Aquatic Mammals 1996, **22.1**, 21–26

Drinking speed of Pacific walrus (*Odobenus rosmarus divergens*) pups

R. A. Kastelein, J. Postma, T. van Rossum and P. R. Wiepkema*

Harderwijk Marine Mammal Park, Strandboulevard-oost 1, 3841 AB Harderwijk, Holland

Summary

Two walrus pups were raised on formula offered in a trough. Their drinking speeds were recorded between the age of 9 and 12 months. There was a difference in the individuals' average drinking speed (15 and 22 ml/sec), which was probably caused by psychological factors. The drinking speed decreased (in one animal significantly) when the formula's temperature dropped below 20°C. To investigate whether the drinking speed was constant during a feed, the amount of formula offered was varied. In both animals the average drinking speed was not related to portion size, if not too small an amount of formula was offered (i.e. ⩾2000 ml). After a night time fast of 18 hours, the drinking speed of both animals was slightly higher than during the remaining 2 feeds. In both animals the drinking speed increased during the 3 month study. Transformation of the drinking durations a day into suckling, suggests that walruses of the age studied here need to suckle 45–80 minutes a day.

Introduction

In the wild, walrus pups depend on their mother's milk for at least 15 months (Fay, 1982). Weaning is not recommended for hand-raised pups before they are 1-year-old (Spotte, 1990). Since the milk transfer pattern in walruses is unknown, it is unclear whether hand-raised walrus pups should be fed on demand, or according to a schedule of meals.

In 1993 two Pacific walrus (*Odobenus rosmarus divergens*) pups at the Harderwijk Marine Mammal Park were raised on formula which was offered in a trough. Their drinking speed was determined for each meal. Drinking from a trough, during which the animal is sucking the formula into its mouth, may be related by some factor to suckling speed from a nipple. If in future studies on captive or wild walruses the total daily suckling time can be determined, information on their sucking speed may help in estimating the daily milk intake for walrus pups. This study investigated the influence of the individual's disposition, satiation and age and the temperature and portion size of the formula on drinking speed.

*Ethology Section, Department of Animal Husbandry, Agricultural University, P.O. Box 338, 6700 AH Wageningen, Holland.

Materials and Methods

Study animals

The study was done on 2 male Pacific walrus pups (OrZH009 and OrZH010) which were born in May 1992. The animals arrived at the Harderwijk Park in November 1992 at the age of 6 months, and were hand raised on formula. The study was done between 24 February and 20 May 1993. At the start both animals were about 9-months-old, but differed in weight. During the 3-month study OrZH009's weight increased from 187 to 268 kg and that of OrZH010 from 116 to 188 kg.

Study area

The walrus pups were kept together in an indoor oval pool (8.6 m × 6.3 m, depth: 1.4 m) containing fresh water of between 12 and 16°C. The air temperature varied between 16.5 and 21.5°C. The pool was surrounded by land, part of which was enclosed with a fence. Before each feed, one animal was lured with his feeding trough into the enclosure, so that the pups could not interfere with each other while drinking. The troughs were placed in frames which were welded to the fence (Fig. 1). The animals could not move their troughs, and the researchers could observe their feeding behaviour.

Food

The animals were fed on formula 3 times a day (at 09.30, 12.30 and 15.45 hours). The formula consisted of the following ingredients: 13 l water, 270 g butter, 540 g oatmeal, 630 g soya flour (Nutrilonsoja®), 900 g milk powder (Multimilk®), and 8 g marine mammal vitamins (Seavit®).

The formula was stirred and boiled, then cooled to below 37°C. Each feed consisted of a fixed amount of this formula. Animal 009 received 15 000 ml a day, and animal 010 12 000 ml a day.

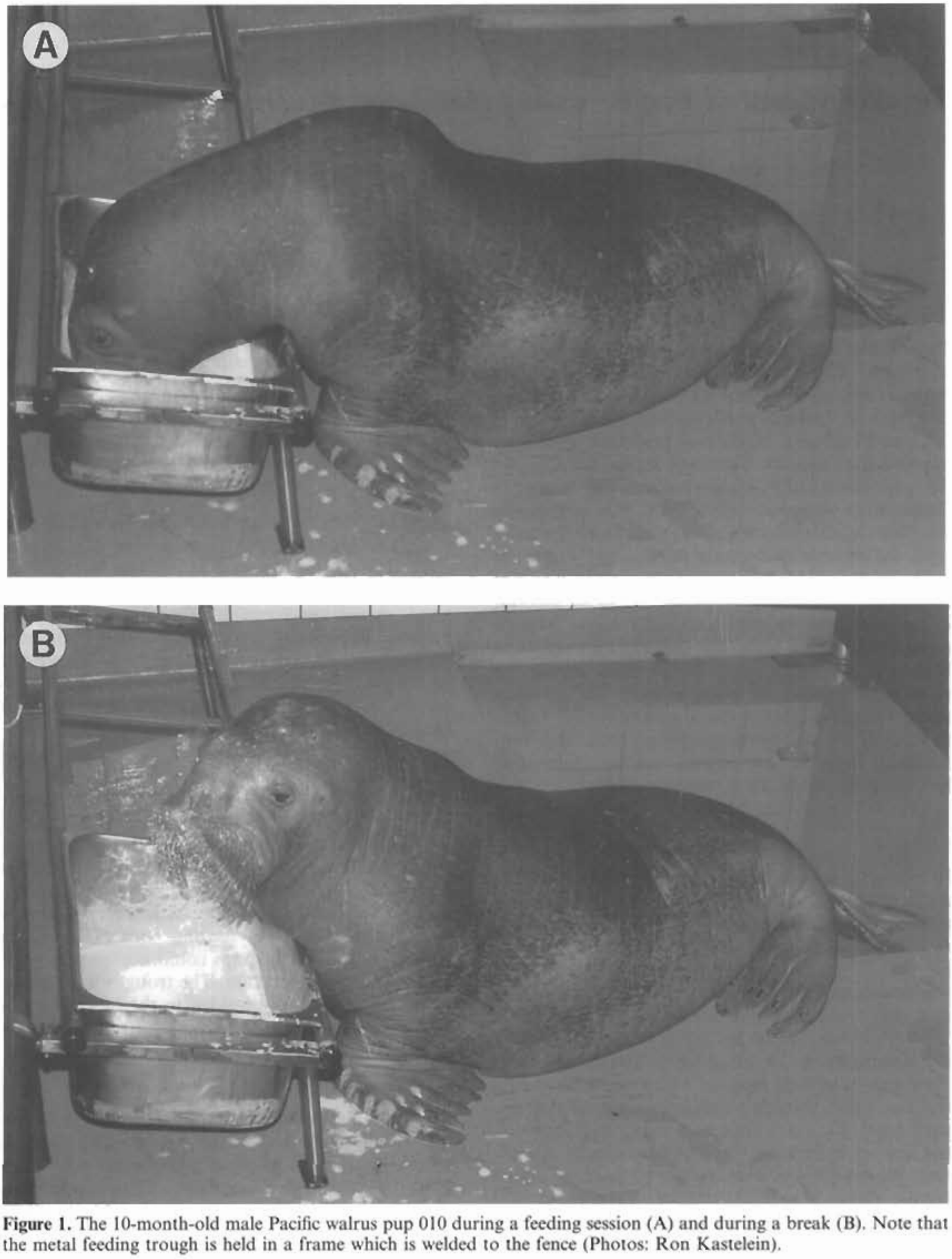

Figure 1. The 10-month-old male Pacific walrus pup 010 during a feeding session (A) and during a break (B). Note that the metal feeding trough is held in a frame which is welded to the fence (Photos: Ron Kastelein).

Recording technique
The animals were fed at the same time. The researchers recorded the drinking time by starting a stopwatch when the animal's mouth came in contact with the formula. As soon as the contact between the head and the formula was broken, the stopwatch was stopped. This continued until the feeding troughs were empty, leaving only a few ml of formula on the walls and bottom of the trough. The volume of formula ingested was divided by the time the animal had spent drinking to derive the drinking speed (ml/s).

Influence of temperature
Under natural conditions, walrus pups probably drink milk which is around 37°C, the body temperature of the mother. To determine whether lower temperatures would influence the drinking speed of the pups, the formula was offered at different temperatures randomly distributed over the 3 meals a day. This was done in order to evaluate whether it was necessary to feed the formula at body temperature. The formula was cooled to the desired temperature by placing the metal troughs in a cold water bath. Meals were cooled to within the following temperature ranges: 9–14, 15–19, 20–25, 26–31 and 32–37°C. Meals of 2000, 3000, 4000 and 5000 ml of formula were used for this aspect of the study.

Influence of portion size
It is possible that drinking speed was high at the beginning of a meal when each animal's stomach was empty, and low towards the end of a meal when each animal became more or less satiated. To investigate whether or not the drinking speed was constant during a feed, a meal (5000 ml for animal 009 and 4000 for animal 010) was sometimes divided into 2 portions which were fed one immediately after the other. For animal 009 the portions were 1000, 2000, 3000, 4000 or 5000 ml. For animal 010 they were 1000, 2000, 3000 or 4000 ml. For each portion the drinking time was recorded and drinking speed calculated. Only meals within the 20–37°C temperature range were used for this aspect of the study.

Influence of satiation
To determine whether the drinking speed was higher during the morning meal after the animals had fasted for 18 hours, the average drinking speeds of the 3 daily meals were determined and compared.

Only meals within the 20–37°C temperature range and of 2000, 3000, 4000 and 5000 ml were used for this aspect of the study.

Influence of age
Because the animals grew during the 3 month study period, the influence of the animals' age on drinking speed was studied by calculating the average drinking speed per week. Only meals within the 20–37°C temperature range and of 2000, 3000, 4000 and 5000 ml were used for this part of the study.

Results

Meal times including breaks lasted between 6 and 8 min. Drinking time varied between 4 and 5 min per feed. The drinking time of animal 009 was much longer than that of animal 010.

Influence of the animal's disposition
There was a difference in the individuals' average drinking speed (15 and 22 ml/sec), which was probably caused by psychological factors. Walrus 009 drank at a much more constant speed than walrus 010, as shown by the small standard deviations of his average drinking speeds in Figures 2 and 3. Animal 009 was a much calmer animal than 010 and only interrupted his drinking to breathe. Animal 010 often stopped drinking to inspect his surroundings.

Some marked differences in drinking behaviour were noticed. Walrus 010 dipped his mystacial vibrissae into the formula, but his nostrils stayed dry most of the time. In contrast, walrus 009 put his head as far into the formula as possible.

Influence of temperature
Walrus 009's drinking speed was on average 15 ml/sec with a formula temperature of between 20 and 37°C, but decreased significantly to on average 11 ml/sec when the formula temperature was between 9 and 19°C (ANOVA, Tukey test, HSD pairwise comparisons of means, critical φ value=3.857, $P \leqslant 0.05$).

Animal 010's average drinking speed was higher than that of animal 009 at all temperature intervals. No significant differences in drinking speed related to temperature were found, although the drinking speed tended to decrease when the formula's temperature decreased.

Influence of portion size
Animal 009 drank significantly slower (9 ml/sec) when he was offered 1000 ml of formula than when he was offered more. His average drinking speed with 2000 and 3000 ml of formula (around 12 ml/sec) was significantly lower than with 4000 and 5000 ml (around 16 ml/sec; ANOVA, Tukey test, critical φ value 3.857, $P \leqslant 0.05$).

Animal 010 drank significantly slower (14 ml/sec) when he was offered 1000 ml of formula than when he was offered more (ANOVA, Tukey test, critical value φ value: 3.632, $P \leqslant 0.05$). His drinking speeds with portions of 2000, 3000 and 4000 ml were similar (around 22 ml/sec).

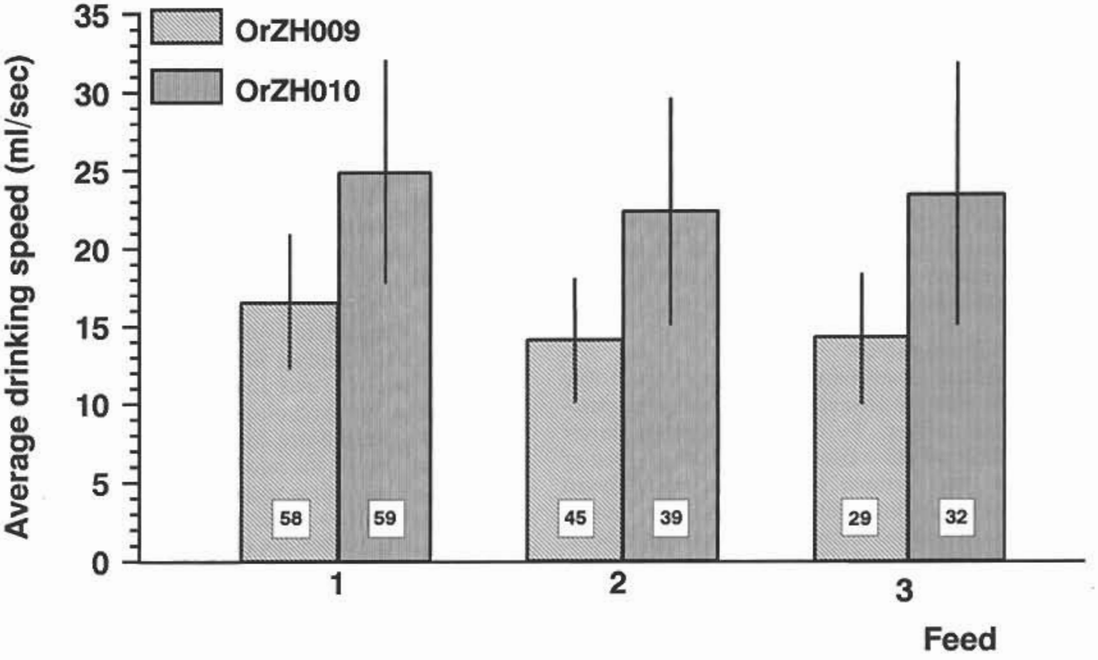

Figure 2. The average drinking speeds of the 2 male Pacific walrus pups during the 3 feeds of the day. The bars indicate standard deviations and the numbers in the columns indicate the sample size.

Both animals needed about the same amount of time to locate and ingest the last remnants of formula. They did this by moving their heads quickly towards the corners of the trough, thus wiping the last amounts together.

Influence of satiation
Only one animal drank faster during the first meal of the day than during the second meal (Fig. 2) (ANOVA, Tukey test, critical φ value 3.314, $P \leqslant 0.05$).

Influence of age
During the study, both animals increased their drinking speed significantly (Spearman rank correlation; $P<0.05$; Fig. 3). In week 4, animal 010 was sick and not all the offered formula was eaten.

Discussion and Conclusions

Influence of the animal's disposition
Although animal 009 was much larger than animal 010, animal 010 was the faster drinker. In general, animal 010 was much more nervous than animal 009. While drinking he could not investigate his surroundings because his eyes were below the rim of the trough (Fig. 1), which appeared to make him uncertain. This nervousness may have influenced his drinking and suggests that psychological factors may affect drinking speed.

Influence of temperature
Both animals' drinking speeds increased (although not significantly) when the formula's temperature increased. The low drinking speed with formula temperatures below 20°C indicates a lower attractiveness. The palatability of the formula may have been reduced because at around 20°C the butter in the formula solidifies, and the components separate. The formula may have had a different taste, smell and texture below this temperature. Anecdotal observations at the Harderwijk Marine Mammal Park suggest that walruses have a strong sense of smell.

Influence of portion size
In general, the more formula was offered, the faster the animals drank. The difference was particularly apparent between portions of 1000 ml and 2000 ml. This may be explained by the animals' drinking technique. During a meal the drinking speed decreased when the animal was taking in the last amount of formula. This was probably because the animal had to search for the formula in the trough, and because the last remnants were difficult to take in efficiently (simultaneously air was sucked into the buccal cavity). These factors influenced the

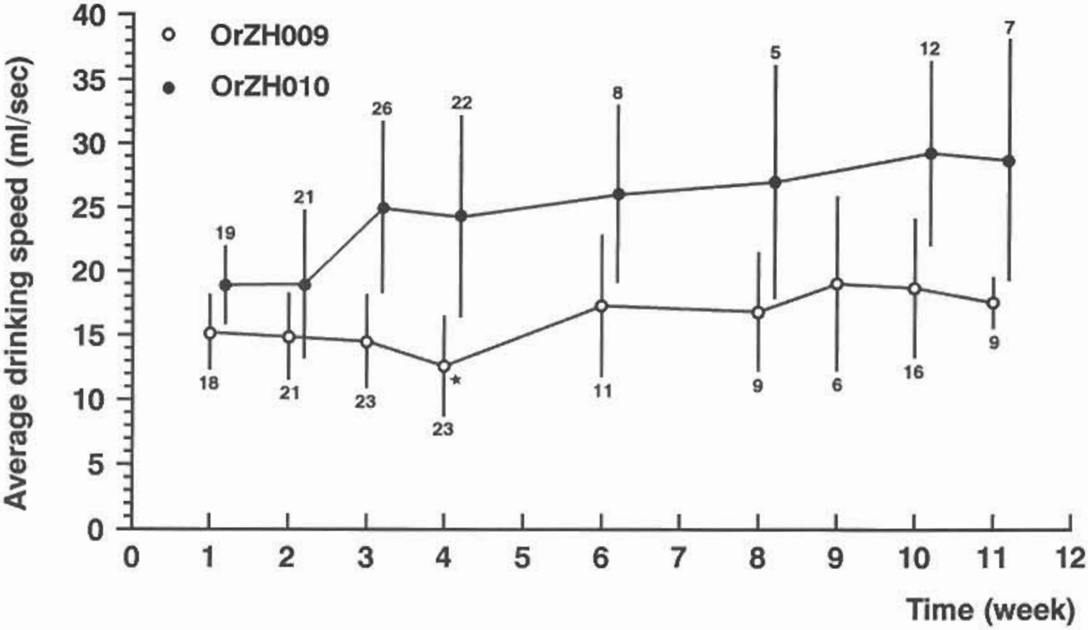

Figure 3. The average weekly drinking speed of the 2 male Pacific walrus pups during the 3 month study. The bars indicate standard deviations. The numbers near the bars indicate the weekly sample size (number of feeds). *Slow food intake which coincided with illness.

drinking speed during all meals, but it had the greatest effect on average drinking speed in the smaller meals.

When drinking, the pups must have been able to determine the depth of their lips. If the lips were not inserted far enough into the formula, as would likely occur with 1000 ml feeds, air entered the oral cavity, causing sucking sounds and a decrease in drinking speed. Possibly the walrus' sensitive mystacial vibrissae (Kastelein & van Gaalen, 1988; Kastelein *et al.*, 1990) were used in determining the level of the lips relative to the surface of the formula, or relative to the bottom of the feeding trough.

With volumes larger than 1000 ml, drinking speed during a meal was practically constant. This suggests that the way the animals drank resembles the suckling reflex, and that they moved their tongues rhythmically in the buccal cavity like a pump (Kastelein & Gerrits, 1990; Kastelein *et al.*, 1991*a*, *b*). The speed must have been fairly constant.

Influence of satiation

The animals drank the first meal a little faster than the following meals. Thus in one animal, 18 hours of food deprivation increased the drinking speed only slightly.

Influence of age

The average increase in drinking speed over time in both animals was probably caused by the growth of the oral cavity, the development of the tongue muscles, and improved locomotory skills of the tongue and facial muscles. This development may run parallel with the general growth of the pups and the increased food requirements.

Ecological significance

In air, the walrus uses its capacity for oral suction mainly during its suckling period. Walruses have a relatively long suckling period of at least 15 months, and are usually weaned when they are 2-years-old (Fay, 1982). Suckling probably occurs both on land and in water (Miller & Boness, 1983). Mammals have a sucking reflex; they produce negative pressure in the buccal cavity by rhythmically retracting and depressing their tongues. The volume created by the retraction of the tongue may be filled with milk in a natural suckling situation (Kastelein *et al.*, 1994). Ray (1960) describes a walrus calf which emptied a 225 ml baby bottle with a rubber nipple in 15 s, and often sucked the plastic container until it was flat. The drinking speed was 15 ml/sec. Although this is anecdotal information, this speed is in the same range as speeds found in the present study. The sucking speed from a bottle with a nipple may be similar to that from a trough.

Drinking speeds from a trough may not be compared with natural suckling speeds, because the milk supply from a female's nipple may not be constant. Animal 009 needed on average 16 min to drink his daily 15 000 ml of formula, while animal 010 needed only 9 min to drink 12 000 ml. In domestic bovine (*Bos* sp.) calves, the drinking speed from a trough is 5 times faster than sucking from a nipple when the supply per time unit is limited (Mees & Metz, 1984). If in walrus pups the drinking speed from the trough is also 5 times faster than the sucking speed from a nipple, walruses of the age of the animals in the present study would have to suckle between 45 and 80 min a day.

Gehnrich (1984) observed a walrus calf's suckling behaviour in a zoological park during its first 2 weeks of life between 06.00 and 20.00 hrs. During the 14 hour observation period the calf suckled on average 10% of time. It is not clear if this represents real suckling time or total bout time including breaks. Wild walrus pups also spent around 10% of daylight hours suckling (Gehnrich, 1984). If the walrus calves suckled at night with the same frequency as during the day, they suckled for about 144 min a day.

Only incomplete information on walrus suckling in the wild exists, due to the difficult circumstances in the Arctic, and the problems of nightly observations. Salter (1978) reports an average suckling bout time of 16.0 min (n=10) of approximately 3-month-old Atlantic walrus (*Odobenus rosmarus rosmarus*) pups on ice or land. Miller & Boness (1983) recorded an average of 11.7 min (S.E.=2.16, range 1.7–53.7 min) for 25 complete suckling bouts of approximately 3-month-old Atlantic walrus pups in the water. They report that the pups were under water about 80% of the time while suckling. If they had been suckling constantly under water, the average suckling time per bout would have been around 9 min. The breaks during the suckling bouts in the water were probably forced by the need to breathe. The data of Salter (1978) and Miller & Boness (1983) can only be in agreement if the breaks on land would constitute about 25% of a suckling bout.

If the 144 min suckling time per day derived from the report by Gehnrich (1984) includes breaks, and the average suckling bout time is assumed to be 16 min (Salter, 1978), walrus pups require 9 suckling sessions a day. The daily suckling times of 45 and 80 min derived from the present study would suggest that walrus pups need 5 to 9 suckling bouts of 9 min a day. However, when comparing data from several studies, the age of the pups should be taken into account. The animals in the present study were between 9- and 12-months-old, and even during this 3-month period an increase in drinking speed was observed (Fig. 3).

Acknowledgements

We thank Hendrik Jan Groenenberg, Saskia Nieuwstraten and Sabrina Labberté for recording drinking speeds, and Rob Triesscheijn for making the graphs. We thank Nancy Vaughan (Bristol University) for her comments on the manuscript.

References

Fay, F. H. (1982) Ecology and biology of the Pacific walrus (*Odobenus rosmarus divergens*) Illiger. North American Fauna, 74, 1–279. Fish and Wildlife Service, Washington, D.C.

Gehnrich, P. H. (1984) Nutritional and behavioural aspects of reproduction in Walruses. Masters thesis, University of Alaska, Fairbanks, pp. 147.

Kastelein, R. A. & Van Gaalen, M. A. (1988) The sensitivity of the vibrissae of a Pacific Walrus (*Odobenus rosmarus*). Part 1. *Aquatic Mammals* **14**(3), 123–133.

Kastelein, R. A., Stevens, S., Mosterd, P. (1990) The tactile sensitivity of the mystacial vibrissae of a Pacific Walrus (*Odobenus rosmarus*). Part 2: Masking. *Aquatic Mammals* **16** (2), 78–87.

Kastelein, R. A. & Gerrits, N. M. (1990) The anatomy of the Walrus head (*Odobenus rosmarus*). Part 1: The Skull. *Aquatic Mammals* **16**(3), 101–119.

Kastelein, R. A., Paasse, M., Klinkhamer, P. & Wiepkema, P. R. (1991*a*) Food dispensers as occupational therapy for the Walrus (*Odobenus rosmarus divergens*) at the Harderwijk Marine Mammal Park. *Int. Zoo Yearb.* **30,** 207–212.

Kastelein, R. A., Gerrits, N. M. & Dubbeldam, J. L. (1991*b*) The anatomy of the Walrus head (*Odobenus rosmarus*). Part 2: Description of the muscles and of their role in feeding and haul-out behaviour. *Aquatic Mammals* **17**(3), 156–180.

Kastelein, R. A., Muller, M. & Terlouw, A. (1994) Oral suction of a Pacific walrus (*Odobenus rosmarus divergens*) in air and under water. *Z. für Säugetierkunde* **2**(59), 105–115.

Mees, A. M. F. & Metz, J. H. M. (1984) Saugverhalten von Kälbern. Bedürfnis und Befriedigung bei verschiedene Tränkesystemen. *KTBL-Schrift, Darmstadt,* **299,** 82–91.

Miller, E. H. & Boness, D. J. (1983) Summer behavior of Atlantic walruses (*Odobenus rosmarus rosmarus*) (L.) at Coats Island, N.W.T. (Canada). *Z. für Säugetierkunde* **48,** 298–313.

Ray, C. (1960) Background for a baby Walrus. *Anim. Kingd.* **63,** 120–124.

Salter, R. (1978) Normal behaviour and disturbance responses of Walruses (*Odobenus rosmarus,* L.) during terrestrial haulout, Eastern Bathurst Island, N.W.T. July–August 1977. Toronto, Ontario, Canada: Report to Polar Gas Env. Program by LGL Ltd., *Env. Res. Assoc.*

Spotte, S. (1990) Artificial milks for unweaned marine mammals. In: *Handbook of Marine Mammal Medicine: Health, Disease, and rehabilitation* (ed. L. A. Dierauf). pp. 521–532. CRC Press, Boston.