

BEHAVIOR OF POLAR BEARS WITH CUBS IN THE DENNING AREA

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Abstract: Observations were made on the behavior of female polar bears (*Ursus maritimus*) with cubs of the year in the first post-denning period in a densely populated denning area at Kongsøya, Svalbard. This period has formerly not been studied. During 2 field seasons 3,148 hours of observations on females, and 6,185 hours on cubs, were obtained from 25 family groups. Mean litter size was 1.96, mean breakout date 17–18 March. The bears usually emerged on sunny days. Mean period spent in the area was 14 days. Family groups tolerated each other within certain limits, but no evidence for a social hierarchy was found. Cub motor ability and play intensity increased throughout the period, as did mutual distance within the groups. Females ate vegetation and bear droppings, but the groups were mainly dependent on the females' fat reserves. Females were inactive 93.5% of their total time, cubs 91.6%. The post-denning period is probably of major importance for training and developing the cubs for hard travels on the ice.

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The purpose of this study was to investigate activities of female and cub polar bears from the time of emergence from dens until the families left the denning area. This paper describes the methods used and presents some results.

Polar bears are born in December–January, and are 3–4 months old by the time of emergence. For a period after this, females with cubs remain close to dens. Estimates of time spent near dens vary from 0.5–7 days (Soviet Union, Uspenski and Kistchinski 1972) to 8–14 days (Svalbard, Lønø 1970) to as much as 1 month (Canadian High Arctic, Harington 1968). No ethological observations have formerly been done on this first post-denning period of polar bears with cubs.

The study was initiated in cooperation with Professor Yngve Espmark, Institute of Zoology, University of Trondheim, and biologist Thor Larsen, Norwegian Polar Research Institute. Special thanks to the latter, without whose support it would have been impossible to carry out the project.

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MATERIALS AND METHODS

Undisturbed female polar bears with cubs of the year were observed from 18 March to 17

April 1978 ($N = 5$) and 13 March to 14 April 1979 ($N = 20$) in the Bogen denning area at Kongsøya, Svalbard (Fig. 1).

Study Area

Kongsøya is situated in the drift ice belt at about 79°N, 28°–30°E, and is one of the most eastern islands in the Svalbard archipelago. From September–October to June it is surrounded by heavy pack ice. In the west the island is dominated by a mountainous area 12 km wide with elevations of 200–300 m. The Bogen denning area faces southwest in a U-shaped valley within this area, 0.5–2.0 km from the sea, with slopes of 30°–60°. Average yearly precipitation in Svalbard is only 200–400 mm, and the eastern parts are even drier (Ernstsen and Dannevig 1981). The prevailing wind direction on Kongsøya is northeast, and during winter exposed parts are covered with only a thin crust of wind-packed snow. The only suitable denning areas are found in the leeward slopes where snow depths vary from 1 to 4 m. The snow is hard, especially in the upper 0.1–1.0 m. In summer the plant cover is very sparse and dominated by lichens, mosses, and small herbs.

Earlier surveys by Larsen (1972, 1976) showed a high, stable density of denning polar bear females on the island. He estimated the den densities per square kilometer of "suitable denning habitat" to be 0.4 in 1972, 0.5 in 1973, 0.7 in 1977, and 0.9 in 1980 (pers. commun.). Similar densities are found only on Wrangel Island in the Soviet Arctic (Belikov 1980).

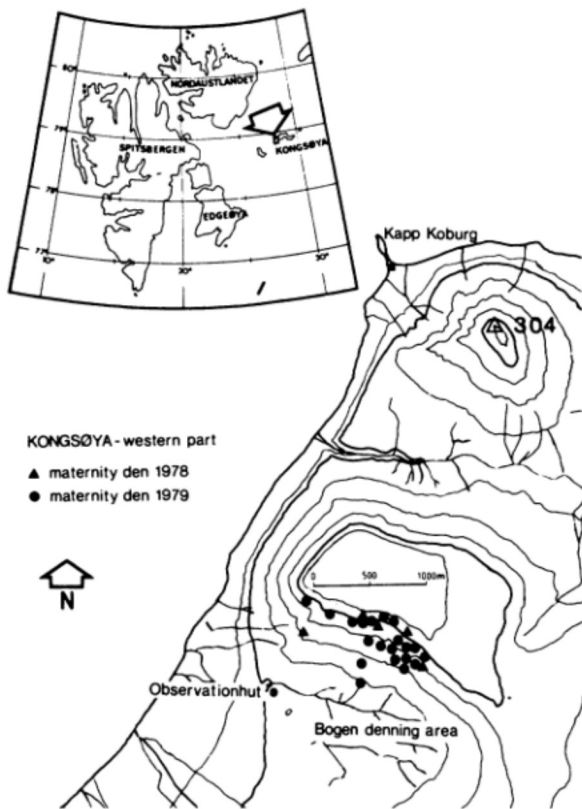


Fig. 1. Location of study area on Kongsøya, Svalbard, and polar bear dens observed in 1978 and 1979.

Sampling Procedure

Behavior was sampled with the focal animal method (Altmann 1974). Observations were coded directly on sheets with a predetermined classification system. Due to the observation distance, a relatively small number of behavior categories were recorded. Cubs could not be individually identified, but family groups were identified by their dens.

Observations started when the first group broke out of the den, and were finished when the last one left the area. Observations were made continuously as long as light and weather permitted; 24-hour recordings became possible from the 1st week of April. Simultaneous recordings were made when more than one group was active outside their dens at the same time.

All observations were made using Bernina binoculars (25 × 80). Verbal descriptions of bear behavior were continuously tape-recorded and combined with data-sheet codings. Additional infor-

Table 1. Time spent in each activity by polar bear females ($N = 25$) with cubs ($N = 49$) in the denning area from mid-March to mid-April at Kongsøya, Svalbard, in 1978 and 1979.

Activity	Number of hours of observation		Percent of total observation time		Percent of time outside ^a	
	Females	Cubs	Females	Cubs	Females	Cubs
In den	2756	5285	80.6	85.5		
Inactive	440	374	12.9	6.1	66.4	41.6
Comfort behavior and grooming	49	58	1.4	0.9	7.4	6.5
Nursing and suckling	10	20	0.3	0.3	1.5	2.2
Ingestion	32	3	1.0		4.9	0.3
Investigative walking	72	119	2.1	1.9	10.9	13.2
Digging	18	1	0.5		2.7	0.2
Play	1	214		3.5	0.2	23.7
Generally active	38	111	1.1	1.8	5.7	12.3
Defecation	2		0.1		0.3	
Total	3418	6185	100.0	100.0	100.0	100.0

^a Time when bears were outside the den and visible to observers.

mation was gathered by drawing, photographing, and filming special and characteristic features of behavior; mapping of den location and investigation of dens; collections of meteorological data 4 times a day (at 0600, 1200, 1800, and 2400); and collection and analysis of bear droppings. The information collected on data sheets was used for quantification and analysis of activity patterns. A combination of data sheets, tape recordings, photos, films, and sketches provide the basis for the descriptive part of the work.

Field Procedure

Lónó (1970) and Uspenski and Kistchinski (1972) report that females with cubs are easily frightened and will run back to their dens. More serious disturbance might cause the group to abandon the den.

Consequently, emphasis was placed upon not disturbing the bears. A portable prefabricated hut was erected in Bogen before den breaking and used for all observation work. Observation range was 200–1300 m. The prevailing wind carried scents away from the denning area. Camouflage clothing was used outside the hut. Although we were occasionally seen by the bears,

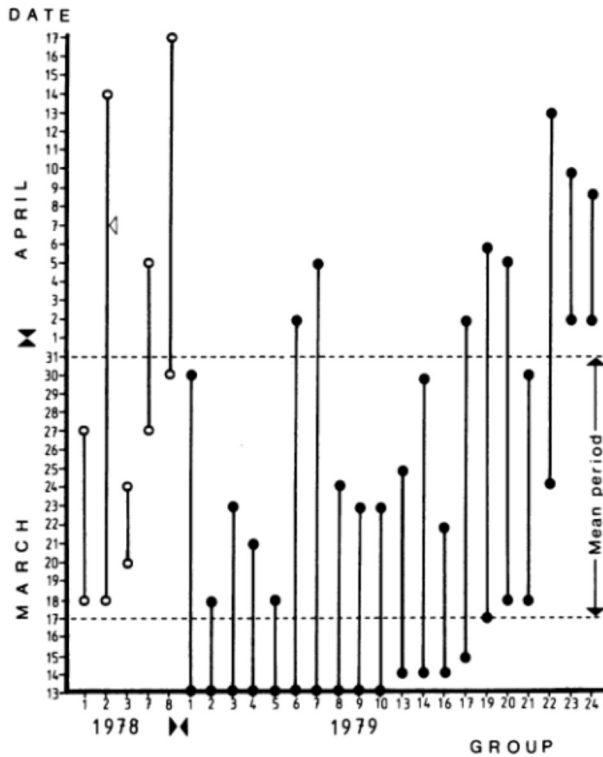


Fig. 2. Den breaking date, time spent in denning area, and departure date for female polar bears with cubs on Kongsøya, Svalbard, in 1978 (open dots) and 1979 (filled dots). Open arrow indicates when female number 2 lost the cub in 1978.

their behavior throughout the period indicated that this small disturbance did not affect them.

RESULTS AND DISCUSSION

Of the total observation time (Table 1), 20.0% for females and 19.3% for cubs were recorded in 1978; the remainder was recorded in 1979. Mean litter size in 1978 was 2.20 ($N = 5$, 1 female with 3 cubs, 4 with 2), and in 1979 1.90 ($N = 20$, 2 with 1 cub, 18 with 2), giving a grand mean of 1.96 ($N = 25$).

Den Breakout and Period in the Denning Area

The mean date when females broke out of their dens was between 17 and 18 March (SD = 6.5 days, $N = 25$) (Fig. 2). Twenty-one of the females broke out when temperatures were between -20 and -30 C. If wind and temperature cooling effects are combined (Weiss 1975), 3 females broke out in -5 to -10 C, 10 in -20 to -30 C, and 12 in -45 to -55 C effective temperature. In 1979, 10 females broke out on the

first sunny day after a long period of stormy and cloudy weather. Twenty-two of the females broke out on days with less than 4/8 cloudcover, 17 of them on completely clear days.

As on Kongsøya, den breaking on Wrangel Island took place in -20 to -25 C (Belikov, et al. 1977). By the time of den breaking, cubs have a lower critical temperature of -30 C and are quite tolerant to windchill (Blix and Lentfer 1979). Thus temperature should normally not be a limiting factor in den breaking. Moderate windspeeds also do not seem to be important, but our results are probably biased, as the wind was measured at a more exposed site than the leeward denning slope. However, the females are not indifferent to the weather, as shown by their strong preference for emerging on sunny days.

Ventilation holes as described by Harington (1968) and Uspenski and Kistchinski (1972) were not seen during the observation period or found when investigating the dens. However, the ceilings of most dens were less than 0.5 m thick, indicating that the females could determine at least the length of day and light intensity before emerging. Although hard snow does reduce sound transmission, it readily conducts sounds from digging and walking. Thus the bears in the most densely populated area may also have been aware of and influenced by the activity and den breakout of neighbors.

In 1978, 1 female stayed in the denning area an unusually long period (27 days, Fig. 2). On the 20th day 1 of her 2 cubs disappeared. Her intensive washing behavior the next day indicated that she ate it. Mother-offspring cannibalism in polar bears has been reported by Uspenski and Kistchinski (1972) and Belikov and Kuprijanov (1977).

General Behavior in the Denning Area

After den breaking, most females spend some time sitting in the den entrance (Fig. 3a) and investigating in the near vicinity of the den. Cubs were seldom seen until after a day or more, but thereafter the group was usually seen together. Cubs followed females on still longer trips, at first having problems in walking on steep slopes. In 1979, one female differed from the others by making trips alone. Her 2 cubs remained at the entrance, apparently unable to follow her on the

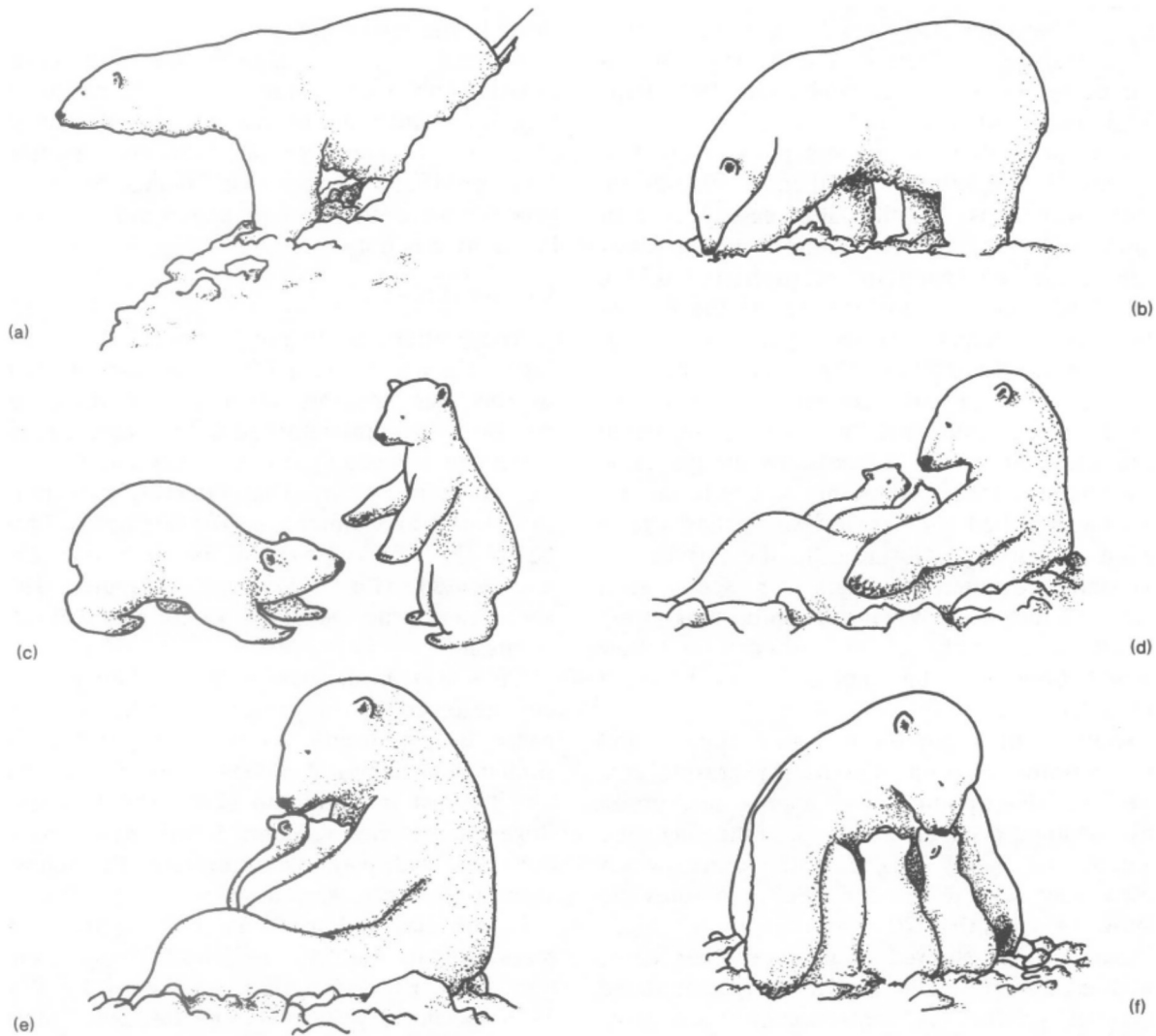


Fig. 3. Typical polar bear postures, based on field sketches. (a) Female in the most common position in the den entrance right after den breaking. (b) Female engaged in easy digging during investigative walking or grazing. (c) Cubs in play position initiating a fight. (d) Female lying back to nurse with the cubs lying on her belly. (e) Female in a more upright nursing position with the cubs on her belly. (f) Female in less common upright nursing position with the cubs sitting on the ground.

50° slope. For all groups, cub play was rarely seen the first 2–3 days. The mutual distance within the group increased with increasing cub locomotor ability and play intensity. Maximum distance registered between group members was 100 m. When the female was inside the den, the cubs at first kept within 5 m from the entrance. This distance increased to 50 m at the end of the period. For the females no conspicuous change in activity was recorded during the field season.

Some groups deviated considerably from the usual developmental pattern. In 1978 a female

with 3 cubs left after only 5 days, while 2 groups in 1979 hardly were seen out of den before they left the area. Three groups were seen on the island up to 1 week after they had left Bogen.

Intraspecific Interactions

The groups tolerated each other within certain limits. In the most densely populated area 4 females sat in the entrance 15–30 m apart without showing overt interest in each other. Passing groups or single bears caused a female in her den

entrance to raise the head and watch them closely. Such behavior always made us aware of other active bears in the area. If the passing group or bear came closer than approximately 100 m the female usually slipped into her den.

A female walking alone was more tolerant of the presence of other bears than if she was together with cubs. In the latter case a bear or group of bears several hundred meters away could cause the group to return hastily to the den. The same behavior occurred in the few instances when females caught sight of one of us skiing on the shore 300–500 m from the dens.

More than 2 groups were seldom seen out of the den at a time, and then widely separated from each other. On 3 occasions groups came closer to each other than 50 m. In one instance a group approached another that was resting after a period of nursing. Obstacles in the terrain and bad sight prevented the bears from seeing each other at a distance. When the approaching group at last caught sight of the other it withdrew quickly. Soon after the other group also returned to the den.

Another time a group came out of the den and went towards a group in a nearby grazing area (see later description). The approaching group was mainly occupied with investigating the ground, and hardly looked at the other, which slowly went back to the den. For 3 minutes the groups were less than 20 m apart.

Some groups showed interest in other dens, and 2 groups moved into dens newly abandoned by other groups. A confrontation took place when a female accompanied by cubs poked her head into a den occupied by another group, whereupon she suddenly jumped back and ran away. This was the only situation seen when threat was probably involved among the females. Belikov and Kuprijanov (1977) reported from a densely populated denning area at Wrangel Island that there was no antagonism among the females.

Pruitt (1976) argued that bears are social when they meet, e.g., at concentrated food sources. Egbert and Stokes (1976) confirmed her view for brown bears (*Ursus arctos*) on a salmon river. From the few observations of polar bears in similar situations, e.g., 32 bears on a salmon river, in Labrador (Russell 1975), and 56 bears on a bow-head whale carcass, in Svalbard (O. Frengen, pers. commun.), no signs of a social system were

reported, but careful behavioral studies were not made in these situations.

Although olfactory signals and vocalizations can also enhance maintenance of a hierarchy, the formation and maintenance of such a hierarchy relies on frequent contact between members (Pearson 1975). The mutual avoidance and the very few confrontations in Bogen indicate that a hierarchy was not established.

Communication

Vocalizations could not be recorded, but both females and cubs were often seen gaping. Some of this was probably yawning, but on several occasions the cubs returned quickly to the female when she was gaping, even if they could not see her doing it. At irregular intervals cubs ran to the female and jumped up for her nose. Brown bears (Pearson 1975) and black bears (*Ursus americanus*) (Burghardt and Burghardt 1972) show the same behavior when reunited after separation.

Cubs also threw themselves on their back under the females' head, reaching for her with their paws. Burghardt and Burghardt (1972) described similar behavior in black bear cubs, and interpreted it as an invitation to play. The females in Bogen sometimes responded with nose contact, but never with play. We interpreted the behavior as an invitation to grooming.

In cub play and confrontations the threat displays "low neck stretching" and "frontal orientation" (described for black bear cubs by Pruitt 1976) occurred with increasing frequency toward the end of the period (Fig. 3c). In similar situations the cubs also often pounded on the snow with the forepaws. This also once occurred in a confrontation between 3 single adult bears. Pounding in this context was never followed by digging. Øritsland (1978) reported an adult polar bear using it as a sign of impatience in treadmill experiments.

Digging

This category (Table 1) contained 2 components: digging of temporary dens and pits, and digging to graze.

Den digging was usually initiated by powerful poundings with the forepaws to break through the snow crust, a technique also used during seal hunting in winter at breathing holes, and in

spring at seal birth lairs (Stirling and Latour 1978). Sometimes the snow was soft enough to be broken just by pushes without lifting the forepaws. An opening big enough for the female to creep into was made, and the den was extended from the inside. As reported from Wrangel Island by Belikov (1976), bears usually completed such dens in 15–40 minutes.

Pit digging varied from moderate scraping in the snow to digging of relatively deep, open niches. Both forepaws were used for vigorous digging; one was enough for slight digging as during graxing (Fig. 3b). Hind legs were never used.

In all investigated dens, narrow tunnels and claw marks showed that cubs dig a lot when inside the den. Pounding prior to digging was never used by cubs. Stirling and Latour (1978) anticipated that even 2-year-old cubs would not be heavy enough to break through hard snow. This is clearly the case with cubs 3–4 months old.

Investigative Walking

This is an artificial behavior category and consists of different activities that do not follow each other in a regular way (Table 1). In investigative walking, the females walked about in the area considerably slower than the approximately 30 paces per minute (P. Watts, pers. commun.) that characterize normal travelling gait. They frequently sniffed in the air and on the ground and looked around, poking out the tongue from time to time. During frequent stops at irregular intervals, investigative behavior was continued, and digging and chewing movements often occurred. When such activities lasted less than 1 minute they were not recorded separately.

Cubs generally adopted the same activity pattern as the female, and followed her closely. Especially in the first part of the period they showed great interest in her finding. The cubs' movements were slow and calm in contrast to those in playful behavior. Details like chewing and tongue extending could not be recorded. Cubs were seen engaged in investigative walking only when they were accompanied by the female.

Grazing and Other Foraging

No polar bear prey species or carcasses of such were seen on or near the island during our stays.

After den breaking the only potential food source available to the females was bear droppings and remains of last year's vegetation.

A considerable amount of the time recorded as ingestion (Table 1) was undoubtedly snow-eating, equivalent to drinking. No other fresh water source was available.

Eating their own droppings constituted 0.2% of the females' time outside the den (mean duration = 3.6 minutes, SD = 2.1 minutes, $N = 20$). They usually did so immediately after defecation. When the droppings were soft, the female sometimes dipped a forepaw in it and licked it off the paw. Ground surveys showed that most visible dark objects were stones or droppings. Hence, unidentified objects eaten by the females were probably droppings. Very few cub droppings were found, indicating that the females usually ate them at once as suggested by Uspenski and Kistchinski (1972). Cubs were never seen eating droppings.

The bears ate vegetation during both observation periods. In 1979 2 areas were dug completely free from snow and were used for grazing. The largest was about 50 m² and situated under a cliff where birds roost in summer, resulting in more nitrogenous conditions and higher summer production of vegetation than in the rest of the area.

Typical female activity in the grazing areas was meandering slowly with the head near the ground, sometimes digging with one forepaw (Fig. 3b). Similar behavior was also often seen in other parts of Bogen, and recorded as investigative walking and ingestion. Nearly all droppings from adults contained plant material.

Cubs nearly always followed the females when they were grazing. Their activity was generally the same as the females', but it was unclear whether they were grazing. The few cub droppings found, however, contained no visible plant material.

Russell (1975) reported that polar bears on Twin Islands in summer feed mainly on plants, berries, and birds. Knudsen (1978) reported that they spend 2–4% of their time feeding, and concluded that they mainly live on stored fat.

Food items available in Bogen are of lower caloric content than those on Twin Islands (Russell 1975). Even though the real time spent feeding

probably exceeds that recorded as ingestion, because in some of the activity recorded as investigative walking ingesting undoubtedly occurred. Thus the energy supplement the females could obtain is very limited, and the groups are dependent on the females' fat reserves. However, grazing may provide important minerals and vitamins.

Play

Cub play was characterized by rapid movements and frequent, irregular shifts in activity. It appeared most often when the female was resting or moving slowly. The proportion of time spent in play increased throughout the period. Detailed studies of cub play could not be recorded.

Of the cub play (Table 1), 66.4% (2.3% of total time, 15.8% of time outside) was recorded as general play. Here, partial activities lasted no longer than 1 minute. A main aspect was investigation, but the speed and shifts in partial activities separated it from investigative walking.

Social play with cubs was the only form of play recorded in females, and only 2 were observed playing. Lying on the side or belly, they gently bit the cubs or pushed them around with the forepaws. On a few occasions the female rolled over on her back, gently fighting with one or both cubs on her belly. Females usually remained passive or continued their activity when the cubs attacked, climbed, or rode on them.

Social play in cubs (1.0% of total time, 6.6% of time outside) was dominated by cubs running after each other, frequently changing between chasing and being chased. Somewhat less frequent was a "king-of-the-castle" game with stalking and rushes against the playmate, a behavior corresponding to adult seal-hunting technique as described by Stirling (1974) and Stirling and Latour (1978). Such confrontations led to an increased frequency of fights as the cubs grew. The cubs would either simply charge each other, or, more often by the end of the period, show threat displays before attack (Fig. 3c). Fighting was mixed with, and interrupted by, numerous other play categories.

The fighting cubs grabbed each other with the forepaws while slapping, biting, and kicking with both fore and hind legs. Cubs with more developed motor ability stood bipedally, slapping each other vigorously on the head and shoulders, sim-

ilar to adult males in ritualized fighting (Latour 1981). Cubs hit with especially hard slaps rolled over backwards. Burghardt and Burghardt (1972) reported that black bear cubs also first engage in stand-up play at about 4 months of age.

Individual cub play (0.2% of total time, 1.3% of time outside) appeared mainly as running in the area around the female, sliding, and rolling down small slopes. Snow clumps were attacked, slapped, and touched with the forepaws, often while the cubs rolled over on the back. Cubs standing up or lying on the back also would play with their own body, mainly using the paws. This may be interpreted as grooming, but occurred in a play context and was followed by play. Individual play in single cubs increased in proportion to play for all cubs. Among twins, the proportion of time spent in individual play decreased throughout the period.

Nursing and Suckling

Before taking a nursing position the female usually found or dug a pit in which she sat or lay down. Three main postures were used for nursing. In 1, the female lay on her back, head up and forward, and the cubs sat on her abdomen (Fig. 3d). In the other 2 she sat upright, again with the head forward, and either the cubs sat on her belly (Fig. 3e) or she leaned forward while the cubs nursed while sitting on the ground (Fig. 3f). The last posture was far less frequent than the other 2. In all 3 positions the female sheltered the cubs with her body if the wind was strong.

When the female had taken a lying-back nursing position, the cubs immediately climbed up and lay down at her nipples side by side. Mean duration of suckling was 9.7 minutes (SD = 7.5 minutes, $N = 64$) (Table 1). Meyer-Holzapfel (1957) reported that the mean duration of suckling at 2.5 months age is 15 minutes. Another 37 events were recorded when females took a nursing position but suckling could not be verified. The activity was then recorded as comfort behavior and grooming.

Our observations of nursing positions differ from those of other observers. Lónó (1970) reported from Svalbard that females usually lay on the side or back when nursing. Uspenski and Kistchinski (1972) reported from Wrangel Island that females stood while cubs stood on their hind

legs under her belly. On a few occasions the cubs in Bogen tried to initiate nursing while the female was standing. These attempts were never successful.

Comfort Behavior and Grooming

After a nursing period and before a resting period, an interval of comfort behavior and grooming was usually seen. One or both cubs crept slowly around on the female or lay on their back between her forepaws and were groomed by her. Such activities (including the unverified nursing positions) made up 1.0% of both the cubs' and the females' total time (4.9% and 6.2%, respectively, of their time outside) (Table 1).

Individual comfort behavior and grooming in females (0.4% of total time, 6.2% of time outside) was most often seen just after den breaking and otherwise when they came out of the den. The females slid in different positions, and rubbed their snout and other parts of the body against the snow as reported from Wrangel Island by Belikov and Kuprijanov (1977).

Very little grooming was seen in the cubs. This is consistent with the observations on black bear cubs by Burghardt and Burghardt (1972).

Activity Budget

The females were inactive or in the den 93.5% of their total time; the cubs, 91.6% (Table 1).

A cub 3–4 months old can gain 3.6 kg in 10 days and have a resting metabolic rate of $4.6 \text{ W}\cdot\text{kg}^{-1}$ (Blix and Lentfer 1979). The cub's rapid growth, high metabolic rate, and high activity depend on the female, who thus must be expected to minimize her energy-consuming activities, and obviously does so. Polar bears unable to hunt seals, but still with some access to food (Twin Islands, Knudsen 1978) were inactive 86.4% of their total time. Seal-hunting polar bears (Devon Island, Stirling 1974) were inactive 66.6% of their total time.

Larsen (pers. commun.) reports that a female with cubs 4 months old can travel more than 40 km per day on the ice for a long period. Providing energy for the cubs and delaying the possibility of getting food for 14 days probably represent a great stress on the female. This heavy investment indicates that the post-denning period is of major importance for training and developing the cubs for the coming hard travels on the ice.

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