Influence of Fireworks on Zoo Animals: Studying different Species at the Zoopark Erfurt during the Classic Nights

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1. Introduction

At the end of certain events such as classic nights, the Erfurt Zoo sometimes has short firework displays. The influence of these on behaviour and stress perception of animals is controversially discussed by staff, animal welfare activists and also visitors. Stress has complex behavioural and physiological consequences.

Healthy animals have a considerable tolerance towards stress. In natural habitats, they adapt to alternating weather conditions, nutritional competition, intra- and interspecific competition (Broom 2001). According to Broom´s approach, short-term events and changes like fireworks do not induce real stress as long as the animals are able to cope with them. Coping strategies in animals vary according to environmental conditions, previous experiences, ontogeny or personality, to name a few. According to Broom´s definition of stress, a short-term arousal or excitement are not considered as 'stress'. So stress occurs only if the adaptational capabilities of an animal are exceeded and long-term negative consequences for health and/or reproduction become evident. Short-term arousals are regarded as stimulation challenge (Broom 2001).

For this reason we expect that zoo animals react with temporary arousal depending on the species. This study analyzes how diverse species react in certain situations and how these reactions differ between different species.

At the moment there are no published studies about the influence of fireworks on zoo animals. Holders of domestic animals report experiences of pets reacting with fear or phobias at New Year´s Eve. Domestic animals are affected by humans more heavily than zoo animals. Similar to the counting horse "Kluger Hans", they react very sensitively to unconscious signals and the sorrows of their holders – presumable they behave more anxiously and cannot be used as a yardstick for zoo animals. However, reports on fireworks and thunderstorm phobias in the veterinary behaviour literature suggest that this is not the only reason for increased noise / light sensitivity in pets (Dreschel & Granger 2005, cf. Levine 2008, Levine et al. 2007, Sheppard & Mills 2003). Coyotes in a breeding centre of the US Agricultural Service also showed significant reactions of the cortisol system during Pioneer Day festivals (Schell et al. 2013). The study also revealed considerable individual differences.

2. Methods

To study the behavioural impact of fireworks on different species the zoo cooperates with students and staff of the university in Jena (Friedrich-Schiller-Universität).

2.1. Study site and general conditions of the festival

The classic nights with fireworks took place on two evenings in summer 2012. Both days had similar mild weather conditions – there was no rainfall and the temperatures were between 10° and 15°C (Deutscher Wetterdienst).
Music pavilions stood in the whole zoo area, also near the enclosures. Classic instruments were played at a moderate volume without technical support like amplifiers. Visitors walked through the zoo until midnight. Only the walk-through enclosures were closed earlier, e.g. the ring-tailed lemures could no longer be visited after around 9 pm. At the same time the lights in indoor-enclosures were turned off to ensure minimum disruption. On 18th August, 2760 visitors were counted, on 25th, 3389, which is roughly twice as many as on event-free days (statistics of the zoo: 500 000 visitors in the year 2011). Fireworks started around 10 pm and continued for eight minutes and six minutes respectively.

2.2. Recording methods and evaluation

Table 1: Details of data collection. In brackets: Method of studying 2 hours before fireworks begin.

zoo animal		date	methods during firework	indoor and outdoor enclosure	only indoor	outdoor with a shelter
elephants *(Loxodonta africana)*	0.3	08-18	Focal-animal-sampling	+		
giraffes *(Giraffa camelopardalis)*	1.2	08-18 08-25	scan all occurrence (scan)		+ +	
ring-tailed lemur *(Lemur catta)*	1.5	08-18 08-25	all occurrence (scan) Focal-animal-sampling	+ +		
white rhinoceros *(Ceratotherium simum simum)*	1.2	08-18	all occurrence (scan)	+		
llamas *(Lama guanicoe)*	0.7	08-18 08-25	Ad libitum (scan) all occurrence (scan)			+ +
cheetah *(Acinonyx jubatus)*	1.0	08-18 08-25	Ad libitum (scan) all occurrence (scan)	+ +		
maras *(Dolichotis patagonum)*		08-18 08-25	Ad libitum all occurrence			+ +
snowy owl *(Bubo scandiacus)*	1.1	08-18	all occurrence: change of species every 20 seconds			+
common caracara *(Caracara cheriway)*	1.1	08-18	all occurrence: change of species every 20 seconds			+
bisons *(Bison bison bison)*	1.5.3	08-18	all occurrence: change of species every 20 seconds			+

Mammals and birds were observed behaviourally, but not examined physiologically (TABLE 1). Observation methods were standardized as far as possible. For data collection ad libitum, scan, focal animal and all occurrence sampling (ALTMANN 1974) were used. Each of the six observers worked with their own behavioural catalogue based on their pilot studies and observed one to three species.

With few exceptions, scan intervals were five minutes. The scan interval for elefants was shorter (two to three minutes) and one evening also focal animal sampling on ring-tailed lemures was performed for this duration. For giraffes only scan sampling was used. During fireworks all other species were observed by all occurrence or ad libitum methods.

Preliminary observations lasted two hours before the fireworks began. Depending on the behaviour of the species, observations ended not sooner than 10 to 30 minutes after the firework. Observations did end when the animals showed the same behaviour as before the firework. Special attention was given to indications of panic, flight and vigilance behaviour. Because of the small sample size, no analytical statistics were attempted. Instead, it was decided for descriptive and non-inductive statistics. Thus drawing comparisons between different zoos and conditions is not possible at the moment.

Results

Classical music did not heavily impact the behaviour of most species. They reacted most strongly in connection with the loudest explosions of the fireworks at the end, but the intensity of reaction depended on the species (TABLE 2).

During fireworks, almost no visitors were near the enclosures. The majority stayed on or near the fairground where the fireworks took place. Fireworks are noticeable also in buildings and indoor-enclosures. The noise-level of the fireworks depends on individual buildings, enclosures and their distance to the fairground. Some zoo animals switched between indoor- and outdoor-enclosures. So the cheetah, elephants and ring-tailed lemures had a higher noise-level because of the open slide-gates and doors between indoor- and outdoor-enclosures than the giraffes. Some species, like llamas, only have outdoor-enclosures, so they use their usual retreat place or barns.

Fireworks explosions are very different in noise and intensity. The loudest explosions normally occur towards the end in the last one or two minutes.

Only a few species did show indications of arousal (TABLE 2). Rhinoceroses, maras and the cheetah were more nervous than during event-free days. One rhinoceros had already been attacked by the others before fireworks began. During fireworks two of the three animals seemed to be very strained: One of them galloped for a short time in the outdoor-enclosure, the other walked around all the time. Both rhinoceros galloped into the indoor stable in the last minute of the fireworks. The quietest animal fed outdoor at the beginning and retired into indoor-enclosure after only a short time. Immediately after the ending of the fireworks all rhinoceroses went outdoor and did not show any more unusual behaviour.

Table 2: Reactions to the fireworks

zoo animal	date	influence of the firework	next 10 minutes after firework
elephants *(Loxodonta africana)*	08-18	nervous during the loudest explosions in the last minute	normal behaviour
giraffes *(Giraffa camelopardalis)*	08-18 08-25	little influence no influence	normal behaviour normal behaviour
ring-tailed lemur *(Lemur catta)*	08-18 08-25	attentive, male is nervous in last 2 minutes attentive	
white rhinoceros *(Ceratotherium simum simum)*	08-18	very nervous	normal behaviour
llamas *(Lama guanicoe)*	08-18 08-25	attentive attentive, running of one animal for a short time in the last minute	normal behaviour attentive, normal behaviour
cheetah *(Acinonyx jubatus)*	08-18 08-25	both days: very nervous during the loudest explosions in the last minute	attentive, normal behaviour
maras *(Dolichotis patagonum)*	08-18 08-25	running for a short time running	not clear, 2 minutes after fireworks still running
snowy owl *(Bubo scandiacus)*	08-18	male animal is nervous in the first 3 minutes	normal behaviour
common caracara *(Caracara cheriway)*	08-18	little influence, short flight and attentive	normal behaviour
bisons *(Bison bison bison)*	08-18	little influence, they are attentive during and shortly after the first explosions	normal behaviour

During both evenings the cheetah was seen only at the last minutes of the fireworks. During the loudest explosions he ran through the outdoor-enclosure. On the second day he retreated inside. On the first classic night it was not clear weather the cheetah stayed indoor most of the time, because it was not seen for a long time. On the second day, he went outdoor directly after fireworks and looked towards the fairground which he also had observed before the fireworks.

Maras were running briefly at the first fireworks, on the second evening they were running for a while longer and several minutes after fireworks.

Common caracas rested for 50 minutes on the same place before fireworks began. Five minutes after the beginning, they did show some reactions. One animal turned the head into different directions. At the end one flew to the other individual. Both animals stayed on one perch and did no longer react obviously.

Snowy owls also hardly reacted to the disturbance. Initially, the male moved around for three minutes and remained motionless for the rest of the time. The female remained at her resting place for the duration of the fireworks and stayed calm.

The elephants first sought each other´s presence and took shelter, but stayed in the outdoor-enclosure during the whole fireworks. They fed next to each other in the covered area. Towards the end, they wandered around and trumpeted once.

The ring-tailed lemures remained in the indoor-enclosure the whole time. Most of

the time solely the young male was seen, while all females sat in the retreat above the viewing window. He twitched distinctly with every explosion. During the loudest ones at the end, he went over to the females retreat and rested there for a very short time. Afterwards he moved into the indoor-enclosure, accompanied by one female individual for a few seconds. On the second event evening cattas did not show any strong reactions: They slept at the beginning, woke up to the first explosions and looked around, especially towards the roof window.

In comparison to preliminary observations llamas were more attentive and looked into direction of the fairground. Only towards the end of the second fireworks they moved more often. One of them ran away from the group, but returned quickly. The same animal also was more active than the rest of the group during the whole first event. All llamas behaved cautiously directly after fireworks.

The giraffes could not go to the outside. From the inside the fireworks sounded dampened. They were calm during the entire fireworks and did not show differences in behaviour from before. One giraffe was lying for the entire time, another one reacted only by turning the head and moving the ears.

The herd of bison grazed for two hours before fireworks and behaved quietly for the whole time. Only some animals looked up at the beginning, but continued grazing immediately afterwards.

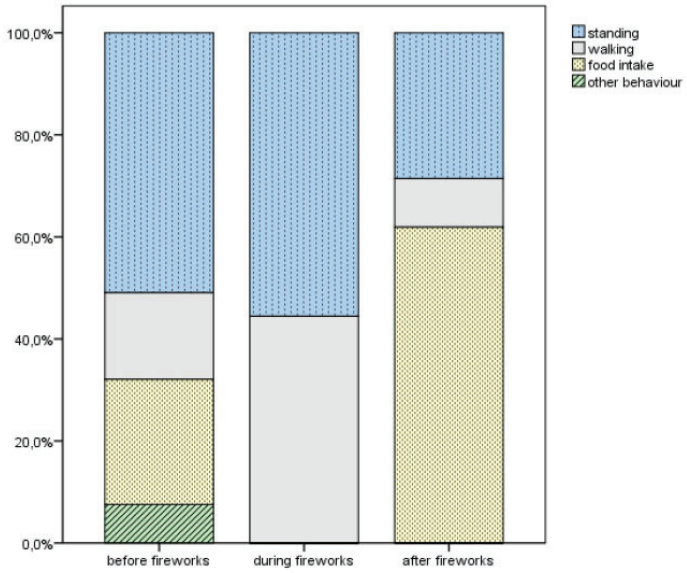

Figure 1: Behaviour of the giraffes: Before fireworks: n_{scans} = 18, scan in 5 minutes; during fireworks: n_{scans} = 3, scan in 2-3 minutes; after fireworks: n_{scans} = 7, scan in 5 minutes

Discussion

In principle, susceptibility to stress and therefore animal welfare depends on different conditions: Nutrition, enriched environment, health, intraspecific conflicts, reproductive status, kind of breeding and experiences to name a few (cf. Broom 2001, Ganslosser 1998). Also the arrangement of the enclosures is essential for near-natural behaviour. Enclosures in the zoo in Erfurt are as appropriate as possible to the species and the observed species live in enclosures with at least the required minimum sizes. Also conditions of nutrition and medical support are good. During the short time of preliminary observations, no signs of chronic stress were seen. However, during the fireworks only behaviour which differs from the preliminary observations is relevant and can be assessed.

Because of the darkness the distinction of individual animals and the registration of small changes of behaviour are often unfeasible. However, to avoid disturbing the rhythm of the animals, light in the enclosures should not be switched on for the observations. Another problem is the multi-site observations, thus exact duration of behaviour often cannot be documented. More studies are necessary for detailed results.

Classical music, in several studies e.g. on domestic dogs in animal shelters, could be demonstrated to significantly calm animals down (Kogan et al. 2012, Wells 2009). Thus, no adverse effects of the music program on the aimals are expected – quite the contrary.

Only maras, rhinoceroses and the cheetah seemed to show distinct signs of arousal or even panic. The loudest explosions, especially at the end, provoked arousal in this species. Because of the intragroup conflicts, nervousness in the rhinoceroses, especially the attacked animal, was high before the fireworks began. So fireworks seems not to be responsible alone for the strong reactions. The trumpet calls of elephants, which can be a signal for anxiety, occured only once.

It should be considered to put animals which react in such a strong way, into the indoor-enclosures, if available. However, the very short duration of fireworks and also short reaction of these three species indicates that they have no serious or even chronic stress and can manage the short-term disturbances with temporary adjustments. Also because they behave without panic or fear directly after fireworks, we can assume that they have the ability to tolerate them.

The other animals were attentive and sometimes a little bit nervous, but did not show panic-filled or anxious behaviour. Some species, like snowy owls or giraffe, did not show any (like the female of snowy owls) or only very weak changes of behaviour. The giraffes even continued lying on the ground. They did not react in the typical way of flight animals by standing up, getting nervous or try to run away. Maybe they did not hear the firework, because they could not go outside. Also llamas, with one exception, remained relatively calm. During certain events zookeepers also walk through the zoo with single llamas. This time, they were brought back to their enclosure shortly before the fireworks began. So llamas know and also tolerate large amounts of visitors.

All species adjusted back to their previous behaviour directly after the fireworks,

except for the cheetah, whose behaviour could not be observed fulltime.

Afterwards, a few people were visiting the enclosures again. It was noticed that visitors looked for the animals with electric torches in the dark indoor-enclosures. That also disturbed the species, especially because animals calmed down after the fireworks at this time. In principle, fireworks are only a few minutes long and therefore a very short disturbance which cannot be compared with New Year´s Eve.

In natural habitats animals have to adapt to disturbances, more than captive animals. In species, which live in groups, social support plays a great role for the reaction to stressful situations and can even reduce stress. So, additionally to quality of live, health or breeding behaviour also social rank, stability of ranks and stability of the whole group influences the stress level (Sapolsky 2010). Aggression in a group can cause a problem as rhinoceroses show. Before the fireworks began, the conflicts caused a higher stress level and stronger reactions. Support behaviour is observed distinctly in the group of elephants and for a short time in ring-tailed lemures. Elephants searched for and stayed beside each other at the beginning of fireworks. Except for the ring-tailed lemures the observed groups existed longer than a half year. Not only during the fireworks, but also for the rest of the time the new male lemur segregated himself from the remaining group. The male lemur has not yet been accepted by the group. Nevertheless, he did not show real panic, only nervousness and tried to get closer to the females for a short time. Hence, lemurs do also generally tolerate the disturbance.

Weather conditions, different situations of competition or predators are only a few disturbances free-living animals have to manage. Fireworks can be compared with strong meteorological perturbations, which do not often happen in our zoos, but can be managed easily, if there are places to retreat. All that shows the importance of husbandry conditions.

Chronic stress, which can have serious behavioural and physiological consequences, is not caused by short-term events. Healthy animals tolerate brief fireworks and can manage them with retreat behaviour, as this study has confirmed. Maladjusted animals or species which are susceptible to stress, like cheetah (Terio et al. 2004), have to be considered separately. For them a new individual solution could be found. So cheetah should be enclosed in indoor-enclosures during the fireworks.

Further and repeated studies should be conducted to confirm the results and execute physiological researches, for example to test the cortisol level. Also individual and species-specific differences in reactions to fireworks should be better explored.

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