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Effects of construction noise on behaviour of and exhibit use by Snow leopards *Uncia uncia* at Basel zoo

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Noise caused by human activities can cause stress in animals. We examined whether noise from construction sites affects the behaviour of and exhibit use by three Snow leopards *Uncia uncia* at Basel zoo. The behaviour and location of the animals were recorded at 1 minute intervals, using the instantaneous scan sampling method over a period of 216 hours (104 hours on noisy days and 112 hours on quiet days). The animals differed individually in their responses to the construction noise. On noisy days, the Snow leopards generally spent less time in locomotion and more time resting, but even on quiet days, resting was the predominant behaviour performed. Under noisy conditions, they increased social resting and decreased resting alone. Walking and social walking were also reduced on noisy days. Furthermore, the Snow leopards spent considerably more time in the remote off-exhibit enclosure under noisy conditions. Independent of background noise, they stayed more than half of the time in the caves and the forecourts of the outdoor enclosure. On quiet days, the Snow leopards used more sectors of their exhibit than on noisy days. The results indicate that the Snow leopards responded to construction noise by increasing the amount of time spent resting and by withdrawing to the remote parts of their exhibit.

Key-words: behaviour; caves; construction noise; exhibit use; resting; snow leopards.

INTRODUCTION

Zoo animals are exposed to external stimuli that are very different from those they would encounter in the wild. In most cases, zoo animals cannot control and escape these external stimuli, which may cause changes in their behaviour or 'stress' (Carlstead, 1996; Morgan & Tromborg, 2007). Stress is a physiological state that influences the behaviour and chronic stress has detrimental effects on the health, well-being, behaviour and

the reproduction of animals (Carlstead & Shepherdson, 1994; Morgan & Tromborg, 2007; Tarlow & Blumstein, 2007). Various factors, such as proximity to other animal species, incompatible conspecifics, visitors, noise or disturbance, can cause stress (Wooster, 1997; Powell *et al.*, 2006). However, in many species, there is considerable variation among individuals in the response to such aversive factors and stress (Morgan & Tromborg, 2007).

Prolonged exposure to intense noise caused by human activities may have detrimental effects on humans, animals and plants (Fletcher & Busnel, 1978; Clark, 1992). For example, construction noise at the Smithsonian National Zoological Park, Washington, DC, USA, led to behavioural and physiological changes in Giant pandas *Ailuropoda melanoleuca* (Powell *et al.*, 2006).

In the winter of 1998/1999, the former carnivore exhibit at Basel zoo was demolished. At that time, the new enclosure had not yet been finished so the Snow leopards *Uncia uncia* remained in their former enclosure adjacent to the construction site and were thus exposed to the noise and other impacts caused by the work. The present study was designed to examine whether extreme noise from the demolition and construction of new buildings influenced the behaviour of the three Snow leopards and their use of the exhibit at Basel zoo. For this purpose, the behaviour and location of each individual were recorded under noisy and quiet

conditions. In particular, the following questions were addressed: (1) does demolition and construction noise alter the behaviour of and exhibit use by the Snow leopards and (2) do the animals show individual differences in their response to construction noise?

MATERIALS AND METHODS

General

The demolition of the former carnivore building, its outdoor cages and of other exhibits in the vicinity of the Snow leopard enclosure started on 26 January 1999. The behaviour and exhibit use of three Snow leopards, an adult 6 year-old ♀ born in Basel, an adult 6 year-old ♂ that has been in the Basel Zoo since 1994, and their 1.5 year-old ♂ offspring, were recorded for 3 months during the demolition and construction work. From their outdoor enclosure (but not from the off-exhibit enclosure), the Snow leopards could see the demolition sites and the work that was going on there.

Housing, feeding and enrichment

The Snow leopard enclosure measured 185 m² and is hereafter called the 'outdoor enclosure'. It contained two large and two small rocks, two old trees surrounded by a 3 m-high fence, several old intertwined tree stems and a water channel including four small ponds (Fig. 1). The loamy soil was bare of vegetation. A wall (coarse-grained sedimentary rock) formed the western boundary of the enclosure. This rock wall included two caves linked by a corridor. The corridor also led to a second, off-exhibit enclosure in the back, which measured 28 m² and was partly roofed, and finally to the sleeping quarters measuring 9.2 m².

The Snow leopards were fed at various times of the day, preferentially between 1400 and 1500 hours. The prey consisted of previously killed Hamsters *Mesocricetus auratus*, rats *Rattus* sp, Rabbits *Oryctolagus cuniculus domesticus* or Chickens *Gallus domesticus* and was usually placed into the off-exhibit enclosure. Occasionally, the food

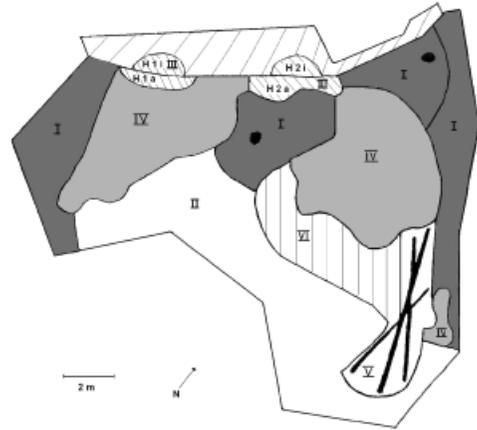


Fig. 1. Map of the Snow leopard *Uncia uncia* enclosure at Basel Zoo. The public viewing area was located along the border of sector II. The main demolition site (former carnivore building and outdoor cages) was located to the west of the western sector I (left-hand side of the figure). Other minor demolition sites were situated to the south of sector II (bottom of the figure) and east of the eastern sector I. Key: ■, I (away from the visitors); □, II (towards visitors); ▨, III (caves: H1 and H2); and forecourts: H1a and H2a); ■, IV (rocks); ■, V (tree stems); ■, VI (water channel); ▩, off-exhibit enclosure.

was offered on the rocks or the forecourts of the caves. At randomly chosen days, usually once a week, the animals were not fed. The feeding regime did not significantly influence the behaviour and exhibit use of the three animals (Sulser, 2001). Therefore, no distinction was made between feeding and fasting days in the data analysis of the present study.

Behavioural observations

The Snow leopards were observed from 12 January to 11 April 1999 for a total of 216 hours, distributed equally over the opening times at the zoo (0800–1800 hours). Instantaneous scan sampling was used to record the behaviour of the three Snow leopards over periods of 1 hour (Altmann, 1974). At 1 minute intervals, the behaviour and the location of the three individuals were recorded. In addition, the occurrence and kind of noise from the building site, the prevailing weather conditions and average temperature were

| BEHAVIOUR TYPE | DESCRIPTION |
|-----------------------------------|---|
| RESTING | |
| Active resting | |
| Lying alone | animal lies on belly, front legs stretched, hind legs bent, head raised or resting on paws, eyes open; or animal rests laterally, tail stretched away from body or nestled on body, eyes open; or dorsal position, back of head touches ground, legs usually do not touch ground, eyes open |
| Crouching | lying on belly, all legs bent |
| Sitting alone | anal region touches ground, hind legs bent, forelegs stretched |
| Social lying | animal rests in close body contact with other resting animal, eyes open |
| Social sitting | sitting in close body contact to other animal |
| Inactive resting | |
| Sleeping alone | animal rests with its belly touching the ground, front legs stretched, hind legs bent, head raised or resting on paws, eyes closed, or animal rests in lateral position, tail stretched away from body or nestled on body and legs, eyes closed, or dorsal position, back of head touches ground, legs usually do not touch ground, eyes closed |
| Social sleeping | like social lying but eyes closed |
| LOCOMOTION | |
| Not stereotypic | |
| Standing | legs stretched, paws touch ground, no locomotion |
| Walking | slow locomotion, a nearly stretched fore- and the diagonal hind-leg moved forward alternately |
| Trotting | fast locomotion, diagonal pair of legs touches ground simultaneously |
| Galloping | very fast locomotion |
| Jumping | hind legs push off body horizontally and vertically, landing on both forelegs |
| High jumping | hind legs push off body vertically, landing on forelegs |
| Social standing | two animals stand next to each other, slight body contact |
| Social walking | two animals walk side by side, slightly touching each other |
| Stereotypic | |
| Stereotypic walking (= pacing) | walking to and fro in the same track, repeated at least twice |
| Stereotypic trotting | trotting to and fro in the same track, repeated at least twice |

Table 1. List of recorded behaviour patterns observed in Snow leopards *Uncia uncia* at Basel Zoo. A detailed ethogram is given in Sulser (2001).

noted once per hour. Noise from the building sites was caused by the following activities: hammering, chopping wood, felling trees, digging, road sweeping, welding, use of power or circular saw, use of the hydraulic crawler excavator, the shovel dozer and the tower crane. Data were collected under two different conditions: presence (L: total of 104 hours) or absence (Q: 112 hours) of construction noise. The background noise caused by visitors and maintenance work did not differ under noisy and quiet conditions, respectively.

The behaviour and location of the animals were recorded exclusively in the outdoor enclosure. When the Snow leopards were in the off-exhibit enclosure or out of sight, the time was recorded. To record the location of

the Snow leopards, the outdoor enclosure was divided into six sectors (see Fig. 1). The behaviours recorded are described in Table 1. A detailed ethogram is given in Sulser (2001).

At the time of our study, the Snow leopards at Basel Zoo benefited from very little behavioural enrichment. First, one of the keepers devoted a considerable amount of time to the Snow leopards and built up a special relationship with them. Whenever the animals noticed him, they became more active and started playing. The days when this keeper was on duty were spread fairly equally over noisy and quiet days and any possible influence on the animals' behaviour is, therefore, similar under both conditions. Second, food was offered at different times and places in

the outdoor enclosure instead of separating the animals in the off-exhibit enclosure and feeding them individually. As a result, the Snow leopards increased their explorative and playing behaviour considerably. We therefore decided to exclude data from days on which this type of enrichment was performed from the analysis.

Data analysis

Contingency tables were used to test whether the frequencies of the various behaviour patterns and the use of the different sectors of the enclosure differed between noisy and quiet days. Statistical tests are based on scan data. The respective behaviour patterns or exhibit sectors of the three animals were added and tested using contingency tables. The scan data were analysed in two ways. First, data for noisy and quiet days were examined to test whether the individuals differed significantly from each other in their behaviour and exhibit use under the two noise conditions. Second, pooled data from noisy days and from quiet days were examined to test whether demolition noise influenced the behaviour of and exhibit use by the Snow leopards. To increase readability, results are presented in percentages (mean values \pm 1 SD are given).

RESULTS

Proportion of time spent in the outdoor enclosure

Under noisy conditions, the Snow leopards spent significantly less time in the outdoor enclosure than on quiet days (78.9 ± 7.3 vs $83.4 \pm 4.2\%$, $\chi^2 = 118.1$, d.f. = 1, $P < 0.001$). Furthermore, the three individuals differed in the amount of time they stayed in the outdoor enclosure under either condition (noisy: ♂ 86.4% , ♀ 71.9% , young 78.4% , $\chi^2 = 397.23$, d.f. = 2, $P < 0.001$; quiet: ♂ 85.2% , ♀ 78.6% , young 86.3% , $\chi^2 = 170.99$, d.f. = 2, $P < 0.001$). The ♀ and young stayed less frequently in the outdoor enclosure on noisy days (in both animals $P < 0.001$), whereas the amount of time the

| BEHAVIOUR | NOISE | QUIET |
|------------------|----------------|----------------|
| Active resting | 40.4 ± 1.1 | 36.7 ± 5.4 |
| Inactive resting | 40.1 ± 6.1 | 34.8 ± 4.9 |
| Locomotion | 11.4 ± 5.1 | 18.1 ± 8.0 |
| Other behaviours | 8.1 ± 2.1 | 10.5 ± 2.7 |

Table 2. Percentage of different behaviours (% of total observation time) in Snow leopards *Uncia uncia* at Basel Zoo under noisy and quiet conditions (mean \pm SD, $n = 3$ individuals). The percentage of time spent on different behaviours differed significantly between noisy and quiet days ($P < 0.001$), d.f. = 6 for the test of individual differences; d.f. = 3 for the test of the effect of noise on the type of behaviour.

♂ stayed in the outdoor enclosure was not affected by noise ($P > 0.1$). For the remaining part of this study, we considered exclusively the behaviour of the animals in the outdoor enclosure. For each individual, the time spent in the outdoor enclosure was set to 100%.

Influence of noise on the proportion of different behaviours

The three Snow leopards differed from one another in the amount of time spent with the various behaviour types on quiet ($\chi^2 = 662.3$, d.f. = 6, $P < 0.001$) as well as on noisy days ($\chi^2 = 362.84$, d.f. = 6, $P < 0.001$). Table 2 shows the percentage of different types of behaviour under noisy and quiet conditions. The differences in behaviour between noisy and quiet days were significant ($\chi^2 = 376.6$, d.f. = 3, $P < 0.001$). On noisy days, the Snow leopards spent less time with locomotion (mean decrease of 6.7%). The ♂ and young also reduced the other active behaviours (mean decrease: 3.5%) under noisy conditions, while in the ♀, the proportion of any other active behaviour was not influenced (9.2% under any condition). All animals spent more time with resting (active resting increased by 3.7% , inactive resting increased by 5.3%) under noisy conditions; the ♂ raised the amount of active and inactive resting, the ♀ mainly raised the amount of time spent with active resting, while the young slightly decreased

| BEHAVIOUR | NOISE | QUIET |
|----------------------------|------------|------------|
| Lying alone | 27.4 ± 6.0 | 32.4 ± 4.6 |
| Social lying | 14.3 ± 3.6 | 8.8 ± 4.0 |
| Crouching | 1.8 ± 2.0 | 1.0 ± 0.6 |
| Sitting and social sitting | 6.9 ± 2.2 | 9.1 ± 0.7 |
| Sleeping alone | 21.4 ± 7.8 | 26.6 ± 8.2 |
| Social sleeping | 28.2 ± 7.2 | 22.1 ± 7.9 |

Table 3. Percentage of time spent on various types of resting behaviour (mean ± SD, $n = 3$ individuals) by Snow leopards *Uncia uncia* at Basel Zoo. The percentage of time spent on various types of resting behaviour differed significantly between noisy and quiet days ($P < 0.001$). d.f. = 10 for the test of individual differences; d.f. = 5 for the test of the effect of noise on the type of behaviour.

the amount of active resting but spent considerably more time with inactive resting.

'Activity' includes all behavioural elements with the exception of active and inactive resting. The three Snow leopards were considerably more active on quiet than on noisy days (Table 2; $\chi^2 = 355.9$, d.f. = 1, $P < 0.001$).

Influence of noise on various kinds of resting and locomotion

The average percentage of time spent with the various types of resting behaviour is shown in Table 3. Resting behaviour in Snow leopards was influenced by demolition and construction noise ($\chi^2 = 354.2$, d.f. = 5, $P < 0.001$). Again, the individual differences in the resting behaviour were significant both on quiet ($\chi^2 = 567.7$, d.f. = 10, $P < 0.001$) and on noisy days ($\chi^2 = 773.5$, d.f. = 10, $P < 0.001$). Under noisy conditions, the Snow leopards spent less time lying alone (mean decrease of 5%) and sleeping alone (mean decrease of 5.2%) and more time with social lying (mean increase of 5.5%) and social sleeping (mean increase of 6.1%).

Both on quiet and noisy days, the Snow leopards differed significantly in their individual locomotion (quiet days: $\chi^2 = 67.7$, d.f. = 6, $P < 0.001$; noisy days: $\chi^2 = 41.4$, d.f. = 6, $P < 0.001$). The percentage of time spent with the various types of locomotion is shown in Table 4. Under noisy conditions, the animals reduced the amount of time spent

| BEHAVIOUR | NOISE | QUIET |
|----------------------------------|------------|------------|
| Walking and social walking | 46.6 ± 6.1 | 51.3 ± 4.4 |
| Stereotypic walking and trotting | 25.2 ± 5.9 | 23.8 ± 6.5 |
| Standing and social standing | 25.2 ± 4.6 | 23.7 ± 7.0 |
| Other types of locomotion | 3.1 ± 2.2 | 1.3 ± 0.4 |

Table 4. Percentage of time spent on various types of locomotion by Snow leopards *Uncia uncia* at Basel Zoo (mean ± SD, $n = 3$ individuals). The percentage of time spent on various types of locomotion differed significantly between noisy and quiet days ($P < 0.001$). d.f. = 6 for the test of individual differences; d.f. = 3 for the test of the effect of noise on the type of behaviour.

with walking and social walking and increased all other types of locomotion ($\chi^2 = 19.1$, d.f. = 3, $P < 0.001$). Stereotypic walking and trotting was only slightly higher on noisy days than when it was quiet. In general, locomotive stereotypies never exceeded 6.1% of the total observation time.

Influence of construction noise on exhibit use

Table 5 shows the percentage of time spent in the various sectors of the outdoor enclosure. The three Snow leopards differed in their individual exhibit use on both types of day (quiet: $\chi^2 = 554.2$, d.f. = 10, $P < 0.001$; noisy: $\chi^2 = 1613.2$, d.f. = 10, $P < 0.001$). Independent of noise, the three animals stayed more than half of the time in the caves and their forecourts, except for the ♂ on quiet days. The average time spent in caves and forecourts was 68% on noisy days, and 52% on quiet days. While little use was made of the forecourts irrespective of noise (% time spent in H1a: 1.6 ± 0.8% under noisy conditions, 2.6 ± 1.5% under quiet conditions; H2a: 8.9 ± 4.9% under noisy conditions, 11.3 ± 6.9% under quiet conditions), the Snow leopards showed a preference for staying in cave H1i on quiet days (48.4 ± 6.2% on quiet days, compared with 31.5 ± 4.2% on noisy days) and clearly spent more time in the cave H2i on noisy days (58.0 ± 2.7% on noisy days, compared with 37.8 ± 3.0% on quiet days), which was located further away from the main demolition site

| SECTOR | NOISE | QUIET |
|----------------------|-------------|-------------|
| Away from visitors | 7.6 ± 4.2 | 10.8 ± 3.1 |
| Towards visitors | 3.6 ± 2.4 | 9.3 ± 5.4 |
| Caves and forecourts | 68.0 ± 12.7 | 51.7 ± 12.6 |
| Rocks | 19.5 ± 7.4 | 25.3 ± 3.9 |
| Tree stems | 0.7 ± 0.5 | 1.5 ± 1.0 |
| Water channel | 0.7 ± 0.4 | 1.4 ± 0.8 |

Table 5. Percentage of time spent in the various sectors of the outdoor enclosure by Snow leopards *Uncia uncia* at Basel Zoo (mean ± SD, $n = 3$ individuals). The percentage of time spent in the various sectors of the enclosure differed significantly between noisy and quiet days ($P < 0.001$). d.f. = 10 for the test of individual differences; d.f. = 5 for the test of the effect of noise on the type of behaviour.

($\chi^2 = 187.6$, d.f. = 3, $P < 0.001$). In general, under noisy conditions, the animals increased the time spent in the caves and their forecourts by 16.3%, whereas under quiet conditions, they spent more time on the rocks (increase of 5.8%) and in the sector close to the visitors (increase of 5.7%) ($\chi^2 = 1011.9$, d.f. = 5, $P < 0.001$). Thus, on noisy days, the Snow leopards used fewer sectors of their enclosure than on quiet days.

DISCUSSION

Under noisy conditions, the three Snow leopards spent more time in the off-exhibit enclosure than in the outdoor enclosure. The high wall of the former provided better protection against noise. This indicates that the animals tried to avoid stress caused by the demolition activities and related noise. Our study also shows that the behaviour of the Snow leopards differed between noisy and quiet days. Similarly, the activity budgets of Giant pandas at the Smithsonian National Zoological Park differed between days with and without ongoing demolition (Powell *et al.*, 2006). However, unlike the Giant pandas, which were more active and 'restless' when demolition was occurring, the three Snow leopards at Basel Zoo spent more time resting on noisy days. Various studies investigated the sleeping and resting behaviour of Snow leopards in several zoos. The amount of resting varied considerably between zoos and between individuals (Freeman, 1975,

1982; Pridatko, 1990; Shilo & Leonova, 1990). The three Snow leopards at Basel Zoo also reacted differently to noise from the construction sites. Under noisy conditions, however, all Snow leopards spent more time lying and sleeping socially. This increase in two types of social resting was assumed to be a displacement behaviour. Because the animals could not escape from the presumably aversive noise, they became lethargic instead. The animals thus appeared to rest more but it is likely that they were in a more vigilant, motionless state. Similar displacement behaviour in carnivores was observed by Pfeleiderer (1990). In addition, the low level of activity of the Snow leopards even on quiet days may also be partly owing to the absence of any suitable environmental stimuli. After this study was completed, olfactory enrichment objects, such as Catmint *Nepeta cataria* (catnip) and Valerian *Valeriana officinalis*, were offered to the Snow leopards and they responded strongly to them (Sulser, 2001).

Contrary to what we had expected, pacing (stereotypic walking and trotting) increased only slightly under noisy conditions. Increased resting was thus the main reaction to the prevailing construction noise.

On quiet days, the Snow leopards made more use of the various sectors of their outdoor enclosure than under noisy conditions. They spent more time on the rocks and in the sectors close to and away from the visitors, as well as on the tree stems and near the water channel. In general, however, they showed a preference for staying in the caves even on quiet days. Under noisy conditions, they showed a preference for cave H2i, which was located further away from the main demolition site than cave H1i (Fig. 1). These findings further support the hypothesis that the animals tried to escape from noisy activities by retreating to locations furthest away from the source of noise.

Demolition and construction work is a temporary inconvenience, which is difficult to avoid in zoos. This study shows that the construction noise influenced the behaviour and exhibit use of the Snow leopards at Basel Zoo and that the animals presumably found

the noise aversive. Demolition and construction work should thus be well timed and carefully planned so as to minimize their duration and effect on the animals in their vicinity.

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