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Zoo Location as a Factor in the Reproductive Behavior of Captive Snow Leopards, *Uncia uncia*

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With 4 Figures

Abstract

This paper examines the impacts of zoo location on the timing of captive snow leopard births. The three location indicators selected as independent variables were: latitude, altitude, and mean last Spring day of freezing temperature. The date of snow leopard births was chosen as the dependent variable to represent the timing of the ♀'s oestrus cycle.

A multiple regression program (BMDO3R) was run on the CDC computer at the University of Washington, and showed no significant relationships between the location variables and dates of birth (with a sample size of 67 birth events in 21 zoos). Therefore, the results suggest that the ♀ snow leopard's cycle is largely endogenous, a characteristic uncommon among the large cats.

This paper also presents a brief discussion of reproductive observations on the snow leopards at the Woodland Park Zoo in Seattle, and summarizes future research directions on exploring the affect of other environmental factors on the successful breeding of captive snow leopards.

Each year as human activities invade more animal habitats, and many species are placed on the endangered list, zoos and wildlife farms are assuming the responsibility of managing a stock of animals whose natural territories are shrinking. Hopefully, some species may eventually be reintroduced into the wild, but until this can be accomplished, zoos must maintain a breeding nucleus of animals otherwise insufficiently protected by law.

While health care, proper nutrition, and expertise all play a role in successful breeding of endangered species, the zoo environment may also be an important influence. At Woodland Park Zoo in Seattle, Washington, the zoo environment is being examined as part of an ongoing research effort to discover factors which affect the potential for breeding captive snow leopards. This paper examines one aspect of that research: testing the effects of geographic situation on the timing of snow leopard births and the ♀ snow leopard's oestrus cycle.

The natural range of the snow leopard is thought to include the high mountain regions of Central Asia: Northwest China, Tibet, the Himalayas, and the Tien Shan. Few observations of snow leopards in the wild have been recorded; therefore, exact local conditions in their habitat are not fully known.

Two statements by Soviet scientists (Marma and Yunchis) at the Kaunas Zoo seem to suggest an intriguing link between the natural environment of the snow leopard and the zoo situation:

The head and body length of the snow leopard is usually between 1.0 and 1.5 m, with a tail length that is between 75 and 90% of the head and body length. Sexual dimorphism has been seen in captive snow leopards with the ♂ usually having a larger head and body than the ♀. Weight varies between 25 and 41 kg. The hair is thick and long, and there is a molt in the spring and fall, with the hair becoming shorter in length during the summer. Black dots and large rings, or rosettes, appear on the sides and flanks, with a base color of white, grey, or yellowish cast. The underside is white or light in color (see Fig. 1).

Photoperiod, or day length, is considered to be one of the most important variables influencing the reproduction of mammals and birds. These reproductive patterns involve endogenous rhythms and a response to geophysical changes.

For example, the *Canidae*, another carnivore family, are typically seasonal breeders and have one litter a year (the domestic dog being the exception, usually having 2 heat periods in one year). In temperate regions the main breeding season is in the winter, with births in early spring [5]. Most *Canidae* are monoestrous, in contrast to the *Felidae* which are seasonally polyestrous in temperate regions and completely polyestrous in tropical regions. There is no known cat species which is monoestrous.

Table 1. Locations used in sample

City/Zoo	Latitude[1]	Altitude (ft.)	Frost[2]	Number of events[3]
San Antonio	29.41	650.0	95.0	1
San Diego	32.71	20.0	30.0	5
Dallas	32.75	435.0	84.0	1
Los Angeles	34.05	340.0	32.0	3
Oklahoma City	35.45	1195.0	116.0	5
San Francisco	37.75	65.0	30.0	3
St. Louis	38.65	535.0	120.0	5
Washington D. C.	38.85	25.0	105.0	2
Cincinnati	39.13	550.0	135.0	3
New York	40.75	55.0	105.0	3
Chicago[4]	41.81	595.0	135.0	15
(Chicago & Brookfield)				
Milwaukee	43.03	635.0	167.0	1
Seattle	47.62	100.0	121.0	2
Calgary	51.05	3557.0	141.0	2
London	51.51	149.0	32.0	2
Krefeld (Ger.)	51.58	125.0	88.0	3
Amsterdam	52.38	5.0	70.0	2
Kaunas (Lith. SSR)	54.86	246.0	125.0	6
Copenhagen[4]	55.66	16.0	100.0	2
Moscow	55.75	548.0	167.0	1
			total	67

[1] Minutes are indicated as a percentage of one degree.

[2] Frost equals the mean last day of 0 °C or below temperature in the spring where January 1 = 1, December 31 = 365.

[3] Event is a snow leopard litter birth where January 1 = 1, December 31 = 365, and an adjustment made for leap years. The number indicates how many events occurred at the zoo during the period covered by the sample. Most births occur during May and June. A complete data list of the 67 events can be supplied upon request.

[4] In the sample of 65, an event with a value of 268 was deleted from the Chicago group, and an event with a value of 46 from the Copenhagen.

"The time of year of oestrus is not always the same. This is probably an effect of captivity." and "A further hazard is that snow leopards do not do well in low altitude zoos." [1]

If zoo location does have an impact on the general health and seasonal cycle of the snow leopard, then perhaps zoos with "negative" locational factors, such as low altitude situations, should reconsider attempts to maintain breeding stocks.

Characteristics and Reproduction

The snow leopard is classified in the Order *Carnivora*, Family *Felidae*, and Subfamily *Pantherinae*. The genus classification is in some doubt as there are two current name combinations: *Panthera uncia* and *Uncia uncia*. The genus *Uncia* includes only the one species *Uncia uncia* (Grey 1867).

Morphological characteristics, especially those found in the cranial region, indicate some differences between the snow leopard and the other big cats, *Pantherinae*, including leopards, jaguars, lions, and tigers. These distinctive characteristics include: (1) the general shape of the skull, which is relatively short and broad, and (2) a wide expansion of the nasal cavity, which could be an adaptation to the harsh mountainous environment by permitting a greater intake of oxygen with each breath.

Differences in behavioral characteristics should also be noted. The snow leopard in captivity has shown a marked tendency for social contact between ♂ and ♀ and a low incidence of aggressive behavior [3]. There have been several instances where both ♂ and ♀ in captivity have taken an active role in the rearing of the young and resident pairs have been seen in the wild [4]. This has not been observed in the spotted leopard, *Panthera pardus*.

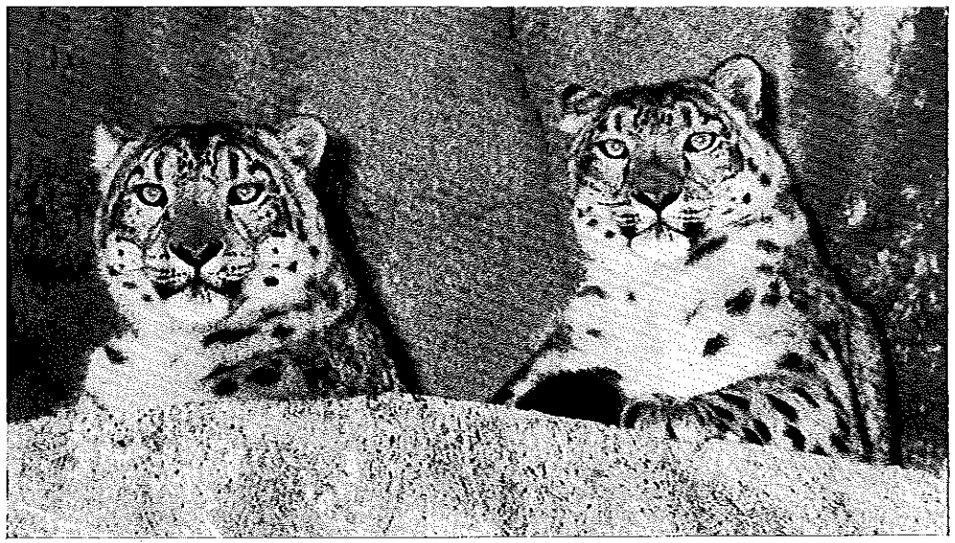

Fig. 1. These adult snow leopards, "*Nicholas*" and "*Alexandra*", were wild-caught in USSR in 1971 and arrived at Woodland Park Zoo, Seattle, WA, USA, in 1972. Photo: Joy Spurr

The sample range for the captive snow leopard births shown in Table 1 is large, from 29° north latitude (San Antonio Zoo) to 55° north latitude (Moscow Zoo). This approximates the natural range, which is roughly 27° to 50° latitude.

These data indicate that snow leopards from zoos in northern latitudes tend to have litters slightly earlier in the year, suggesting that photoperiod may function to some extent as a "zeitgeber" or trigger for the onset of oestrus and reproductive behavior. Data tests, however, showed that its influence is not the major component in the reproductive biology of captive snow leopards.

Reproductive behavior has not been observed in the wild. In captivity, copulation has been observed in the ventral/dorsal position. At Seattle, the ♀♀ turned their heads to look back at the ♂♂. The ♂ grasped the ♀ with a bite to the back or nape of the neck while she was down on all four legs in a squat or crouch position, rear haunches elevated and the tail turned to one side. Following copulation, the ♀ exhibited rolling behavior, rubbing her back against the ground. The adult ♂ gave a high piercing vocalization while thrusting, but this was not heard from the young inexperienced ♂. No aggressiveness has been observed, prior or following copulation. In other cat species, the ♀ may meet the initial advances of the ♂ with attack behavior, such as spitting and striking out at him with her claws. After acceptance and copulation she may still show some form of aggression by turning and striking at the male.

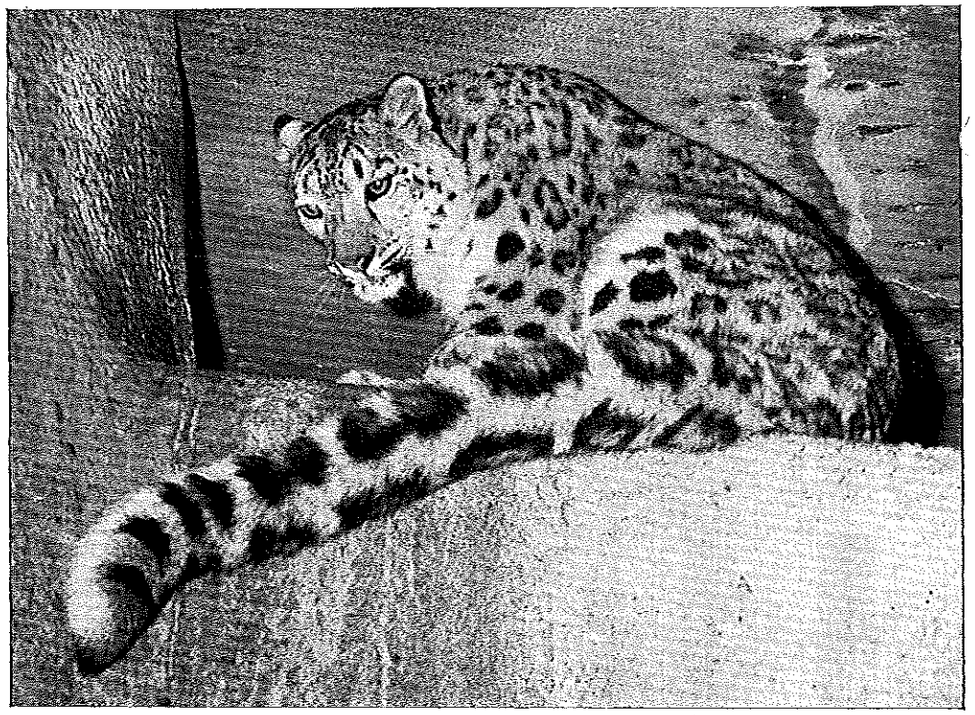

Fig. 2. "*Alexandra*", the adult ♀, curling up to rest on one of the high ledges which she prefers. Photo: Joy Spurr

Table 2. Data test results

Trial	Sample Size	Simple Correlation Coefficient			Multiple Correlation Coefficient
		lat.	alt.	frost	
A	67	.267	.052	.090	.274
A (frost deleted)					.272
A_1 (< 50° N)	49	.096	.110	.092	.245
A_1 (frost deleted)					.146
A_2 (> 50° N)	18	.386	.050	.089	.541
A_2 (frost deleted)					.404
B	65	.228	.007	.177	.262
B (frost deleted)					.228
B_1 (< 50° N)	48	.198	.096	.190	.324
B_1 (frost deleted)					.220
B_2 (> 50° N)	17	.259	.037	.139	.371
B_2 (frost deleted)					.300
		Latitude	Altitude	Frost	Birth Date
Trial A					
Mean		42.61	485.49	103.37	147.11
Standard Deviation		7.45	633.21	40.16	31.67
Trial B					
Mean		42.42	491.03	102.90	146.8
Standard Deviation		7.39	640.17	40.59	25.42

Breeding is the most seasonal in felids in the higher latitudes, and this is of particular importance in the reproductive pattern of the snow leopard. The mating season for ♀ snow leopards is generally the end of winter (December through February), followed by a gestation period of 98—103 days. As illustrated in Tab. 2, the majority of captive births is in the spring, in contrast to the evidence suggested by Marma and Yunchis. This does indicate a difference from the other cats, such as the jaguar, whose breeding patterns have been changed in captivity [6].

From Table 1

Feet	Meters
650	198.12
20	6.10
435	132.59
340	103.63
1195	364.24
65	19.81
535	163.07
25	7.62
550	167.64
55	16.76
595	181.36
635	193.55
100	30.48
3557	1084.17
149	45.42
125	38.10
5	1.52
246	74.98
16	4.88
548	167.03

From Table 2

Feet	Meters
485.49	147.98
633.21	193.00
491.03	149.67
640.17	195.12

Testing Locational Influences

The basic question considered was: do locational factors affect the cycle of the ♀ snow leopard, and therefore, influence the birth dates of litters? If the hypothesis that no relationship exists between location of zoos and the dates of snow leopard births could be substantiated, then one could assume that the ♀'s cycle was endogenous. To test this hypothesis, 3 independent variables were defined: zoo altitude, latitude, and the mean last day of 0 °C or below temperature in the spring. This last variable was coded "Frost" in the programs and measured progressively where January 1 equalled a value of 1. The altitude variable was chosen in response to the Soviet statement noted above. The second variable, latitude, was a measure of responsiveness to photoperiod, and the third was chosen as an indicator of climatic conditions. All 3 independent variables were suspected to be important components of the snow leopard's natural environment and apparent influences on the timing of vertical migration in high mountain areas. The dependent variable chosen was the date of birth of snow leopard litters, where January 1 equalled a value of 1, with dates progressing numerically and leap years taken into account. Since the gestation period is known, the birth dates would be indicators of oestrus cycle timing, with a higher numerical value pointing to a later birth event and therefore, later cycling.

Data collection was accomplished through a literature search, using the International Zoo Yearbook, the snow leopard stud book, and standard geographical texts. Personal correspondence with other zoos supplied some data. One data problem was the use of city elevations to approximate zoo altitude, an unsatisfactory method given the variability of zoo location within an urban area.

Eventually, a sample size of 67 birth events in 20 zoos in North America, Europe, and the USSR was obtained (see Table 1). This represents a substantial share of the total population of zoos having snow leopards. There were no events recorded from southern hemisphere zoos, although their inclusion would be useful for comparison in future studies. The BMDO3R, Multiple Regression with Case Combinations program developed by the UCLA Health Sciences Computing Facility was employed, with a secondary BMDO2R program run as a check and to obtain a plot of residuals against the separate independent variables. The sample of 67 was broken down into 2 subsamples, with 50° N latitude chosen as an arbitrary breaking point. Tests were also run deleting the Frost variable to select out any cross-correlations with altitude or latitude. Finally, the whole process was repeated with a sample size of 65, removing 2 extreme birth cases.

Conclusions and Suggestions for Future Work

Table 2 presents the results of the data tests. No strong relationships emerged, either in simple correlation of the 3 independent variables individually against birth dates, or in multiple correlations using all 4 variables simultaneously. In each trial, latitude not only showed a slight inverse relationship with birth dates, but also proved more influential than either altitude or Frost. This consistent, though very weak, inverse relationship suggests earlier births with higher latitude and with more variable photoperiod.

However, none of the relationships appeared well developed, and the test outcomes seemed to support the hypothesis. Therefore, there is good basis for belief that the ♀'s cycle is endogenous and that zoo location has little effect on oestrus timing.

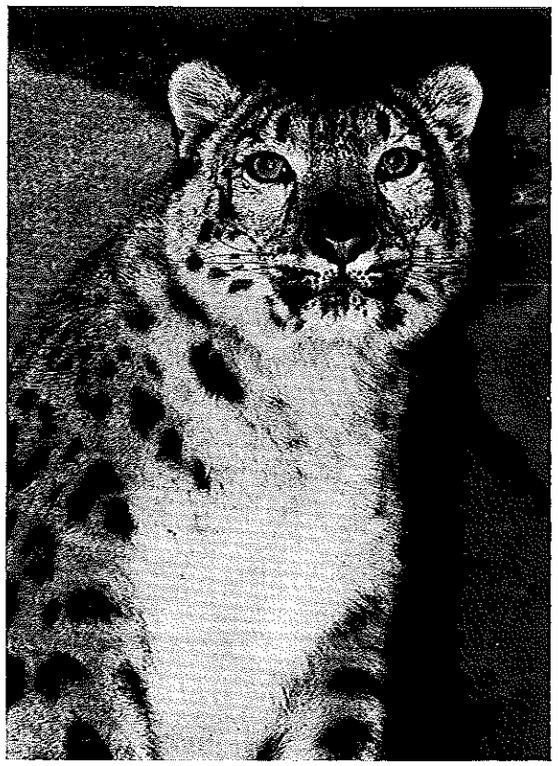

Fig. 3. ♀ adult snow leopard in alert posture. Photo: Joy Spurr

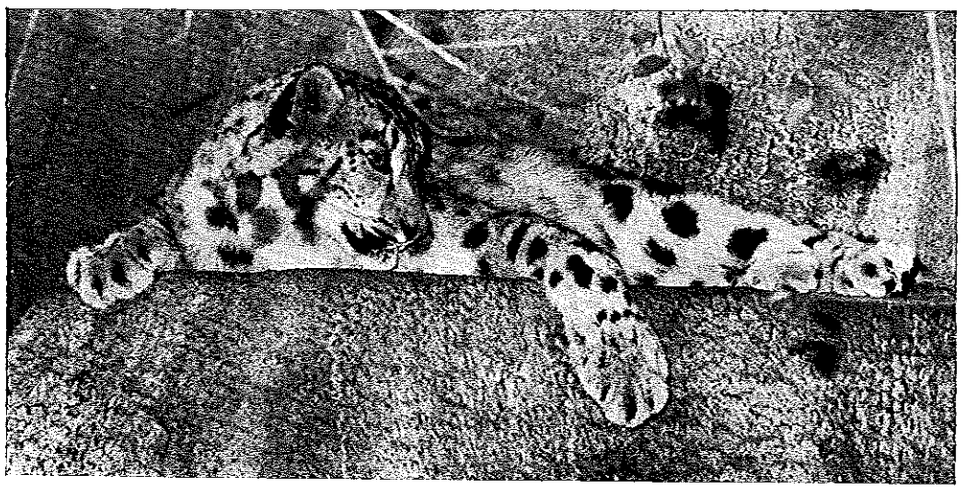

Fig. 4. ♂ cub, "*Rimsky*", at one year of ago. He was born at Woodland Park Zoo in May, 1974. Photo: Joy Spurr

[4] Ullrich, W., and Tylinek, E. and I. (1972): Endangered Species. New York, 28—30. —Also see: Sitwell, N. (1972): The Snow Leopard in Pakistan. Animals 14, No. 6, 256—259. Also: Freeman, op. cit.
[5] Ewer, R. F. (1973): The Carnivores, Ithaca.
[6] Asdell, S. A. (1964): Patterns of Mammalian Reproduction. Ithaca.

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This research is only the beginning of exploratory work on envorinmental factors that may affect snow leopard reproductive behavior. In this case, the oestrous cycle was chosen as a test variable, but breeding activity could also be represented by rate of natural growth of a zoo's snow leopard colony, infant mortality, differential sex survival, or size of litter. At Woodland Park Zoo, there is considerable interest in examining the factor of cub-rearing by the mother. The breeding ♀ at the Woodland Park Zoo presents a not uncommon case of a mother becoming nervous during parturition and rejecting her own cub. This lack of proper maternal behavior resulted in zoo authorities having to remove the cubs born during the past 2 years and hand-rearing them. The ♀ became pregnant again in 1975 and was provided the choice of two maternity dens directly off her large outside enclosure. The dens were equipped with closed circuit television cameras so she could be monitored without any human disturbance. A litter of 3 cubs was born, and then successfully mother-raised, indicating the changes made by by Zoo management enabled the ♀ to now feel secure and relaxed.

While the research presented in this paper covered some external environmental influences on breeding behavior, internal environmental factors also bear examination. These internal environmental conditions include spatial arrangements and environmental stimuli within the enclosure such as vegetation, play objects, and cage size. In the case of cub-rearing by the mother mentioned above, the availability of alternate den sites away from the main cage and the public may prove to be an important influence on the behavior of the pregnant ♀. Data is currently being collected from world zoos to examine some of these internal variables and their possible impacts on reproductive behavior.

Ethologists believe that it is necessary to study an animal in its natural habitat in order to establish a baseline or ethogram of behavior. However, with the snow leopard, there are few observations from the wild to substantiate the conclusions of this research on captive snow leopards. By comparing the data from a number of zoos, a normal sub-set of behaviors can be developed and then tested against independent variables. Zoo locations may yet prove to be a factor in the successful propagation of these large cats.

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References

[1] Marma, B. B., and Yunchis, U. U. (1968): Observations on the Breeding, Management, and Physiology of Snow Leopards. Internat. Zoo Yearbook. 8, 66—70.

[2] Hemmer, H. (1972): *Uncia uncia* Mammalian Species, American Soc. Mammalog., No. 20, 1—5.

[3] Freeman, H. (1975): The Breeding and Behavior of the Captive Snow Leopard. In: The Worlds Cats (in press).