CARE, GROWTH AND COST OF CAPTIVE MOOSE CALVES

Murray W. Lankester[1], Tanya Wheeler-Smith[1] and Stefan Dudzinski[2]
[1]Department of Biology, Lakehead University, Thunder Bay, ON, P7B 5E1; [2]Kakabeka Falls Game Farm, Kakabeka Falls, ON, P0T 1W0

ABSTRACT: Weights of captive moose calves increased at an average of 0.78 kg/day reaching a mean weight of 178 kg (max. 196kg) at 33 weeks of age. Calves were fed up to 2L/day of milk formula (1 part canned evaporated milk: 1 part whole cow's milk, plus 2 egg yolks per 770 mL), commercial dairy ration, and alfalfa hay. Egg yolks, added to raise the formula lipid and protein content, may reduce or prevent neonatal diarrhea. Comparisons with other studies suggest that milk volume may be of greater importance than formula composition in determining early growth, but volumes exceeding 2.0-2.5L/day risk increasingly serious problems with diarrhea.
Costs including capture, staff, holding facilities, and feed for 7 calves totalled $36,500.00 for the first 8 months of life. Orphaned or abandoned calves are acquired at lower cost but availability is unpredictable, some may be congenitally handicapped or in poor condition, and aquisition over an extended period will include some older animals that are much less tractable.

ALCES VOL. 29 (1993) pp.249-262

Moose have been reared in captivity, on an irregular basis, at a number of research and educational facilities in North America. Techniques and advice on raising calves are commonly passed verbally from a few individuals who have had a measure of success (and admitted good luck) to others, usually at the time of a crisis. Schwartz (1992) made an important contribution by compiling much of the available anecdotal and published material on the subject. A variety of husbandry techniques used at 29 zoos, research facilities, and game farms are evaluated relative to his own extensive experience at the Moose Research Center (MRC) on the Kenai Peninsula, Alaska. But, raising moose calves remains a difficult task and very few studies provide an adequate basis for comparing the effectiveness of various neonatal diets and feeding regimes used (*see* Reglin *et al.* 1979, Addison *et al.* 1983, Welch *et al.* 1985).

Several years ago while trying to improve our success in raising young cervids at the Kakabeka Falls Game Farm, the owner, Mr. Stefan (Steve) Dudzinski (S.D.) began adding whole cow's milk and eggs to increase the protein and energy content of canned milk, the milk substitute frequently used. The egg whites or albumin were excluded on the advise of Dr. S. Magwood (Department of Biology, Lakehead University) because of suspected digestibility problems and the possibility of protein sensitization as is apparently seen in human infants and artificially fed young of other mammals. This formula has since been used at the Kakabeka Falls Game Farm to successfully rear over 15 moose, 12 caribou and a few fallow deer. The Dudzinski formula, or modifications of it, have also been adopted by other facilities (*see* Schwartz 1992) but its relative effectiveness has yet to be assessed.

Our recent experience raising moose for parasitological studies provided an opportunity to monitor growth of calves fed the Dudzinski milk formula and compare it with growth achieved at other facilities and with that of wild moose of similar age. We also describe, for the first time, estimates of the costs associated with the capture and care of young moose.

METHODS AND MATERIALS

Capture and Transport

Four moose calves were captured 16-18 May, 1992, in Algonquin Park, Ontario (45^0

39' N, 78^0 39' W), by searching islands and peninsulas using methods described by Addison *et al.* (1985) and Wilton and Garner (1991). A protocol approved by an Ontario Ministry of Natural Resources (OMNR) Animal Care Committee was followed. A group of 6-8 people, a canoe and an outboard motor were flown by DeHaviland Piston Beaver on floats to island sites where cow moose were known to have had their calves in previous years. Members of the capture team, each with a portable radio and wearing a hunter-orange cap, walked abreast, always maintaining visual contact and communicating softly on the radios.

Once a cow and calf were spotted, everyone converged, maintaining a safe distance from the cow and keeping a large tree close by in case of a confrontation. The aim was to either force the cow far enough away from the calf so it could be captured on land or to drive both the cow and the calf into the water where the calf could be picked up by two people in the concealed canoe. A calf captured on land was quickly delivered to the canoe at the shoreline while the other team members kept the cow at a distance. The calf was taken immediately to the aircraft where it was gently restrained and kept as calm as possible by covering the eyes and maintaining quiet surroundings.

After a 15-minute flight, and a short drive while restrained on someone's lap in the front seat of a truck, the calves arrived at a 30x30 m enclosure made of snow fencing 1.3 m high. A horse-trailer, previously parked inside the enclosure, was later used for long distance transport. For the first 4-6 hours of captivity, calves were kept inside the trailer with handlers who attempted to comfort and familiarize them with the new taste of the milk formula and bottles with nipples. At the time of capture, calves were estimated to be 4-6 days old.

After all four calves were accustomed to sucking from the bottle (each within a day or two of capture), they were transported 1500 km to Kakabeka Falls, Ontario, in a horse trailer containing straw used as bedding. The bottle feeding schedule was maintained throughout the 2-day trip. With unseasonable heat during transport (daily maximums of 32^{0}C), the provision of cool water by bottle every 1-2 hours was probably very important. On arrival at the Kakabeka Falls Game Farm, calves were released into a fenced enclosure (40x40 m). The enclosure contained a 4x4 m outbuilding provided with straw bedding, feeding troughs, and a 40 litre water pail. The calves drank from the pail immediately upon arrival.

Three orphaned or abandoned moose calves were obtained with the co-operation of OMNR personnel in the Dryden, Terrace Bay and Chapleau districts of northern Ontario. (23-27 May). The calves were transported 300-600 km on a foam mattress in the box of a covered truck while being comforted and periodically restrained by a handler. At the game farm, the 3 were placed in a similar enclosure, adjacent to that housing the 4 calves from Algonquin Park. All 7 calves could see and contact each other through the fencing and frequently were allowed to run together. Otherwise they were separated overnight and for bottle feeding. After weaning, the gate between the two enclosures was left open but solid feed and alfalfa hay were provided in both shelters.

Feeding

Calves were fed a formula of Carnation evaporated milk (385 mL can) mixed with an equal volume of homogenized, whole milk and two egg yolks (egg whites removed). Initially, the milk was warmed to slightly above body temperature and fed in glass bottles (60 ml) sealed with black rubber lamb's nipples. Larger, glass, soft-drink bottles (2 L) with heavy rubber calves' nipples were used as calves grew and required larger volumes. All glassware and nipples were washed in hot

soapy water and rinsed thoroughly as quickly as possible following use.

Solid feed, consisting of good quality alfalfa hay and a dairy ration grain mix (Nutrena Sweetflow-16: crude protein 16.0%, fat 2.8%, fibre 10.0%) was made available to calves shortly after their arrival at the farm. Small amounts were periodically forced into their mouths to familiarize them with the taste. After the calves were eating noticeable amounts, their daily ration was weighed once weekly. Hay eaten by all 7 moose was estimated for 1 day each week by noting the portion of a 45 kg bale (fresh weight) consumed. No allowance was made for hay dropping to the ground during feeding. Salt blocks (blue) were always available.

Fresh browse was provided daily from the time of capture. This included; balsam poplar (*Populus balsamea*), trembling aspen (*P. tremuloides*), raspberry (*Rubus* sp.), bush honeysuckle (*Diervilla lonicera*), mountain maple (*Acer spicatum*), red osier dogwood (*Cornus stolonifera*), willow (*Salix* sp.), hazel (*Corylus cornuta*), pin cherry (*Prunus pennsylvanica*), choke cherry (*P. virginiana*) and occassionally paper birch (*Betula papyrifera*), and mountain ash (*Sorbus americana*). Branches were tied to fixed objects, 1-2 m off the ground.

Care, Training and Data Collection

The seven calves were tended by two handlers who were each present for an 8-hr shift from 0700-2300 hr, seven days a week. Handlers spent as much time as possible with the animals. A daily journal noted general health, consistency of feces, any required medication, changes in behaviour, moulting pattern and consumption of milk, solid feed, dirt, salt, browse, and grass. All calves were ear-tagged to facilitate identification.

Beginning at 4 weeks of age, each animal was weighed weekly. Bi-weekly, body dimensions were taken using a cloth measuring tape and a blood sample was taken from the saphenous vein. The animals were trained during bottle-feeding to mount a platform scale and stand while data were collected. After weaning, the attention of calves was maintained by feeding them sliced apples. Animals habituated to this routine from an early age, readily submitted to having measurements and blood taken for up to 1.5 yr without the need of restraints or tranquilizers. Collection of data required 3 people.

Body measurments included neck circumference (behind angle of jaw), chest girth (circumference posterior to withers), shoulder height (from withers to the ground), and hind leg (from tip of hock along canon bone to the ground at the side of hoof).

RESULTS

Of the 4 calves captured in Algonquin Park, 2 were females (Nos.1 & 2) and 2 were twin males (Nos.3 & 4). The Algonquin calves (*A. a. americana*) were more reddish in color than the 3 orphaned/abandoned calves from northern Ontario, at the same age. The calves from northern Ontario included a small female from near Terrace Bay, (No.5), a small male known to be one of a set of twins near Chapleau (No.6)(it alone was abandoned), and a larger statured, dark, male calf (No.7) from near Dryden who preferred being close to human habitation; its mother called repeatedly from nearby. This calf might be considered *A. a. andersoni* in the sense of Peterson (1955). The birth date of all calves was assumed to be May 12.

Calves were bottle fed 5 times daily at 4 hour intervals (0700, 1100, 1500, 1900, and 2300 hours) until 7 weeks old, at which time they consumed almost 1800 ml of formula per day (Table 1). The number of feedings per day was then reduced but the daily milk volume was held at about 2 L until 11 weeks. Calves were weaned after 17 weeks (Sept. 5). At 12 weeks, each calf consumed an average of 1.3 kg of dairy ration per day. Little interest was shown in the alfalfa hay until about 22

Table 1. Mean volumes and costs of milk formula and solid feed consumed by captive moose calves in the first 33 weeks of life.

	Milk Formula				Solid Feed			
Age in weeks	No. of feedings/ day	ml/ feeding	ml/calf/ day	Cost/calf/week ($)	kg/calf/ day (dairy ration)	kg/calf/ day (alfalfa)	Cost/calf/week ($)	Total cost/calf /week
1	*	*	*	*	*	*	*	*
2	5	174	870	12.88	-	-	-	12.88
3	5	232	1160	17.15	-	-	-	17.15
4	5	290	1450	21.42	-	-	-	21.42
5	5	348	1740	25.70	-	-	-	25.70
6	5	360	1800	26.56	-	-	-	26.56
7	4	464	1856	27.41	-	-	-	27.41
8	4	493	1972	29.13	-	-	-	29.13
9	4	493	1972	29.13	-	-	-	29.13
10	4	493	1972	29.13	-	-	-	29.13
11	3	656	1968	29.13	-	-	-	29.04
12	3	522	1566	23.13	1.3	-	2.94	26.07
13	2	754	1508	22.27	2.5	-	5.60	27.87
14	1	754	754	11.14	3.1	-	6.93	18.07
15	1	754	754	11.14	2.4	-	5.39	16.53
16	1	754	754	11.14	3	-	6.72	17.86
17	1	754	754	11.14	2.9	-	6.51	17.65
18	-	-	-	-	3	-	6.72	6.72
19	-	-	-	-	3	-	6.72	6.72
20	-	-	-	-	3	.8	7.42	7.42
21	-	-	-	-	3.3	.8	8.12	8.12
22	-	-	-	-	3.3	1.6	8.82	8.82
23	-	-	-	-	3.4	1.6	9.03	9.03
24	-	-	-	-	3.4	1.6	10.50	10.50
25	-	-	-	-	3.6	3.3	10.92	10.92
26	-	-	-	-	3.6	3.3	10.92	10.92
27	-	-	-	-	3.6	3.3	12.39	12.39
28	-	-	-	-	3.6	5	12.39	12.39
29	-	-	-	-	3.6	5	13.72	13.72
30	-	-	-	-	4.5	6.5	15.75	15.75
31	-	-	-	-	4.5	6.5	15.75	15.75
32	-	-	-	-	4.5	6.5	15.75	15.7
33	-	-	-	-	4.5	6.5	15.75	15.75
TOTALS				$337.60			$214.76	$552.27

Calculations are based on the following unit costs (CDN. $, 1992): whole milk $1.37/L, canned milk $0.90/385 mL can, eggs $1.55/doz., dairy ration $8.00/25 kg, cut alfalfa $5.65/45 kg.

weeks (Oct. 4). No further measurements were taken after 33 weeks (Dec. 26). At 33 weeks of age, each calf consumed on average, 4.5 kg of dairy ration plus 6.5 kg of alfalfa per day (Table 1).

Within the first week of captivity, all calves were mouthing and nipping leaves from browse provided. By 3 weeks, calves stripped the leaves from large bundles of browse in a few hours. It soon became impossible to keep browse available throughout the day. At this time it was provided once in mid-morning and again in late evening. Calves frequently went down on their "knees" to eat grass and dandelion flower heads.

Eating of dirt by one calf was seen on its first day in the enclosure. All others were seen chewing small amounts of dirt along with small stones and rootlets within a week; this behaviour ceased by mid-July. All calves used the available salt blocks, particularly following bottle-feeding. On one occasion, a bull calf repeatedly went from salt to water to browse over a period of about 10 minutes.

The weight of 5 calves increased almost linearly at an average rate of 0.78 kg/day (from 4 weeks of age) attaining a mean of 178 kg at 33 weeks; the heaviest was a male (No.7) at 196 kg (Table 2, Figs. 1, 2, and 3). However, the growth of 2 male calves (No.4, the twin of No. 3, and No. 6, an abandoned twin) progressed more slowly from the beginning and their lower weights were clearly evident after 9-10 weeks. These two were given identical volumes of milk formula to the faster growing calves but they were often less interested in solid feed and browse. Both developed intermittent, soft to watery feces for prolonged periods following weaning. This was followed by weight loss by No.4 after 21 weeks. Scouring was diminished but not stopped entirely with large doses of bismuth subsalicylate (Peptobismol). Calf No.6 recovered somewhat and began to gain weight.

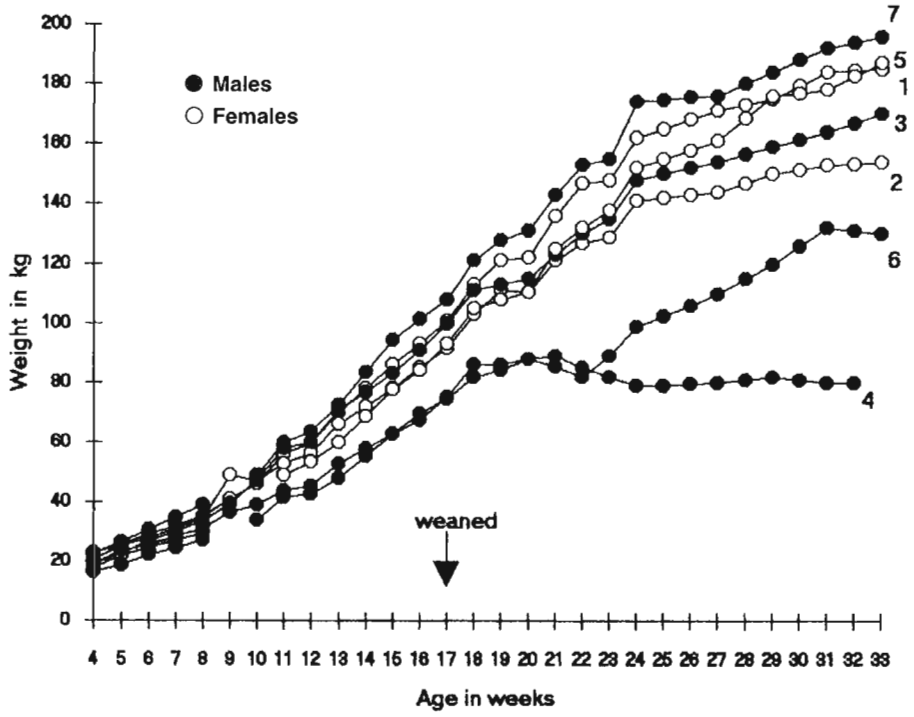

Fig. 1. Weekly weights of 7 captive moose calves.

Figs. 2. and 3. Captive calves during their first winter.

Table 2. Selected mean dimensions (±S.E.) of five captive moose calves (May 12 to December 26, 1992).

Age in weeks	Weight (kg)	Chest girth (cm)	Height at shoulder (cm)	Hind leg length (cm)	Neck circ. (cm)
4	20.7±1.0	67.3±1.9	90.8±2.1	43.4±1.1	35.3±0.7
5	24.3±0.9	70.6±1.7	96.0±1.1	44.1±1.1	35.7±0.6
6	27.7±1.1	74.6±1.4	98.4±1.2	47.0±0.1	39.0±0.7
7	-	77.0±1.1	99.0±1.3	48.3±0.1	40.0±1.6
8	34.3±1.5	78.2±1.2	101.0±1.4	48.6±0.1	41.0±1.2
9	43.1±2.3	-	-	-	-
10	47.4±0.6	-	-	-	-
11	55.2±1.9	91.4±1.6	111.4±1.4	53.8±0.2	39.5±0.3
12	58.6±1.7	96.4±1.9	116.6±0.7	-	44.6±1.5
13	67.8±2.2	99.8±1.3	118.4±1.7	54.2±1.1	44.3±1.0
15	83.8±3.1	-	-	-	-
16	90.9±3.2	113.4±1.6	126.0±1.2	57.1±0.5	50.0±0.8
17	98.7±2.3	-	-	-	-
18	110.6±3.2	124.8±1.4	132.2±0.7	59.8±1.1	58.2±1.4
19	116.2±3.6	-	-	-	-
20	117.8±3.9	-	-	-	-
21	129.6±4.2	-	-	-	-
22	137.8±5.1	136.2±2.1	141.2±1.3	61.1±1.0	62.9±0.6
23	141.0±4.7	-	-	-	-
24	155.4±5.7	-	-	-	-
27	161.2±5.7	144.6±2.1	144.0±0.9	65.0±0.6	69.6±2.1
29	168.8±6.2	148.2±2.4	148.8±1.1	65.0±0.6	70.4±1.8
31	174.2±7.0	149.8±3.3	151.8±0.9	65.3±1.5	72.7±1.2
33	178.4±7.4	153.6±4.3	151.8±0.9	66.2±1.3	74.1±1.7

No scouring was seen in any of the calves while they were being fed the milk formula.

Moulting of calf hair began as early as 10 July and was completed in about 8 weeks. It began and finished about a week earlier in the females. Although there was minor variation in the pattern of hair loss between individuals, the moult always began in the saddle region of the back, and thereafter on the legs, backs of the ears, the head pole, the rump and then over the ribs. The neck, belly and hind quarters followed with calf hair on the face being lost last. This pattern of neonatal hair loss is consistent with that reported by Samuel *et al.* (1986) and Sokolov and Chernova (1987).

Calves were recognizeable by their body and facial appearance and fairly consistent, individual behaviour. Generally, female calves were thought to be more aggressive than males and to have no difficulty "holding their own" in strenuous bouts of running and close interaction among the group. Calf No.1, a female, appeared to dominate all other calves. Female No.2 was more passive but thought to have higher status than female No.5. No.5 was the only calf that would not stand to have blood

taken from the hind leg. The large male, No.7, was always very active, commonly initiated play, and interacted aggressively with others. Male No.3 was subordinate to No.7. Male No.4 (the twin to male No.3) was the most passive. He stayed close to the other Algonquin animals and seldom demonstrated aggression toward others. Male No.6 (an abandoned twin) was not quite as passive as No.4 but often bedded away from its pen-mates.

The total cost of capture and transporting the 4 calves from Algonquin Park to their final destination is estimated at $12,050 (CDN$, 1991). This includes 60 person-days @ $130/day (including salary, room, and board = $7,800); 2 week rental of truck ($500) and horse-trailer ($350), fuel and mileage charge ($900), and 9 hours of flying plus ferrying and stand-by with a DeHaviland Beaver ($2,500). The three orphaned/abandoned calves were picked up at OMNR District Offices where they were being temporarily held. The total cost was $850 (4 person days @ $50.00/day, 2600 km @ $0.25/km mileage charge).

Total cost for 2 animal care staff for the bottle-feeding period (17 weeks) was $13,050 (salary and benefits @ $1,500/month plus $100/month travel assistance). Incidental costs, included two visits by veterinarians (total $250). Feeding and care after weaning was provided by S.D.

Milk formula costs totalled $2,366 ($338/calf from arrival to weaning at 17 wks) (Table 1). Solid feed costs for 7 calves over the first 33 weeks of life were $1,505 ($215/calf). Leafy browse provided during the summer months and grass available on pasture in the enclosures are not included in feed costs.

The market value of housing 7 calves for 33 weeks is estimated at about $6,468 ($4.00/calf/day). Secure, fenced property with subdivided enclosures, animal shelters, kitchen facilities, running heated water, and 24-hr supervision are essential. All of this, plus his many years of experience raising animals, plus all feed costs, were provided by S.D. for $100/animal/month.

DISCUSSION

Five of seven calves raised in this study were vigorous and showed steady growth (0.78 kg/day) up to 33 weeks of age. Two of the 7, however, showed slower growth from the beginning. One was an abandoned twin and the other a twin taken from the female along with its sibling who did well. The two slower growing animals consumed equal volumes of milk formula to the faster growing calves and had no apparent digestive problems while receiving milk formula. But they were always less interested in solid feed rations and when forced to rely heavily on it after weaning, they both developed intermittent diarrhea and growth slowed considerably. Both were particular passive in their interactions with others. These observations suggest that some abandoned or orphaned moose calves may be unfit from birth and that the survivorship of twins may differ markedly.

Various milk formulae have been used to raise moose calves in captivity (Schwartz 1992) but assessing their relative merits is difficult. Several variables, other than milk composition, undoubtedly influence growth of captive neonates and seriously confound the task. These include, among others, age at capture, differences in daily milk volumes, weaning times, type, amount and start date of supplemental solid feed, and extent of any neonatal diarrhea. We also suggest that individual behavioural differences seen here among calves may affect their growth and survival in captivity, as well as in the wild. Nonetheless, it is instructive to compare the maximum weights attained in the few growth studies that have been accompanied by detailed feeding protocols for moose (Fig. 4).

One of the earliest of these was a description of calf rearing protocols at the MRC, Kenai Peninsula, Alaska (Reglin *et al.* 1979). Calves (*A. a. gigas*) were fed a commercial

milk replacer (Suckle, Carnation Co.) (100 g powder to 1 L water) 5 times per day until 37 days. Milk volume was steadily increased from 2.4 to 4.2 L/day during this time and gradually reduced thereafter until weaning at 100 days of age. Solid feed given by Reglin *et al.* (1979) was a commercial pelleted feed (Don's Calf Starter, Alaska Feed Mills, Anchorage) that was replaced in subsequent MRC calf studies by pellets comprised primarily of Aspen sawdust (*P. tremuloides*) and referred to as the MRC Special diet (Schwartz *et al.* 1980). Calves were provided with native browse. Diarrhea was encountered only occasionally, except in 2 calves that seldom ate solid feed and later died. Six healthy calves with a mean capture weight of 15.0 kg attained a mean weight of 91 kg at 100 days for an average daily weight gain (from capture) of 0.76 kg/day.

Schwartz *et al.* (1987) studied weight increases of 6 *A. a. gigas* calves reared at the MRC using the same bottle-feeding regime as Reglin *et al.* (1979) and using the MRC Special pellets. Growth was described, separately for each sex, by two equations, 1) an initial accelerating growth phase that intersected at about 160 days of age with 2), a self-

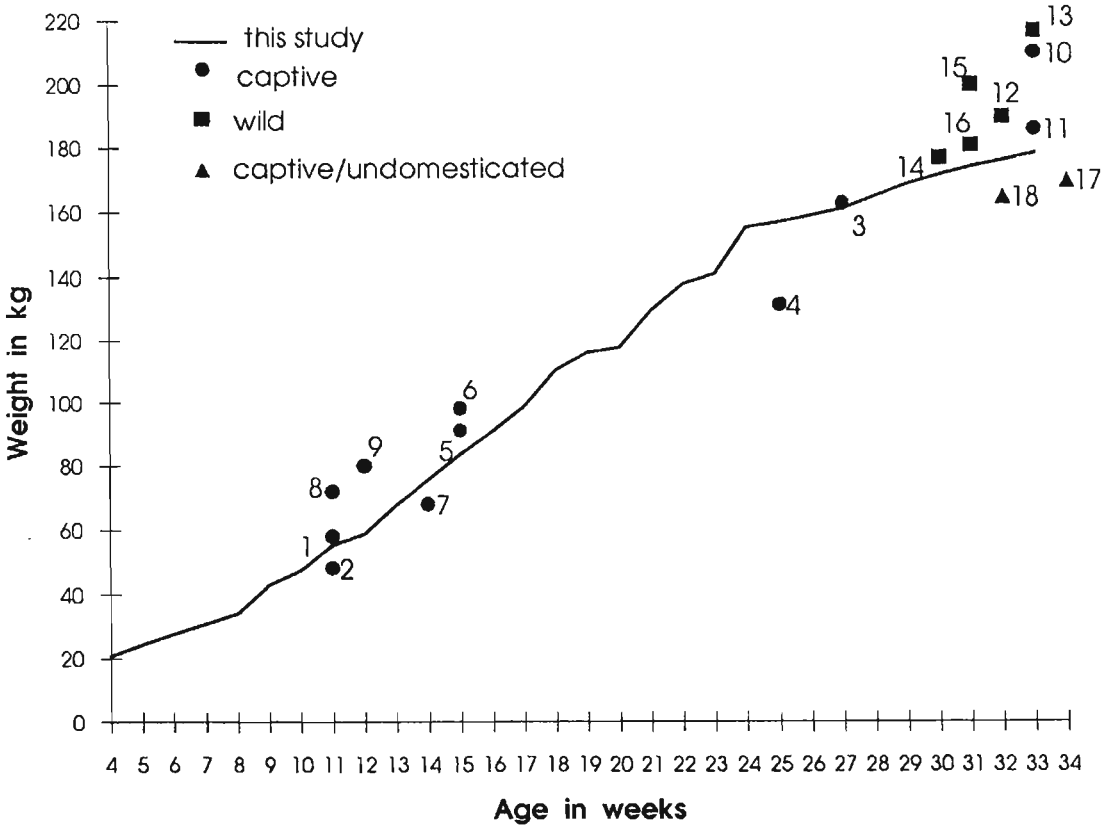

Fig. 4. Mean maximum weight attained by hand-reared moose calves compared to those of wild moose at similar age (solid line, this study, n=5; 1. Denniston (1956), n=1; 2. Dodds (1959), n=1; 3. Speidel (1965), n=1; 4. Markgren (1966), n=2; 5. Reglin *et al.* (1979), n=6; 6.,7.,8.,&9. Welch *et al.* (1985), n=44; 10. Schwartz *et al.* (1987), n=6; 11. Addison, E.M., (unpublished data), n=18; 12. Blood *et al.* (1967), n=9; 13. Haigh *et al.* (1980), n=3; 14.,15.,&16. Crichton (1979, 1980, and unpubl. data), n=1,2, & 8; 17. Verme (1970), n=6 reported the weights of calves raised by captive females; 18. Franzmann *et al.* (1978), n= 39, reported weights of captive but naturally nursing and foraging calves plus some free-ranging calves.

inhibiting phase of growth that fluctuated seasonally throughout later life. Using equations for the second phase, mean weight of the calves (both sexes) at 231 days (33 wks) of age was 210 kg, representing an average daily weight gain of about 0.84 kg from day of capture.

Addison *et al.*(1983), as well as providing valuable advice on calf husbandry, described feeding regimes and diets used to raise moose calves (*A. a. americana*) over 3 different years. In their most successful year, all of 18 calves were reared to weaning. Calves were bottle-fed a formula of 1 part canned evaporated milk and 2 parts whole cow's milk. They were fed 5 times each day until 40 days; thereafter the number of feedings was reduced. Milk volume was quickly increased to about 2 L/day within 2 weeks of capture and maintained around that level until weaning at 64-78 days after capture. Calves were weaned onto a commercial pelleted ration (Calf Manna, Carnation Co.) to which they had been introduced during the first month. They were also provided with a variety of browse species. Diarrhea began to occur when the volume of milk exceeded 2 L/day and 2.5 L/day was therefore the recommended maximum. The mean weight of the 18 calves at 225 days (32 weeks) was 186 kg for an average daily gain of about 0.80 kg/day (from day 16)(Addison, pers. commun.) (Fig.4).

Welch *et al.* (1985) reared 44 calves (*A. a. andersoni*) in Alberta over 4 years on a milk formula of 1 part canned evaporated milk to 1 part whole, unpasterized cow's milk with about 100 mL of bovine colostrum added to each feeding. Animals were fed 6 times each day for the first three weeks. Milk volume was increased quickly to 2.2 L/day within the first week, reaching a maximum of 2.7 L/day in the fifth week (2.8 and 4.0 L/day, respectively, used one year were considered too high). Diarrhea was a common to severe problem when milk volume exceeded 2.5 L/day. In each of the 4 years, calves were weaned after means of 79-106 days onto different solid foods, including the Alaskan MRC Special, a local deer ration, and in the final year, deer ration and Calf Manna. Calves were also provided with alfalfa/timothy hay and native browse species. Mean weights reached at weaning in 4 consecutive years were 82, 98, 68, and 72 kg (Fig. 4) with average daily weight gains of 0.75, 0.65, 0.49, and 0.71 kg/day (from day of arrival). Most of these animals were kept well beyond weaning but no further weights are available.

Average daily weight gains of moose calves on the different milk formulae used are remarkably similar over the longer term of 7 to 8 months. In the shorter term, however, Welch *et al.* (1985) generally achieved higher weights at weaning than in our calves. It is tempting to suggest that this may have resulted from the higher milk volumes given. But similar growth was seen in each of two years of their study when maximum milk volumes differed greatly (2.7 and 4.0 L/day). The larger size of Alaskan animals at weaning (Reglin *et al.* 1979, Schwartz *et al.* 1987) might be due in part to subspecific differences but likely the larger milk volume fed from the beginning is also a contributing factor. Greater initial growth probably does result with larger milk volumes. However, diarrhea in some animals can quickly reduce growth if it cannot be controlled.

In the study reported here, weight gain was respectable (0.78 kg/day) and no diarrhea was encountered during the bottle-feeding period. Whether this was due to the addition of egg yolks in the formula or to slightly lower milk volumes, is not clear. Greater volumes of this formula (2.5-3.0 L/day) have been given by S.D. to individual moose calves raised in other years without causing diarrhea. We suggest that the higher lipid content may increase milk holding time in the abomasum allowing more complete digestion of lactose, which is higher in cow's milk than in moose (Renecker 1987). Persistent lactose may cause

problems posteriorly in the digestive tract causing diarrhea. However, further evaluation of the possible role of egg yolks in preventing neonatal diarrhea will require a properly controlled study. The same is required to make meaningful comparisons between the various milk and solid feed diets given to captive moose calves.

It is expected that free-ranging moose calves will gain weight at greater rates than hand-reared animals but this is difficult to confirm. Many of the data on weight of wild calves are from field dressed, fall (Oct.-Dec.), hunter harvested animals and few workers have had opportunities to investigate the relationship between dressed and whole weights. A wide range of conversion estimates exist. Nunan (1965) found that moose with just the viscera and blood removed lost on average 24% of their live weight with cows losing more in the early season because bulls had less in their stomachs. Timmermann (1972) found eviscerated animals shot early in the season lost 15-29% of whole weight (10 dressed calves weighed on average 140 kg, range 109-186 kg). Crichton (1980) reported weight losses of 31% and 33% for bulls and cows, respectively, and 37-39% for calves. Comparisons can be further complicated by differing definitions of "dressed". For example, dressed weights reported by Blood *et al.* (1967) are for carcasses without blood, viscera, hide, head, and feet, in which case, known whole weights were reduced by 50%.

For these reasons the most accurate comparison of weight gain between hand-reared and wild calves should be done using whole weights. In most cases, the whole weights of wild calves are slightly heavier than the captive weights available for comparison. Nine calves from Elk Island National Park were weighed whole by Blood *et al.* (1967), November 24 to January 6 when calves are estimated to have been 30-34 weeks old. Their mean weight was 190 kg (Fig. 4). Franzmann *et al.* (1978) weighed 134 Alaskan moose less than 33 weeks old, many of which were captive but nursing and foraging naturally within large enclosures. Calves grew to a maximum weight of about 186 kg at 20 weeks and thereafter declined to an average of about 165 kg at 32 weeks of age, and even lower through winter (from Fig. 3, p.302). Haigh *et al.* (1980) weighed 3 whole calves at a mean of 217 kg December to February (estimated 33+ weeks old). In controlled hunts on Hecla Island, Manitoba, Crichton (1979, 1980, and unpubl. data) weighed 1 whole calf in 1978 at 177 kg, 2 in 1979 at a mean of 200 kg (one orphan at 102 kg excluded), and 8 in 1980 at 178 kg; the heaviest was 214 kg (1979). The Hecla Island calves were shot in the first week of December, an estimated 31 weeks old. Interestingly, the weight gain of 4 calves born to, and raised by, captive female moose in Michigan (Verme 1970), were lower than that of some hand-reared calves. The captive calves raised by their mothers averaged 114 kg when 12 weeks old, 159 kg at 24 weeks and 170 kg at 34 weeks.

Many factors must be kept in mind when comparing weights of hand-raised and wild moose. Considerable variation can be expected in both circumstances as a result of differing birth dates, birth weights, age and condition of the cow, subspecific differences, and individual genetic fitness. Between year differences in mean weights of wild calves are seen in Norway (Saether 1985) and are suspected in Manitoba (V. Crichton, pers. commun.). It has been demonstrated that the nutrient quality and level of secondary compounds in moose browse varies between summers probably accounting for some annual variation in weights (Saether 1985, Hjeljord 1993). Also, differences in the length of the "green period" each year will affect nutrition available to both the cow and the calf (Stewart *et al.* 1976). Hand-raised animals will reflect less variation due to these factors, provided the solid feed given is of good quality.

The time of year at which the weights of hand-raised and wild calves are compared is also important. A series of weights taken by Franzmann *et al.* (1987) throughout fall and winter demonstrates that Alaskan moose calves gain weight until mid- to late-October and then drop back somewhat until the following spring. Hand-reared calves, however, may initially lag behind wild calves, but easy access to quality feed throughout winter allows continued growth and eventually they may equal or surpass the weights of wild animals by spring. For this reason it may not be wise to risk diarrhea by pushing milk volume to attain maximum early growth when some catch-up can occur over winter.

Franzmann *et al.* (1978) concluded that total length of moose may be a better measure of growth than whole weights. Carcass total length, as well as chest girth, is highly correlated with whole weights (Karns 1976, Franzmann *et al.* 1978, Haigh 1980).However as a field method, chest girth with the rib cage opened could over-estimate whole weight. Total length, on the other hand, is useful in the field but less so in comparing field data with growth in live, hand-raised calves. The repeatability of this measurement on live animals is low.

The total cost of capturing, transporting, housing, feeding, and caring for 7 moose calves in this study is estimated to be about $36,500.00. Actual cost of capture would be greatly reduced if staff, vehicles and aircraft could be treated as agency fixed costs, meaning they were already in place and available without charge. On the other hand, the 3 days required in the field to capture the animals would have been been considerably greater without the help of individuals who were experienced at capturing calves in this manner and who had prior knowledge of calving sites from previous years. Using a fixed-wing aircraft to access known calving sites is the least costly. Use of a helicopter to capture calves spotted in shallow ponds in late afternoon is also effective for capturing older calves when they follow females into the water, but is expensive. Orphaned or abandoned animals are usually acquired at very low costs but their availability is usually unpredictable, many are handicapped or in poor condition, and acquisition is often spread out in time to include older animals that are much less tractable.

The availability of adequate, caring, totally dedicted staff was identified by Addison *et al.* (1983) as a key factor in rearing calves successfully and we agree entirely. Three individuals plus an experienced supervisor is a minimum for raising 1-8 calves.

Volume discounts are difficult to realize with components of milk formula but bulk buying of solid feed and hay will be reduced with more animals. Our estimates of costs to house moose calves were validated by Dr. Wm. Samuel, University of Alberta, who is charged $4.35/day (1993 rates) to keep moose in the University's Biosciences Animal Service facility. This includes the cost of supervisory staff, only, and the cost of solid feed. The only other estimate of the cost of keeping moose was provided by Lautenschlager and Crawford (1983) at $2,000/yr to feed 3 moose (0.5-2yr-old).

ACKNOWLEDGEMENTS

We greatly appreciate the support of Mssr. Mike Wilton and Ernie Martelle (OMNR) who made it possible to capture calves for scientific purposes and for providing financial and logistical support. The experience and participation of Mr. Mike Wilton, Dr. Ed Addison, and Mr. Mike Buss (OMNR) in capture efforts were invaluable. Our success in rearing the calves is credited to the hard work and dedication of Sandra Beitz, T.W.-S., and S.D. Dr. Roy C. Anderson, Department of Zoology, University of Guelph, provided supplemental financial support which is gratefully acknowledged.

REFERENCES

ADDISON, E.M., R. F. MACLAUGHLIN and D. J. H. FRASER. 1983. Raising moose calves in Ontario. Alces 19:246-270.

_____, M. L. WILTON, R. F. MACLAUGHLIN and M. E. BUSS. 1985. Trends in natality and calf mortality of moose in southcentral Ontario. Alces 21:1-16.

BLOOD, D.A., J.R. MCGILLIS and A.L. LOVAAS. 1967. Weights and measurements of moose in Elk Island National Park, Alberta. The Can. Field Nat. 81:263-269.

CRICHTON, V.F.J. 1979. An experimental moose hunt on Hecla Island, Manitoba. Proc. N. Am. Moose Conf. Workshop 15:245-279.

_____. 1980. Manitoba's second experimental moose hunt on Hecla Island. Proc. N. Am. Moose Conf. Workshop 16:489-525.

DENNISTON, R.H. 1956. Ecology, behavior and population dynamics of the Wyoming and Rocky Mountain moose, (*Alces alces shirasi*). Zooligica 41:105-118.

DODDS, D. G. 1959. Feeding and growth of a captive moose calf. J. Wildl. Manage. 23:231-232.

FRANZMANN. A. W., R. E. LERESCHE, R. A. RAUSCH and J. L. OLDEMEYER. 1978. Alaskan moose measurements and weights and measurement-weight relationships. Can. J. Zool. 56:298-306.

HAIGH, J. C., R. R. STEWART and W. MYTTON. 1980. Relations among linear measurements and weights for moose. Proc. N. Am. Moose Conf. Workshop 16:1-10.

HEYLAND, J.M. 1964. Analysis of data on hunter-killed moose: controlled hunt, 1962-63-64. Quebec Wildlife Service. Typwritten, unpubl. report.

_____. 1966. Analysis of data on hunter-killed moose: controlled hunt, 1965-66. Quebec Wildlife Service. Typewritten, unpubl. report.

HJELJORD, O. 1993. Sunny and shaded growth sites - influence on moose forage quality. Alces, Suppl. 1: 112-114.

KARNS, P. D. 1976. Relationships of age and body measurements to moose weight in Minnesota. Proc. N. Am. Moose Conf. Workshop 12:274-284.

LAUTENSCHLAGER, R.A. and H.S. CRAWFORD. 1983. Halter-training moose. Wild. Soc. Bull. 11:187-189.

MARKGREN, G. 1966. A study of hand-reared moose calves. Viltrevy 4:1-35.

NUNAN, P.J. 1965. Moose weighing project, Port Arthur District. Ont. Dep. Lands and Forests Unpubl. District Report. 8pp.

PETERSON, R.L. 1955. North American Moose. Univ. Toronto Press, Toronto, 280 pp.

REGELIN, W.L., C.C. SCHWARTZ and A.W FRANZMANN. 1979. Raising, training and maintaining moose (*Alces alces*) for nutritional studies. Int. Congress of Game Biol. Proc. 14:425-429.

RENECKER, L.A. 1987. The composition of moose milk formula following late parturition. Acta Theriol. 32:117-121.

SAETHER, B.-E.. 1985. Annual variation in carcass weight of Norwegian moose in relation to climate along a latitudinal gradient. J. Wildl. Manage. 49:977-983.

SAMUEL, W. M., D. A. WELCH and M. L. DREW. 1986. Shedding of the juvenile and winter hair coats of moose (*Alces alces*) with emphasis on the influence of winter tick, *Dermacentor albipictus*. Alces 22:345-358.

SCHWARTZ, C. C., W. L. REGELIN and A. W. FRANZMANN. 1980. A formulated ration for captive moose. Proc. N. Am. Moose Conf. Workshop 16:82-105.

_____, W.L. REGELIN and A.W. FRANZMANN. 1987. Seasonal weight dynamics of moose. Swedish Wildl. Res. Suppl. 1:301-309.

_____. 1992. Techniques of Moose husbandry in North America. Alces, Suppl. 1:177-192.

SOKOLOV, V.E. and O.F. CHERNOVA. 1987. Morphology of the skin of moose (*Alces alces*). Swedish Wildl. Res. Suppl. 1:367-375.

SPEIDEL, G.. 1965. Care and nutrition of moose in captivity. International Zoo Yearbook 6:88-90.

STEWART, R.R., R.R. MACLENNAN, and J.D. KINNEAR. 1976. Annual variation of plant phenological events and its theoretical relationship to energy balance in moose. Proc. N. Am. Moose Conf. Workshop 12:1-30.

TIMMERMANN, H. R. 1972. Some observations of the moose hunt in the Black Sturgeon area of northwestern Ontario. Proc. N. Am. Moose Conf. Workshop 8:223-239.

VERME, L.J.. 1970. Some characteristics of captive Michigan moose. J. Mammal. 51:403-405.

WELCH, D. A., M. L. DREW and W. M. SAMUEL. 1985. Techniques for rearing moose calves with resulting weight gains and survival. Alces 21:475-491.

WILTON, M. L. and D. L. GARNER. 1991. Calving site selection in south central Ontario, Canada. Alces 27:111-117.