Assessment of Cat Bait Consumption by Mongoose Species

Bachelor thesis

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Declaration

Ich erkläre hiermit, dass ich die Bachelorarbeit selbstständig und ohne Benutzung anderer als der angegebenen Quellen und Hilfsmittel verfasst habe. Die Arbeit wurde noch nicht in einem anderen Studiengang als Prüfungsleistung verwendet.

I hereby declare that this is my own work and no use was made of any sources not listed here. This work has not been submitted for any other degree requirement.

Frankfurt, 28th May 2013

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Abstract

Feral cats and mongooses are species of concern when it comes to serious threats to biodiversity in fragile ecological systems. Baiting, using mainly poisoning with specially developed baits as an eradication tool, has been used in Australia to control feral cats but has not been applied in mongoose control. Feral cats and mongooses have many similarities in physiology and feeding habits and it therefore, may be concluded, that baiting is likely to be an effective control method and that mongooses would accept feral cat baits and could also be treated with the same toxicant.

To test the consumption of the amount of bait accepted by three groups of captive banded mongooses (*Mungos mungo*) two kinds of baits were used: the Eradicat® bait and the Curiosity® bait. The two baits were offered consecutively in a series of trials at 10 AM and 2 PM, alternatively, the baits were offered with the normal diet of the mongooses. Furthermore, the animals were observed for an hour how they handled the bait before they consumed it.

This study showed that the acceptance of Curiosity® was considerably lower than that of Eradicat®. The two different feeding times showed a difference in bait acceptance: less bait was consumed at 2 PM compared to 10 AM. The mongooses´ behaviour in bait handling can be described in three categories (approach, acceptance, ignoring).

It can be concluded that meat baits as Eradicat® and Curiosity® can serve as baits for free-ranging mongooses. Bait uptake was also influenced by the different behaviour of the mongoose groups.

The application of baiting as a control technique for mongooses requires not only a specifically designed bait but also a specific toxicant which could be tailored to mongooses´ metabolism.

1 Introduction

Invasive species are one of the main threats to biodiversity worldwide. Their eradication and management could help to preserve native biota and relieve negative impacts on natural ecosystem processes, especially on previously isolated ecosystems on islands with a high level of endemism. Four carnivores are listed among the IUCN`s list (International Union for the Conservation of Nature) of 100 of the world`s worst invasive alien species: the feral cat (*Felis catus*), the small Indian mongoose (*Herpestes auropunctatus*), the stoat (*Mustela erminea*) and the red fox (*Vulpes vulpes*) (Global invasive species database 1998-2000). Carnivores, as feral cats and mongooses were introduced for many different reasons. Some escaped from captivity such as from fur farms or during stopovers from ships, but others were deliberately released for: economic gain, recreational hunting, or biological control of introduced pests such as rats and rabbits before they became a pest themselves. By now, these animals are distributed throughout the world and occur on many islands as well. Some of them, significantly feral cats and small Indian mongooses, are recognized as a distinct threat to fauna conservation (Algar 2005) and have been implicated in the failure of fauna reintroduction programs (Algar and Burrows 2004).

The small Indian mongoose is indigenous to southern Asia but has been intentionally introduced as a biocontrol agent for snakes and rats to at least 45 islands (including eight in the Pacific), but also to islands in the Adriatic Sea. By now, the species is also distributed in two continental areas: the northeast coast of South America and the Croatian peninsula (Invasive Species Specialist Group, ISSG 2012).

Mongooses are extremely effective opportunistic predators upon small mammals, ground nesting birds, snakes, lizards, frogs, toads and crabs and are implicated in the extinction of several species. For example, two species of rails, a petrel species and two species of skinks on the Fijian islands, three shrew species on Haitian islands and a snake on Antigua and St. Lucia (Hays and Conant 2007). A number of island populations of ground nesting birds were extirpated when mongooses were introduced: Banded Rail (*Rallus philippensis*), Sooty Rail (*Porzana tabuensis*), White-Browed Rail (*Poliolimnas cinereus*) and the Purple Swamphen (*Porphyrio porphyrio*) on Fiji (Gorman 1979). Small Indian mongooses prey upon the eggs and young of at least four endangered species of sea turtle: the Hawksbill Sea Turtle (*Eretmochelys imbricata*), the Leatherback Turtle (*Dermochelys* *coriacea*), the Green Sea Turtle (*Chelonia mydas*) and the Loggerhead Sea Turtle (*Caretta caretta*) (Nellis and Small 1983). Two outright extinctions were caused by the small Indian mongoose: the Barred-Wing Rail (*Nesoclopeus poecilopterus*) in Fiji and the Jamaica Petrel (*Pterodroma caribbaea*) on Jamaica (Hays and Conant 2007).

By the time of the introduction of cats, mongooses or other carnivores no risk assessment was undertaken due to the lack of analytical techniques for estimating the undesired outcome of an introduction or even due to a lack of imagination of the consequences. Today the extent of a biological invasion can be better assessed. Because these species are typically elusive, wary of traps and occur at low densities, their population dynamics are difficult to determine and quantitative evaluations of control programs are rarely conducted. Non-invasive DNA analysis can now provide new data (Berry et al. 2012).

A variety of tools for management and eradication have been developed. Control tools range from: trapping (both lethal and live-trapping) with snares and other traps, shooting and poisoning to the exclusion of the pest population by using physical barriers (usually fences). Other non-lethal methods such as fertility control or conditioned taste aversion have been suggested as more humane control methods. The decision as to which method is to be applied depends on the biology of the target animal and the environment concerned. Until the present time the need for mongoose control and eradication is limited to small geographic areas. Many islands inhabited by the mongoose are too large for eradication, but localized control could relieve stress on populations of the prey species. Successful eradications were achieved by trapping and secondary poisoning on at least six islands smaller than 115 ha: Buck, Leduck, Praslin, Codrington and Green (Barun 2011). Particularly box traps and padded leg-hold traps have been used successfully on Hawaii for adult mongooses. Kill traps have been used on Okinawa and Amami-Oshima (Yamada 2002) in an eradication program that is still ongoing. Of the alternatives outlined, poisoning is likely to be the most viable in the near future (Roy *et al*. 2002) because of lower costs compared to trapping which is very labour intensive.

Poison baiting as the only eradication method in mongoose control is not far advanced and only a combination of toxic baiting and trapping has been described as a successful tool in mongoose control and eradication in earlier studies (Lorvelec *et al*. 2004, Nellis 1982, Nellis *et al.* 1978, Pimentel 1955, Yamada and Sugimura 2004). Studies by Creekmore *et al*. (1994) showed that mongooses appear to have low selectivity and consume most bait types. Baiting, using mainly poisons with specially developed baits as an eradication tool, has been used in Australia to control feral cats and is recognised there as the most effective method when there is no risk posed to non-target species (EA. 1999, Algar and Burrows 2004, Algar *et al*. 2007, Algar and Brazell 2008). Feral cats (*Felis catus*) and mongooses (*Mungos mungo*) have many similarities in physiology and feeding habits, such as a carnivorous or omnivorous diet with a preference for meat. Another similarity is their choice of prey (e. g. small rodents, birds). The physiology of a carnivore and a specialized dentition are a common feature of both species, as well as a high reproduction rate. Both species are very adaptable and opportunistic feeders and have, in most places, no natural predators (e. g. on the Hawaiian Islands). They have also learned to peacefully co-exist with each other, e. g. on Hawaii, where they are often observed sharing the same food at artificial feeding sites (Barun *et al*. 2011, Hays and Conant 2007).

Whenever toxic baits are used to manage an unwanted species, there is a risk that non-target species will also be affected. Special attention has to be given to the type of toxin and the way it is delivered. In case broad-spectrum baits and toxins are used, there is an increased likelihood that native species will also be killed. The most widely used toxin for control of vertebrate pests is Australia is sodium-monofluoracetate (1080). Sodium-monofluoroacetate is a white fluffy powder that is odourless and tasteless (Anon 2009). Thus, the research is directed at finding species-specific baits or toxins to improve target-specificity (Marks 2001). There are toxins that are effective against only one trophic level, e. g. para-aminopropiophenone (PAPP) for control of carnivores (Savarie *et al*. 1983).
PAPP is a compound that oxidizes haemoglobin to methaemoglobin (MetHb) which is unable to transport oxygen and causes a reduction of red blood cells. This leads to a lower oxygen level and a higher concentration of MetHb (Savarie *et al*.1983; Scawin 1984). PAPP is the preferred toxicant for cats and other eutherian mammals such as canids and stoats in Australia and New Zealand as they are highly susceptible compared to most non-target species on islands (Marks *et al*. 2006, Savarie *et al*. 1983). No lethal dose data exists for mongooses currently, but it can be expected that mongooses would be also susceptible to PAPP (Barun 2011).
Apart from a carefully selected toxin the method of bait presentation can be adapted to the target species. Baits must be applied at a rate that allows each target animal to obtain a lethal dose while minimizing the risk of excessive bait being available to non-targets. This can be achieved by placement of baits along roads or tracks that are used by the target animals. Furthermore, baits may be applied in bait stations or other delivery devices

designed to be accessible only to the target-species. The application of meat baits which contain toxic pellets make use of specific physiological attributes of feral cats. Their dentition is adapted to the cutting, shearing and crushing required for the consumption of vertebrate prey. The lack of grinding pre-molars and reduced chewing efficiency allows the ingestion of pellets the size of 4.7 mm diameter if delivered in meat baits (Marks *et al*. 2006) and prove a selective method to control feral cats. The two poison bait products for the management of feral cat populations in Australia are Eradicat® and Curiosity®. Both products are registered trademarks of the Western Australian and Commonwealth governments and can be easily and cheaply manufactured. They consist of kangaroo meat mince, chicken fat and flavour enhancers and stay intact, when distributed from an aircraft over broad-scale areas.

It may be concluded, that baiting is likely to be an effective control method and that mongooses would accept feral cat baits and could also be treated with the same toxicant (Barun *et al*. 2011). The comprehensive Australian studies in feral cat poison baiting support the idea that mongooses might accept the same type of baits and lead to the focus of this study:

- Are feral cat baits a suitable tool for mongoose eradication or management?

- Are there observable behaviours which show which baits are more suitable?

- Can one use these behaviours to make the baits more effective, i. e. a comparison of the animals feeding habits in regard to their complex social behaviours ?

2 Methods and material

2.1 Study species

2.1.1 Short description of banded mongooses

Mungos mungo:
Order: Carnivora, Family: Herpestidae, Genus: Mungos

The study species of this research is the banded mongoose (*Mungos mungo*), which are suitable to represent the small Indian mongoose, because both are medium sized mongooses with many similarities in physiology and feeding behaviour, such as reproduction, diet or hunting and catching of prey. The banded mongoose (*Mungos mungo*) is a social, diurnal, small carnivore classified in the family Herpestidae (Wozencraft 1982). Banded mongooses are widely distributed throughout much of Sub-Saharan Africa in woodlands, savannahs and grasslands (Gilchrist 2002). They are present in Senegal and Gambia and are found as far north as Sudan and Somalia and thought to be rare in West Africa (IUCN Red List August 2011). Banded mongooses occupy a range of habitats but they show a preference for wooded areas, especially dens in old termite mounds (Nowak 1999) and are absent from desert and semi-desert habitats (IUCN Red List August 2011). The home range of the banded mongoose can vary in size, from 0.8 to 4 km^2 (Stuart and Stuart 1988).
As its name suggests, the animal has a number of distinctive dark bands that run horizontally across its back. An adult animal can reach a length of 50-65 cm and a weight of one to two kg. The tail is 18-25 cm long (Nowak 1999). The banded mongoose lives in large, social groups between five and 40 individuals (average around 20). The social group is significant in protecting the individual from predators and in allowing more effective care of the young (Rood 1975).

Feeding behaviour

Being diurnal, the banded mongoose usually emerges from its den early in the morning and will spend most of the day foraging. A group can cover up to three kilometres a day in search of food (Nowak 1999, Gusset 2007). Banded mongooses feed primarily on invertebrates but their diet can also include: rodents, nesting birds and eggs as well as fruit (Stuart and Stuart 1988). Mongooses have non-retractable claws that enable them to dig for insects and pry apart eggs. If the egg shells cannot be opened using their claws or razor sharp teeth, the animals will hurl the egg with their front legs at a hard surface (Stuart and Stuart 1988, Muller 2009).

Reproduction and social behaviour

In groups of banded mongooses, three or more females in a pack may mate and be reproductively active at the same time (Cant 2000). The gestation period is typically 60-70 days. In most breeding attempts, all females give birth either on exactly the same day (Cant 2000, Gilchrist 2006) or within a few days. Litters range from two to six pups and average four, making the reproduction rate high for a carnivore. Banded mongoose pups are cared for communally and are allowed to suckle from any lactating female which ensures the survival of a greater number of pups (Stuart and Stuart 1988, Hodge *et al.* 2011). Later, individual pups can be cared for by a single adult who escorts the pup to help it find food (Gilchrist 2004). Banded mongooses´ social behaviour is very complex. Each pack comprises several breeding adults of both sexes, their offspring, full and half siblings and cousins. Apart from cooperative breeding and the raising of the offspring, pack members work together in driving off larger predators such as monitor lizards (genus Varanus), jackals and birds of prey (Cant 2008).

2.2 Study site

This study was carried out in Landau Zoo (Rhineland-Palatinate, Germany, 49°12´N, 8°7´O), one of 20 zoos in Germany keeping banded mongooses (Graf *et al*. 2013). Currently there are three different groups of banded mongooses at Landau Zoo (Table 1), all of which were bred in captivity:

- Group 1 consists of two adults (M1, F1) and two young (M2, F2), the male is father of the young.
- Group 2 consists of three female young (F3, F4, F5, of the same litter), it is not clear which of the adult females (F1, F6 or F7) was mother.
- Group 3 consists of two adult females (F6 and F7, one is presumed mother of group 2 young, the other presumed mother of Group 1 young).

Though banded mongoose societies are relatively egalitarian and a group size of nine individuals (one male, three female and five pups) is rather small, aggressive behaviour can occur. Dominant males and females respond by forcibly evicting subordinates from the group (Cant 2000). This happened to the two females of Group 2 which were subject to ferocious biting attacks and had to be separated from the obviously dominant female (F1) and male (M1) and are now housed in a separate cage. Because of lack of milk of the mother animal the three young (F3, F4 and F5) had to be hand-raised and were fed with cat milk and fennel tea every two to three hours (pers. comment of zoo staff member).

Table 1: Current stock of banded mongooses at Landau Zoo kept in three groups of different size in two different enclosures (date 2012-12-02).

No.	Sex	Internal registration	Date of birth	Father	Mother	Descent	Arrival date	Comment
Group 1								
M1	♂	M00256	2008-06-11			Landau Zoo	2008-06-11	open enclosure
F1	♀	M00286	2008-07-17	unknown Salzburg Zoo	unknown Salzburg Zoo	Salzburg Zoo	2011-11-26	open enclosure
M2	♂	M00292	2012-06-10	M00256	M00287	Landau	2012-06-10	open enclosure
F2	♀	M00291	2012-06-10	M00256	M00287	Landau	2012-06-10	open enclosure
Group 2								
F3	♀	M00294 "Rikki"	2012-06-15	M00256	unknown	Landau	2012-06-15	since 06-18 in carnivore house, since 06-20 hand-raised to be sent to Aachen Zoo
F4	♀	M00295 "Tikki"	2012-06-15	M00256	unknown	Landau	2012-06-15	since 06-18 in carnivore house, since 06-20 hand-raised to be sent to Aachen Zoo
F5	♀	M00296 "Tavi"	2012-06-15	M00256	unknown	Landau	2012-06-15	since 06-18 in carnivore house, since 06-20 hand-raised to be sent to Aachen Zoo
Group 3								
F6	♀	M00287	2008-07-17	Unknown Salzburg Zoo	Unknown Salzburg Zoo	Salzburg Zoo	2011-11-26	expelled, in carnivore house since 2012-06-15 socialized with M00288 to be sent to Aachen Zoo
F7	♀	M00288	2008-07-17	Unknown Salzburg Zoo	Unknown Salzburg Zoo	Salzburg Zoo	2011-11-26	expelled, in carnivore house since 2012-10-17 socialized with M00287 since 2012-10-25 to be sent to Aachen Zoo

Landau Zoo has been keeping banded mongooses for many years. The precise date of arrival of the first mongooses at the zoo cannot be accurately determined from the zoo´s records. The three different groups of banded mongooses inhabit two different enclosures. Group 1 animals are shown in an open enclosure (Figure 1) of approximately 20 m^2 size.

Figure 1: Enclosure of group 1 animals at Landau Zoo, the feeding site is indicated by an arrow.

The open enclosure uses a variety of rocks, stones, logs, large branches and bushes (*Pyracantha coccinea*). The floor is covered with sand, thus offering opportunities for the animals to cover and dig holes. The well structured enclosure matches the preference of natural banded mongooses´ habitats, where the species lives in rock shelters, thickets, gullies and warrens under bushes. Close to the entrance of the sleeping den (Figure1) a heating lamp was installed to allow the animals to stay outside on cold days. Water is offered permanently in a separate vessel in the left corner of the enclosure (not shown on Figure 1).

The two other groups of banded mongooses (Group 2 and Group 3) are housed in two separate cages in a former carnivore house which is adjacent to an open enclosure currently inhabited by a Eurasian lynx (*Lynx lynx*). The cages offer a variety of items to play with and bury, such as tubes, cardboard boxes and toys (Appendix 3 and 4). The floor is covered with straw which the animals move from one place to the other and cover items with.

Generally, the mongooses are fed twice a day, at 10 AM and 2 PM but the feeding time varies, due to other staff duties and to avoid putting the animals into too much of a feeding routine. Mongooses can be considered omnivorous, however the diet was only meat, vegetables or fruits were not offered the days the trial took place. The food consisted of horsemeat, one-day-old-chicken, canned cat food and cooked small white mice. The portions calculated for each animal were: one chicken, more or less one to two pieces of meat the size of three to five cm or two to three small mice. The amount of cat food was half a tin (200 g) for the three member group and a whole tin (400 g) for the four member group. Additionally, for every portion a spoonful of mineral powder was added. On Day 2 of the experimental trial with Curiosity® bait, soaked dry dog food was offered along with the horsemeat.

2.3 Bait consumption

2.3.1 Bait used in the trial and preparation

To test the consumption of the amount of bait accepted by the banded mongooses, two kinds of baits were used: the Eradicat® bait and the Curiosity® bait. The baits were imported frozen from Australia and stored in a domestic chest freezer until their use. They were then allowed to thaw overnight. Deviating from the Australian trial procedures, no heater was used to warm the baits and they were not allowed to "sweat". Nevertheless, the odour of the baits was undiminished and attracted the animals.

Eradicat® bait

Eradicat® is a bait currently used by the Western Australian Department of Environment and Conservation (DEC) to control feral cats in Western Australia. It is manufactured by the DEC in Harvey, Western Australia and consists of 70 % kangaroo meat mince, 20 % chicken fat and 10 % digest and flavour enhancers (Patent No. AU 781829, Algar 2004). It resembles a chipolata sausage and weighs approximately 15 g when dried. In toxic form it contains 4.5 mg of the toxin sodium monofluoroacetate (1080), which is injected in liquid form into the bait matrix during the manufacturing process.

Rhodamine B as bait marker

Rhodamine B (RB) is a systemic biomarker and effective indicator of bait consumption to determine whether a species would ingest a pellet hidden in the bait (Fenner *et al*. 2009). It enables detection of bait consumption as the compound causes short-term staining of body tissues, digestive and fecal material with which it comes in contact. Certain metabolites of RB are absorbed by the body and are incorporated into the structure of growing hair. A band is produced by the dye in whiskers (vibrissae) that appears fluorescent orange under ultraviolet light (Fisher 1998).

Curiosity® bait

Curiosity® bait is a modified Eradicat® bait, also developed for the control of feral cats by the same manufacturer. A key difference between both bait products is that the toxic compound is housed within an encapsulated pellet containing 1080 or an alternative toxin such as para-aminopropiophenone (PAPP). The encapsulation reduces the exposure of non-target native species by exploiting different feeding behaviours of feral cats compared to native species (Marks *et al*. 2006, Hetherington *et al*. 2007). A further difference to the Eradicat® bait is the pH of the meat in the Curiosity® bait, which is slightly alkaline (approximately pH 7.5). The pH buffering by calcium carbonate is meant to enhance the stability of the encapsulated pellet and to reduce premature degradation of the Hard Shell Delivery Vehicle (HSDV), so that its robust character can be retained for a period of more than ten days and the toxin does not disperse throughout the bait. The pellet has been promoted as a mechanism to deliver an encapsulated toxin to the acidic environment of a cat`s stomach, where once exposed to this acidity, the pellet will dissolve rapidly and release the toxin (Hetherington *et al*. 2007).

The Rhodamine B dye was injected in liquid form into Eradicat® bait and as an encapsulated pellet in the Curiosity® bait of trial C. The Curiosity® bait used on Day1 and Day 2 did not contain any Rhodamine B.

2.3.2 Trial Chronology

The consumption of the amount of bait accepted by the banded mongooses was examined in a series of trials. The first series was conducted with Eradicat® bait on four days in a row, the second one with Curiosity® bait, also on four days in a row (Table 2).

In trial A, each animal was offered its normal ration of food and non-toxic feral cat bait. In trial B, the animals were offered baits and alternative food on Days1 and 3 and baits only with the absence of alternative food (Days 2 and 4). A third trial, trial C, was used to determine the acceptance of non-toxic pellets in the Curiosity® bait. It was conducted after the previous trials showed the acceptance of Curiosity® bait. By mistake it was conducted as a two day trial instead of a one day trial.

The baits were offered at both feeding times for mongooses at Landau Zoo (10 AM and 2 PM) in order to examine whether the time of the day had any influence on bait consumption. Baits and normal food were offered on two different plates. With the exception of the first day (Day 1) each animal was offered one bait which made observation of the animals and quantifying of the residues easier. The baits that were not consumed immediately, or after a feeding break were removed after one hour of observation time. During the trials all animals were observed during the feeding time at 10 o`clock in the morning and at 2 o´clock in the afternoon. Baits were examined for signs of consumption, gnawing, damage or disturbance. The remaining weight of the residues was estimated. Any used bait was not offered again. The uneaten standard ration offered to each individual each day was noted.

Table 2: Chronology of the trial

	DAY 1		DAY 2		DAY 3		DAY 4	
Eradicat®	A	10.00	B	10.00	A	10.00	B	10.00
				14.00		14.00		14.00
	DAY 1		**DAY 2**		**DAY 3**		**DAY 4**	
Curiosity®	A	10.00	B	10.00	A (C)	10.00	B (C)	10.00
		14.00		14.00		14.00		14.00

2.4 Animal Behaviour

Although the primary purpose of the study was to assess the consumption of the different baits, there were marked differences in the animal´s behaviour during the feedings. After presenting the baits, the animals were observed for an hour as to how they handled the bait before they consumed it. No specific method in Behavioural Biology was applied. The individual behaviours were however noted and are later depicted as a chart for each bait. Group 3´s results have been eliminated from the trial after Day1using Curiosity® bait. The animals consumed no baits whatsoever and it was expected that their behaviour would not change the following three days, so no bait was offered on Days 2, 3 and 4.

3 Results

3.1 Bait consumption

Only the results of the trial with Group 1 animals are depicted in Figures 2- 6 because these animals showed a notable difference in bait handling and acceptance. The three young females of Group 2 consumed all baits at every feeding time and the two adult females of Group 3 completely ignored the bait. The Group 3 animals were excluded from the Curiosity® trial after one day because they showed only one single behaviour pattern.

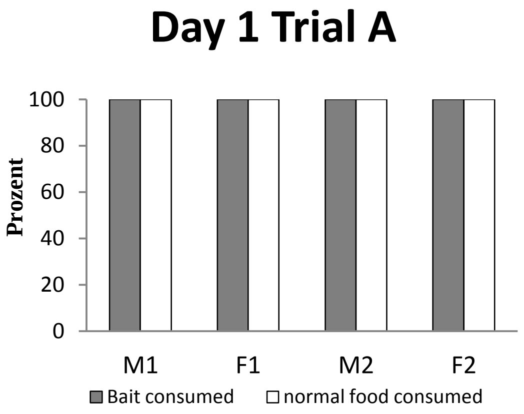
On the whole, the acceptance of Curiosity® bait was considerably lower than that of Eradicat®. The two different feeding times showed a difference in bait acceptance: less bait was consumed at 2 PM compared to 10 AM.

The trial showed that Eradicat® bait was consumed by all four animals of Group1. This was also evidenced by the distinctive red colour of the animals feces caused by the Rhodamine B dye. Figure 2A shows a 100 percent acceptance of the bait. On Day 3 the animals consumed the meat after a long feeding break and left two baits (Figure 2C). On Day 4 at trial B a total of 2 baits were consumed (2 left untouched). No new baits were offered at 2 PM because the animals did not touch the two remaining baits from the morning feeding time (Figure 3). Trial A on Day1 at 2 PM (Figure 3) could not be conducted because the animals did not come out of their sleeping den the whole day (day temperature below freezing the whole day, Appendix 6).

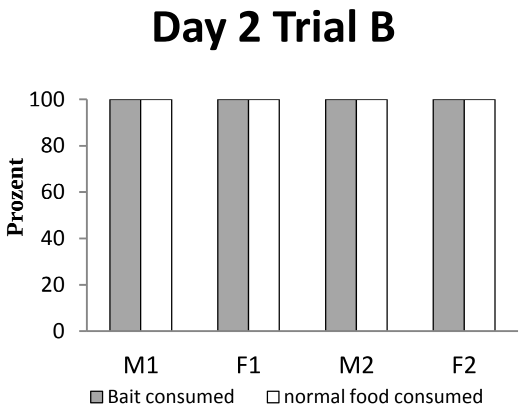
On Days 1 and 3 of the Curiosity® bait trial no baits were consumed when there was an option of “normal” food (Figure 4A and 4C). On the days the baits were offered before the “normal” food, the animals then consumed them eagerly. In sum, only one additional bait portion more was consumed in Curiosity® bait trial B than in trial A (Figure 4). On Days 2 and 4 a total of three baits were eaten when four portions were offered during the feeding times (Figure 4B and 4D). No baits were consumed on Days 1 and 2 at feeding time 2 PM (Figure 5A and 5B). Day 3 shows a relatively high acceptance of the bait. Only the young female (F2) ignored the bait (Figure 5C). It was observed that the pellet inserted in the bait matrix was too large for the animals to swallow (Curiosity® trial Days 3 and 4). Only one animal out of seven even chewed on the pellet (M1) and had difficulty in crushing it. All other animals spat the pellet out immediately. Nevertheless, they consumed the bait (Figure

4D and 5C). Day 4 led to no result in bait consumption (Figure 5D). During the observation time neither normal food nor bait was eaten.

Feeding time: 10 AM / ERADICAT® bait



(A)



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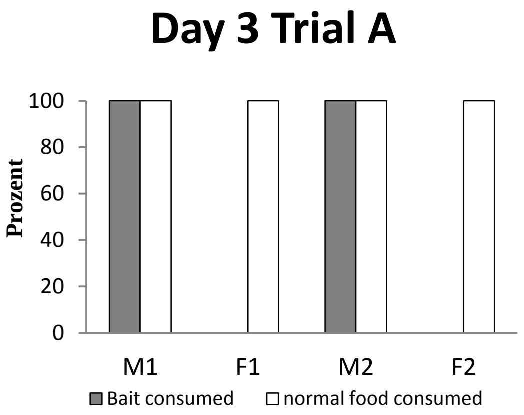
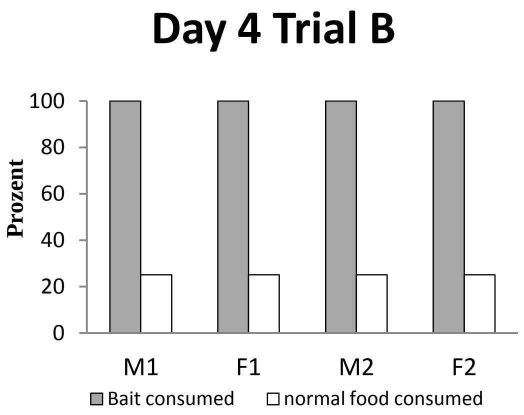


(C)

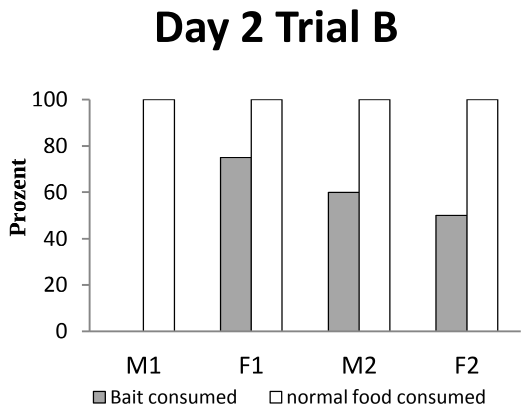


(D)

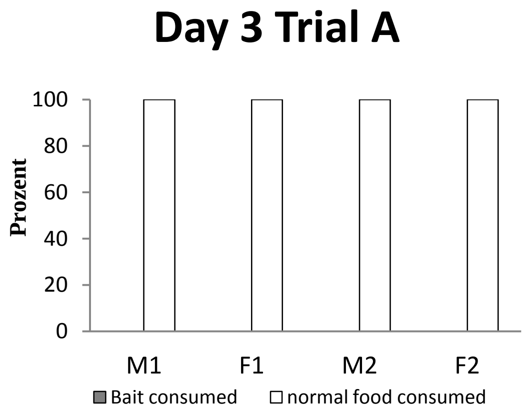
Figure 2: Consumption of Eradicat® at feeding time 10 AM by Group 1.

A:Trial A: normal food: horsemeat, **B**: Trial B normal food: 4 chicken, **C**: normal food: horsemeat, **D**: canned cat food (400 g) and leftover 25%

Feeding time: 2 PM / ERADICAT® bait



(A)



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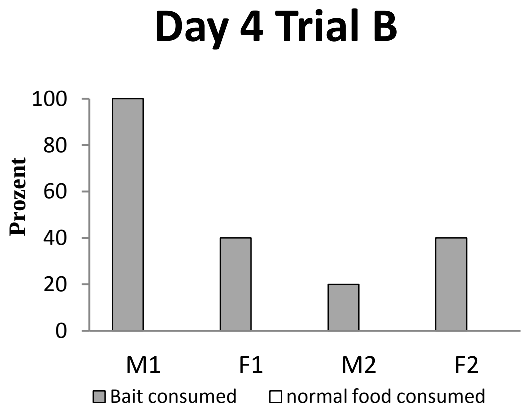
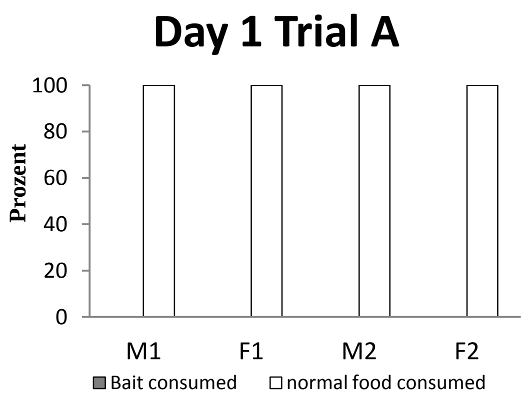


(C)

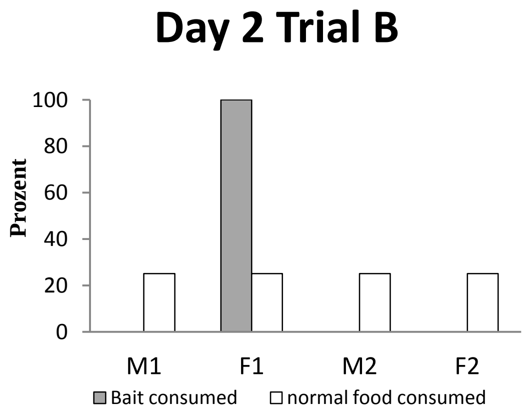
Figure 3: Consumption of Eradicat® at feeding time 2 PM by Group 1.

A: Day 2 Trial B: normal food: 4 chicken, **B**: normal food: horsemeat, **C**: normal food: not offered because of leftover from 10 AM

Feeding time: 10 AM / CURIOSITY® bait



(A)



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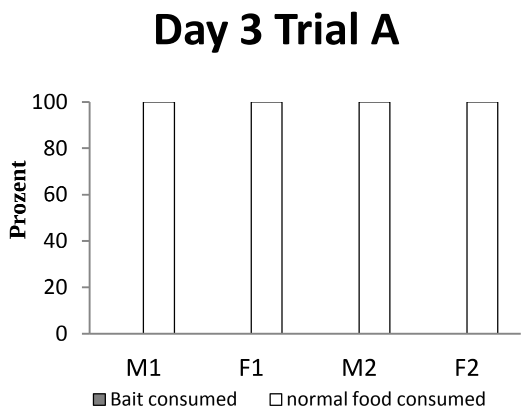

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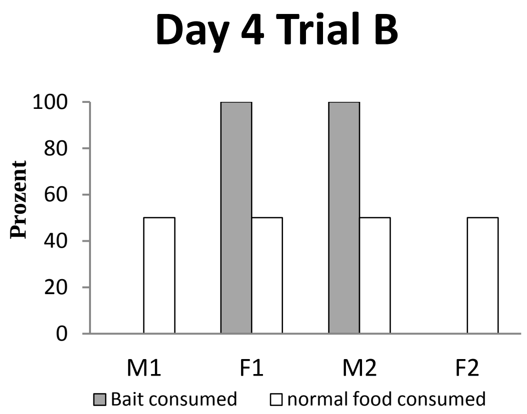
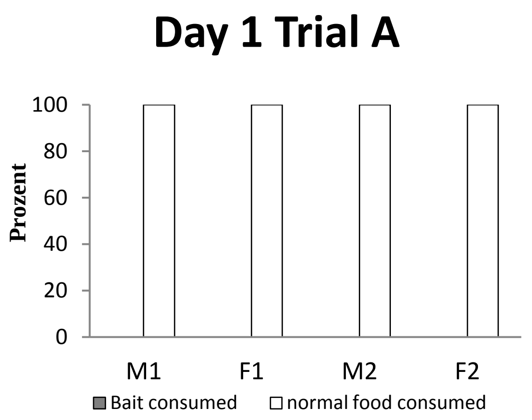


(D)

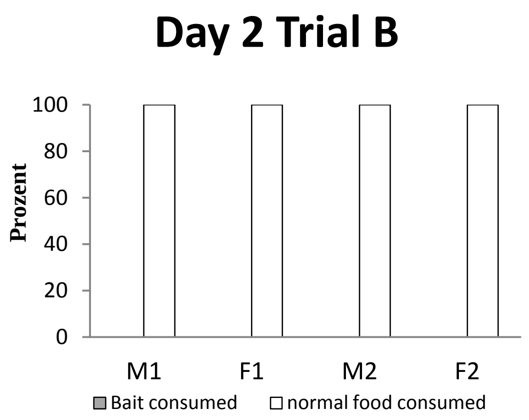
Figure 4: Consumption of Curiosity® at feeding time 10 AM by Group 1.

A: Day 1 Trial A: normal food: canned cat food (400g), **B**: Day 2 Trial B: normal food: dry dog food + horsemeat, **C**: Day 3 Trial A: normal food:4 chicken + 4 mice, **D**: Day 4 Trial B: normal food: horsemeat (2 pc) + mash (ferret food) (*Mustela putorius furo*)

Feeding time: 2 PM / CURIOSITY® bait



(A)



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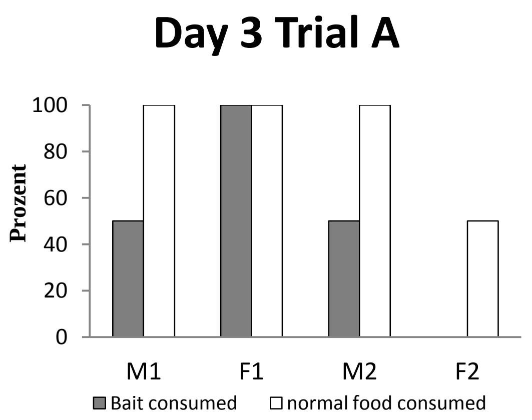
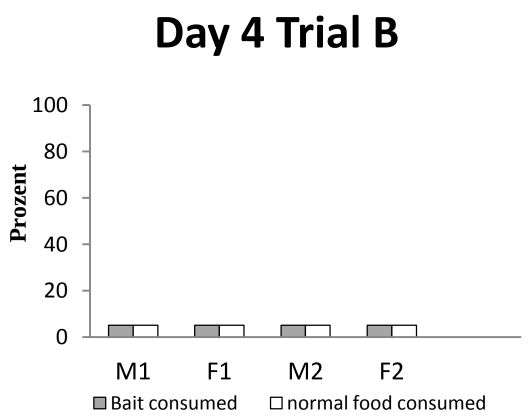


(C)



(D)

Figure 5: Consumption of Curiosity® at feeding time 2 PM by Group 1.

A: Day 1 Trial A: normal food: 4 chicken, **B**: Day 2 Trial B: normal food: 4 chicken, **C**: Day 3 Trial A: normal food:4 chicken + 4 mice, **D**: Day 4 Trial B: normal food: not offered, no baits offered because of leftovers from 10 AM

Figure 6 shows an increase in bait consumption the longer the trial took place. Also, the higher acceptance of Eradicat® compared to Curiosity® is illustrated.

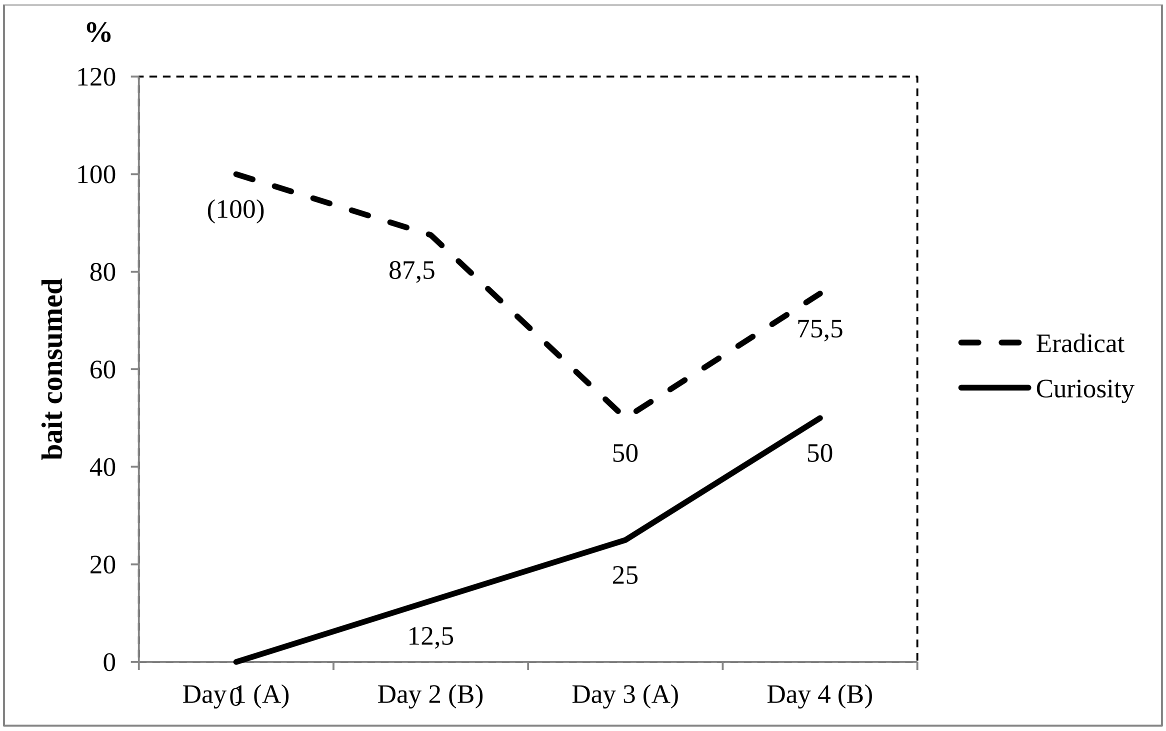


Figure 6: Comparison of the percentage of both baits consumed as a sum of both feeding times.

The data are calculated as means of the two feeding times 10 AM and 2 PM (Appendix 1).

3.2 Animal behaviour

The mongooses´ behaviour in bait handling can be described in three categories (approach, acceptance, ignoring) which are illustrated in Figures 7 and 8. Their first contact was to sniff (**sn**) or lick at the bait. Then the animals tossed the bait around and played with it (**pl**). In doing so, the animals often scratched the bait with their claws (**sc**). The next step was to gnaw or nibble at the bait (**gn**). Then the baits were dragged off to a "secure" feeding place and consumed (**dg+f**). The mongooses defended the bait against other individuals before consumption (**df+f**). Sometimes the bait was simply dragged off and hoarded (**h**). One individual even exchanged the bait with a piece of normal food (**e**).

When the bait was ignored, further behavioural patterns were shown, as the animals pushed the bait vehemently from the plate (**s+i**) or scratched the empty plate afterwards (**s+s**). Often the bait was completely ignored and other food eaten (**i**). One individual turned the plate upside down and covered the bait with the plate (**c**).

When the pellet in the Curiosity® bait (Trial C) was discovered, the animals played with it intensively the first day (**pp**). Only one individual (M1) chewed on the pellet but spat it out after a short time (**ch**). The next day the pellet was completely ignored by all animals (**ip**).

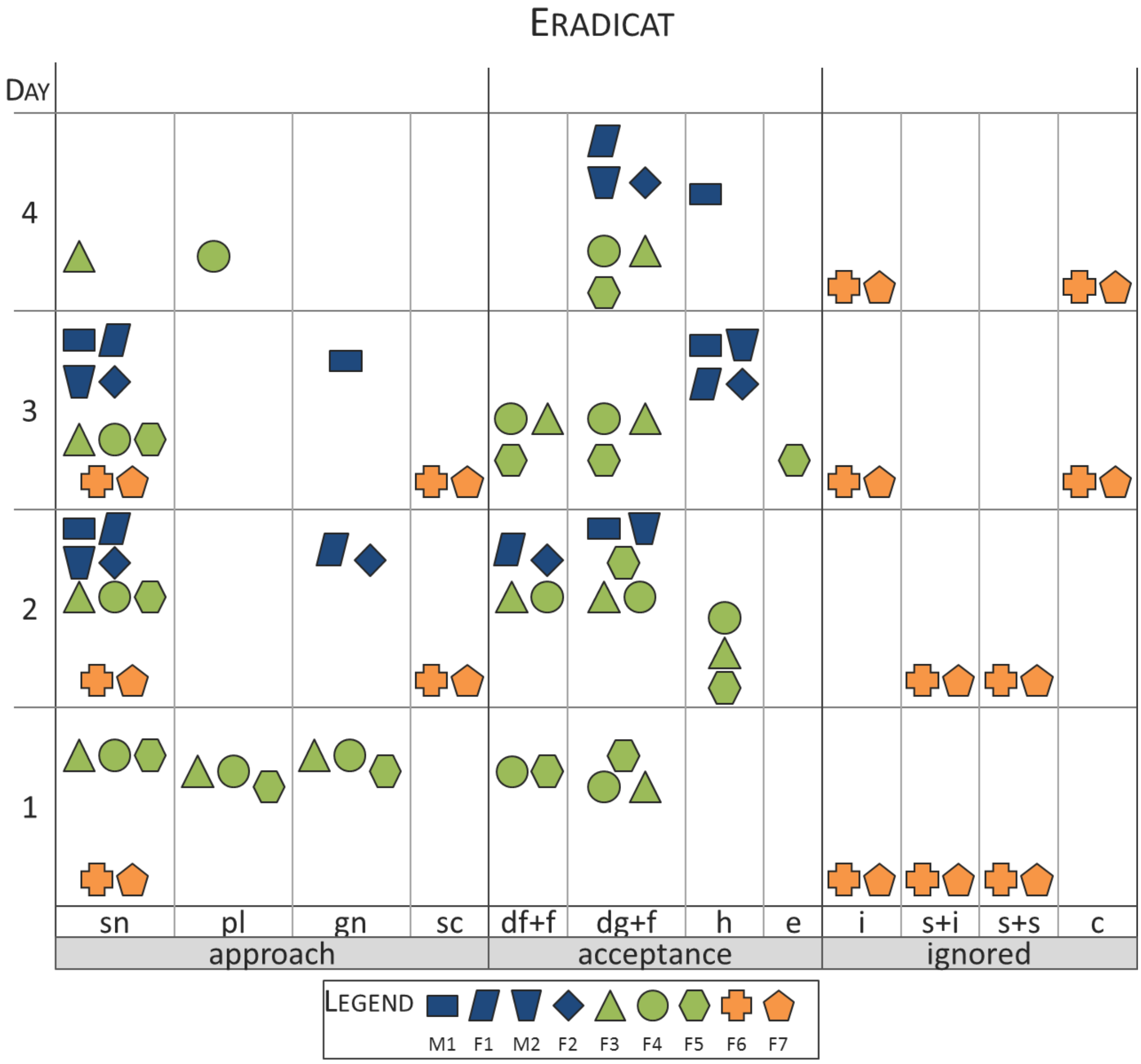


Figure 7: Variation in animal behaviour when handling the bait Eradicat®.

sn: to sniff, **pl**: to play, **gn**: to gnaw, **sc**: to scratch **df+f**: to defend and feed, **dg+f**: drag off and feed, **h**: hoard, **e**: exchange with other food, **i**: ignore, **s+i**: shove from plate and ignore, **s+s**: shove from plate and scratch on it, **c**: cover the bait

Notable is that Group 3 animals (F6, F7) showed only one pattern of behavior (ignorance). Group 2 animals (F3, F4, F5) never ignored the bait and immediately played with it and consumed it. Group 1 (M1, F1, M2, F2) behavior was more differentiated.

Eradicat® bait was accepted as food by the Group 1 and Group 2 animals displaying all sorts of behaviour; the animals sniffed and played with the bait. Especially Group 2 animals dragged off and fed on the bait, respectively depositing the bait in a particular part of the cage (hoard). The two females of Group 3 even stopped sniffing at the bait on Day 4.

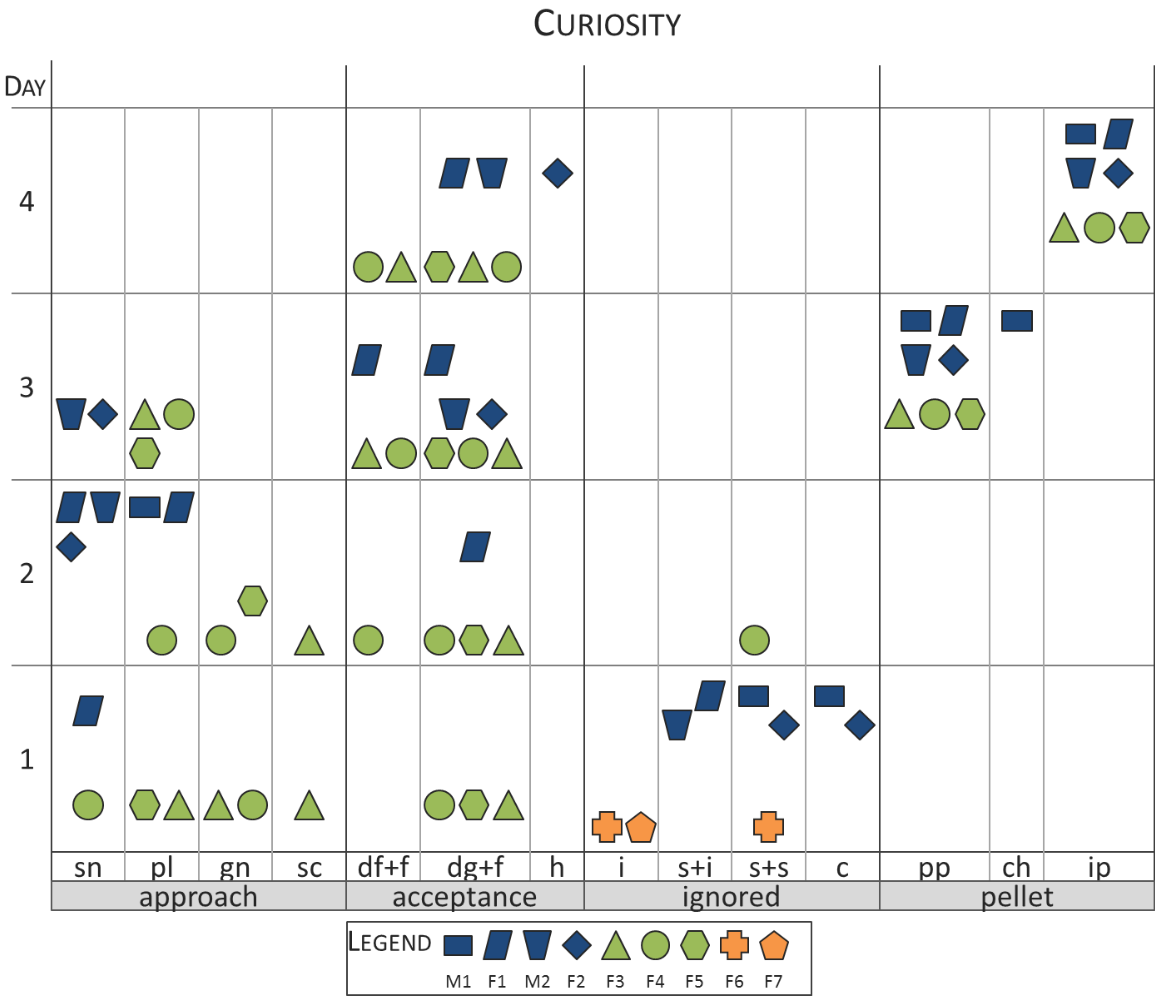


Figure 8: Variation in animal behaviour when handling the bait Curiosity®.

sn: to sniff**, pl**: to play**, gn**: to gnaw**, sc**: to scratch, **df+f**: to defend and feed, **dg+f**: drag off and feed**, h**: hoard, **e**: exchange with other food, **i**: ignore**, s+i:** shove from plate and ignore, **s+s**: shove from plate and scratch on it, **c**, **pp**: to play with the pellet, **ch**: to chew on the pellet, **ip**: to ignore the pellet

Figure 8 shows that Curiosity® was on the whole accepted less willingly. The animals approached the Curiosity® bait more hesitantly and were cautious. They sniffed thoroughly at the bait before consuming it and preferred their normal food when it was offered to them as an option. The adult male of Group1 (M1) was the only individual which chewed on the pellet.

Group 2 again shows all behaviours except ignorance. Group1 accepted the bait markedly later.

4 Discussion

The study demonstrated that captive banded mongooses generally accepted feral cat baits as food. However, three factors had an influence on bait uptake:

- taste of the two baits, with a preference of Eradicat® compared to Curiosity®
- feeding times, as less bait was consumed at 2 PM compared to 10 AM
- social behaviour which led to a significant difference in bait uptake.

The acceptance of Curiosity® bait was considerably lower than that of Eradicat®. This affinity to Eradicat® was clearly shown and led to a rapid consumption, especially when the animals were hungry. Curiosity® was sniffed at and played with more thoroughly.
Former studies have shown that mongooses are very sensitive to chemicals (Stone *et al*. 1995). This is confirmed in this study as Eradicat®, which contains the taste enhancer glutamate, was preferred to Curiosity® containing less or no glutamate. The fact that the animals distinguished well between both bait types can only be explained by the different taste and smell of the baits as the composition is almost identical except of the pH buffering of Curiosity® bait. The inclusion of sugar could be useful if masking the taste of chemical additives in the bait (e. g. toxin) is required. The use of sweeteners to increase rodent bait consumption is almost universal (Marsh 1988). Other taste enhancers in studies on bait acceptance of rodents used sugar, oils, egg yolk and yeast as additives (Shafi *et al*. 1990, Clapperton 2006). The attraction of eggs to mongooses was made use of in a study to evaluate the use of conditioned taste aversion to control predation by mongooses upon eggs (Nicolaus and Nellis 1987). A study by Creekmore (1994) used baits blended with whole eggs and fishmeal to attract mongooses in order to deliver oral vaccine to mongooses in Antigua (Creekmore *at al*. 1994) The use of chemical attractants enhanced the discovery of baits by red foxes (*Vulpes vulpes*) but did not result in identifying a chemical that would be suitable for use in the field to attract a large proportion of a fox population to baits at any time of the year (Saunders and Harris 2000). In a trial with feral cats the presence of food lures may have affected the consumption of Eradicat® bait. The food lure (sardines, peanut butter) could have reduced bait consumption by satiating the animal first, or could have increased the consumption in a situation of captivity (Hetherington *et al*. 2007).

The pellet in the Curiosity® bait was rejected by all animals and proved not a suitable mechanism to deliver a toxicant within a bait. Unlike feral cats who are presumed to swallow relatively large portions of food and inert material such as bone (Marks *et al*. 2006) mongooses were observed to grind the food (pers. observation, Appendix 2 and 3) and are more likely to ingest smaller particles of food. Also a smaller size of the bait should be considered and might lead to the consumption of whole baits as the trials showed that the mongooses did not eat all baits immediately and often only after feeding breaks. A toxicant injected into the bait matrix as in Eradicat® bait would be a better solution because the pellet was always discovered by the animals and never swallowed.

The social behaviour of the mongooses at Landau Zoo corresponds to the behaviour of banded mongooses in the wild and is shown in the same variety of behaviour in interaction (playing, fighting, dominance, synchronized breeding). Nevertheless, human contact could be a factor in bait acceptance. The three young females displayed a behaviour which is typical for hand-raised zoo animals which are very much imprinted to their keepers. Zoo animals, especially when hand-raised do not expect any harm from their keepers and are accustomed to good handling (Taylor 1978). This was evidenced as towards both types of baits, the Group 2 animals showed no reluctance. Curiosity® bait was consumed immediately on all four days of the trial. Otherwise, a vigorous, relatively fearless approach to an object is shown in carnivores and approximates the pattern that might normally be used in capture and consumption of prey (Glickman and Sroges 1966). As young animals normally do, the three individuals of Group 2 (F3, F4 and F5) acted in a curious manner and were eager to play with anything new that was offered to them. It must be noted that the absence of danger for animals in captivity influences their playfulness (Glickman and Sroges 1966).

The timidity of Group 3 animals could have been caused by their violent eviction from the group after birth of the young in 2012 as they hardly approached the Curiosity® bait the second day of the trial. Thus, social dynamics within a group might be a consideration in bait uptake.

The two different feeding times showed a difference in bait acceptance. Less bait was consumed at 2 PM compared to 10 AM. It must be considered that the baits were an additional food item and that, all in all, more food was offered than usual. For example, on Day 4 the animals were obviously not hungry at the 2 PM feeding time. During the observation time neither normal food nor bait was eaten. On Day 1 the food was left in the outside enclosure for the night. On the next morning there were neither bait nor normal food left, so it can be concluded that the animals came out during the night and ate. On Days 1 and 3 of the Curiosity® bait trial no baits were consumed when there was an option of “normal” food (Fig. 4A, 4C). On the days the baits were offered before the “normal” food, the animals then consumed them eagerly. This confirms the assumption that when food is abundant a bait needs to elicit much stronger cues to be competitive with regularly available alternatives (McFarland 1977). The willingness to consume a bait is greatly affected by the ease of access to other foods and efforts needed to find alternative food. This was shown in a study by Weerakoon and Banks (2011) on black rats (*Rattus rattus*).

Landau Zoo provides a diet that reasonably simulates mongooses natural feeding behaviour as a great portion of the diet consists of whole animals (chicken, mice) which the animals would feed on in the wild. The groups always fed as a unit, but each individual found its own food and made use of the well furnished enclosure when caching the food (Appendices 1-4).The mongooses were observed poking their noses into any available crevice and often appeared to locate the food by olfaction. Prey is frequently obtained by digging (Rood 1975). This behavioural pattern was shown by the animals in the open enclosure and could be used to improve a species specificity of a poisoning campaign. For example, the poison baits could be placed in rock crevices to make them more accessible to mongooses and less to feral pigs or monkeys. This approach has been used in baiting campaigns for foxes and feral cats (Roy 2002) in Australia. The study showed that the mongooses´playfulness and curiosity towards new elements (baits) in a familiar habitat could help make the bait more effective.

The impact of habituation could be observed during the Curiosity® trial. It was obvious that the animals consumed more bait, the longer the trial lasted. The percentage of both baits consumed would show a lower average consumption if four baits had been offered twice a day (e. g. on Days 1 and 3 with Eradicat® and Days 1 and 4 with Curiosity®). This was not the case because the animals left whole baits untouched. So the eaten baits were replenished only.

The animals did not come out to feed on the first day of the trial using Eradicat® when the temperature was -4°C (Appendix 6, Table 4). The outside temperature could have been an interesting point to look at in this study as the animals ate significantly less than usual, especially on Day 4 of the trial with Curiosity® bait. Under conditions in a natural habitat, the temperature would not be a criterion because of the warmer climate.

5 Conclusion

It can be concluded that meat baits as Eradicat® and Curiosity® can serve as baits for free-ranging mongooses. The taste of Eradicat® compared to Curiosity® obviously made a difference to the animals, as they preferred Eradicat®. The pellet in the Curiosity® bait was rejected by all animals and proved not a suitable mechanism to deliver a toxicant within a bait. There is evidence to suggest that to increase bait acceptance, the addition of taste enhancers could be a means to make baits more attractive as competition to other available food. The application of baiting as a control technique for mongooses requires not only a specifically designed bait but also a specific toxicant which could be tailored to mongooses' metabolism. The synergy of a specific delivery mechanism with a relatively specific toxicant can be very selective and exclude the danger for non-target species. As baiting efficacy may change seasonally, geographically or with the availability of naturally occurring foods, an investigation of bait uptake in the field and the interaction between mongooses and other predator species is needed. This would lead to a greater understanding of population and behavioural ecology of the species.

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Appendices

Appendix 1: Group 1 animals next to entrance to their sleeping den (photo by C. Hübner).

Appendix 2: Young male animal (M2) of group 1 consuming Eradicat bait (photo by C. Hübner).

Appendix 3: Group 2 animal (one of F3, F4 or F5) feeding on Eradicat bait (photo by C. Hübner).

Appendix 4: Group 2 animals (F3, F4 and F5) feeding on Eradicat baits (photo by C. Hübner).

Appendix 5:

Table 3: Data for Figure 12 (Appendix)

	Eradicat®			**Curiosity®**		
Date	**Bait offered**	**Bait consumed**	**%**	**Bait offered**	**Bait consumed**	**%**
Day1	4 pc (2 baits)	4 pc	100	4	0	0
Day2	8	7	87,5	8	1	12,5
Day3	4	2	50	8	2	25
Day4	8	6	75	4	2	50

Table 4: Bait consumption and weather Feb. 2013

Date	**Highest temp.**	**Lowest temp.**	**Eradicat consumed**	**Curiosity consumed**
Day 1 (A) 2013-02-13	1°C	-4°C	(100)	
Day 2 (B) 2013-02-14	3°C	-7°C	87,5	
Day 3 (A) 2013-02-15	3°C	0°C	50	
Day 4 (B) 2013-02-16	5°C	0°C	75,5	0
Day1 (A) 2013-02-19	4°C	-2°C		0
Day2 (B) 2013-02-20	2°C	-2°C		12,5
Day3 (A/C) 2013-02-21	0°C	-4°C		25
Day 4 (B/C) 2013-02-22	-1°C	-6°C		50