Terrestrial Ecology and Behaviour
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 66 (3), 2014: 365-371

Behaviour of Eurasian Lynx, *Lynx lynx* (L.), in Captivity during the Breeding Season

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Abstract: Current studies on Eurasian lynx (*Lynx lynx*) in the wild rarely include behavioural traits of this species. Moreover, being a cryptic species, its behaviour is very difficult to be studied in the wild. In order to record and analyse the lynx behaviour during the breeding season, a cameratrap was put in a lynx enclosure in Sofia Zoo for 64 days to follow the reproductive period of the lynx pair. A total of 2972 video clips were collected and analysed in order to define the frequency and duration of the social/ non-social behaviour, the influence of the temperature, time of the day and the moon phase. The analysis of behavioural acts, 28 non-social and 20 social, showed a high frequency of the social behaviour during the day. There was no significant difference between the number of exhibited behavioural acts in males and females, although the male showed more pronounced marking behaviour, mating calls and approaches to the female. Totally, 29 acts of head-tossing were observed as part of the lynx courtship behaviour. Six copulations were also recorded, followed by successful pregnancy and birth.

Key words: *Lynx lynx*, breeding behaviour, cameratrap, captivity

Introduction

The large carnivores in Europe have been severely persecuted for many centuries, although they have a positive balance and sanitary role in ecosystems. This persecution is still happening in many countries, which brought the bear, wolf and the lynx to the verge of extinction in vast part of the continent. In many western countries in Europe the large carnivores are more or less totally extinct (Kaczensky *et al.* 2013). In Bulgaria, the most affected was the lynx, which was extinct from the country from the early 1940s (Atanasov 1968, Spiridovov, Spassov 1985). Today due to a number of socio-economic and ecological processes, the species is recovering back to the country (Spassov *et al.* 2006, Spassov 2007, Zlatanova *et al*. 2009, Kaczensky *et al.* 2013) but its survival is uncertain.

One of the key elements of the successful conservation of the lynx is the comprehensive knowledge about the species biology and behaviour in nature, especially the aspects of reproduction. Because of its early extinction from Bulgaria and its secretive way of life, little is known in the country (and even on European scale) about lynx natural traits of behaviour during vulnerable periods such as the breeding season and raising cubs.

The publication review worldwide shows that even the monographs on the species (Matjuschkin 1978, Leyhausen 1979, Kos *et. al*. 2004) do not present sufficiently detailed data on the lynx breeding behavior. A few papers (Kvam 1991, Stehlík 2000, Henriksen *et. al*. 2005, Nilsen *et. al*. 2012) deal only with reproductive biology (litter size, maturity age, reproductive and fertility rates, time of birth, sex ratio, etc.) but quantitative or qualitative analyses of behavioural sequences are hardly made. Only one paper (Stehlík 1983) describes some behavioural displays as a part of the lynx reproductive behaviour but with no attempt of quantification. Schmidt

(1999) made an attempt to analyse the patterns of the lynx daily activity via radio-telemetry but he also did not present any description of the behavioural sequences or ethogram.

The study of the lynx breeding behaviour in nature even with distance methods is hardly possible. This is due to the lynx shy behaviour and very well developed senses leading to total avoidance of humans, unlike the other two opportunistic large carnivores – the bear and the wolf. Thus, the observation of the lynx behaviour in captivity is a valuable opportunity for acquiring important data on behavioural traits, especially during the breeding season, which is critical for its population survival (Stehlík 1999, Breitenmoser *et al.* 2000, Festa-Bianchet *et al.* 2003).

The aim of the present study is to gain more insights in attempt to fill a gap in the knowledge on lynx behaviour and time budget of the lynx pair during the reproductive season. Although the data are collected in captivity and on only one pair, they could provide a baseline overview of the most typical types of behaviour expressed within the mating time and better understanding of amount of time the animals spend together and their courtship rituals.

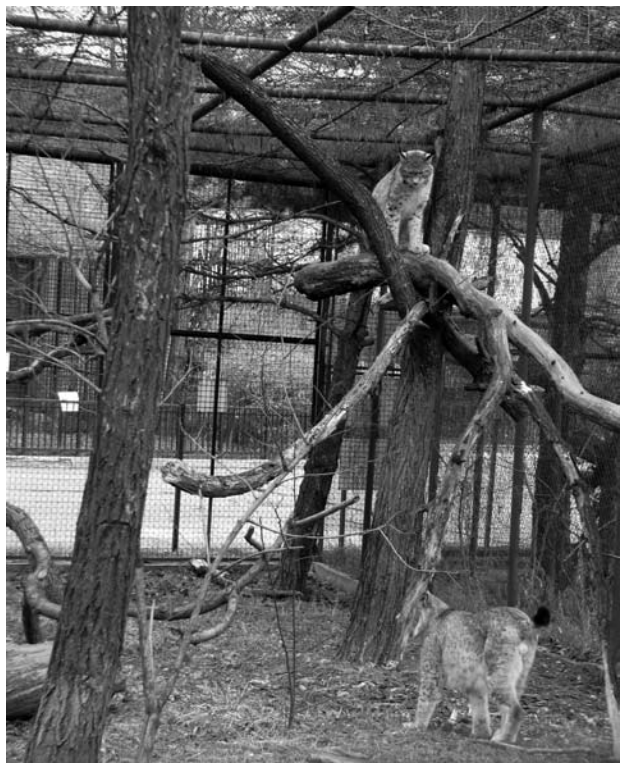

Fig. 1. The lynx enclosure and studied specimens (top – female, bottom – male)

Material and Methods

The study was conducted in Sofia Zoo on two (male and female) adult captive born individuals that were put together for breeding purposes within the breeding period (from 17.02.2009 to 21.04.2009, 64 days). During the time of the study, the male was around 7 years old and the female – around 6 years old. The animals were previously housed separately in adjacent enclosures with a size of 5 x 15 m, and a height of 4 m. The animals could see, hear and smell each other. The enclosures were covered with natural substrate (soil and grass), with several tall pine trees and equipped with additional logs and trunks for climbing and hiding (Fig. 1). There were two additional inside chambers (one per each animal) which were used to isolate the animals during keepers' routines. During the breeding season, the enclosures were connected and free for the animals to use *ad libitum*.

For collection of data one passive sensor cameratrap Moultie Game Spy I-40 (4.0 MPx with infrared flash) was used. The device was put in the enclosure of the female, which was mostly used by the animals (Fig. 2). The animals had equal opportunity to inhabit both enclosures so we worked under the hypothesis that the recorded by the cameratrap behaviours represent exhaustive part of their overall behaviour and time budget. The cameratrap was set on video clip,

Fig. 2. The location of the cameratrap within the lynx enclosure

30 seconds/per recording event during the day and 5 seconds/ per recording event during the night. The interval between clips was set on 1 min and the flash could light up to 15 m distance. Each of the video clips was followed by a photo, representing the last frame of the video clip and containing info-strip with the date and time of the video clip event, ambient temperature, moon phase and camera ID (Fig. 3).

The total number of the video clips for the study

Fig. 3. Cameratrap photo sample with info strip

period was 2972, from which 46.1% night clips (n =1370), 53.4 % day clips (n = 1586) and 0.5 % (n = 16) failures due to cameratrap malfunction. The success rate of the individual registrations (number of video clips recording animal presence) was 90.6 %. The individual identification was not possible in 10.3 % of the video clips (n = 278) due to recording only part of the animal body or a swift movement in front of the camera. The total duration of all video clips was 772 min (46320 sec) while all the clips with recorded animal behaviour had duration 728.28 min (43673 sec).

The recording sequence of the cameratrap correspond to the scan sampling method for studying animal behaviour (Altmann 1973, Mellen *et al.* 1983, Kleiman *et al*. 2010), in which the behavioural state is recorded at a predefined interval, *e.g.* in this case on every minute. Cameratraps are widely used for studying animals' behaviour in nature, especially for cryptic animals, such as the lynx (Claridge *et al*. 2004, O'Connell *et al*. 2011, Zlatanova *et al*. 2009). In the present study, this method and equipment was adapted to a captive study. The advantage of using the cameratrap is that disturbance is likely to be less than would be expected if the researcher is present and observes directly the behaviour (Bridges *et al*. 2004). The method also allows recording behaviour during the night, which is understudied period for many behavioural research projects (McCallum 2012).

All behavioural events were statistically analysed with the program SigmaStat for Windows ver. 3.5 (Systat software, Inc.) against their frequency and according to the time of the day, the temperature and the moon phase.

Results and Discussion

General description of the lynx behaviour

The basic lynx behaviour was formally divided into two major groups (Table 1): Individual or Non-Social behaviour (n = 28) and Social behaviour (n =20). The total number of Non-Social behaviour occurrences was 83.3 % (n = 2248) of all occurrences. Social behaviour seems to occupy less than 20 % of the animals' time when they were together (16.7 %, n = 452). With the beginning of the breeding season (beginning of February) the male showed an increased locomotion activity, rubbing its head against trees and fences, sniffing the ground and marking behaviour, accompanied with a mating call. The female showed less pronounced anxiety, mainly as increased frequencies of marking with urine behaviour and occasional calls. After they were brought together, the female avoided the male for about 24 hours by climbing high up (Fig. 1) or fighting with the male, then she allowed him to approach her. Most of the initial period of 'avoidance' was used by both animals for "studying" and marking the partner's enclosure (sniffing, scraping ground, rubbing against trees and marking)

Frequency and duration of the exhibited behaviour

There is no significant difference between the frequency of behavioural occurrences of the male and female during the study period (Kruskal-Wallis One Way Analysis of Variance on Ranks, H = 0.748, 1 d.f., p = 0.387). In nature, the lynx is predominantly nocturnal (Breitenmoser *et. al.* 2000), but in our study, both animals during the breeding season showed a significant increase in their diurnal (6-18 h) activity (Fig. 4) (expressed as a number of behavioural acts), in particular due to their social behaviour (74.9 % of all behavioural acts during the day). This increase was clearly observed in two distinctive peaks: in the morning (6-10 h) and in the afternoon (13-18 h), the two peaks being in accordance with Schmidt (1999) (Fig. 5). The main hypothesis of social behaviour increase during the day is that the animals can get use of all their senses in their full capacity, which enriches their behaviour display, thus benefiting and stimulating the reproduction abilities. Although there was noted reversed activity during the day (8-16 h) due to the life in captivity, the hourly distribution of the social behaviour shows that the animals exhibited this behaviour more or less outside of the time period with significant human presence – the keepers' routine with the lynx were usually between 10 a.m. and 12 a. m., while the afternoon hours were

Table 1. Ethogram and frequency of the recorded lynx behaviour in Sofia Zoo

Behaviour Group	Code	Description	Frequency	
			male	female
Non-social behaviour	L1	Locomotion - directional move through the enclosure	766	447
	L2	Locomotion - move along the fence of the enclosure	185	107
	L3	Running	28	33
	L4	Climbing	7	21
	R1	Sleep	48	21
	R2	Rest - laying with head up	168	126
	R3	Rest - laying on the back or on the stomach with head down	0	1
	I1	Standing motionless, observing	234	189
	I2	Standing - looking and listening around	124	60
	I3	Sniffing the ground or an object	57	21
	M1	Marking - spraying urine	219	23
	M2	Marking – clawing	16	3
	F1	Anxiety related to anticipation of food (running around)	5	1
	F2	Feeding	14	22
	F3	Food manipulation - burrowing, carry around	7	4
	F4	Eating of grass	2	4
	P1	Prowl of another animal outside the enclosure or human	20	5
	P2	Play behaviour - with object or food	7	31
	St	Stereotypic behaviour - repeated pacing along the fence of the enclosure	80	1?
	C1	Self-grooming - licking, teeth-combing	49	38
	C2	Self-grooming - shake off skin	21	8
	C3	Rubbing back against the ground	5	5
	C4	Stretching, yawning	50	27
	C5	Scratching skin	7	1
	C6	Coughing, sneezing	2	0
	C7	Burrowing scats	0	2
	H	using shelter (out of sight)	1	2
	N	Indefinite non-social behaviour	52	71
Social behaviour	B1	The two individuals are chasing each other	75	70
	B2	Play behaviour - the two individuals are playing/scuffling	92	82
	B3	Mutual grooming - licking, teeth-combing	15	30
	B4	Head tossing	29	29
	B5	Rubbing against the partner, touching the partner	13	39
	B6	Mating call	19	5
	B7	Attempt for copulation/copulation	6	6
	B8	Sniffing partner	24	11
	B9	Prowling partner	9	15
	B10	Following partner	10	8
	B11	Rubbing against and object (displaced activity)	4	2
	B12	Observing partner	27	42
	B13	The female lays on her back in front of the male	0	6
	B14	Invitation for contact - biting or pushing partner	8	12
	B_Am	Aggression – male	3	0
	B_Af	Aggression – female	0	2
	S1	Sniffing the urine mark of the other partner	71	27
	S2	Flehmen response	8	1
	S3	Approaching partner with intention of a contact	15	0

usually not preferred by the visitors of the zoo. The comparison of the captive lynx activity with the activity in the wild (Schmidt 1999) shows that the major daily pattern of the overall natural activity of the wild animals is still well preserved even in captivity. Yet there is need for more data on the social interactions of the lynx in the wild to support or reject the hypothesis of increase in the lynx social behaviour *in-situ* during the day.

The male exhibited 541 socially directed behavioural acts which took 15 % of his time budget. The total duration of his social behaviour was 86.55 min (5193 sec). The female exhibited less social acts (n = 349) but with longer duration (97.83 min. or 5870 sec., 24 % of its time budget).

Both animals showed play behaviour as they played with objects or with the food, the female being more active than the male (n = 7 for the male and n = 31 for the female). The female played with branches, smaller logs, stones, pieces of food, even with the cameratrap.

Of specific interest to the zoo management is the display of stereotypic behaviour (Mason, Rushen 2006). Although both animals are captive bred, only the male showed stereotypic behaviour n = 80, 2265 sec.). This behaviour was interrupted only by M1 (marking with urine). During this stereotypic display, the female did not make attempts to interact with the male, displaying either a type of non-social behaviour or just observing the male. From all 1996 behavioural acts of the male, the stereotypic behaviour is 5.1 % of all non-social behavioural acts (n=1570). Compared to other captive carnivores in Sofia Zoo, the male exhibits less stereotypic behaviour than the Brown bears (11.5 %), Himalayan bears (9.4 %) and the American black bears (8.3 %) (Stoyanov 2013)

Relationship between the lynx behaviour and the temperature / moon phase

There is a clearly pronounced peak of the lynx activity between -5 and 20° C (Fig. 6), as most of the behavioural acts were displayed between 0 and 5° C.

There are clear peaks and drops of the lynx activity in different phases of the moon (Fig. 7). There is no significant correlation between the moon phases (in the context of amount of light during the night at each phase) and the overall number of lynx Non-social ($\chi^2 = 0.165$, $p > 0.05$) or Social behavioural acts ($\chi^2 = 0.246$, $p > 0.05$). Yet, both animals were least active during full moon, but there was a significant increase in Social behaviour observed after that, at waning gibbous moon. These data comply with another moon-related study on wild badgers activity (Racheva *et. al.* 2012), in which a drop in the

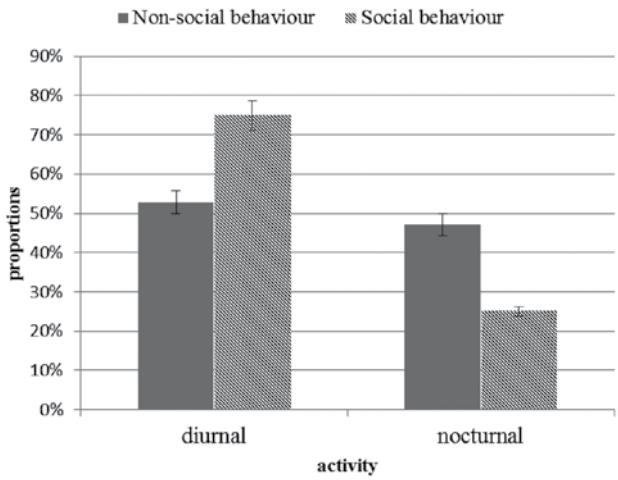

Fig. 4. Proportions of diurnal and nocturnal behaviour in their social context

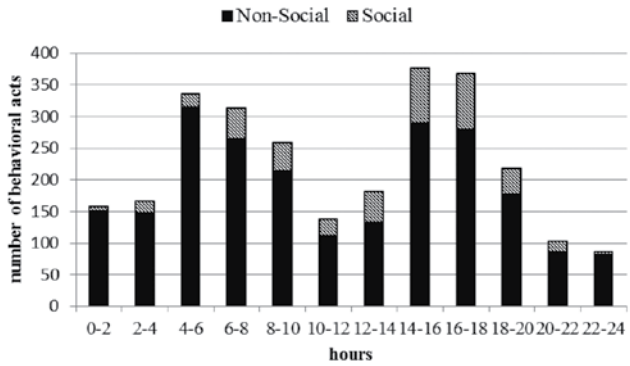

Fig. 5. Distribution per hour of the non-social and social behavioural acts

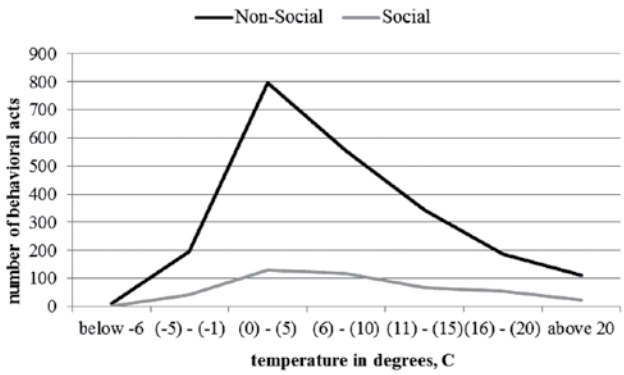

Fig. 6. Relationship between the temperature and the number of behavioural acts

animals' activity during full moon (although not so pronounced) was also observed, followed by a significant increase at waning gibbous moon.

Description of observed specific reproductive behaviour

Head tossing (Fig 8): This behaviour was first reported by Stehlík (1983) as a part of the lynx ritu-

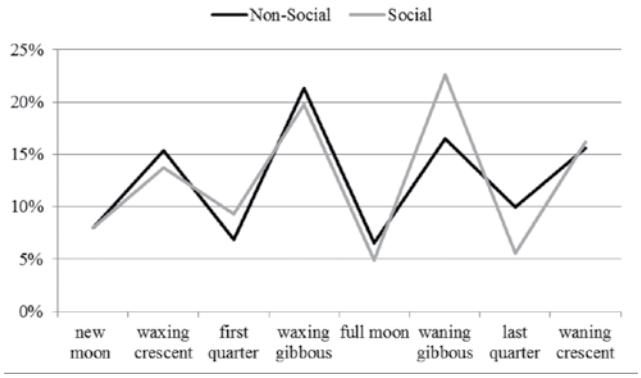

Fig. 7. Relationship between the moon phase and the number of behavioural acts

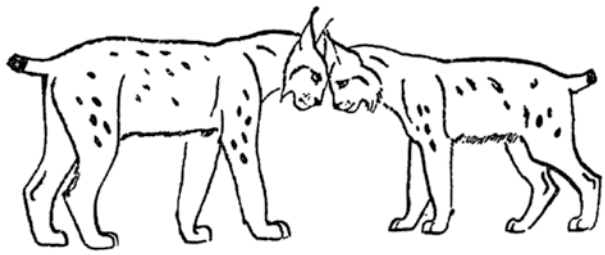

Fig. 8. Lynx 'head tossing' behaviour (Stehlík 1983)

alised courtship/approaching behaviour, but little is known about the duration of this act. During this behaviour one of the individuals (in few cases – both) initiated hitting\tossing the head of the other partner frontally, which later could continue as rubbing or licking the forehead of the partner.

We observed 29 specific head tossing behavioural acts during the study period. This behaviour was observed predominantly during the day (in 86.2 % of the cases, n = 25) without any correlation to specific temperatures or moon phases. In 41.4 % (n = 12) of the cases this behaviour was observed alone or interrupted by non-social behaviour. In 31.03 % (n = 9) of the cases it was followed by a play behaviour and in 6.9 % of the cases – by rubbing to/licking each other. Other combinations were also occasionally observed – partners chasing each other or exhibiting play fight, sniffing each other or observing each other at a close distance.

Marking behaviour and mating calls: The male marked more actively the territory with urine (8.4 % of all behaviours, n = 219) than the female (1.4 %, n = 23). The male was also more frequently claw marking (n = 16) that the female (n = 3).

The mating calls were also more pronounced in the male (4.4 % of all social behaviours, n = 19) than in the female (1.3 %, n = 5). The male was the individual approaching the partner to initiate a social contact. He was also more active in sniffing the marking spot of the female (n = 71 to n = 27 for the female) and exhibiting Flehmen response (n = 8 for the male and n = 1 for the female)

Copulations: Totally 6 copulations were observed during the day and the night (50:50) within a period of 40 days (from 9 of March to 17 of April 2009). Usually the copulation was preceded by following of the female by the male or play behaviour (the animals chased each other). The female gave birth to three cubs on 12 of May 2009 which complies with the finding of Henriksen *et al.* (2005) about the timing of birth. The cameratrap was removed before the birth to reduce the disturbance of the female.

Conclusions

The behaviour of cryptic animals such as the lynx is very difficult to be studied in nature, so zoo animals can provide a valuable input for observing rare or unseen before behavioural sequences. This study gave us an opportunity to get more insights of the lynx behaviour during the breeding season, which could be used for more effective conservation of this not well known species in the wild.

Acknowledgements: We would like to thank the staff of Sofia Zoo and especially the Felid keeper Maria-Teresa Kortes for their support of this study and their appreciated input. We also like to thank Prof. Nikolai Spassov for his valuable comments on the paper.

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Received: 17.07.2013
Accepted: 17.03.2014