Maternal care and cub development in the sun bear

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Abstract: All bears give birth to highly altricial young, but maternal style is markedly divergent among species. Like many aspects of sun bear (Helarctos malayanus) life history, maternal care in this species is poorly documented. Using detailed systematic behavioral observations, we provide the first quantitative report on the mother–cub relationship and early behavioral development in a sun bear. We summarize temporal changes in mother–cub behavior as the cub ages and evaluate maternal investment in the cub. We also provide developmental milestones documented in 2 cubs born (one in 2004, one in 2006) at the San Diego Zoo and compare them with those available in the literature. This sun bear mother displayed behavior indicating a high level of behavioral investment in young offspring while still in the den. She held the cub off the ground, cradled it to reduce the cub’s exposure to ambient air, and was attentive to the cub’s needs, responding to nearly 50% of the cub’s vocalizations and grooming the cub frequently. We conclude that the maternal care behavior of sun bears appears to be active, comparable to the giant panda (Ailuropoda melanoleuca) and different from the more passive maternal care displayed by American black (Ursus americanus) and brown bears (U. arctos) during the denning phase. A growing number of studies of maternal care in ursids are beginning to provide insights into comparative life histories.

Key words: behavior, development, Helarctos malayanus, life history, maternal care, sun bear


The sun bear Helarctos malayanus is the smallest member of the Ursidae. A tropical mammal, it is currently listed as vulnerable to extinction (International Union for Conservation of Nature [IUCN 2007]) and has been listed as an Appendix 1 species under CITES (Convention on International Trade in Endangered Species) since 1975. Primary factors contributing to the decline of the sun bear include habitat loss due to clearing for agriculture and timber extraction as well as hunting (Santiapillai and Santiapillai 1996, Meijaard 1999, McConkey and Chivers 2004). Conservation efforts for this species are limited in part by the lack of biological information describing even the basic parameters of sun bear reproductive characteristics and feeding strategies (Servheen 1990, Meijaard 1999, Wong et al. 2004). The vulnerability of the sun bear in situ has not led to increased ex situ conservation efforts to reach a self-sustaining population. In fact, the captive sun bear population has been on the decline in recent decades, as many institutions appear to have reached their carrying capacity for the species (Schwarzenberger et al. 2004). In North America, historically, most captive sun bears were of unknown origin and many were likely the result of interbreeding between distinct natural populations. The current goal of the AZA (Association of Zoos and Aquaria) Species Survival Plan is to optimize reproduction in the subspecies, H. m. euryspilus, from Borneo (Shrake and Frederick 2004). However, prior to 2004, there were no Bornean sun bear births in North America.

Sun bears in captivity have highly variable patterns of estrus and births (Spady et al. 2007). In European facilities, sun bears show no obvious reproductive seasonality, are polyestrous, and may conceive more than once in a year (Dathe 1962, Schwarzenberger at al. 2004). By contrast, in some North American zoos and in at least 1 captive facility in Malaysia, sun bear breeding appears to be seasonal, with a peak in summer–fall (Onuma et al. 2001, 2002; Hesterman et al. 2005). Despite the appearance of seasonality in these cases, Schwarzenberger et al. (2004) suggest variability in breeding and birthing periods for the Bornean subspecies, as Bornean sun bear cubs have been seen year round in the wild.

Like many aspects of sun bear life history, maternal care in this species is poorly documented. It is likely that wild female sun bears segregate themselves from males during the den phase (Nomura et al. 2004) as is common for other species of bear such as the grizzly (Ursus arctos; Haroldson et al. 2002), the giant panda (Ailuropoda melanoleuca; Schaller et al. 1985), and the American black

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bear (*U. americanus*; Pelton 2003). Sun bear bedding sites include hollow fallen logs or earthen cavities beneath trees (Wong 2002, Wong et al. 2004), and Augeri (2005) suggested the characteristics of birthing dens are likely to be similar. It is not known how long a female may use a den after giving birth, but among many ursids this period varies from 2–4 months (Garshelis 2004). The sun bear mother gives birth to 1 or 2 cubs (Nowak 1999) but most details of cub rearing behavior are anecdotal (Poglayen-Neuwell 1986, Kühme 1990), and quantitative studies are lacking.

In 2004 the San Diego Zoo had the first Bornean sun bear born in North America. Here we report on the mother–cub relationship and early behavioral development in a sun bear. Knowledge of maternal care in a species can aid in the successful management of the mother–cub relationship in captivity. For an example with giant pandas, see Zhang et al. (2000) and Zhou et al. (2004).

### Materials and methods

The subjects for the behavioral study were a single female (studbook #665) and her male offspring (studbook #683) born on 17 February 2004 at the San Diego Zoo, California, USA. We also obtained developmental milestones for a second cub, a female born at the San Diego Zoo in 2006. The mother, a wild-caught animal, was believed to have been 8 years of age at the time of the birth of the male cub and, in all likelihood, was nulliparous. Her pregnancy was the result of a natural mating with another wild-caught animal at the same facility.

Immediately post partum, the mother was housed in an off-exhibit area consisting of a raised den with adjacent den room and a supplemental room. The rooms measured approximately 3.1 x 1.8 x 2.7 m each. The cement den was approximately 1.2 x 0.9 x 1.2 m high. The den entrance was open to the ambient air and light and was visible from an adjacent corridor. Temperatures inside the den were not recorded, but average external temperatures ranged throughout the denning phase from 15–17°C. The mother was provisioned daily with food and water. Bermuda hay was available and used as nesting material.

Beginning 1 day postpartum, we collected behavioral data during 2-hour sessions approximately 6 times/week, divided into live observations commencing at 07:30 and real-time videotaped sessions commencing at 18:30. This continued until the end of the denning phase, established when the cub first spent more than 50% of its time outside the den, at 105 days of age. Videotaped sessions included audio and were limited to the observation of den activities, whereas live observations allowed for data collection in the adjacent rooms as well. Two observers were responsible for the collection of all data, and inter-observer reliability was established at 90% or greater. We developed an ethogram modified from our observations of other bear species and used point-in-time and all-occurrence focal sampling (sensu Martin and Bateson 1996). Additionally, we used data from time-lapse video (recorded 16 hr/day) to assist in determining major developmental milestones.

We correlated behavior data with advancing cub age using the Spearman rank-order correlation. We used the cub’s age in days to calculate the correlation coefficient, \( r \). To demonstrate general trends in behavior, we grouped data into 3 time blocks, each representing a third of the den phase: days 0–34, 35–70, and 71–105.

### Results

In total, more than 180 hours of real-time data were collected. Live observations accounted for 55.5% (100 hours) of the data, whereas the remainder was decoded via videotape.

We compared milestones from the cubs born in San Diego in 2004 and 2006 to comparable data from the literature (Table 1). Both cubs were highly altricial at birth, although no weights or measurements were available because we did not want to separate the cub from the mother for a physical exam. The mother remained in continuous contact with the cub, fasting until 1–5 days postpartum, when she first left the den to consume food that had been available, but ignored, since birth. She did not bring the first cub out of the den until 17 days postpartum, but waited only 8 days for the second cub. She was active >50% of the time by day 4 for the second cub, but not until day 19 for the first cub. The mother was regularly observed ingesting her own urine stream throughout the denning period, usually at the mouth of the den.

Both cubs’ eyes opened around 42 days postpartum. Crawling commenced by days 36–39, followed by the first wobbly steps by days 58–66. By days 66–81 postpartum, cubs followed the mother out of the
den, although maternal assistance was needed to negotiate the steps to the den entrance upon return. Food items were tested at 89 days postpartum, and the cubs drank from a small, continuous stream of water on days 95–96. By days 97–105, the cubs spent more than 50% of the day out of the den, and thus the denning phase was concluded.

The sun bear mother exhibited a period of reduced activity for 18 days postpartum (Fig. 1a); when active, the majority of her time was spent interacting with her cub (Fig. 1b). This interaction consisted of repositioning the cub for suckling or resting, stimulating the cub’s anogenital region, and responding to the cub’s vocalizations with behaviors such as nuzzling. She frequently situated herself in a curled position around her cub, shielding the cub from the ambient air and hiding it from view. As such, the cub was frequently not visible to observers in the early weeks of life.

The mother was first observed feeding on the fifth day postpartum with her first cub, although she first fed on the day after the birth of her second cub (Table 1). Early feeding bouts were brief, and the female typically left the den only long enough to retrieve food and return with it to the den to eat. Her first extended feeding bouts outside of the den occurred at 10 days postpartum (Fig. 1c). In the following weeks, she fed outside the observation and videotaped sessions, though keepers reported small amounts of food consumed overnight. A regular daytime feeding pattern did not begin to emerge until the cub reached 60 days of age. The percentage of time the mother spent grooming and licking her cub did not exceed 10% during the first 2 weeks, increasing to 10–25% of her time until about 20 weeks, tapering off thereafter (Fig. 1d).

Despite changes in the number of vocalizations emitted by the cub as the denning phase progressed, the sun bear mother responded to cub vocalizations at a fairly consistent rate throughout the period (Fig. 1e). In the first 4 weeks, she responded to an average of 44.5% (range 19.6–70.0%) of the cub’s vocalizations within 5 seconds of the cub emitting the vocalization.

The mother did not leave the den until the fifth day postpartum with her first cub, although with her second cub she left on the first day after birth (Table 1). For the first few weeks, her time spent out of the den was very limited and did not exceed 20% of her time budget until the third month (Fig. 1f). After day 66 postpartum, she began spending increasingly greater portions of her day out of the den.

The mother and cub were in physical contact most of the time in the early days of the denning phase, but this dropped off substantially as the cub aged (Table 2). Early in the denning phase, the mother maintained a posture in which she curled her head and limbs around the cub. As the cub aged, the female used this posture with decreasing frequency. She was more likely to be observed reclined on her back as the cub aged, and less likely to lie on her side.
Initially, the cub was held against the mother’s body or limbs nearly exclusively, but over time the female allowed the cub to be in contact with the ground (Table 2). When the nature of the physical contact between mother and cub could be ascertained, the most common position for holding the cub off the ground in the first third of the denning phase was the foot rest (Table 2), in which the female rested the cub on the anterior surface of her rear lower leg and foot, usually curling her body around the limb to envelop the cub. As the cub aged, the mother used other methods of elevating the cub above ground, sometimes involving the cub climbing atop the mother’s abdomen and resting with little or no support from her. During the first third of the denning phase, the mother kept the cub covered, but as the cub aged she gradually allowed it to become more exposed (Table 2).

Early days in the denning phase, the cub was often difficult to observe due to the mother’s efforts to cover it. It was apparent, however, that the cub was quite inactive in the first 3 weeks postpartum (Fig. 2a). After the first month, it became increasingly more active, began to explore and play after 2

Fig. 1. Maternal behavior in a San Diego Zoo sun bear during live and videotaped observations of the denning phase, 2004.
Exposure of cub to ambient air

tions/hr on 5 of the first 21 days of life. Some (Fig. 2e). The cub emitted more than 40 vocalizations
first month, although daily values varied widely

Maternal positioning of cub
behavior occupied as much as 16
was likely underestimated during this period. As the
difficulty in observing the cub, the rate of suckling
more than 12
month of life, the cub was not observed suckling
periods after day 70 postpartum (Fig. 2c). In the first
months of age (Fig. 2b), and left the den for longer
periods after day 65, and the affiliative cluck observed in social encounters was heard only
once during the den phase, on day 70.

Discussion

Although some developmental milestones have been
documented with Malayan sun bear cubs (Weber 1969,
Khüme 1990, Puschmann 2004), this research provides
the first comprehensive data on quantitative changes in
maternal care and cub behavioral development in sun
bears. These behavioral trends elucidate previously
unpublished aspects of sun bear biology and can assist
other institutions experiencing sun bear births in
understanding the normal range of behavior in this
species. Although some inter-individual differences are
to be expected, it seems likely that other sun bear
mothers will also display active maternal care behav-
ior, such as holding the cub off the ground. However,
multi-institutional studies to increase sample size are
clearly needed to determine the range of maternal care
styles in sun bears. Indeed, developmental milestones
(Table 1) suggest a great deal of variability, although
some of this variability may be attributed to subspecies
differences, different observational conditions (e.g.,
hand-reared versus mother-reared), or observer differ-
ences in interpretation (for example, eyes open
gradually over the course of several weeks). On the
other hand, some of this variability is undoubtedly
real, subject to intra- and inter-individual variability.
Most prominent in our dataset for 2 cubs are the
changes in maternal behavior from the first to the
second cub: with the second cub, she left the den for the
first time earlier and more often, was more active, fed
more, and brought the cub out of the den earlier—all
observations suggesting a relaxation in maternal
protectiveness.

Our data document important temporal trends
during the denning period when cubs transition from
complete dependency to greater thermal and behav-
ioral self-sufficiency. As the sun bear cub aged,
changes in the form of contact with the mother

Table 2. Percent time observed for various positions and exposure as a function of cub age for a San Diego Zoo sun bear mother–cub dyad, 2004.

<table>
<thead>
<tr>
<th>Maternal body position</th>
<th>Day (%)</th>
<th>Day (%)</th>
<th>Day (%)</th>
<th>ρa</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother, cub in</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>contact</td>
<td>97.22</td>
<td>89.02</td>
<td>69.90</td>
<td>0.71</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Curledb</td>
<td>89.40</td>
<td>65.25</td>
<td>22.39</td>
<td>0.657</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lay on back</td>
<td>3.38</td>
<td>8.72</td>
<td>22.82</td>
<td>0.553</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lay on side</td>
<td>65.13</td>
<td>60.08</td>
<td>37.85</td>
<td>0.284</td>
<td>0.096</td>
</tr>
<tr>
<td>Lay on ventrum</td>
<td>7.36</td>
<td>0.54</td>
<td>5.84</td>
<td>0.161</td>
<td>0.143</td>
</tr>
<tr>
<td>Seated</td>
<td>23.37</td>
<td>28.50</td>
<td>20.37</td>
<td>0.009</td>
<td>0.931</td>
</tr>
<tr>
<td>Maternal positioning of cub</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground contact</td>
<td>9.4</td>
<td>45.1</td>
<td>72.4</td>
<td>0.80</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Incidental contact</td>
<td>0</td>
<td>0</td>
<td>6.8</td>
<td>0.62</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>indiscerniblec</td>
<td>51.0</td>
<td>19.6</td>
<td>7.0</td>
<td>0.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>On mother–unknown</td>
<td>24.5</td>
<td>6.9</td>
<td>0.1</td>
<td>0.43</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>On mother–otherd</td>
<td>1.2</td>
<td>6.3</td>
<td>9.1</td>
<td>0.38</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hip hold</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0.19</td>
<td>0.071</td>
</tr>
<tr>
<td>Hand hold</td>
<td>5.8</td>
<td>10.2</td>
<td>4.0</td>
<td>0.11</td>
<td>0.313</td>
</tr>
<tr>
<td>Hold in mouth</td>
<td>0</td>
<td>1.2</td>
<td>0.5</td>
<td>0.08</td>
<td>0.461</td>
</tr>
<tr>
<td>Foot rest</td>
<td>7.8</td>
<td>9.2</td>
<td>0.5</td>
<td>0.08</td>
<td>0.461</td>
</tr>
<tr>
<td>Arm cradle</td>
<td>0.1</td>
<td>0.9</td>
<td>0</td>
<td>0.02</td>
<td>0.821</td>
</tr>
<tr>
<td>Neck cradle</td>
<td>0.1</td>
<td>0.6</td>
<td>0</td>
<td>0.01</td>
<td>0.931</td>
</tr>
<tr>
<td>Exposure of cub to ambient air</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully exposed</td>
<td>0.8</td>
<td>7.9</td>
<td>52.3</td>
<td>0.85</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Partially exposed</td>
<td>13.0</td>
<td>56.7</td>
<td>29.5</td>
<td>0.51</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Not exposed</td>
<td>46.3</td>
<td>5.0</td>
<td>0.1</td>
<td>0.62</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Exposure not discernible</td>
<td>39.9</td>
<td>30.4</td>
<td>18.1</td>
<td>−0.2</td>
<td>0.099</td>
</tr>
</tbody>
</table>

aSpearman rank ρ, corrected for ties.
bThe curled position could be adopted while simultaneously
engaged in other positions, such as lay on back and curled.
cIndiscernible contact refers to time in which it was not possible
to identify the exact position of contact between mother and
cub due to the mother's effort to cover the cub.
dOn mother–other refers to contact in which the cub was
somewhere on the mother's body but not in other defined
positions.

months of age (Fig. 2b), and left the den for longer
periods after day 70 postpartum (Fig. 2c). In the first
month of life, the cub was not observed suckling
more than 12% of the time (Fig. 2d), but due to the
difficulty in observing the cub, the rate of suckling
was likely underestimated during this period. As the
cub aged and viewing became easier, suckling
behavior occupied as much as 16% of the cub’s time.

The cub emitted vocalizations at a high rate in its

coincided functionally with the cub’s dependency on the mother for warmth and other needs. Initially, the mother spent most of her time curled around the cub, minimizing exposure to ambient conditions, but as the cub aged she began to uncurl. She also transitioned from lying on her side to lying on her back—a posture that exposes the cub to the ambient air—and also allowed the cub more contact with the ground. The function of this behavior probably largely serves to keep the cub warm, especially before the pelage gradually grows in, but also to keep the cub dry in the wet, humid environment where sun bears are found. The warmth of the tropics also suggests another possible function of the mother’s efforts to keep the cub off the ground. Unlike temperate environments in winter, tropical bears may encounter large numbers of biting insects (such as ants), pathogens, and snakes that may compromise the health of a cub (Fredriksson 2005). In the first few weeks the mother remained sequestered in

Fig. 2. Cub behavior in a San Diego Zoo sun bear cub during live and videotaped observations of the denning phase, 2004.
the den, ingesting small amounts of food while providing comfort and protection to the cub, but after 2 months her time outside the den increased considerably as her food consumption returned to pre-birth levels. Her activity levels also were suppressed when the cub was young, presumably a mechanism to prevent accidental crushing of the cub or otherwise disturbing the cub when resting.

Unlike hibernating bears, each day the sun bear mother spends in the den involves maternal sacrifice in terms of lost foraging opportunities and other activities that the mother would otherwise engage in. Sun bears, like pandas, also do not appear to engage in hyperphagia or undergo significant increases in weight before denning, so remaining active in the den to care for offspring entails further costly investment in the cub. Although not demonstrated conclusively here, maternal care in sun bears would certainly meet the criteria for maternal investment in that it must certainly delay and reduce the mother’s ability to invest in future offspring (Clutton-Brock 1991). These sacrifices also speak to the cub’s critical needs for maternal care, especially in the early post-partum period. At this stage even relatively brief departures or lapses in care of the cub could jeopardize the cub. Thus, the early post-partum period should be carefully safeguarded against extrinsic stressors that may compromise the ability of mother to care for the cub.

Our observations underscore the active nature of maternal care in the sun bear, particularly in comparison to the larger, hibernating species we have studied. Employing the same methods described here, we have studied maternal care during the denning phase in American black bears (8 mothers, 8 litters) and brown bears (2 mothers, 4 litters) (Dewing 2005, Owen and Swaisgood, unpublished data), and have obtained a similar dataset for more than 20 individual female pandas, both captive and wild (Zhang et al. 2000; Swaisgood, unpublished data). These larger datasets (collected in the same way and therefore directly comparable) help place our data for sun bears in life-history context with other ursids. Although our small sample size for the sun bear precludes direct statistical comparison, none of the brown and black bears we studied previously showed rates of cub-directed behavior that even approached what we found in this sun bear. Most striking in this comparison is the more passive nature of maternal care in brown and black bears, which rarely hold their cubs above the ground (<5% time near birth; 0% by 3 weeks of age for both species) and spend less than half the amount of time interacting with their cubs as we observed for this sun bear during the denning phase. Giant panda mothers, like the sun bear we studied here, cradle the cub on their body and are extremely attentive to cubs’ vocalizations and other signals of need (Zhang et al. 2000, Zhu et al. 2001, Snyder et al. 2003). Other differences in life-history patterns, such as hibernation and litter size (Garshelis 2004), may explain species differences in maternal care. A larger sample size, obtained across many institutions and from free-living bears, will provide the sound scientific foundation for species comparisons. Our research group is working towards this goal, not just for sun bears but for all ursids, and we hope that this brief report will stimulate similar research by others.

Acknowledgments

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Table 3. Frequency (bouts/hour) of vocalizations by age of a San Diego Zoo sun bear cub, 2004.

<table>
<thead>
<tr>
<th>Vocalization</th>
<th>Day 0–34</th>
<th>Day 35–70</th>
<th>Day 71–105</th>
<th>ρ*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cry</td>
<td>0.8</td>
<td>0.4</td>
<td>0.1</td>
<td>0.24</td>
<td>0.026</td>
</tr>
<tr>
<td>Loud squawk</td>
<td>2.1</td>
<td>1.2</td>
<td>0.4</td>
<td>0.55</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Soft squawk</td>
<td>6.9</td>
<td>6.1</td>
<td>2.2</td>
<td>0.38</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Croak</td>
<td>0.4</td>
<td>1.4</td>
<td>0.1</td>
<td>0.17</td>
<td>0.117</td>
</tr>
<tr>
<td>Hum fragment</td>
<td>6.7</td>
<td>1.0</td>
<td>0.4</td>
<td>0.81</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hum constant</td>
<td>3.2</td>
<td>2.1</td>
<td>0.7</td>
<td>0.48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Soft whine</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.07</td>
<td>0.492</td>
</tr>
</tbody>
</table>

*Spearman rank ρ corrected for ties.
San Diego State University, San Diego, California, USA.


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