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Hibernation behaviour and ethogram of captive Asiatic black bear (*Ursus thibetanus*)

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Abstract: This study was undertaken to create an Asiatic black bear (*Ursus thibetanus*; ABB) ethogram during hibernation and to describe the time budget of hibernating behaviours in ABB. Seven captive adult ABB were included in the study and began hibernation between October and December. Data were collected for three consecutive years (2013–2015) during ABB hibernation (total 169 days) using closed-circuit television. During the study, we observed 21 distinct behaviours in hibernating ABB (4 least active and 17 active behaviours). Five bears started hibernation less than seven days after feeding cessation, and by the end of one week, all bears hibernated. The most commonly observed behaviour was "sleep curling inside nest", and "nest maintenance" was the second most common behaviour. Among the active behaviours, "sitting in the nest", "change stance", "drinking and eating" were mostly shown as documented during the observation times. Our results provide new insights into the hibernating behaviours of ABB.

Keywords: bear; behaviour observation; captive management; re-introduction; winter sleep

The Asiatic black bear (*Ursus thibetanus*; ABB) is a globally endangered species, and a re-introduction project to establish a self-sustaining population of ABB in the Republic of Korea was initiated in 2002 (Jeong et al. 2010). During that project, some ABB were moved to captivity because of habituation on human and serious injuries related to attempted poaching. Most of the bears were born in the wild and hibernated every year. Thus, they were offered various enrichment programs in captivity and winter hibernation was induced to preserve their unique ecological characteristics while in captivity. Although most bears hibernated successfully in captivity, some emerged from the den site and resumed activities, and one bear died during hibernation. To prevent similar unexpected occurrences, observation of hibernating bears while in captivity is necessary. Many ecological or physiological studies have reported on hibernation and denning behaviours of wild (Ciarniello et al. 2005; Manchi and Swenson 2005; Johnson et al. 2018; Mangipane et al. 2018) and captive (Itoh et al. 2010; Robbins et al. 2012) bears. However, to the best of our knowledge, there is no report describing, in detail, ABB behaviour during hibernation. Thus, this study was undertaken to create an ethogram for ABB behaviours during the hibernation period and to describe the time budget of ABB hibernating behaviours.

https://doi.org/10.17221/135/2019-VETMED

MATERIAL AND METHODS

Seven clinically healthy adult ABB (one female, six males; age range, 5–13 years; weight range, 134–203 kg) at the Species Restoration Technology Institute, Gurye, Republic of Korea were included in this study. Each bear was housed individually in an indoor room (3 × 4 × 3 m; tiled floor and walls; direct sunlight via a 1 m × 1.4 m roof window). The bears spent 4–6 h per day in a semi-natural outdoor enclosure (4 561 m^2) that resembled a wild bear habitat. They were fed acorns, chestnuts, fruits, vegetables, sweet potatoes, and commercial feed (Omnivore Diet Dry®; ZuPreem, Mission, TX, USA) twice a day (first feeding, 09:00 h to 10:00 h; second feeding, 17:00 h to 18:00 h). The daily amount of food was doubled in October and November and was gradually decreased beginning in December. In mid-December, feeding was stopped to induce hibernation. In addition, several bales of straw (30 kg) were provided for the creation of a denning nest in the room and the roof window was covered with a blanket to block direct sunlight. However, other windows in the facility were left uncovered so that each room was illuminated by natural light. Water was provided whenever the individual bear's water container (30 × 20 × 15 cm) was empty (about once a week). Temperatures in the denning rooms were not controlled and ranged between −12 °C and +4 °C.

Between 2010 and 2012, the hibernating behaviours of captive ABB were observed by using

Table 1. Full ethogram of hibernating captive Asiatic black bear (*Ursus thibetanus*) in this study

Behaviour			Code	Definitions of observed behaviours
Inside nest	least active	lying down	ISL	lying on its abdomen on the ground hardly moving
		curling	ISC	the body is rolled like a ball; nose placed near tail
	standing		IST	bi-pedal or quadrapedal stationary stance without staring
	sitting		ISI	sitting with buttocks on the floor without staring
	staring		ISS	staring at something in concentration more than 5 seconds
	activity		IAC	sitting or lying down moving the legs; sometimes rubbing the body parts with legs
	elimination		IEL	defecation or urination
	nest maintenance		INM	rubbing or gathering insulation materials with forefoot
	change stance		ICS	any change between the stance
	eating or drinking		IED	ingestion of edible material or consumption of water
Outside nest	least active	lying down	OSL	same description with behaviours in "inside nest", but the place behaved is outside nest
		curling	OSC	
	standing		OST	
	sitting		OSI	
	staring		OSS	
	activity		OAC	
	elimination		OEL	
	nest maintenance		ONM	
	change stance		OCS	
	eating or drinking		OED	
	pacing		OPA	locomotion (straight ahead) along a full length of denning site

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a closed-circuit television system (CCTV, H4032; IDIS Korea, Daejeon, Republic of Korea), and, based on those observations, an ethogram was created. Subsequently, CCTV data were collected between 2013 and 2015 during captive ABB hibernation (86 days in winter 2013–2014, 83 days in winter 2014–2015). Behaviours were assessed daily for three hours (after midnight, between 01:00 h and 02:00 h, time 1; around sunrise, between 06:00 h and 7:00 h, time 2; around sunset, between 17:00 h and 18:00 h, time 3) at 1 min intervals using a scan-point sampling method (Martin and Bateson 2007).

Initially, data were grouped into least active and active behaviours. In addition, after excluding the least active behaviours, the individual active behaviours were calculated as percentages of the total active behaviours. One-way ANOVA and Tukey's multiple comparisons were used to compare differences between observation time periods (times 1, 2, and 3) and between weeks during the hibernation period. All statistical tests were performed by using a statistics program (SPSS Statistics 18 software®; IBM, Foster City, CA, USA). $P < 0.05$ was considered statistically significant and the results are presented as mean ± SEM (standard errors of the mean) values.

During the study, we observed 21 distinct behaviours in seven hibernating ABB. Those behaviours were then categorized as either inside or outside the nest, and as the least active behaviours, which were grouped into "lying down" and "curling" as indicative of the stance. Pacing behaviour was shown only outside the nest. The full ethogram consisted of 21 behaviours (4 least active and 17 active behaviours) and is presented in Table 1.

RESULTS

Five ABB started hibernation less than 7 days after stopping feeding (0 weeks; least active behaviour 54.23% ± 1.2% of total behaviour), but after one week, all bears had hibernated (1st week; least active behaviour 94.74% ± 1.04% of total behaviour). The least active behaviour percentages in 1st, 8th, 9th, and 10th week of hibernation were less than 95%, whereas those in the 2nd, 3rd, 4th, 5th, 6th, and 7th week were more than 95%. In the 11th week, six bears awoke from hibernation (least active behaviour 50.33% ± 1.9% of total behaviour) and in the 12th week all bears had awakened (least active behaviour 34.64% ± 1.6% of total behaviour). In addition, among the weeks in which all bears were hibernating (i.e., between 1st and 10th week), total least active behaviour in the 10th week was significantly lower than those in the 2nd, 3rd, 4th, 5th, 6th, and 7th weeks ($P = 0.007$, $P = 0.006$, $P < 0.001$, $P = 0.014$, $P = 0.002$, $P = 0.001$, respectively) (Figure 1).

Overall, the percentages of least active and active behaviour between the 1st and 10th weeks, in which all bears were hibernating, were 95.10% ± 0.17% and 4.90% ± 0.03%, respectively. The most com-

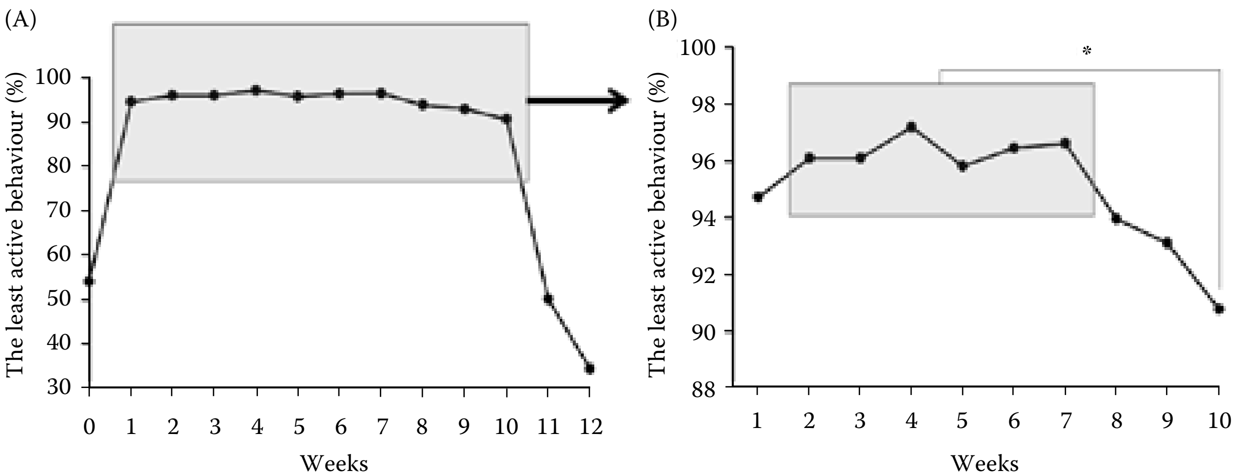

Figure 1. The rate of least active behaviours (%) by week during the hibernation period in captive Asiatic black bears. (A) Presents data for all hibernation weeks from the cessation of feeding to when all bears were awake (i.e., between 0 and 12 weeks). (B) Presents data only for the weeks that all bears seemed to sleep (least active) (i.e., between the 1st and 10th week)

*$P < 0.05$

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monly observed hibernating behaviour was "curling in the nest (ISC)", which comprised 92.40% ± 0.50% of the total hibernating behaviours, and "nest maintenance in the nest (INM)", which was the second most common hibernating behaviour (1.71% ± 0.16% of the total hibernating behaviours). The other hibernating behaviours except for ISC and INM occurred less than 1% of the time, and "lying down outside nest (OSL)" was not observed (Table 2).

Table 2. Total mean of the least active and active behaviours in captive Asiatic black bears (*Ursus thibetanus*) during hibernation period

Least active behaviours (%)		Active behaviours (%)	
code	mean ± SE	code	mean ± SE
ISL	0.89 ± 0.18	IST	0.13 ± 0.02
		ISI	0.57 ± 0.05
		ISS	0.70 ± 0.06
		IAC	0.43 ± 0.08
ISC	92.40 ± 0.50	IEL	0.04 ± 0.02
		INM	1.71 ± 0.16
		ICS	0.36 ± 0.02
		IED	0.41 ± 0.09
OSL	0	OST	0.02 ± 0.01
		OSI	0.04 ± 0.01
		OSS	0.01 ± 0.00
		OAC	0.02 ± 0.01
OSC	0.01 ± 0.01	OEL	0.05 ± 0.01
		ONM	0.03 ± 0.01
		OCS	0.08 ± 0.01
		OED	0.01± 0.01
		OPA	0.30 ± 0.10
Total	95.10 ± 0.17	Total	4.90 ± 0.03

IAC = activity in the nest; ICS = change stance in the nest; IED = eating & drinking in the nest; IEL = elimination in the nest; INM = nest maintenance in the nest; ISC = body curling in the nest; ISI = sitting in the nest; ISL = lying down in the nest; ISS = staring at something in the nest; IST = standing in the nest; OAC = activity outside nest; OCS = change stance outside nest; OED = eating & drinking outside nest; OEL = elimination outside nest; ONM = nest maintenance outside nest; OPA = pacing outside nest; OSC = body curling outside nest; OSI = sitting outside nest; OSL = lying down outside nest; OSS = staring at something outside nest; OST = standing outside nest

Values are presented as mean ± SE

Among the active behaviours, "sitting in the nest (ISI)" was the most frequent behaviour recorded in observation times 1 and 2 ($P = 0.001$), INM was observed significantly more in observation times 2 and 3 ($P = 0.001$) than in time 1, whereas, "change stance (ICS)" was mostly shown in observation time 1 ($P < 0.001$). In addition, "eating or drinking in the nest (IED)" and "eating or drinking outside nest (OED)" were most frequently observed in observation time 3 ($P < 0.001$ and $P = 0.02$, respectively) (Table 3).

DISCUSSION

In a captive Japanese black bear study (Itoh et al. 2010), the bear started hibernation in a curled-up position between 3 and 5 days (less than 1 week) after the cessation of feeding and exhibited decreased least active time between 65 and 79 days (9.3 to 11.3 weeks) after the cessation of feeding. In that study, the total hibernation period ranged between 68 and 89 days (9.7 to 12.7 weeks). In captive brown bears (Robbins et al. 2012), lying behaviour increased after the cessation of feeding (lying behaviour percentages: less than 50% at last feeding; about 67% at approximately one week later; about 88% at approximately 2 weeks later; about 94% at approximately 3–4 weeks later) and reached a maximum level at 6.4 weeks. The proportion of lying behaviour was maintained at about 98% during the subsequent 9 weeks (weeks 6.4 to 15.4 after stopping feeding) but then decreased to about 75% at approximately 20 weeks after the cessation of feeding. Additionally, at around 20 weeks, feeding started and lying behaviour was reduced to about 50% of total behaviour (Robbins et al. 2012). The overall hibernation patterns observed in those two studies (Itoh et al. 2010; Robbins et al. 2012) revealed an increase in least active behaviours after the cessation of feeding and a decrease in activities for several weeks, patterns that were similar to the results in the present study. However, there were differences in the length of time before starting hibernation after stopping feeding and in hibernation period. These differences may be due to species differences and/or temperatures in the den site, which can be affected by latitude (Haroldson et al. 2002) and meters above mean sea level (Talay 1975). The Japanese black bear is a subspecies of the ABB, and both ABB and Japanese black bears hi-

https://doi.org/10.17221/135/2019-VETMED

Table 3. Mean values of active behaviours by time groups during the hibernation period

Code	T^{c}	Mean ± SE	*F*	*P*-value	Code	T^{c}	Mean ± SE	*F*	*P*-value
	1	3.58 ± 1.19				1	0.03 ± 0.02		
IST	2	4.87 ± 1.18	1.66	0.19	OST	2	0.02 ± 0.02	1.01	0.33
	3	2.54 ± 0.53				3	0.01 ± 0.01		
	1	18.29 ± 2.93				1	0		
ISI	2	20.50 ± 2.32	6.94	0.001	OSI	2	0.01 ± 0.01	1.48	0.23
	3	10.49 ± 1.35^{a,b}				3	0.13 ± 0.09		
	1	12.90 ± 4.17				1	0.31 ± 0.31		
ISS	2	13.81 ± 3.02	0.46	0.62	OSS	2	0.07 ± 0.05	1.37	0.25
	3	9.84 ± 2.93				3	0.44 ± 0.17		
	1	7.09 ± 2.09				1	0.83 ± 0.59		
IAC	2	5.40 ± 1.37	0.45	0.63	OAC	2	0	2.09	0.13
	3	7.27 ± 1.53				3	0.95 ± 0.46		
	1	0.35 ± 0.26				1	0		
IEL	2	0.85 ± 0.59	0.51	0.59	OEL	2	0.08 ± 0.05	0.73	0.48
	3	0.31 ± 0.22				3	0.29 ± 0.25		
	1	30.77 ± 2.23				1	0		
INM	2	39.58 ± 2.41^{a}	0.7	0.001	ONM	2	2.13 ± 0.95	1.52	0.21
	3	44.72 ± 2.36^{a}				3	1.70 ± 0.74		
	1	23.51 ± 3.39				1	0.66 ± 0.51		
ICS	2	9.88 ± 1.63^{a}	12.77	< 0.001	OCS	2	0.37 ± 0.28	0.91	0.4
	3	9.74 ± 1.43^{a}				3	1.03 ± 0.38		
	1	1.09 ± 0.95				1	0		
					OED	2	0.08 ± 0.06	3.89	0.02
IED	2	1.09 ± 0.63	11.25	< 0.001		3	0.52 ± 0.20^{a}		
						1	0		
	3	8.33 ± 1.71^{a,b}			OPA	2	0.37 ± 0.33	0.63	0.53
						3	0.13 ± 0.09		

IAC = activity in the nest; ICS = change stance in the nest; IED = eating & drinking in the nest; IEL = elimination in the nest; INM = nest maintenance in the nest; ISI = sitting in the nest; ISS = staring in the nest; IST = standing in the nest; OAC = activity outside nest; OCS = change stance outside nest; OED = eating & drinking outside nest; OEL = elimination outside nest; ONM = nest maintenance outside nest; OPA = pacing outside nest; OSI = sitting outside nest; OSS = staring outside nest; ST = standing outside nest

$^{a}P < 0.05$ = significant difference from time 1; $^{b}P < 0.05$ = significant difference from time 2; ^{c}T = time; time 1, 01:00 h ~ 02:00 h; time 2, 09:00 h ~ 10:00 h; time 3, 17:00 h ~18:00 h

Active behaviours are calculated as 100%. Values are presented as mean ± SE

bernated at similar latitudes and altitudes (about 35° 14’ 31” N, 130 m and about 35° 42’ 59” N, 24 m, respectively; the hibernation sites were confirmed by Google Earth on the website). By contrast, brown bears hibernated at 46° 43’ 49” N and 940 m above sea level (confirmed by Google Earth).

In this study, we observed that ISC was the main behaviour exhibited by ABB during hibernation and that ABB slept most deeply within a 6-week period (between the 2nd and 7th weeks after the cessation of feeding). In addition, INM seems to be an important behaviour during hibernation because it was the

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most common behaviour among the various active behaviours. Behaviours related to maintaining a nest and gathering or rearranging bedding material have been reported in hibernating captive Japanese black bears (Itoh et al. 2010), American black bears (Nelson et al. 1973), and brown and polar bears (Robbins et al. 2012). Furthermore, Halfpenny (2007) reported on a pregnant female brown bear that made a nest from softer materials for newborn cubs than those used when hibernating in a non-pregnant state; that is, the bear used moss and grass as nesting materials when pregnant and used boughs when not pregnant. However, in this study, the INM behaviour appeared to be related to enduring cold rather than to providing soft nesting material as some bears brought in straw, which acted as a buffer between the animal and the cold ground, while others increase the height of the flattened edge of the nest. Additionally, although bears minimize their energy expenditure to aid in overcoming harsh conditions during hibernation (Robbins et al. 2012), the fact that INM was the most frequent active behaviour suggests that it is an essential behaviour in hibernating ABB.

Regarding the diel behavioural differences, INM was observed more often in times 2 and 3 than in time 1, and this pattern may be related to temperature. Around sunrise is typically the coldest part of the day, and the increased temperature that occurs during the day typically starts to decrease around sunset. Thus, during the cooling and coldest daily time periods, the ABB were probably doing the greatest amount of gathering or rearranging their bedding material. ICS was mostly shown in the time 1 period (just after midnight) in the present study, which may be related to a daily activity pattern in the wild and/or in response to pain due to the long sleep periods. Although daily activity is influenced by various environmental factors, in general bears are diurnal and are rarely active around midnight (Hwang and Garshelis 2007; Lewis and Rachlow 2011; Ogurtsov et al. 2018). Accordingly, around midnight, several hours have passed since the bears have begun to sleep and they may feel some pain or discomfort from staying in the same position such as the ISC. Thus, ICS could be a behaviour associated with pain reduction and/or with blood circulation improvement during hibernation. Both IED and OED were most frequently observed in time 3, and this association may be related to feeding activities because, in our study, the second feeding time in the pre-hibernation period was 17:00 h ~ 18:00 h (time 3). Although there was no food provided during the hibernation period, some bears may have formed a feeding time pattern that remained during hibernation.

To date, there have been few studies on hibernating ABB. In this study, we focused on hibernating-related behaviours and made a full ethogram of ABB during hibernation. In the present study, we determine how long time the ABB hibernated and the behaviours they exhibited during hibernation. The results would be helpful to understand the hibernating behaviours of ABBs and to manage ABB while hibernating in captivity.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

Ciarniello LM, Boyce MS, Heard DC, Seip DR. Denning behaviour and den site selection of grizzly bears along the Parsnip River, British Columbia, Canada. Ursus. 2005 Apr;16(1):47-58.

Halfpenny JC. Biology and behavior, the bear year. In: Halfpenny JC, Francis MH, editors. Yellowstone bears in the wild. 1st ed. Helena, MT: Riverbend Publishing; 2007. pp. 25-32.

Haroldson MA, Ternent MA, Gunther KA, Schwartz CC. Grizzly bear denning chronology and movements in the Greater Yellowstone Ecosystem. Ursus. 2002 Jan;13:19-37.

Hwang MH, Garshelis DL. Activity patterns of Asiatic black bears (Ursus thibetanus) in the central mountains of Taiwan. J Zool. 2007 Feb;271(2):203-9.

Itoh K, Ide K, Kojima Y, Terada M. Hibernation exhibit for Japanese black bear Ursus thibetanus japonicus at Ueno Zoological Gardens. Int Zoo Yearb. 2010 Feb;44(1):55-64.

Jeong DH, Yang DH, Lee BK. Re-introduction of the Asiatic black bear into Jirisan National Park, South Korea. In: Prital S, editor. IUCN Global reintroduction perspectives. 1st ed. Abu Dhabi: IUCN/SSC/ Re-introduction Specialist Group; 2010. pp. 254-8.

Johnson HE, Lewis DL, Verzuh TL, Wallace CF, Much RM, Willmarth LK, Breck SW. Human development and climate affect hibernation in a large carnivore with implications for human – carnivore conflicts. J Appl Ecol. 2018 Oct;55(2):663-72.

Lewis JS, Rachlow JL. Activity patterns of black bears in relation to sex, season, and daily movement rates. West N Am Nat. 2011 Jan;71(3),388-95.

https://doi.org/10.17221/135/2019-VETMED

Manchi S, Swenson JE. Denning behaviour of Scandinavian brown bears Ursus arctos. Wildlife Biol. 2005 Jun;11 (2):123-32.

Mangipane LS, Belant JL, Gustine DD, Hilderbrand GV, Mangipane BA. Sex-specific variation in denning by brown bears. Mamm Biol. 2018 Aug;93(1):38-44.

Martin P, Bateson P. Recording methods. In: Martin P, Bateson P, editors. Measuring behaviour: An introductory guide. 3rd ed. Cambridge: Cambridge University Press; 2007. pp. 48-60.

Nelson RA, Wahner HW, Jones JD, Ellefson RD, Zollman PE. Metabolism of bears before, during, and after winter sleep. Am J Physiol. 1973 Feb;224(2):491-6.

Ogurtsov SS, Zheltukhin AS, Kotlov IP. Daily activity patterns of large and medium-sized mammals based on camera traps data in the Central Forest Nature Reserve, Valdai Upland, Russia. Nat Conserv Res. 2018 Jun;3(2):68-88.

Robbins CT, Lopez-Alfaro C, Rode KD, Toien O, Nelson OL. Hibernation and seasonal fasting in bears: the energetic costs and consequences for polar bears. J Mammal. 2012 Dec;93(6):1493-503.

Talay TA. Introduction to the aerodynamics of flight. Wahington, D.C.: NASA SP-367, National Aeronautics and Space Administration; 1975.

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