

MATING BEHAVIOUR IN CAPTIVE PINE MARTENS MARTES MARTES



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Mating behaviour in captive Pine Martens *Martes martes*

Introduction

The pine marten *Martes martes* is a native species, which by the early 1900s had reached its lowest recorded population level¹. It has



Pine marten in rowan tree

since started to spread back to Scotland but there is no evidence of its numbers increasing in either England or Wales.

Fragmentation of the population has occurred due to deforestation and trapping for its fine fur². The population lies somewhere between 3000 and 3650 individuals in Britain, with approximately 150 found in England and Wales^{2,3}. However, our knowledge regarding both population levels and conservation of this species is neither abundant nor particularly accurate. Pine martens are elusive mammals, nocturnal and forest dwelling, making them extremely difficult to track. They also have multiple dens and extremely large territories for their body size⁴.

General Ecology

Pine martens are a slow breeding species with a delayed maturity and do not start breeding until their second or third year. They produce on average 2-3 young in their lifetime and only live for five or six years in the wild. In captivity they can live for up to 18 years. The pine marten feeds on a varied diet, predominantly dependent on the habitat in which it is found. Small mammals, carrion, insects, frogs, waterfowl, fish, fungi and fruit and berries when in season are all taken.

As the pine marten is primarily a forest species, open ground can restrict the rate and extent of recolonisation². Limiting factors and threats thought to affect population numbers and distribution include deforestation, habitat fragmentation, road kills, illegal trapping

and poisoning. Little conservation action has been taken so far and as long as suitable habitat remains scarce and fragmented, pine martens will remain a rarity to most people. It is presently illegal to catch, kill or disturb a pine marten in its place of abode but a licence can be obtained for scientific work. Investigations into potential reintroduction sites have taken place, showing that the pine marten is a particularly suitable mammal for reintroduction. Due to its value as a fur bearer, the pine marten has been the object of numerous attempts at captive breeding.

The pine marten is comparable in size to a small domestic cat and similar in both appearance and movement. Martens are the largest of the small mustelids, standing 15cm in height and between 53-84cm in length (including the head, body and tail).



Pine marten in its natural habitat

Legal Status

Pine martens are a fully protected species, listed on Schedule 5 of the Wildlife and Countryside Act 1981 (amended 1988). This makes it an offence to kill, injure or take a marten without a licence; illegal to damage, destroy or obstruct access to a place or structure being used by a marten for shelter or protection; or disturb a marten whilst it is using such a place or structure. They are also found on Schedule 3 of the Conservation Regulations 1994, the Bern Convention Appendix III and EU Habitats and Species Directive, Annex V.



There is a slight size dimorphism between the sexes; the males are slightly larger. Pine martens are characterised by dark brown fur, a cream or orange chest and throat patch, large rounded ears and a long fluffy tail⁵. Their pointed snout and large rounded ears give pine martens a distinctive heart-shaped face.



Pine marten showing throat patch

Habitat

Although they occur in a wide range of habitats, martens prefer coniferous forests, up to 200m above sea level, which are well-wooded with plenty of cover. Marten dens are commonly found in hollow trees or the fallen root masses of Scots pines. Pine martens tend to travel on the ground but they can climb trees extremely well.



Typical pine marten den site

Britain and Ireland provide a range of three-dimensional rocky habitats as alternatives to forest, which although not always optimal for pine martens, have the ability to support viable populations⁶. Rock crevices and cliffs covered with scrub are frequently used as alternative den sites. Commercially managed plantations which have a low biodiversity prove to be unsuitable for pine martens, offering very few potential den sites and low prey abundance. Martens avoid large areas of open woodland, favouring closed canopy woodland with a large extent of cover. When carrying out a reintroduction for this species, it should not be forgotten that with the correct number of

suitable den sites and high prey abundance, pine martens can survive in three-dimensional rocky habitats.

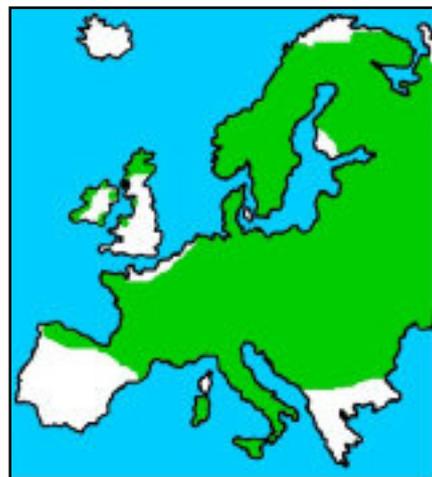


Pine marten rocky habitat in Snowdonia

Distribution

Today the pine marten's distribution remains restricted predominantly to those refuges where it retreated over a hundred years ago⁶. Although these areas do not represent ideal pine marten habitat, they demonstrate the areas of least persecution during the early 20th century. The pine marten's range has expanded since the 1930s, especially from northern Scotland. The pine marten is found throughout forest areas of mainland Europe, although it is absent from most of the Low Countries, Spain, Greece and parts of north-west Russia⁴.

Having a Palaearctic distribution, fossil evidence suggests that the pine marten spread northwards soon after the last glaciation, allowing it to reach Britain before the English Channel



Current pine marten distribution in Europe

formed⁶. It is widespread in the northwest of Scotland and Grampian but infrequent in both north Wales (such as Clwyd and Powys) and northern England (such as Cumbria and Northumberland)^{2,3}. Isolated populations are found in southern Scotland. In Ireland, pine martens are mostly confined to wood and scrub areas of the Midwestern region⁵.



Breeding

There is very little information on the breeding biology of wild pine martens, especially in southern Britain. Little is known except that in wild populations litters are large, consisting of 1-6 kittens. Young appear to be sleeping in the nursery den as late as August in northern England. There are confirmed breeding records for England and Wales from 1800-1988. There are no confirmed records for the following two years (1989-1990)⁷.



Pine marten kit

Pine martens are slow breeders in comparison to other mustelid species and so the rate at which populations increase is dramatically reduced. When averaged over a pine marten's lifetime, the number of young produced by a single female is approximately two per year⁸.

Breeding success is likely to be compromised where the territory system breaks down due to low population density. As pine martens breed relatively slowly and live at very low densities, they are likely to be susceptible to random demographic perturbations or high mortality in some years². The

peak time for persecution of pine martens coincides with the period in which the females are in late pregnancy, giving birth and feeding the young kittens⁷.



Pine marten pelts - in the past they were often hunted for their fine fur

Mating Period

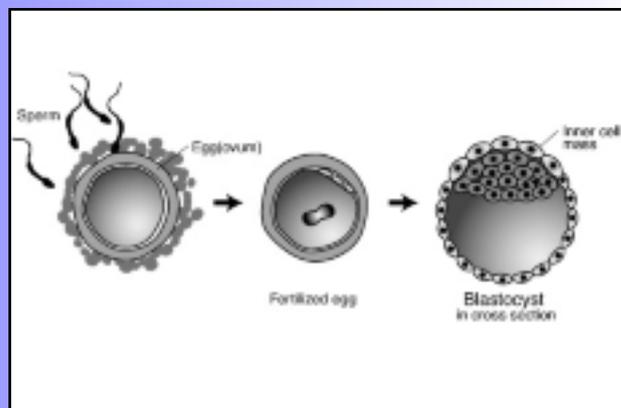
Pine martens mate predominantly from July to August, with most matings occurring in July, within a 30-45 day period. They produce a

single litter of 1-6 kits in either March or April of the year following mating, due to delayed implantation (see below). Litters of five are rare, with three young being the most common. There is a post-implantation period of 30 days, meaning that the actual pregnancy does not start until January. The young emerge from the den in either June or July and disperse between August and October. The limits of the mating season have been observed to run from July 10th-September 2nd and the length of the mating season varies from 24-46 days⁹. If displaying intensifies in late June, pine martens can be placed together at this stage, if it is felt to be safe to do so¹⁰.

Delayed Implantation

Pine martens have a delayed implantation period of 165-210 days¹¹. In mammals, this is a condition in which a fertilised egg reaches the uterus but delays its implantation in the uterine lining, sometimes for several months. In pine martens the embryo does not implant immediately following fertilisation but remains in a state of suspended growth or diapause, in the blastocyst stage, allowing birth to occur under the most favourable conditions.

Metabolic and environmental cues are critical in determining the length of the embryonic diapause, although the true gestational stage is generally stable. Delayed implantation gives the offspring an extra 3-4 weeks to perfect their foraging skills, thus increasing their chances of survival over winter¹².



The blastocyst stage is retained during delayed implantation



Marten scat counts are much higher in summer than in winter and increased activity is seen during daylight hours throughout the mating period⁷. Martens are most active during the transitional hours of the day, from sunrise to 10am and from 3pm until dark, therefore most matings occur during these periods⁹.

American martens have been observed to have an oestrous cycle with 2-3 periods of heat separated by short inactive periods of rest of between 7-10 days⁵. However, captive pine martens exhibit 1-4 periods of sexual receptivity, usually lasting 1-4 days and occurring at 6-17 day intervals¹².

Martens show an increase in scent marking from both the abdominal gland and through urination when coming into breeding condition. Changes in external genitalia are also observed during this period, including enlargement of the testes and penis. This should be visible from early June and they should remain enlarged until after the mating season, receding in early September.

Male pine martens appear to be fertile approximately one month before matings occur. Photoperiod is presumed to be the primary environmental cue for timing of breeding in all species of *Martes*¹².

During the breeding season, males increase the size of their home range to encompass a larger number of females in breeding condition. Males generally occupy larger home ranges than females, where overlap between animals is seen. Male territories overlap those of females but no intra-sexual overlap is seen in males. Faeces act as territory or boundary markers and conical piles of scats are also used to mark the area close to the entrance of a breeding den. The term 'territory' cannot easily be applied to animals in confined spaces in captivity.

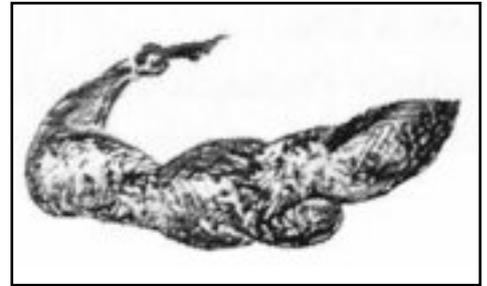
Breeding Age

Sexual maturity is reached at a later age in martens than other members of the weasel family, presumably due to the increased longevity of the species⁹. No sexual activity is

seen in pine martens until at least the second season.

However, this is dependent not only upon the sex of the

animal but also whether they are wild caught, captive bred or wild individuals.



Typical pine marten scat

In captivity, males show no obvious development of the testes during their first season⁵. Some males have been seen to produce sperm and show mating behaviour in the second season but fail to fertilise a female until their third season. This can also be seen in females, who fail to produce offspring until the third season. In captivity, pine martens do not breed until 24-27 months of age¹².

Females seem to have a preference for older males and tend not to mate with individuals younger than two years old¹⁰.

Puberty may be delayed in both wild populations and captive individuals due to nutritional deficiencies. In the wild, the age of first mating in females has been noted as anywhere between 14-39 months, whereas in males it is between 14-27 months. Altered behaviour or stress in captive animals could be responsible for failures to mate¹². The percentage of sterile matings is often high in captive animals¹.

Mating Behaviour

Mating behaviour in captive bred individuals or wild caught individuals will not mimic that of wild pine martens, due to the numerous limitations of their enclosures.

Martens are promiscuous and do not form pair bonds, as a single female can mate with several males during oestrous. The first visible sign of oestrous is the enlargement of the vulva, with most matings occurring when vulval swelling is at a maximum¹².

The vulva also exhibits a colour change as the females approach oestrous⁹. Males



play no part in rearing the young, mainly due to the fact that it cannot be determined which male fertilised the female.

Courtship involves playful chasing and the male following the female. It has been suggested that the female may control both direct and indirect interactions prior to matings¹³. Excited vocalisations can be heard when a female comes into oestrous, where she emits high-pitched clucking noises. These clucking noises, used to attract the males, are entirely different to those heard at other times of the year. Both sexes have been observed to rub their bellies across the tops of nest boxes and any projecting limbs⁹.

During copulation, both sexes purr and growl to a large extent¹⁴. The female is restrained by the neck and held down by the male during copulation where she assumes the mating posture voluntarily⁵. The male will often seize the female from high up in a nest box or on branches and will persist until he has dragged her down to the pen floor. When the female does not readily accept the male, he will chase and struggle with her until mating is accomplished⁹. Mating occurs predominantly on the ground, although pine martens have been observed mating in the branches of trees. Copulation usually lasts an hour, but can last from fifteen to over seventy-five minutes. The male may drag the female around on the floor for up to half an hour before intercourse occurs⁹.

Odd behaviour is often recorded in captive animals, such as males attempting to mate with individuals of the same sex. This may have more to do with stress of captivity rather than the animal's natural instincts¹⁴. 2-3 matings within a day between a single pair is not unusual and females often accept a different male the following day⁹. Female martens have been recorded mating up to 18 times during the breeding season¹⁵. Females are extremely aggressive towards each other during the mating season, often resulting in fatalities⁹. Aggression reaches its peak during this period, between both individuals of the same sex and those of opposite sexes.

Captive Breeding Objectives

Pine martens are predominantly carnivores, which greatly reduces their suitability for reintroduction. Captive bred individuals do not have the potential to learn traits from their parents which are necessary for survival upon release. The main problem with reintroductions for this species, other than the obvious lack of suitable habitat, is their ability to find suitable prey species in the wild. Pine martens feed



A wild pine marten hunting - captive bred individuals would have no experience of this

mainly on field voles but will have had no experience in captivity of catching their own food.

However, if a breeding stock can be produced in captivity, there will be more potential for reintroductions in the future and, with a larger number of individuals being released, the chance of a percentage of those individuals surviving is increased. The pine martens' low population numbers and slight sex bias ratio (weighted towards males), means that their future survival is necessarily dependent to a large degree upon captive breeding. At present, there is very little data on the mating behaviour of pine martens either in captivity or in the wild, due to their elusive behaviour. Obtaining information about the mating behaviour of pine martens will benefit anyone hoping to breed pine martens in captivity in future.



Wildwood Captive Breeding Project

Enclosures

The pine marten enclosures at Wildwood are surrounded by a large area of natural woodland. The dimensions of each enclosure are approximately 7.4m x 3.65m x 3m, comprised of a wooden frame covered in mesh (1.6cm² mesh size). Each enclosure houses two nest boxes; a Vincent Wildlife Trust design (60 x 27 x 55cm) and one of our own design. The Vincent Wildlife Trust boxes are situated at



Vincent Wildlife Trust nest box

approximately 1.6m above the ground and our own boxes are at ground level. Pine martens at Wildwood show a preference for the Vincent Wildlife Trust (VWT) design. The key features of the VWT nest box include: den chamber size similar to natural den sites, good thermal insulation, reduced heat loss by siting entrances at the bottom and double 'chimney' entrances which prevent the den from being exposed to rain and mimic wild habitats by offering a choice of entrance.

Our own design is very simple; a small nest box with one entrance hole at the front.



Wildwood's nest box design

Wildwood's Pine Martens

Wildwood is home to six pine martens at the time of this study; three males and three females. Each individual pine marten has its own enclosure, as they are solitary animals and also highly territorial, especially during the breeding season. Each male pine marten's enclosure is joined to a single neighbouring female enclosure via a short tunnel which runs close to ground level. These tunnels remain closed throughout the year and are only opened if and when necessary during the mating season. Due to the incompatibility of some of Wildwood's pine martens, we proposed to only introduce a single pair between July and August 2006; Poop and Twix.

Poop is a male pine marten, hand-reared at the New Forest Otter and Owl Centre. Poop was 9 years old at the time of this study (born 13/04/97), which is relatively old for a pine marten. However, mating behaviour was observed. Poop was expected to be relatively unstressed, having been at Wildwood for six years (since 25/06/00), thus increasing the chance of mating. Poop has previously mated and produced offspring when he was 2-3 years old. A male pine marten has previously been used for breeding by Martin Noble (a pine marten captive breeder) until the age of twelve¹⁰.

Twix is the female pine marten living adjacent to Poop. Unlike Poop, she was wild born in Cumbria and parent-reared. Her date of birth is therefore uncertain but she is thought to be approximately 9 years old, the same age as Poop. She has been resident at Wildwood for 4 years (since 26/02/02). DNA typing of Poop and Twix, carried out at the Waterford Institute of Technology, identifies both as British pine martens.



The floor of the enclosure is comprised of natural soil, additionally lined with wood chips. Enrichment devices are incorporated into the internal design of the enclosure to encourage natural behaviour. These include posts and branches running around the internal diameter and through the centre of the enclosure, as well as raised pathways.

Mating Tunnel Design

Before this project started, there was a single tunnel (3.5 x 0.4 x 0.4m) running close to ground level between the two enclosures, closed at both ends. This was based on a design used elsewhere, the idea being that during the mating season, the tunnel could be opened, allowing the male access to the female. This was trialled at Wildwood some years ago but resulted in a fatality, hence the need to design a new tunnel system.

Due to the aggressive nature of pine martens, particularly during the breeding season, it was felt necessary to incorporate numerous tunnels into the new design. Males have larger territories than females and should initially enter the female's territory. With this in mind, tunnels were designed to run from the male's enclosure, all the way around the female's enclosure and back to the male's enclosure (0.27 x 0.27 x 50.5m (total length)).



Tunnel system surrounding the enclosures

Shut-offs were placed at every corner so that the male could be trapped within the tunnels if he became aggressive towards the female. Four shut-offs were placed on each of the two enclosures, allowing each individual to be trapped within their own enclosure and denied access to the tunnels if necessary. Four shut-offs were also placed within the tunnels; a total

of twelve shut-offs were incorporated.



Shut-off as seen from inside an enclosure

A short tunnel, connected to those running externally around the enclosures, passed through the centre of the female's enclosure, allowing the male to enter her territory. A second short tunnel (3.45 x 0.27 x 0.27m) was placed 2.4m off the ground above the original tunnel joining the two enclosures.

	Length /m	Width /m	Height /m	Distance above ground /m
Enclosure	7.4	3.65	3.0	N/a
Nest boxes	0.6	0.27	0.55/ 0.6	1.5
Long tunnel	50.5	0.27	0.27	2.4
Short tunnel (ground level)	3.45	0.4	0.4	ground level
Short tunnel (2.4m up)	3.45	0.27	0.27	2.4

The system of tunnels was designed with the intention that the female could never get trapped by the male without some form of escape. The aim was to allow the female to become accustomed to the male moving around and through



her territory, as well as a chance for them to become used to each other's scent, before allowing any direct contact between them. It also allowed us to monitor their behaviour and vocalisations, ensuring that the shut-offs were not opened until they were ready to mate.

It is extremely important in such a captive breeding situation, that all aspects of their behaviour are understood before allowing direct contact between the two pine martens. Although both the Wildwood enclosures can be seen by the public, they are at such a distance (minimum 10m) that it was felt this should not interfere with or affect the pine martens' behaviour unduly. Furthermore, it was expected that mating behaviour would predominate during hours when Wildwood is not open to the public.

Feeding Regime and General Husbandry

Wildwood's six pine martens are fed twice a day, once in the morning and again in the afternoon. A scatter feed of fruit and unsalted peanuts is spread around the enclosure in the morning. At this time water bowls are also emptied, scrubbed out and clean water provided. Every 2-3 days the majority of faeces are removed from the enclosures. It is important to leave some scats, as these are used as territory markers. The afternoon feed may consist of chicks, rats, mice, rabbit or rat pups. Our martens have a preference for chicks so these are fed on most days.



A Wildwood pine marten being hand fed by its keeper

During the winter months, the pine martens' food supply is increased by one or two chicks each day. The females are fed less than the males; usually 8 chicks for females and 10 for

males. These are hidden within the enclosure to encourage wild behaviour of finding food for themselves. Live foodstuffs are never provided (zoo licensing requirement). Enrichment devices are provided throughout the year, as and when needed.



Enrichment device; food is hidden in the holes

Timetable of Observations

Martens are most active during the early and late hours of the day, generally from dawn until 10am and from 3pm until dusk. Therefore, most matings occur during these periods⁹. When light levels are low or cloud cover is high, pine martens have been seen to mate as late as midday.

The initial aim of this study was to carry out two periods of observation from Monday to Friday; 9am-10am and 4pm-5pm. No observations were taken at weekends.

The encircling main tunnel (50.5 x 0.27 x 0.27m) was opened for the first time on 4th July. This gave Poop access to the tunnel system but not to the female's enclosure, allowing him to move through her territory without the two of them coming into contact. Their behaviour could therefore be observed, allowing an understanding of the specific risks associated with introducing them.

Twix's small tunnel (3.45 x 0.4 x 0.4m) was opened on the morning of 5th July. At this time, all feeding was taking place in the tunnels to try to encourage the use of them. On 12th July all the shut-offs were closed, keeping Poop inside his



enclosure so that Twix could have an opportunity to use the tunnels and familiarise herself with their layout. On 17th July all shut-offs were opened, allowing both pine martens access to one another's enclosures. Shut-offs to each enclosure were closed for one hour at approximately midday on a daily basis. This allowed the pine martens to be fed separately, as we did not want to trigger any aggressive behaviour due to disputes over food.

Daily Observations

Tuesday 4th July (3:30 pm for 1 hour)

Poop entered the tunnels almost immediately after they were opened. Scent marking was seen in the central tunnel running through Twix's enclosure, just under where she had often been seen sitting. As soon as Poop entered the tunnels, Twix went into her nest box and remained there for the whole hour. At one point Twix's head was visible from one side of the nest box and Poop displayed aggressive behaviour towards her through the wire mesh. For most of the hour Poop displayed stereotypic behaviour within his own enclosure. This involved running around the enclosure at ground level, scent marking in the same places on each circuit.

Wednesday 5th July (9am for 1 hour & 4:40pm for 1 hour)

Poop was seen scent marking in the tunnel surrounding his enclosure for the first time. One of the small tunnels between the two enclosures was opened to Twix and she was fed within it. When in the tunnels, Poop spent most of his time in the central tunnel running through Twix's enclosure. He was seen lying asleep in there, washing and scent marking. Twix was seen feeding on top of her central tunnel. No interaction between the two was seen during the two observation periods.



Central tunnel in Twix's enclosure on top of which mating took place

Thursday 6th July (3:30pm for 1 hour)

Poop showed severe aggressive behaviour towards Twix when he was inside the central tunnel and she was above it. Twix moved into her nest box and remained there for the rest of the observation period. Poop moved through the tunnels for a short time scent marking and then slept for the rest of the time in the central tunnel.

Friday 7th July

No activity seen.

Monday 10th July (9am for 1 hour & 3:30pm for 1 hour)

Non-aggressive contact between Poop and Twix was observed for the first time, consisting of low-pitched growling. Both were seen sitting and walking alongside each other on opposite sides of the tunnel. Twix was observed actively scent marking along the walkways adjacent to the tunnels, something she had not been seen to do before. Poop always engaged with Twix first but was also the first to move away.

In the afternoon, Poop collected food from his enclosure and took it to an area of tunnel adjacent to Twix's enclosure to feed. He also attempted to hide some of his food in the tunnels. Both pine martens seemed unaffected by the other's presence. Both were seen displaying stereotypical behaviour. Twix was observed sitting on top of the central tunnel and also dragging herself along it, scent marking as she went.

Tuesday 11th July

Shut-offs were being constructed on this day so there was no proper observation. Poop was shut into his enclosure in late afternoon, with no access to the tunnels. Shut-offs in Twix's enclosure were opened to allow her access to the tunnels. According to pine marten breeder Martin Noble, nest boxes in the female's enclosure should have only one entrance, allowing her to defend herself from within. Extra nest boxes of this type were placed in Twix's enclosure. Twix was not seen in the tunnels, but all her food was placed in them to encourage her to enter.



Wednesday 12th July (9am for 1 hour)

All food placed in the tunnels the previous evening was no longer there, so Twix had entered the tunnels at some point overnight. Poop was seen going up to the shut-offs in his enclosure, attempting to enter the tunnels. Twix was seen in the tunnels but was very wary and for the majority of the time would not go as far as Poop's enclosure. Towards the end of the observation period, she moved through the tunnel to the area bordering Poop's enclosure, where they encountered each other with non-



Additional nest boxes with single entrance holes

aggressive sniffing and growling. Twix walked away towards her own enclosure after no more than a minute. Poop was seen scent marking on top of his shut-offs.

Thursday 13th July

No activity seen.

Friday 14th July

No activity seen.

Monday 17th July (2pm for 3 hours)

Poop and Twix were shut into their own enclosures at 12:30 pm and fed separately. At 2pm all shut-offs were opened. After approximately 10 minutes, Poop entered Twix's enclosure. He scent marked high up within the enclosure, before noticing her on top of the central tunnel and moving towards her. As he approached her, she emitted a high-pitched clucking noise for no more than five seconds. The encounter was non-aggressive; both were sniffing each other and low-pitched growling was heard from both.

At 2:15pm, Poop grabbed Twix by the scruff of her neck and mounted her. Twix displayed herself to Poop, holding her tail up and to the side. All activity took place on top of the central

tunnel where their two territories overlapped. Poop dragged Twix up and down the central tunnel for 110 minutes without separating. A very quiet low-pitched growling was heard from Poop and constant high pitched vocalisations were heard from Twix. At 4:05pm they separated and Twix moved into the tunnels.

Poop scent marked on top of the central tunnel and was observed entering one of Twix's nest boxes. Twix had a small amount of blood on the back of her neck, something not uncommon in mustelid matings. During 55 minutes, until 5pm, Poop mounted Twix four times within the tunnels, for no longer than 15 minutes each time. As he approached her within the tunnels for the first time, high pitched clucking noises were heard from Twix again. When they were mounted within the tunnel there was no way of separating them if they became aggressive. On each occasion, Twix pushed Poop off her and through one of the shut-offs into her enclosure. She would not enter Poop's enclosure, although she was seen actively scent marking above the shut-offs.

After Poop had mounted Twix three times, they were observed lying close to each other within the tunnels. Poop then mounted her for the final time during this observation period.



Pine martens mating on the central tunnel

Pandora, the female pine marten in the nearest of the other enclosures, seemed very interested in Poop and Twix's activities and watched them continually. Both Poop and Twix were very aware of their surroundings and even the slightest noise caused them to freeze.

The morning scatter feed was stopped for both Poop and Twix but their afternoon feed was increased.



Tuesday 18th July (3pm for 2 hours)

At the start of the observation period, Twix was moving in and out of her nest box and displaying stereotypical behaviour. After no more than five minutes she retreated to her nest box and remained there for the rest of the observation period.

Poop was seen scent marking within Twix's enclosure but not in the same places as she used. Poop discovered six chicks that Twix had cached and removed them all but did not eat them. Scats were seen in the tunnels for the first time, later identified as Poop's by their content. Scats are used to mark territory boundaries,

so this was a good sign that the tunnels were being used to extend the size of the male's territory.



Poop in the tunnels

Poop had become more inquisitive of Pandora, the female in the nearby enclosure. During the first hour of observation, no stereotyping was seen coming from Poop but between 4-5pm he was seen stereotyping and only left his enclosure to use the tunnels once.

At the start of the observation period, it had been noted that one of the small nest boxes in Twix's enclosure appeared to have been knocked over. Poop was unable to fit through the entrance of this box and it could have been knocked over if he attempted to follow her in. On the morning of the 18th, Twix had been seen by one of the animal keepers, sleeping in Poop's nest box.

Wednesday 19th July (9am for 1 hour & 2pm for 1 hour)

Poop was seen stereotyping to a lesser degree than before. He was also moving through the tunnels more often, presumably to increase the size of his territory to encompass the tunnels and parts of Twix's enclosure.

Thursday 20th July (4pm for 1 hour)

Scats (later identified as Poop's) were found in the same location as those previously found on 18th July.



Scats within one of the tunnels

Friday 21st July (9am for 1 hour & 2:45pm for 2 hours)

Poop and Twix were separated at approximately 1pm for their afternoon feed. When reintroduced to each other at 2:50pm, Poop mounted Twix for fifteen minutes. No calling was heard from Twix prior to or during mating. She remained in her enclosure whilst Poop moved back into the tunnels. At this point, Twix was heard clucking and Poop came back into her enclosure, grabbed her from on top of her nest box and dragged her to the ground. She displayed herself for him and he mounted her for ten minutes. When mating on the ground, Poop seemed to have more control over Twix. She showed aggression towards him when they split and he was seen moving back into the tunnels again.

Twix moved to the top of the central tunnel, while Poop moved inside it. Non-aggressive growling was heard. After approximately 30 minutes, Poop entered Twix's enclosure and went into one of her nest boxes, where he stayed for a short time before retiring into his own enclosure.

Saturday 22nd July (observation by animal keeper)

When the pair were let back into the tunnels after feeding, Poop was seen chasing Twix, who ran away. He attempted to mate with her and she then started to chase him, after which he retreated to his own enclosure.



Sunday 23rd July (observation by keeper)

Poop and Twix were seen mating in the morning by their keeper at approximately 10am. They separated as he approached and it was not possible to know how long they had mated for, whether Twix displayed herself for Poop or if clucking noises were made.

Monday 24th July

No activity seen.

Tuesday 25th July

No activity seen.

Wednesday 26th July

No activity seen.

Thursday 27th July

Poop and Twix were separated by closing the shut-offs leading into her enclosure. This still allowed Poop access to the tunnels. He was showing severe signs of aggression, presumably as Twix was no longer on heat, and would chase her back into her nest box whenever she ventured out into her enclosure.

Friday 28th July

No activity seen.

Sunday 30th July (observation by keeper)

Twix was seen to be on heat, making a high pitched clucking noise. Poop was observed in the tunnels around Twix's enclosure, purring at her and being non-aggressive.

Monday 31st July

No activity seen.

Tuesday 1st August

The pine martens were reintroduced to each other, as they seemed unaggressive and Twix had appeared to be on heat on 30th July. Twix was initially in her nest box. When the shut-offs were opened, Poop moved straight into her nest box and dragged her out and onto the ground. They immediately mated and she was observed to have assumed the mating posture voluntarily, as well as making a high pitched clucking noise. The pair were separated indefinitely in the afternoon, after aggressive behaviour from Poop had been observed.

Discussion

When looking at the results, it must be kept in mind that throughout the mating period, 24 hour observation did not take place. All results are based on observation periods of no longer than three hours on any particular day. Weekends were also generally omitted, as it was not possible to have an observer present on those days, but anything relevant seen by the pine martens' keeper was noted and added to the results above.

It was not possible to carry out 24 hour observations for such a prolonged period of time. Infra-red lighting and an infra-red viewer could have been used at night to observe the pine martens. Infra-red cameras could also have been used over a 24 hour period and the footage viewed at a later date. However, it would have been very difficult to encompass both enclosures and all the tunnels in such a way. Another option which could be used in future would be a plan to sample the pine martens' activity by watching for a set period each night at different times, which would cover the whole time period evenly over the course of the study.

Although mating was observed four times during the 17-day period 17th July-2nd August, it is not yet known if offspring will be produced. It is known that Poop is capable of siring young, as he has mated successfully in the past. Due to the length of delayed implantation in this species, it will not be known until spring 2007 whether the mating has been successful. As 24 hour observation did not occur, it is not known how many times the pair mated when no observers were present.

If future matings are to occur, it could be beneficial to observe changes in external genitalia in both the male and female pine martens. Catching up the animals, especially during the breeding season, can be stressful and therefore may not be beneficial. Vulval swelling in the female is another way to determine if she is in oestrous. Enlargement of the male's testes and penis should be visible from early June and they should remain enlarged until after the mating season, receding in early



September. High pitched clucking noises were heard from the female in all but one of the matings. This sound indicates that the female is in oestrous and therefore in breeding condition. Twix had not previously been heard to make this noise during the mating season. Having her in a closer locality to Poop through the presence of the tunnels could have induced such a call.

Captive pine martens have been seen to exhibit 1-4 periods of sexual receptivity, usually lasting 1-4 days and occurring at 6-17 day intervals¹². According to the observations above, the initial period of sexual receptivity lasted five days, followed by an eleven day interval before another one day on heat. The last day on heat could have occurred over a longer period but the pair were separated indefinitely on 1st August until the next breeding season. Furthermore, the two were separated on 27th July due to aggressive behaviour on the male's part. Twix could therefore have been on heat before they were reintroduced. These periods of sexual receptivity seem to fit in quite well with the guidelines stated above.

The length of the mating season in captive pine martens varies from 24-46 days⁹. As our pine martens were not introduced until mid-July, a mating season of only 17 days was observed. This could have been prolonged into August under different circumstances, but Poop's aggressive behaviour made it necessary to separate them in early August. We were advised by Martin Noble not to let the mating run too far into August, as this is when the male can become aggressive.

An increase in scent marking, on the part of both pine martens but especially by Poop, was observed. However, Twix was never seen scent marking in Poop's enclosure and was only observed to go into his enclosure on one occasion. The use of the tunnels by Twix was only rarely observed, predominantly when the tunnels were initially opened to her. Poop used the tunnels to increase his territory size, actively scent marking throughout and leaving scats within the tunnels on two occasions. Furthermore, he was seen scent marking on numerous occasions within Twix's enclosure,

especially on top of her nest boxes and on projecting tree branches. The tunnels were important to Poop, allowing him to increase his territory size and incorporate Twix's enclosure within it. In the wild, a male's territory can overlap several female territories, as they are promiscuous and mate with more than one individual in a mating season.

Copulation in pine martens generally lasts for about one hour. The first mating between Poop and Twix lasted one hour and fifty minutes. Mating has been known to last for over 75 minutes but 110 minutes is still a relatively long mating. This could be due to the confined conditions of a captive mating, human presence or even the prolonged period where the two were kept separated. This long initial mating took place on top of the central tunnel. Poop seemed to find it increasingly difficult to maintain Twix in this position in such a confined area for such a prolonged period of time. Further matings either occurred within the tunnels or Poop dragged Twix down to ground level. On the ground of the enclosure he seemed to have greater control and there was less growling on both sides.

Conclusions

Judging the initial point at which pine martens should be introduced to one another is extremely important to avoid unnecessary aggression. The following recommendations should be kept in mind:

- The earliest that pine martens should be introduced is the last two weeks in June, but only if there is reason to think they are ready to mate.
- If or as soon as the male displays aggressive tendencies the two should be separated.
- The initial sign that the female is in oestrous is when she emits a high pitched clucking noise. It should be quite safe to introduce the pair at this point, as long as the male is not aggressive towards the female.
- Pine martens should



not remain together for more than one or possibly two weeks into August.

- The male should on no condition be allowed access to any offspring.

These results should form the basis for future captive matings of pine martens. The tunnels can be incorporated but are not a necessity. We used them as it was felt that it would be safer to do so, due to the previous aggressive behaviour shown by Poop towards other females. Martin Noble uses a single tunnel joining the male and female enclosures and this has worked successfully for him.

Nest boxes with a single entrance hole are safer and should be used during the mating season, predominantly in the female's enclosure. This allows her to defend herself from within the nest box. It was noted that human presence does seem to affect the pine martens' behaviour and perhaps the presence of other pine martens in a close vicinity may also. It would be advantageous to keep pine marten pairs at such a distance from each other that they do not have a negative effect on each other during the mating season.

Final Note

Since these observations were completed, Poop has retained access to the external tunnel network. He has used this daily and has frequently been observed sleeping, grooming and patrolling in the tunnels. Animal staff feel that the tunnel system has helped him to relax, engaged his interest and greatly reduced previous stereotypical behaviour.

We plan on using the tunnel system to link another pair of our pine martens in summer 2007, both in hopes of breeding success and also to extend the male's territory, encouraging relaxation and reducing stereotypical behaviour. Our observations suggest that a tunnel system can be a very important behavioural enrichment device for this species.

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