Beach area; also compared to the MRI catalogue. The study found the reaction by adult females to attempted suckling by non-offspring calves to range from tolerance to violent resistance. It is suggested by the researchers that a resistant response to non-offspring could be attributed to the female saving her milk for her smaller offspring, while tolerance could be attributed to possible relatedness to the non-offspring calf. This study was significant as it provided the first recorded observations of simultaneous nursing attempts by offspring and non-offspring calves in baleen whales. The researchers suggested monitoring the future calving history of the females that nursed non-offspring calves, to observe the results of the costly lactation for calves that do not increase the fitness of the female.

Contribution

This article was chosen for its context on the nursing of Southern right whales, while providing observations of the suckling by calves and the energetic consequences of nursing for females. This study advances the knowledge of the field by providing observations of females of cow-calf pairs seen approached by non-offspring calves for suckling. With the use of the MRI catalogue and biopsy sampling, this study does extensive identifying of the individuals over a large time scale. With the biopsy sampling, they introduce the idea that the allonursing observed could be the result of some relatedness to the non-offspring calves.