Int. Zoo Yb. (1997) **35:** 139–147

Management and husbandry of the Snow leopard

Uncia uncia†

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The international studbook for the Snow leopard *Uncia uncia* was established in 1976. The species has been the focus of intensive captive management and as at 1 January 1992 541 animals were maintained at 160 collections. This paper gives an overview of the diet, housing, breeding and captive management of the species with specific reference to animals maintained in North American collections. A summary of veterinary care reported in the Snow leopard captive-management survey is also given.

Key-words: breeding, enclosures, husbandry, medical, nutrition, snow leopard, veterinary care, zoo

The first record of a Snow leopard *Uncia uncia* in captivity was in 1891 when London Zoo acquired an animal from Bhutan (Godman, 1891; Sclater, 1896). In 1894 a ♂ Snow leopard was imported to London Zoo (Flower, 1894) and by 1903 New York, Berlin and Moscow were also exhibiting the species (Anon., 1903; Peel, 1903). The first recorded birth in captivity was in 1906 at Hamburg (Rieger, 1982). Births were also recorded in 1912 at Leipzig and 1938 at Dresden (Crandall, 1964). However, it was only in the 1950s that standard management protocols for Snow leopards began to be established. It was not until a wild-caught pair at Copenhagen began breeding in the 1950s that cubs survived long enough to breed (Crandall, 1964).

Some institutions have had particular success with the species: to date Helsinki Zoo has recorded 70 births and NY Bronx has recorded 69 births. Between 1961 and 1991 the number of collections maintaining the species increased from ten to 160 and as at 1 January 1992 the captive population was 541 (Blomqvist, 1995). Most of these animals are part of scientifically managed programmes, such as the SSP and EEP, which aim to maintain stable and self-sustaining populations in both number of animals and genetic variation. The captive population may act as a 'reserve' gene pool in case of natural disasters in the wild (Wharton & Freeman, 1988).

DIET

Before the development of commercial diets Snow leopards were fed on a basic diet of horse meat to which small, whole animals were added. In the 1940s a Snow leopard kept at New York was fed 1·8 kg horse meat five or six times a week which was supplemented twice a week with bone meal and cod liver oil. Once per week, kidneys (0·5 kg) and liver (1 kg) were fed instead of muscle meat. This diet was not followed rigidly and fowl or pigeon were also offered two or three times each week (Crandall, 1964). At St Louis Zoo a pregnant or lactating ♀ was fed freshly killed rabbits, pigeons and chickens in addition to horse meat (Frueh, 1968). At Helsinki Zoo the early diet included horse meat supplemented with vitamins A and D. Newly weaned cubs were fed day-old chicks, freshly killed rabbits and milk sup-

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† This article first appeared as: Wharton, D. & Mainka, S. A. (1994): Captive management of the snow leopard (*Panthera uncia*). In *Proceedings of the seventh international snow leopard symposium:* 135–147. Fox, J. L. & Du Jizeng (Eds). Chicago: International Snow Leopard Trust, Chicago Zoological Society.

plemented with egg yolk and vitamins A and D (Koivisto *et al.*, 1977). It is now known that excessive amounts of vitamin A supplement can cause liver damage and the addition of this vitamin to the diet is not recommended unless it is prescribed by a veterinarian and the dosage is carefully monitored.

In North America most zoos feed a commercial feline diet which consists of ground beef or horse meat and vitamin and mineral supplements. The diet is varied to avoid monotony and bones are provided to promote healthy teeth and gums. Each week at NY Bronx each animal is fed 1·5 kg commercial feline or carnivore diet for 5 days and 1·5 kg chicken backs and beef knuckle bones for 2 days. Although vitamin supplements are not necessary with a properly balanced commercial diet, cubs up to 6 months old are given *c.* 0·20 litres of Kitten Milk Replacer (KMR) and 5 g calcium daily. Some zoos feed their own diet; for example, at Philadelphia Zoo each animal is fed 1·5 kg of solid and ground horse meat for 6 days and a whole chicken on 1 day a week. To each 2·2 kg of solid horse meat, 5 g of mineral mix is added consisting of 10 parts oyster shell flour, nine parts skimmed milk powder and one part iodized salt (Rosenthal & Ott-Joslin, 1988).

Fresh water should be provided *ad libitum.* The Nelson or automatically filled water dish is frequently used in North America.

HOUSING AND SOCIAL MANAGEMENT

In North America outdoor enclosures range in size from *c.* 25 to 190 m^2. Indoor enclosures are usually smaller and range from 6 to 50 m^2 (Rieger, 1978; Rosenthal & Ott-Joslin, 1988). Although large enclosures are preferable, smaller areas can be textured and enriched. Rockwork, logs and platforms allow the animal to take advantage of vertical space and Snow leopards will actively move to different levels in an enclosure and rest in elevated areas or on platforms. Floors are traditionally made of poured concrete, however, in more naturalistic enclosures sand, grass or wood mulch substrates are used. Off-exhibit dens are often provided to allow animals privacy and shelter from the elements. Dens can be as small as 2 m^2 but are usually between 4 and 6 m^2. Maternity dens tend to be larger so that they can accommodate nestboxes, which are usually constructed of wood and measure *c.* 2 × 1·5 × 0·25 m high. The nestbox provides a warm and dry environment for the ♀ and her litter, and the wooden floor can offer better traction for the feet and legs of developing cubs. Many animals have access to heated or cooled indoor areas because they are housed in buildings which house different species or are designed for visitor comfort. Snow leopards do not seem to need heated or cooled quarters as long as they have access to shelter in winter and shade and/or pools during hot summers.

The enclosures can be made from a variety of materials, such as non-refelective laminated glass or stainless steel tension wires spaced 5 cm apart which can be used to create large, relatively inexpensive and naturalistic exhibits. A low-voltage electric fence will ensure that the animals do not push against the wire. Because Snow leopards can climb and leap exhibits must be enclosed on all sides and on the top. Landscaping with trees, grass, bushes and rocks enriches the exhibit for the felids and it is easier to inform the public about wildlife conservation if the animals are housed in an environment which is similar to their natural habitat. The 'Himalayan Highlands' exhibit at NY Bronx uses these materials and concepts to excellent advantage. The perimeter of the Himalayan Highlands exhibit is *c.* 1·8 m high and constructed of 5 × 5 cm welded stainless steel wiremesh which is *c.* 2 mm in diameter (Doherty, 1987). A second layer of the same wire can be added if there is concern about the quality or strength of the welding on the wiremesh. The roof is

constructed of *c.* 1 mm diameter stainless steel chicken mesh which is draped over the structure and tied to posts, the weld-mesh and cables. Except where trees grow through the roof, the entire exhibit is enclosed. All wiremesh is oxidized black to make it less visible to the public.

Although Snow leopards are generally considered to be solitary (Jackson, 1987), they can be housed together under certain circumstances, particularly if the enclosure is large and enriched, and the animals were introduced to each other as juveniles. The disadvantage of keeping a pair together at all times is that it is difficult to control breeding. A ♀ will remain compatible with two or even three cubs for several years as long as she does not produce a subsequent litter. At between 24 and 30 months of age ♂ offspring may mate with their dam and they should be removed before this time. Siblings often remain compatible for a number of years. In most cases, ♀ siblings and same age ♀♀ put together as juveniles will be compatible for as long as they are housed together continuously, even into advancing age. Males are less predictable and once they are over 3 years old aggression may start to develop. Three ♂♂ can rarely be housed together past the age of 3 years, although two ♂♂ can be maintained together until they are 5 years old or over (D. Wharton, pers. obs). When animals are compatible they may not need to be separated during feeding (Rieger, 1978).

Although the majority of zoos never introduce an adult ♂ to a ♀ with cubs it is possible to introduce the sire when the cubs are between 5 months and 1 year old (Freeman, 1978). Because of the variable character of ♂♂, the ♂ and the ♀ and cubs should be housed in adjoining enclosures over a period of time prior to introduction. The ♂ and ♀ are then usually given access to each other for short periods for several days before the ♂ is introduced to the ♀ and cubs. The ♀ does not become pregnant while she is housed with cubs from the previous season, even when mating occurs (H. Freeman, pers. comm.). It should be noted that the majority of zoos never introduce an adult ♂ to a ♀ with cubs.

BREEDING

Depending on ♂–♀ compatibility two breeding management techniques have been developed. In order to maintain permanent similar-aged, monogamous pairs the animals should be introduced before they become sexually mature. Once established such pairs need little manipulation. Alternatively, adults can be maintained as solitary animals using a schedule of annual introduction of selected animals prior to oestrus for breeding purposes.

An analysis of studbook data correlating breeding unit size with offspring per individual showed that more cubs are born at institutions which maintain larger numbers of Snow leopards or which have non-monogamous arrangements (Rieger, 1980). Institutions with highly successful breeding programmes, such as NY Bronx, Helsinki, Oklahoma and Chicago LP, do not keep ♂♂ and ♀♀ together continuously (Kitchener *et al.*, 1975; Koivisto *et al.*, 1977; Turner, 1980). The breeding success of monogamous pairs might be increased if the animals are provided with some sort of sensory contact with conspecifics. However, monogamous pairs are often the only Snow leopards at a facility.

Compatibility for mating is not a significant problem. In many collections animals which are to be paired for breeding are placed in adjoining enclosures in late autumn so that they have olfactory and auditory contact with each other. In December, January or even as late as February, when mutual interest is low, solid doors are replaced with fine mesh doors so that the animals also have visual and tactile contact. As the breeding season approaches mutual interest begins to increase and eventually the door between the dens is opened for between a few minutes and 1 hour each day (usually

in the morning). All pairs are observed but pairs that have not mated with each other previously are watched more closely. During introductions the doors to den areas are closed to prevent 'hiding' and the possibility of aggression occurring in an enclosed space out-of-sight of the observers. The door between the two enclosures is left open so that the animals can either stay in familiar surroundings or explore the territory of the potential mate. Water hoses with pressure nozzles are kept close at hand in case of serious fighting. Initially during introduction even animals which have previously mated display some aggressive behaviour, such as slaps, growls and threatening postures, but it is rarely necessary to separate the animals quickly.

At NY Bronx the breeding season begins in mid-February and mating occurs between February and June, inclusive. In 1973 one ♀ had four oestrous periods (Bronx 18), none of which resulted in pregnancy. Another ♀ (Bronx 15) was observed to mate in June in two separate years about 3·5 weeks after giving birth to stillborn cubs. Neither of these matings resulted in litters. There are unpublished reports of post-partum oestrus occurring *c.* 24 days after a birth at other institutions.

Some mounting without copulation may occur 1 or 2 days before oestrus. An introduction period of *c.* 1 hour in which copulation does not occur is usually a sign that full oestrus has not yet begun. Once copulation starts the animals are left together for between 4 and 8 hours per day. Because mating is more frequent at night it has been suggested that induced ovulation might be hampered by non-access to mates at night (Rieger, 1980). However, experience at NY Bronx would suggest that several hours contact during the day is sufficient stimulation for successful mating.

Introductions are carried out every day until mating does not occur on two successive days. Oestrus, as exhibited by copulatory behaviour, lasts from 4 to 8 days but is usually around 5 or 6 days. Rieger (1984) reported a mean oestrous period of 4·4 days.

The animals are often introduced again daily beginning 3 weeks after the first oestrus. These introductions continue for 1 week or until a second oestrus begins, or until it is clear that oestrus will not occur, which may indicate pregnancy. From April no further introductions are made. Dens are prepared at least 1 month before the expected birth date and, where feasible, video cameras are mounted and made operational. Most ♀♀ will show an increase in girth in the last trimester of pregnancy, although a ♀ carrying a single cub may not. Behavioural changes, including increased interest in the nestbox, are often noted a few days before birth. The provision of secluded dens and a choice of more than one nestbox may have contributed to the increase in mother-rearing. Mean litter size is 2·3 cubs and gestation period is *c.* 102 days (D. Wharton, pers. obs). (Doherty & Wharton, 1988.)

POPULATION MANAGEMENT

The Snow leopard has been the subject of intense focus by the American Association of Zoological Parks and Aquariums (now AZA) and its Species Survival Plan (SSP). Initiated in 1984, the Snow leopard SSP now manages over 230 animals in 50 zoos in the USA and Canada. By analysing the captive population according to age, sex and ancestry each animal can be assigned a role in the survival plan. Annual recommendations are issued by the SSP which is comprised of a Species Coordinator and a Propagation Group of nine zoo professionals. The goal is to maintain a stable population, not only in numbers but also in genetic variability as represented by the original wild-caught founders.

It has been estimated that a well-managed captive population of *c.* 230 Snow leopards can maintain nearly 90% of orig-

inal genetic variability for 200 years (Wharton & Freeman, 1988). Because Snow leopards are housed in many institutions there is some protection against sudden losses in the population as a result of disease or natural disaster. Stability is also achieved by reducing breeding in the captive population. Although ten litters are biologically possible it is recommended that most pairs only produce two or, at most, three litters in their lives. Breeding restrictions can help to achieve target genetic representation for each individual. Unless breeding is restricted the population might increase so rapidly that facilities would run out of space, thus breeding would have to be stopped and entire age classes would be missing from the population. This would not only affect the Snow leopard population but it would also deprive other large cat SSPs of much-needed space. It has been estimated that only 25–30 cubs per year are needed to achieve population stability in North America (Wharton & Freeman, 1988).

PREVENTATIVE MEDICINE

Quarantine When transferred to a different institution all Snow leopards should undergo a routine minimum 30 day quarantine period during which baseline data on each animal should be collected and health status should be assessed. Medical history details would be beneficial and should be requested before shipment. Recommended tests include: (1) CBC and serum biochemistry; (2) serology to check for antibodies to feline leukaemia (FeLV), feline immunodeficiency virus (FIV) and feline infectious peritonitis (FIP); (3) parasitology to check for endoparasites, ectoparasites and hemoparasites, such as *Haemobartonella* sp. It is generally recommended that at least two negative faecal samples, at least 1 week apart, should be obtained prior to releasing the animal from quarantine. If the cat has not already been immunized it should be vaccinated (using a killed vaccine) against feline diseases including feline respiratory viruses, feline panleucopaenia and rabies.

Vaccination All institutions participating in the Snow leopard captive-management survey (Rosenthal & Ott-Joslin, 1988) vaccinated Snow leopards for feline panleucopaenia and upper respiratory tract viruses. Rabies immunization was carried out at 18% of participating zoos and vaccines for leptospirosis, tetanus and feline leukaemia were used at one zoo each. Vaccination protocols for neonates begin at between 4 and 8 weeks of age and continue for 12 to 16 weeks at intervals of *c.* 3 weeks, followed by an annual booster vaccination. No side effects to vaccination were reported.

Parasite checks If parasites are detected the animal should be treated while in quarantine, before it comes into contact with other felids in the collection. More than 80% of institutions participating in the survey had identified ascarid parasites in their animals. Other parasites included coccidia, fleas, ear mites and sporadic incidence of strongyles, lungworm, demodex and sarcoptid mites, giardia and hookworm. Fenbendazole was the most commonly used anthelmintic followed closely by mebendazole, pyrantel pamoate and ivermectin. Other agents which have been used include piperazine, levamisole, thiabendazole and lime sulphur. Many institutions commented that in the case of ascarid infections, medications could control but not eradicate the parasite.

Routine veterinary care for Snow leopards is similar to that for other exotic felids and is described by Fowler (1986). Regular parasitology screening and vaccination will help to maintain the health of the animals. Opportunistic collection of samples, such as serum, will be beneficial to ongoing research into Snow leopard diseases.

Anaesthesia Ketamine with or without xylazine has been used routinely to anaes-

thetize Snow leopards (Jalanka, 1989a). Medetomidine and its reversal agent atipamezole has also been used (Jalanka, 1989b). Inhalation anaesthesia has been used routinely for surgery although in one case the animal exhibited a persistent hypercapnia, possibly related to poor ventilation during the procedure (Mainka, 1988).

All institutions participating in the survey used ketamine for immobilization and 50% combined ketamine with diazepam or xylazine. Premedications used by *c.* 15% of responding zoos included acepromazine, diazepam and atropine. Three institutions used tiletamine-zolazepam. The most commonly used inhalation anaesthetic was isoflurane followed by halothane. Yohimbine has been used as an antagonist in Snow leopards. (Table 1.)

Problems related to anaesthesia include seizures/rigidity, vomiting and excess salivation. Most animals were fully recovered within 2–3 hours of immobilization.

MEDICAL

Common health problems reported in the survey include: (1) hip dysplasia. Fourteen zoos reported Snow leopards with some evidence of hip dysplasia, seven of which were classified as moderate to severe. An animal with severe hip dysplasia needed total hip replacement before being able to breed (Mainka, 1988); (2) ringworm; (3) chronic renal disease. Snow leopards appear to be subject to all or most of the diseases that affect other felids, such as canine distemper (Fix *et al.*, 1989) and *Scopulariopsis brumptii* (Calle *et al.*, 1989). Hepatitis is also common in this species (Munson & Worley, 1991). Two Snow leopards in North America have tested positive for FIV (Barr *et al.*, 1989). Specific reports on parasitic infections include cases of demodicosis (Fletcher, 1980) and cuterebrosis (Ryan *et al.*, 1990). A comparison of pyrantel embonate and ivermectin suggests that both are effective anthelmintics, however, ivermectin had longer-lasting effects (Jalanka & Vane-Tempest, 1990). As with other felids the use of organophosphate anthelmintics should be avoided.

ANAESTHETIC	MEAN DOSE (mg/kg)	DOSE RANGE (mg/kg)
Ketamine	9·7–12·4	5–20
Xylazine	0·66–1·2	0·2–2
Tiletamine-zolazepam	2	
Acepromazine	1–2·2	
Atropine	0·04	
Diazepam	5·5–7·5	2–10
Yohimbine	0·14	

Table 1. Anaesthetics used for Snow leopards *Uncia Uncia* from captive-management survey summary (Rosenthal & Ott-Joslin, 1988).

Other cases reported in the literature include: a developmental abnormality, ununited anconeal processes identified in an infant that was being hand-reared (siblings were all healthy) (Mainka, 1986); mandibular osteomyelitis (Karesh & Asterino, 1988); ingrown claws; self trauma; infected anal sacs; foot pad ulcers; cataracts; inherited ocular coloboma has been detected in a bloodline in Europe (Gripenburg *et al.*, 1985) and two institutions participating in the Snow leopard captive-management survey reported occurrence of ocular coloboma in their collections; one case of ovarian dysgerminoma (Karesh & Russell, 1988); labyrinthitis in cubs (Fowler, 1986); bladder diverticulum and ascites in a ♀ (Isenbügel & Weilenmann, 1988).

Necropsy reports include seven cases of neoplasma (four of which were squamous cell and carcinoma), nine cases of parasites and one report of death as a result of trauma caused by another animal. (Table 2.)

REPRODUCTION AND VETERINARY CARE

Standard protocols for neonates, such as prophylactic antibiotics, disinfection of the umbilicus, vitamin and mineral supplements, should be used. Vaccination

ORGAN SYSTEM	NO. CASES	ANIMALS < 1 YEAR OLD
Gastro-intestinal	22[1]	13
Respiratory	15	9
Genito-urinary	11	
Musculo-skeletal	5	1
Cardiac	5	1
Reticulo-endothelial	3	1
Central nervous system	2	1
Endocrine	2	
Integument	1	

[1]Seventeen cases of gastro-intestinal disease involve liver conditions of which eight were diagnosed in animals under 1 year old.

Table 2. A summary of pathology reports for Snow leopards (including 50 necropsy reports) from the captive-management survey summary (Rosenthal & Ott-Joslin, 1988).

schedules usually begin when cubs are 6 weeks old with immunization for feline respiratory diseases and feline distemper.

Although rare, inability to deliver cubs does occur in Snow leopards and has resulted in the death of a ♀ on at least one occasion (Blomqvist, 1978). Caesarean sections have been performed successfully and a ♀ at Calgary Zoo required repeated Caesarean sections to deliver several full term litters safely. Cubs delivered by Caesarean section are always hand-reared.

HAND-REARING

Most cubs born in North America in the last 15 years have been mother-reared. When hand-rearing is necessary, both milk replacer (Esbilac) and domestic cat's milk replacer (KMR) can be used with good success. Cubs should be fed at least five times per day for the first 10 days (Koivisto *et al.,* 1977; Brunstein, 1978). Cubs should be maintained at a relatively low temperature (21–23°C) to prevent hair loss. Bedding material should be changed often because of the copius amounts of urine produced by cubs of this species (Frueh, 1968; Brunstein, 1978). Hand-rearing is necessary if the ♀ demonstrates certain behaviours, such as continual neglect of the cubs and the nestbox soon after the birth has occurred, carrying the cub(s) around the enclosure and/or leaving them outside (Freeman & Hutchins, 1978).

Although not specifically recorded in Snow leopards, progestogen implants have been associated with an increased incidence of mammary adenocarcinoma, uterine leiomyoma and mammary hyperplasia in many felid species (Raphael, 1990; Munson & Mason, 1991). As of 1992, virtually all of the ♀ Snow leopards in the North American SSP program that have had progestogen implants (>20) have become pregnant once the implant has been removed. In most cases the implant was left in place for 3 years or less.

ACKNOWLEDGEMENTS

We wish to thank James Doherty and Ellen Dierenfeld for their comments and guidance in preparing this paper.

PRODUCT MENTIONED IN THE TEXT

Nelson water dish: Nasco, 901 Janesville Avenue, Fort Atkinson, WI 53538-0901, USA.

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Manuscript submitted 27 November 1995

Int. Zoo Yb. (1997) **35:** 147–152

Developing a regional collection plan for felids in North America

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In 1988 an analysis of inventory information indicated that over 4332 felids were being maintained at ISIS-member zoos world-wide. Many animals were of unknown genetic provenance and of the species that were well represented, most were large cats already managed by studbooks and SSP-type programmes. The Felid TAG developed a North American regional collection plan which recommended that AZA-member zoos conserve threatened species through a nationally co-ordinated management plan while meeting institutional, exhibit and financial needs. The TAG also encouraged AZA zoos to support conservation programmes in other regions and *in situ* projects. The selection of species for conservation action involved a realistic assessment of founder population size and specimen availability. The plan is flexible and open to change as new information becomes available. In 1995 the number of 'spaces' occupied by managed and unmanaged felid species was analysed and a 5 year plan was prepared with separate collection plans for large and small felids.

Key-words: Felid TAG, felids, SSP

Cats are traditionally a popular exhibit species. In 1988 an analysis of inventory information reported to ISIS indicated that felids were 'safe' because they were abundant in captivity and reproducing frequently (ISIS, 1988). According to the inventory over 4332 felids were being maintained at ISIS-member zoos. Most of these felids (>75%) were reported by North American collections and an equal number was probably being held at zoos in other regions and at private institutions (Shoemaker, 1990). This seemingly large population gave a false sense of security because many of the animals were of unknown genetic provenance. Only a few species were well represented but all of these were large cats which were already managed by regional and/or international studbooks and co-ordinated management programmes (Species Survival Plan (SSP)), including Tiger *Panthera tigris,* Lion *Panthera leo,* Leopard *Panthera pardus,* Snow leopard *Uncia uncia,* Clouded leopard *Neofelis nebulosa* and Cheetah *Acinonyx jubatus.* Only 1136 animals *(c.* 26%) could be defined loosely as small cats, of which Northern lynx *Lynx lynx,* Canadian lynx *Lynx canadensis,* Bobcat *Lynx rufus,* Caracal *Caracal caracal,* Puma *Puma concolor* and Serval *Leptailurus serval* were of little con-