BIOL3001: Personal research
381753

Welfare and conservation in captive canids: Analysis of enclosure use and general activity in socialised and unsocialised wolves (*Canis lupus*).

Nadia Gunning

Project advisor: Dr Sarah Collins

Abstract
Carnivores that naturally have a wide range in the wild, are more vulnerable to welfare problems in captivity. Few studies have focused on enclosure utilisation in relation to improving the overall welfare of wolves in captivity. A useful way to understand and eventually develop the well-being of captive animals is to contrast different living and social conditions. In the present study, observations of three different wolf enclosures were carried out at two different locations. The enclosure utilisation and related general activity were used as welfare criteria in the three different packs of North American wolves (*Canis lupus*). Results show that the proportion of time resting was higher in large, comfortable enclosures. In each enclosure animals used only a part of the available space, the proportion being lower in large enclosures.
With further research these results could be applied while planning enclosure design, resource allocation and reintroduction and captive breeding efforts for wolves and possibly other socially hierarchical species.

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1. Introduction

1.1 Welfare in captive carnivores

Carnivores commonly occur in captivity and yet show high species variance in captive breeding success and/or morbidity (Clubb & Mason 2007). Some species (not just carnivores) such as the brown bear and ring-tailed lemurs typically adapt well to captivity and show few signs of poor welfare, while other species such as the Asian elephant and polar bear are often prone to breeding problems and abnormal behaviour (Clubb & Mason 2003). This is cause for concern in relation to the difficulties of conserving such species in both *ex-situ* and *in-situ* situations. In understanding the fundamental source of such differences, the extent of infant mortalities could be reduced and the elimination of abnormal behaviours could be enabled in zoos and breeding centres, this could be through increasing the appropriateness of enclosure designs and environmental enrichments (Clubb & Mason 2007). Clubb & Mason (2003) show that welfare problems in captive carnivores stem from restricting natural ranging and related behaviours (Clubb & Mason 2003; Clubb & Mason 2007). The evident tendency for species such as the coyote (*Canis lantrans*) and wolf (*Canis lupus*) to develop pacing is due to the fact that they range widely in the wild (Clubb & Mason 2007). Stereotypic pacing may also originate from territorial patrolling behaviour. Wolves for example, generally are highly territorial, with territory ranges varying from tens to thousands of square kilometres (Mech 2003). There is therefore a positive correlation between species stereotypic behaviour levels and the distances they typically travel in the wild and/or their natural home-range sizes; and territorial carnivores will display more pacing than non territorial species (Clubb & Mason 2007).

The behavioural needs of canids (and other carnivores with a wide natural home range) in captivity then present a challenge due to limited space (Bauman 2004). The challenge is increased in social captive carnivores, because as well as careful enclosure design being required to meet the specific biological and physiological needs of the species, consideration of how many animals are housed in the enclosure is needed, and how much space will be required for each animal.

Even with the range of morphology and ecology in the Canidae family, social behaviour remains similar throughout its members. Some specialisations have occurred in group living species to maintain group cohesion and to reduce intra specific aggression. In comparison to the bat eared fox which developed contact behaviours such as social grooming; the wolf has evolved more specialised agnostic postures that serve to maintain social hierarchy (Kleiman 1967). An understanding of the complex social organisation is therefore necessary in order to address the needs of captive wolves while assuring the safety of humans (White 2001).

1.2 Welfare in captive wolves

Concern has been expressed that captive wolves are more aggressive toward pack-mates than wild wolves (White 2001). Higher aggression in captivity could be detrimental to the animals' health and human safety (White 2001). A stricter hierarchy is typically maintained within a captive wolf pack in comparison with wild packs (White 2001), where dominance displays and intraspecific aggression are infrequent except in the competition for food and mates (Mech 1999). The distinction has been associated with the difference in social bonds between related and unrelated wolves. Through the majority of captive packs consisting of un-related individuals who have not matured with their co-specifics, there is therefore no family structure of a basic wild wolf pack to enforce dominance and as a result captive wolves are left to aggressive behaviours and displays to implement the hierarchy (Mech 1999). Information on the optimum environment for safety and stability in the pack could improve the quality of life for captive wolves and increase the safety for personnel working with wolves as the need for staff to separate individuals or attend injuries will be greatly reduced (White 2001).

The wolf is very appealing for visitors in Europe and has a very good reproduction rate in captivity, which is probably why it is a common species in European zoos. Despite this, their conditions in captivity are extremely varied. Even with the number of articles on wild and captive wolves (see Mech 1999, Briscoe *et al.* 2002; Mech & Boitani 2003; Theuerkauf 2003) and although there is enough information to produce general guidelines for their husbandry and management needs (see Laidlaw 2000; Dangerous Wild Animals (Northern Ireland) Order 2004; Grisham *et al.* 2007) most studies have not aimed on improving the overall welfare of wolves in captivity. Schassburger (1987) provides a design plan for a wolf enclosure and how to optimise them for behavioural research, until a recent report by White (2001) and Frezard & Le Pape (2003) however; no studies have specifically addressed the effects of pack social dynamics and of enclosure size as a contribution to welfare of wolves in captivity. White (2002) and Frezard & Le Pape (2003), highlight that there is a need to provide appropriate enclosure size and complexity while also considering pack social dynamics when housing unrelated individuals together. The aim of this study was to understand the needs of a captive wolf pack in relation to enclosure size and design and contribute to their welfare in captivity and in captive breeding programs.

2. Material and methods

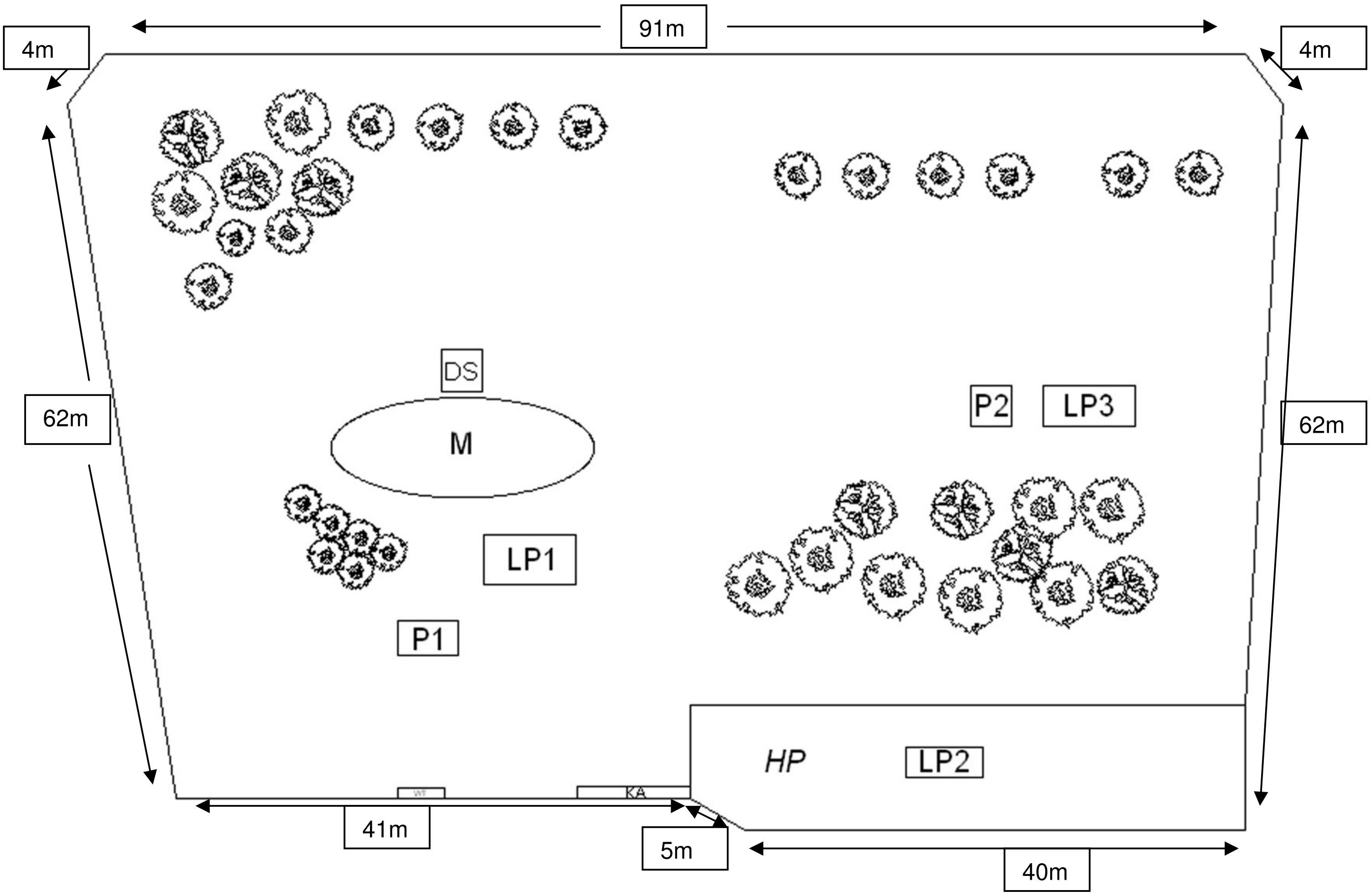
2.1 Subjects and housing

Three packs of wolves were observed in two different locations, two enclosures were studied at the UK Wolf Conservation Trust (UKWCT) in Beenham, Reading. The other was at Dartmoor Zoological Park (DZP), Sparkwell. The characteristics of the enclosures and pack composition are described in Table 1. Detailed diagrams are also included to illustrate each enclosure and their features (Figs. 1-3).

Table 1: Descriptions of the enclosures and pack composition.

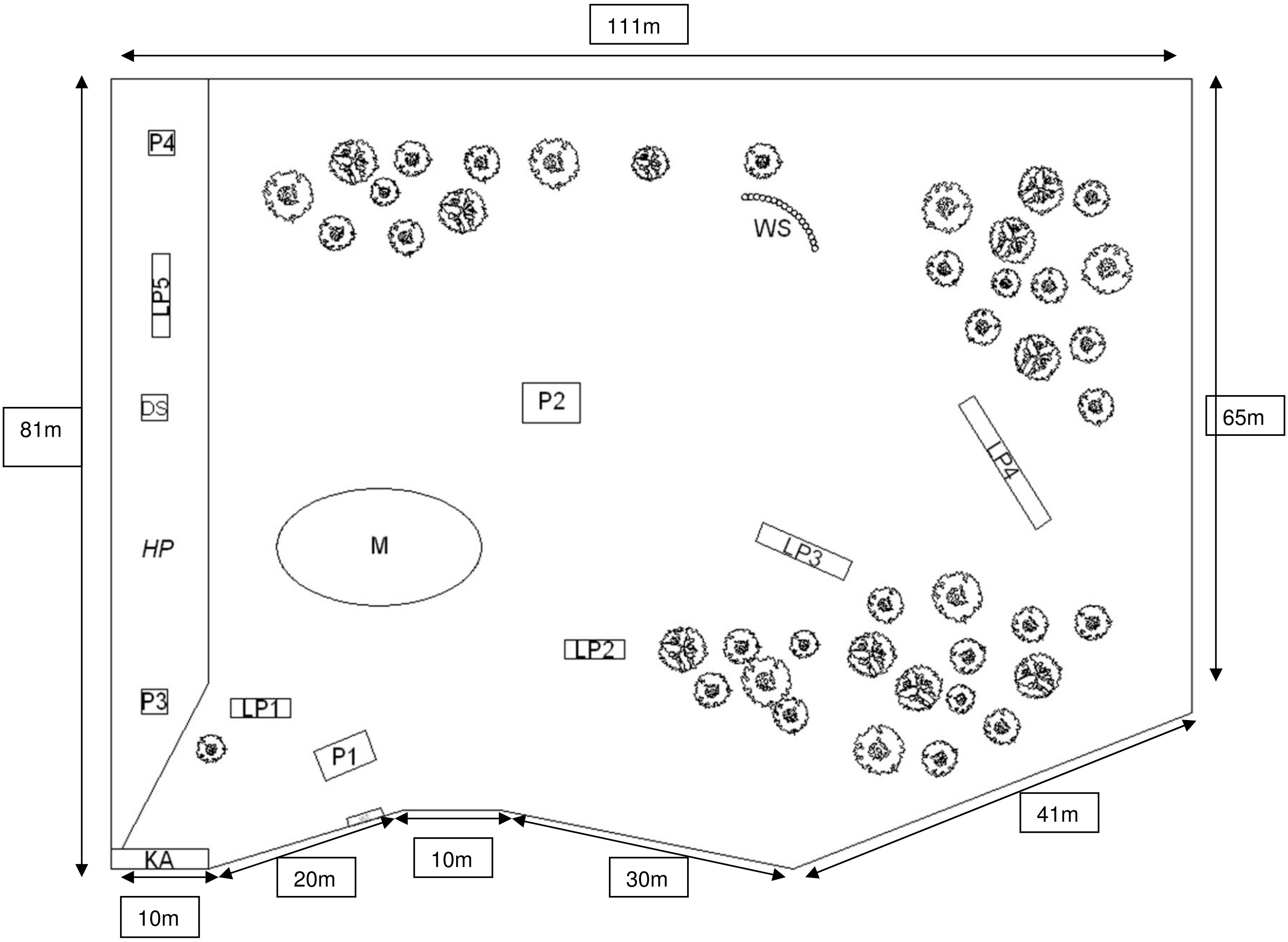
Enclosure and Surface area (m^2)	**Vegetation**	**No. of wolves and Pack composition**	**Age of pack members**
North American pack, UKWCT. 6018m².	Good – dense tress, shrubs, earth and grass (concrete kennel area).	3: 1 male, Kodiak, and his 2 female sisters, Duma and Dakota. All socialised wolves.	(All captive born) Kodiak born in 1994. Duma and Dakota born in 1998. All born at Woburn Safari Park, Bedfordshire (Appendix A).
Juvenile pack, UKWCT. 8443.5m².	Good - dense tress, shrubs, earth and grass (concrete kennel area).	3: 1 male, Torak. 2 female sisters, Mai and Mosi (not related to Torak). All socialised wolves.	(All captive born) All born in 2006. Torak born at Anglian Wolf Society. Mai and Mosi born at DZP (Appendix A).
Sparkwell pack, DZP. 2397.28m².	Average – Trees, earth and leaf litter.	7: 2 male brothers, Sooty and Parker. 5 females, Ivy, Lizzy, Prettyface Lady P. and Sarah (the latter two wolves are sisters to each other and to the 2 males). Sooty, Parker, Sarah and Lady P. are the offspring of Prettyface. All unsocialised wolves.	(All captive born) Ivy, Lizzy and Pretty face born in 1997 at Howletts. Sarah, Sooty, Parker and Lady P, born in 2004 at DZP.

Figure 1: Diagram of the North American enclosure at the UKWCT.



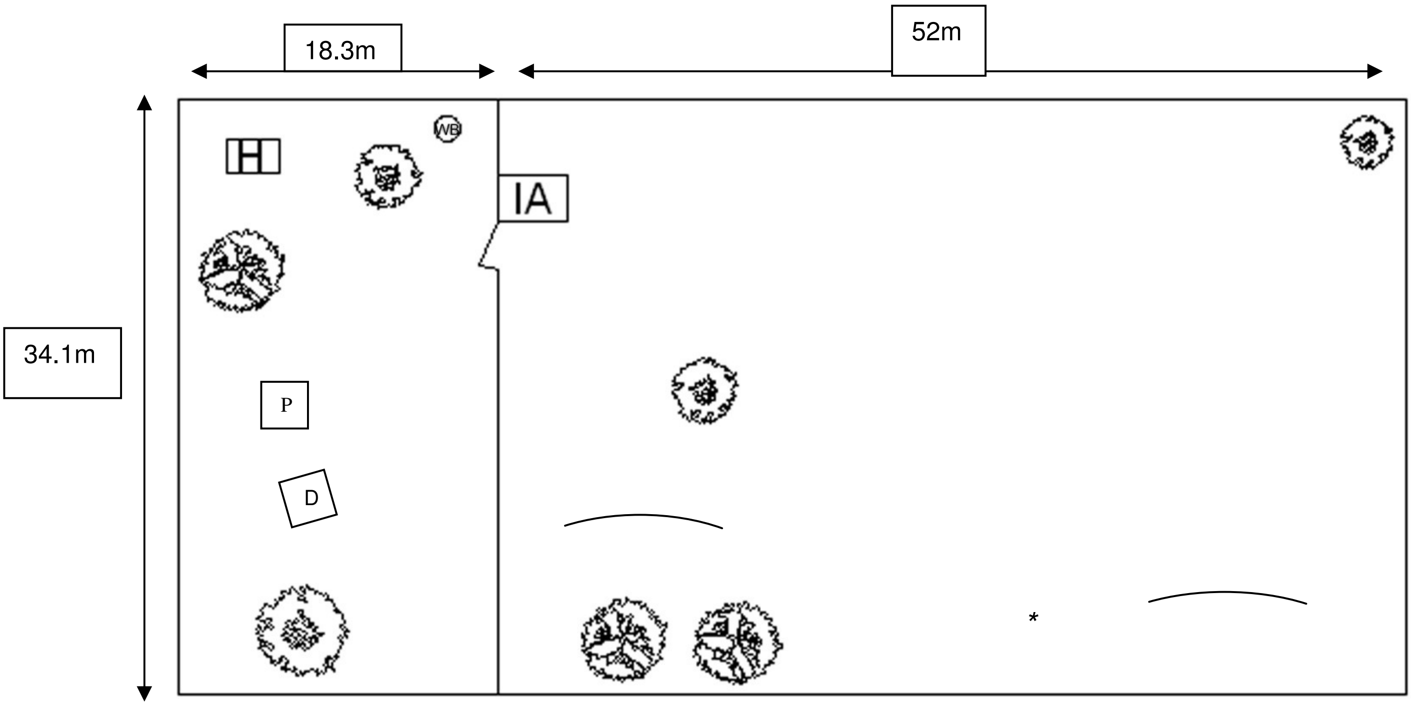
K*ey*: **M**- Mound, **HP**- Holding Pen (this is available as part of the enclosure), **KA**- Kennel Area (this is a concrete area that has water bowls and leads to shutters which lead to indoor kennels that the wolves are able to use at night, however is closed during the day), **WT**- Water Trough, **DS**- Day Shed, **P1-P2**- Platform1 & 2, **LP1-3**, Log Pile 1-3.

Figure 2: Diagram of the juvenile enclosure at the UKWCT.



Key: **M**- Mound, **HP**- Holding Pen (this is available as part of the enclosure), **KA**- Kennel Area (this is a concrete area that has water bowls and leads to shutters which lead to indoor kennels that the wolves are able to use at night, however is closed during the day), **WT**- Water Trough, **DS**- Day Shed, **WS**- Wooden Structure, **P1-P4**- Platform1-4, **LP1-5**, Log Pile 1-5.

Figure 3: Diagram of the Sparkwell enclosure at DZP.



Key: H- Hut, WB- Water Bowl, IA- Indoor Area (this was not open until the last day of my study) , D – artificial Den available to provide more shelter if dens that have been dug become flooded, P- Platform (available in the new enclosure) * - this signifies where at the present study Parker had dug a temporary den where he would canter in the presence of keepers), - vantage points. There are more trees located in this enclosure; however the main trees used are shown.

2.2 Observation Method

Data were collected using scan sampling (Martin & Bateson 2007). A scan was realised every 5 min during several hours per day for several days, the details of each observation period are given in Table 2. To remove bias in the observation of the two packs at the UKWCT, recordings were alternated every day. Activity and location were recorded at each scan for each subject. Specific and social behaviour were also recorded.

Table 2: Observation duration and dates for all three packs.

Enclosure	Observation duration	Observation dates
North American pack, UKWCT.	1h per day, 30mins in morning and 30mins in evening	11 consecutive days in August
Juvenile pack, UKWCT.	1h per day, 30mins in morning and 30mins in evening	11 consecutive days in August
Sparkwell pack, DZP.	12½h in total, an average 4h per day, 2h in morning and 2hr in evening.	4 days in November, over a 2 week period

2.3 Behaviour sampling

Behavioural data was grouped into 39 categories which were used for all three packs (Tables 3 – 5); with amendments for the Sparkwell pack (Table 6). This is due to the months of October to November when the pack was studied in which hormonal changes were occurring in the build up to the breeding season of January to March. The two packs at the UKWCT were settled into their hierarchy in the August month. Another factor is that the Sparkwell pack consists of more members, and so more agnostic behaviours were seen at feeding times for example. The packs social dynamics were in a state of uproar as their alpha male, Zak, had recently passed away.

Table 3: Description of general activity used for all three packs (adapted from Goodmann & Klinghammer 2002).

Behavioural categories
1. R (Resting):*A general inclusive term for lying in a relaxed manner*
2. XR (Sphinx Rest): *Lying with forepaws extended in front, hind legs tucked close to either side, body erect and head up.*
3. SXR (Sphinx Rest sprawled): *Forequarters are in XR, hindquarters twisted so that the weight rests on one hip and both hind legs are stretched to the side.*

4. SR (Side Rest): *Lying flat on one side, body stretched out, with legs to one side.*
5. CR (Curl Rest): *Lying down with legs tucked close to the body. The back is curved and the tail often lies over the paws and nose.*
6. Sit: *The wolf's forelegs are straight, or slanting in front of the wolf. The rump and hind legs from hock to paw are all on the ground. The wolfs' back slopes to the ground.*
7. BW-STR (Bow Stretch): *On getting up from resting, a wolf may combine a bow with a stretch. A bow is a lowering of the forequarters while the hindquarters remain stationary.*
8. Standing: *The animal is standing motionless.*
9. YW (Yawn): *A wide gape with deep inhalation. The eyes may be slits or closed. The tongue often protrudes and curls upwards.*
10. ROL-BK (Roll on Back): *After lying down on ventral surface or side, the animal rotates its body on the longitudinal axis coming to rest on the dorsal surface. The forelegs may assume various positions and the hind legs may relax and rotate out to the side from the hip joint.*
11. TRT (Trot): *A diagonal two beat gait in which the left rear and right front legs move together and the left fore and right hind legs move together. It is an extremely efficient traveling gait.*
12. WAN (Wander): *Meandering about, often sniffing things with no observable goal.*
13. WLK (Walk): *A wolfs' walk is often a slow pace with lateral legs moving together.*
14. Canter: *A three beat gait with left hind leg starting, the right hind and left leg striking the ground together and the right foreleg landing and supporting the whole weight of the animal. There is a moment of suspension before the sequence is repeated and the sequence may be reversed.*
15. Climb: *To move to a higher elevation. It includes walking, trotting or running up a slope.*
16. RLU (Raised Leg Urination): *The wolf walks up to the spot to be marked, usually sniffs and steps past it, so the spot is past its inguinal area. In wolves RLU' s are determined more by social rank and degree of assertiveness than by gender.*
17. SQU (Squat Urination): *A posture typical of females and immature male pups. Depending on the depth of the squat it may resemble a sit, but the wolf is up on their hind toes.*
18. SCP (Scrape): *Forceful scratching backward against the ground with the hind legs and sometimes with the front ones too. It is usually done after a RLU and appears to be associated with an assertive mood.*
19. DF (Defecate): *To excrete feaces. A fearful animal may DF during a ritualised fight or when receiving an offensive threat.*
20. Consume: *To ingest substances (water, food)*
21. GN (Gnaw): *To chew at something persistently, usually the molars and premolars are primarily used.*
22. SLJ (Stiff Legged Jump): *The wolf rears up on its hind legs and comes down hard on its forelegs. The forelegs may be used to quickly pin small prey.*

23. Hunt: *To seek, test, chase and attempt to kill prey.*
24. KLBT (Killing Bite): *A bite which quickly causes death.*

The above behaviours however were collapsed into two groups of resting behaviour and general behaviour in order to carry out the chi-square tests on the association between behaviour and location of the packs in their enclosures. Tables 4 and 5 however remained the same and were also applied to the chi-square test.

Table 4: Description of specific behavior that were used for all packs.

Specific behavioural categories
25. GM (Groom): *To care for the coat and skin by licking, nibbling and scratching the coat free of dirt, irritating substances or parasites.*
26. SCR (Scratch): *Raking the claws across the skin and fur.*
27. SNF (Sniff): *Bringing the nose to close contact with an object, companion or substance and inhaling.*
28. SH (Solo Howl): *One wolf making relatively brief howls separated by almost equal length.*
29. WH (Whine): *Repeated relatively brief vocalisations of falling pitch.*
30. DH (Duet Howl): *Two wolves howling at the same time, but not necessarily in synchrony.*
31. CH (Chorus Howl): *Three or more wolves howling at the same time.*
32. G (Growl): *A throaty rumbling vocalisation, usually low in pitch. It may be used in aggressive or defensive interactions.*

Table 5: Description of social behaviour that were used for all packs.

Social behavioural categories
33. P (Pin): *Lunge and bite (inhibited) another wolf and holding it to the ground.*
34. MGR (Muzzle Grab - soft)
35. C/O (Carry Object): *Holding something in the mouth while standing or moving about.*
36. GM-SOL (Groom Solicit): *To solicit grooming from another individual. May involve pawing, nibbling the other wolf all with the goal of eliciting grooming.*
37. TW (Tail Wag): *A tail may be wagged from side to side, in circles, or by thumping on the ground by a resting wolf. A tail that is liber when wagged indicates friendliness and possibly submission. A tail that is level with the back or above it and wagged stiffly indicates excited often aggressive arousal (seen in courtship displays). A tail that is held between the legs and wagged indicates fear and submission.*
38. RA (Rally): *Three or more wolves pressing together with tail wagging, greeting and sometimes including active submission.*
39. H12 (Hackles): *Piloerection of the fur along the spine. The numbers for*

the areas of the back where fur may be piloerected: scruff/withers, back, rump and tail (1, 2, 3, 4 respectively).

Table 6 was also collapsed into the resting and general behaviour in order to carry out a chi-square test. One of the amendments had to include 'out of sight', as the highly socialised wolves at the UKWCT would carry on their normal behaviour in the presence of human observers. The Sparkwell pack however is unsocialised and observations were made behind a hide.

Table 6: Amendments to behaviour categories that were used for the Sparkwell pack.

Behavioural categories
41. S-P1 (Submissive- passive 1): *Falling or lying on the side or back, ears are flattened and the tail may be between the legs.*
42. AP (Agnostic pucker): *A vertical retraction of the lips.*
43. GR (Greet): *A general term for interacting in a friendly manner.*
44. OR (Orient): *To direct the eyes, ears, and nose toward something.*
45. Other
46. Out of sight

2.4 Statistical analyses

Data were subjected to chi-square tests to determine if there were associations between behaviour and location of the individual wolves in each enclosure. Second a modified Spread of Participation Index (SPI) was calculated to determine their use of available space (Plowman 2003). The modified SPI is the exact mathematical equivalent of the original SPI if zone sizes are equal, however in a range of realistic situations the modified SPI is more sensitive and more accurately reflects the extent of enclosure utilisation (Plowman 2003).

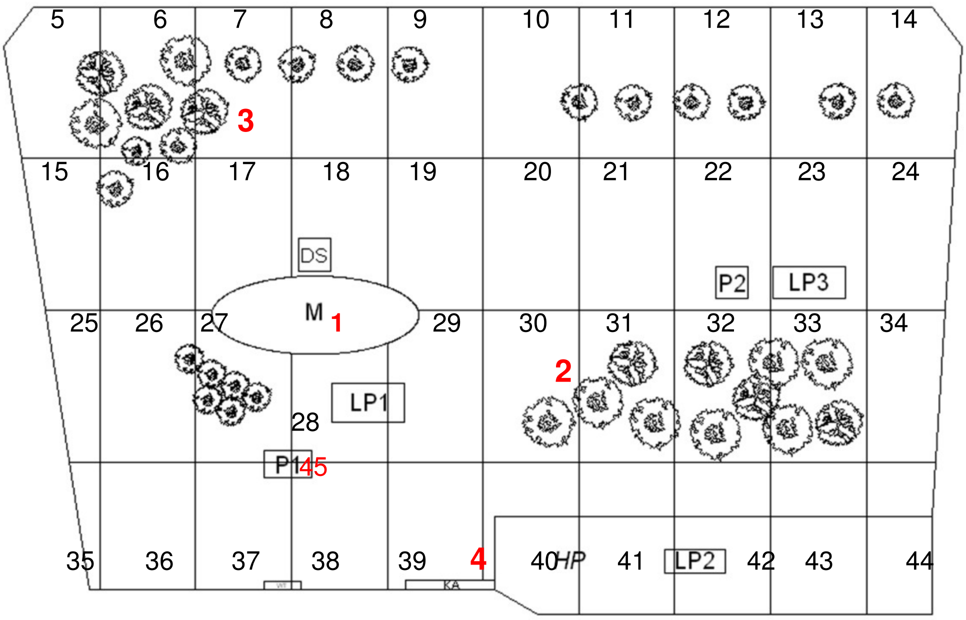
The modified formula:

$$SPI = \frac{\Sigma |f_o - f_e|}{2(N - f_{emin})}$$

Where f_o is the observed frequency of observations in a zone, f_e the expected frequency of observations in a zone, based on zone size assuming even use of the whole enclosure. $|f_o - f_e|$ the absolute difference between f_o and f_e, Σ summed for all zones, N the total number of observations in all zones and f_{emin} the expected frequency of observations in the smallest zone.
If the SPI=1.0, this indicates minimum utilisation, i.e wolves spend their time in one area. Conversely if SPI=0, there is maximum utilisation, i.e all areas are used equally.

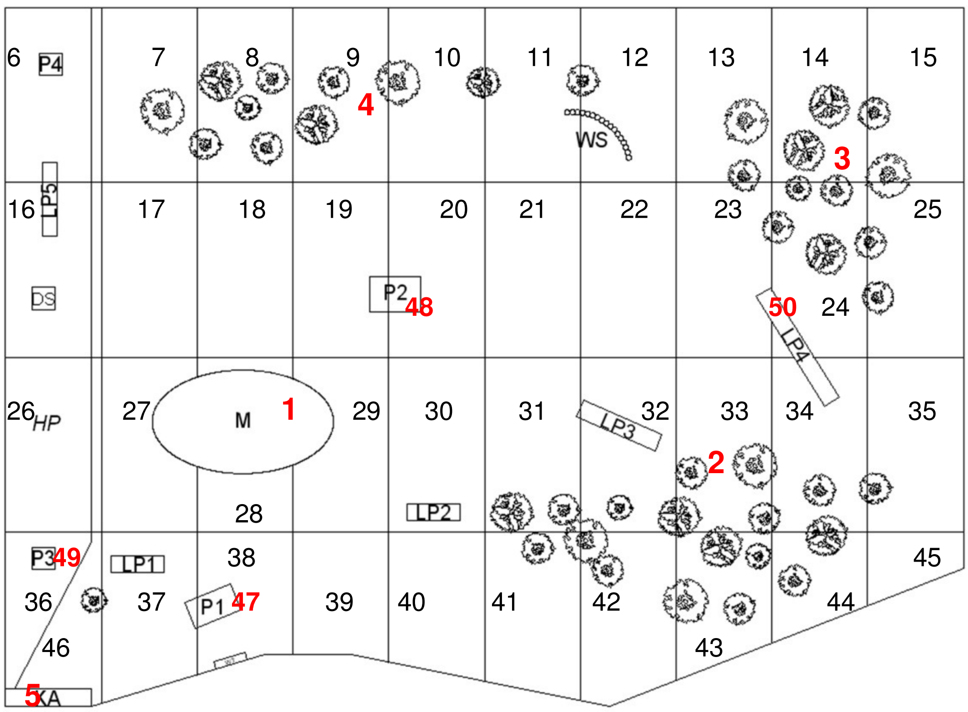
To determine SPI, each enclosure was divided into zones using the modified Spread of Participation Index method. This allowed for the inclusion of unequal and equal zones to give a more accurate representation of enclosure utilisation and resource allocation (Figs 4-6).

Figure 4: North American enclosure divided into unequal zones.



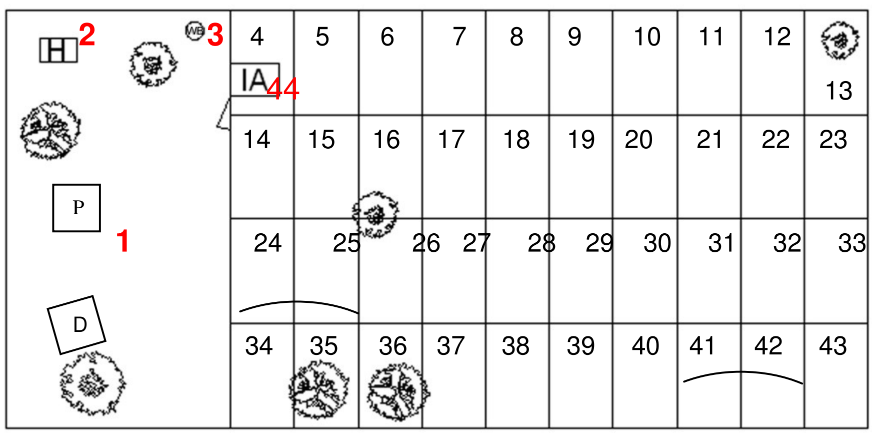
Key: Zone 1- Mound (M), Zone 2- Dense trees, Zone 3- Dense trees, Zone 4 – Kennel Area (KA), 5-44 –the enclosure divided into 10x4 zones of mostly an equal size. Zone 45 – Platform 1 (P1).

Figure 5: Juvenile enclosure divided into unequal and equal zones.



Key: Zone 1- Mound (M), Zone 2- Dense trees, Zone 3- Dense trees, Zone 4 – Kennel Area (KA), 6-46 –the enclosure divided into 10x4 zones of mostly an equal size. Zone 47 – Platform 1 (P1), Zone 48 – Platform 2 (P2), Zone 49 – Platform 3 (P3), Zone 50 – Logpile 4 (LP4).

Figure 6. Sparkwell enclosure divided into unequal and equal zones.



Key: Zone 1- New enclosure, Zone 2- Hut (H), Zone 3 – Water Bowl (WB), 4-43 – the older enclosure divided into 10x4 equal zones, Zone 44 - Indoor Area (IA).

In order to analyse the observed association and interactions between the pack members, association indices were constructed from the formula:

$$\text{Index of association} = N_{GH} / (N_G + N_H + N_{GH})$$

Where N_{GH} is the number of occasions *G* and *H* are seen together; N_G is the number of occasions *G* is seen without *H*; and N_H is the number of time *H* is seen without *G*. This index has the merit that all scores between 0 (no association) and 1.0 (complete association) (Martin & Bateson 2007).However, for the two packs at the UKWCT, estimated sociograms were constructed to indicate strengths of association between individuals,

3. Results

3.1 Spread of Participation Index

All individuals overall were only using part of their enclosure indicated by Figs. 7-9. The proportion being lower in the larger enclosures.

Figure 7. SPI for the North American pack at the UKWCT.

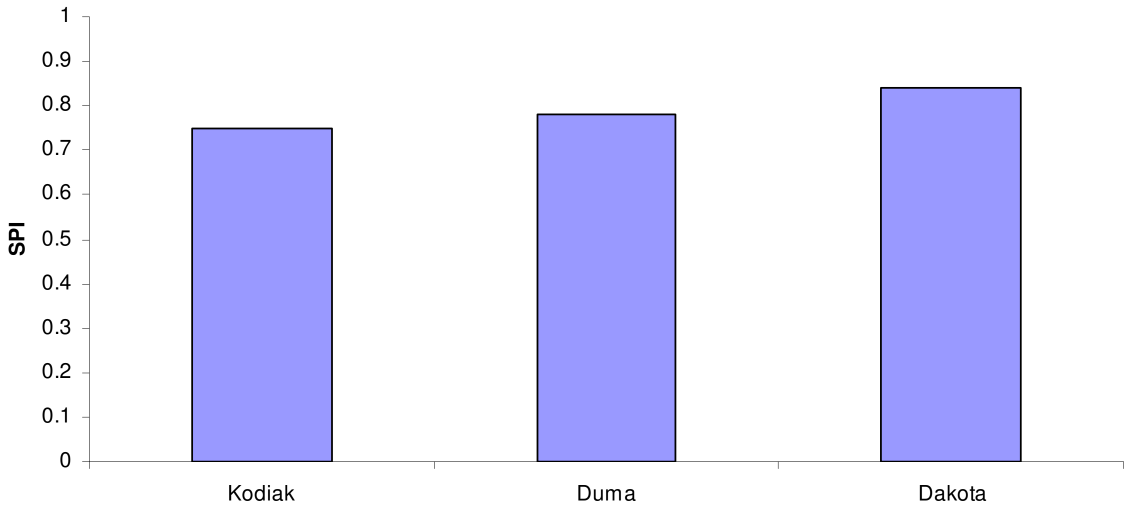


Figure 8. SPI for the juvenile pack at UKWCT.

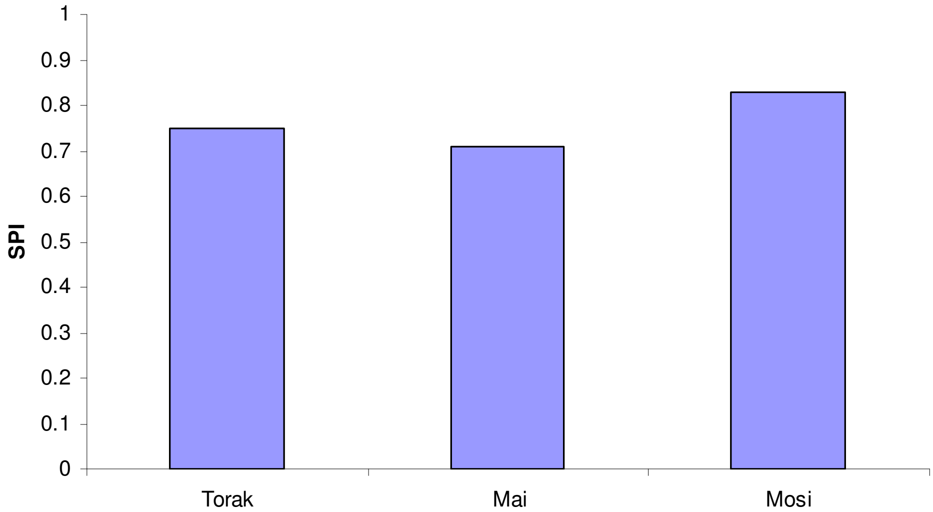
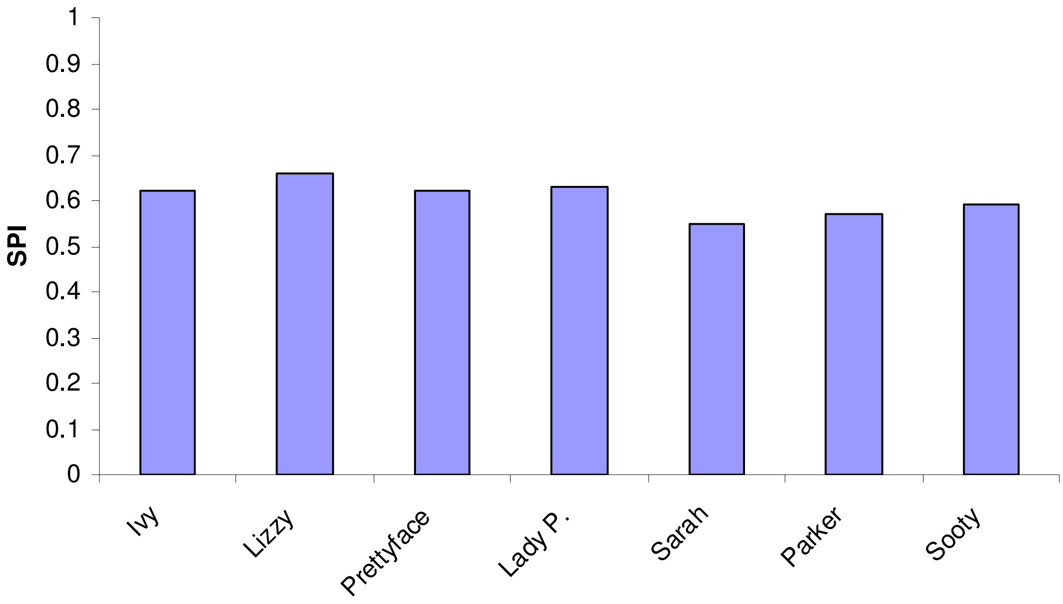


Figure 9. SPI for Sparkwell pack.



3.2 Association indices

The strength of association between each of the pack members is highlighted in Table 8. To indicate the varying strength between individuals, green represents a high association (from the range of data collected - see Appendix B) blue represents a medium association; red however represents hardly any association observed between individuals.

Table 7: Association index values between all Sparkwell pack members.

	Ivy	Lizzy	Prettyface	Lady P.	Sarah	Parker	Sooty
Ivy		0.06	0.02	0.08	0.05	0.08	0.10
Lizzy			0.07	0.25	0.01	0.07	0.01
Prettyface				0.15	0.007	0.01	0.003
Lady P.					0.02	0.06	0.03
Sarah						0.15	0.11
Parker							0.16
Sooty							

The strength of association for the two packs at the UKWCT however, is presented diagrammatically (Figs. 10 & 11). It is an estimated strength of association between members based on observations that were recorded.

Figure 10: Sociogram of strengths of association between pack members in the North American pack:

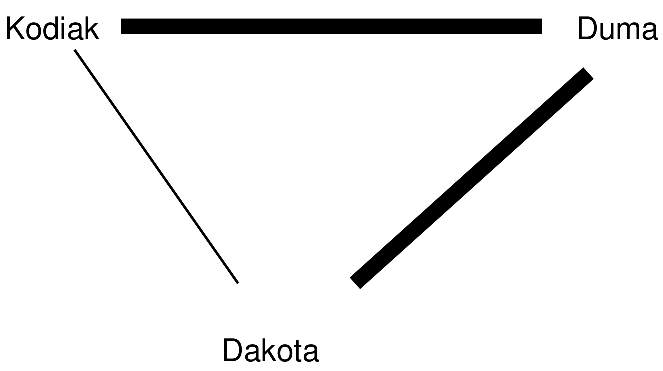
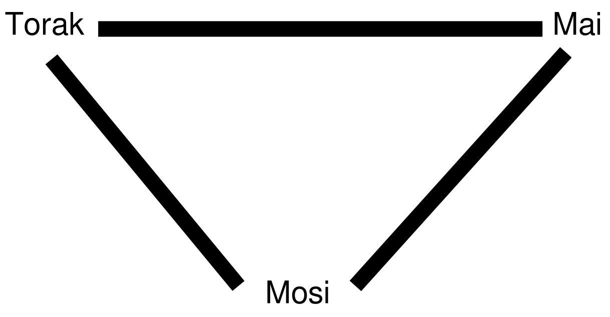


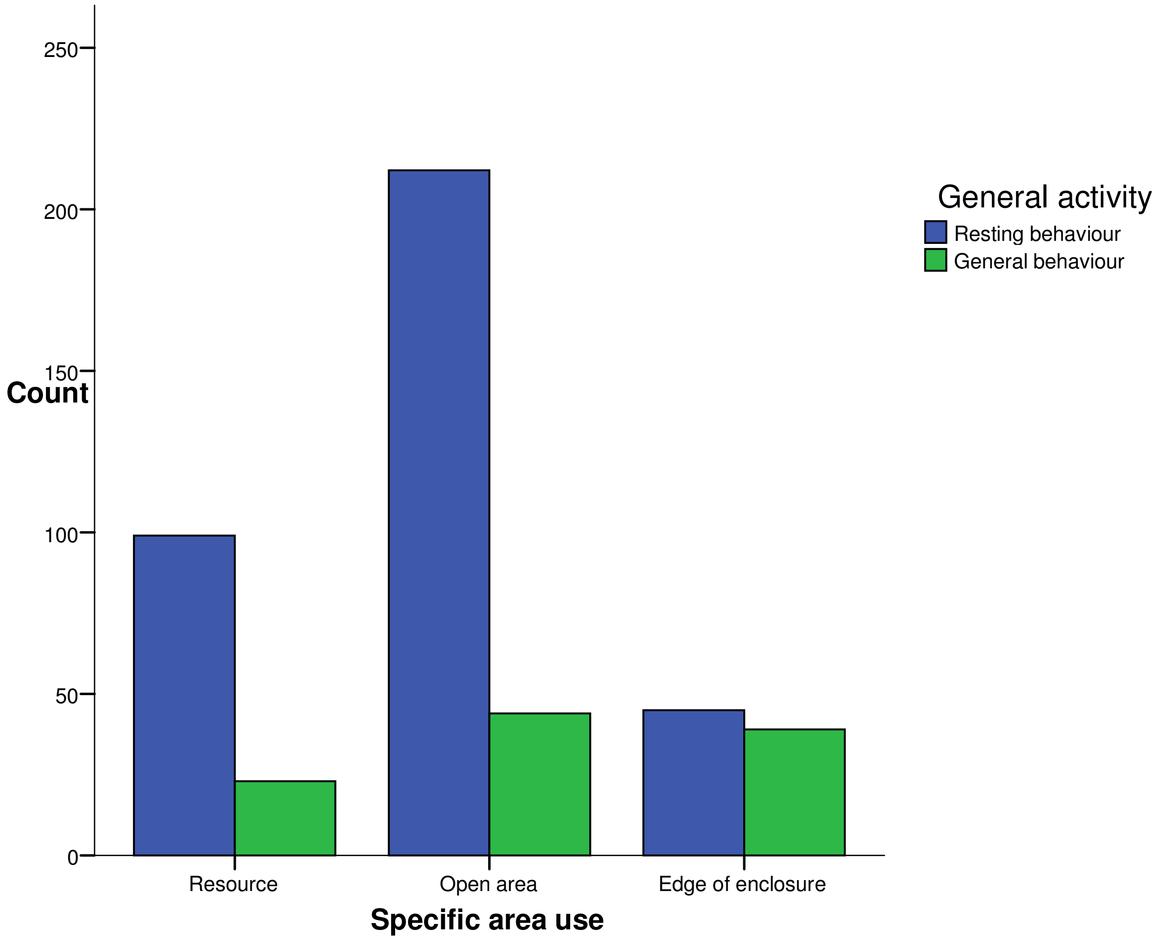
Figure 11: Sociogram of strengths of association between pack members in the Juvenile pack:



3.3 Chi-square

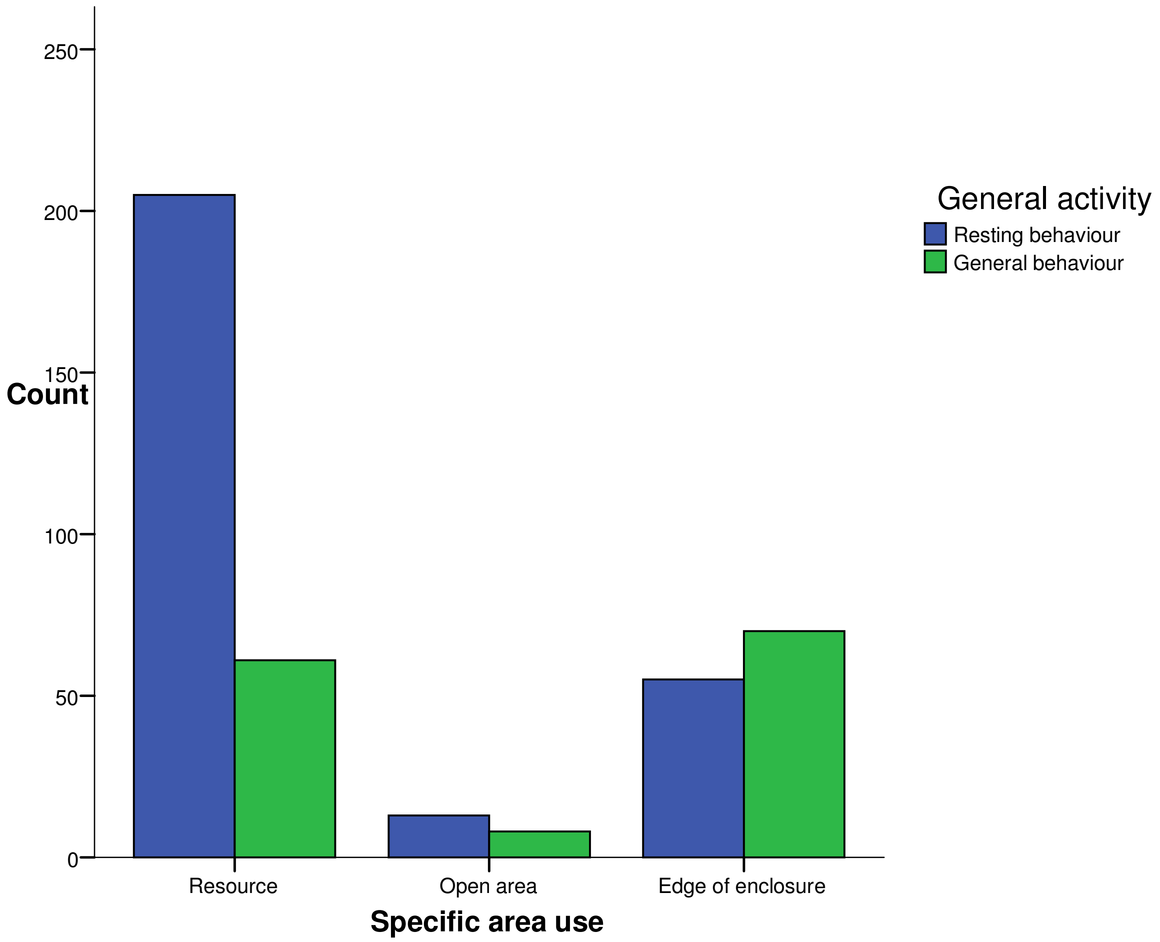
Behavioural categories were collapsed into resting and general behaviour by grouping them appropriately together. This was also applied to the zones used to calculate the SPI. The zones were grouped into i) Resource, ii) Open area and iii) Edge of enclosure respectively for each of the three enclosures (Figs.12-14).

Figure 12: Clustered bar chart of North American enclosure



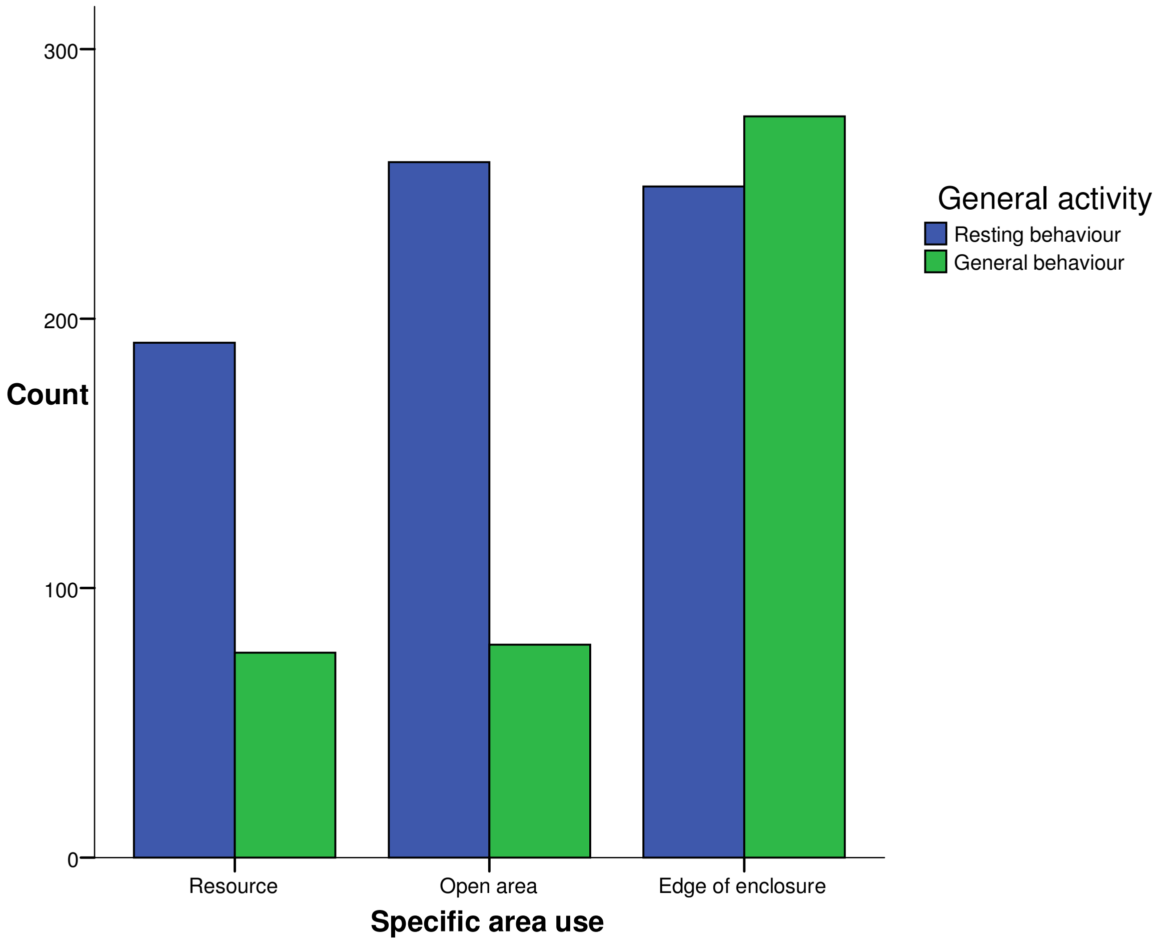
The proportion of time spent resting is higher in open area (particularly zone 16). General activity in this pack is lower and again the highest proportion is found in open areas of the enclosure.

Figure 13: Clustered bar chart of Juvenile enclosure.



For the juvenile pack, an immediate difference is seen in where the highest proportion of time is spent resting. This was primarily zone 1 for the juveniles. General activity was highest at the edge of enclosures where the juveniles would explore and hunting behaviours were observed the most.

Figure 14: Clustered bar chart of Sparkwell enclosure.



An immediate difference is then seen between the proportion of general activity between the two packs at the UKWCT and at Sparkwell; here the general activity occurs mostly at the edge of the enclosure. Resting is occurring in open areas where the wolves were at a vantage point as the wolves were constantly anticipating keepers or visitors.

Table 9 shows the chi-square value of the above three figures. The percentage of time resting was taken from the overall number of counts.

Table 8: Chi-square results of area in enclosure and related resting and general behaviour.

Wolf Pack	Degrees of freedom	Chi-square	Percentage of time spent resting
North American pack, UKWCT.	2	.000	76
Juvenile pack, UKWCT.	2	.000	61
Sparkwell pack, DZP. 2397.28.	2	.000	56

Discussion

Enclosure use

Carnivores in captivity spend more than 75% of their time in less than half of their enclosure space (Mallapur 1999). The study by Frezard and Le Pape (2003) also supports Mallapur (1999) as they found in their comparison of enclosures for the six packs of wolves, in each park the animals used only a part of the available space. The proportion was found to be lower in the larger, more comfortable enclosures. This is also seen in the North American pack, as their overall resting behaviour was over 75%. The juvenile pack spent an overall 61% proportion of their time resting, the pack were generally more active as they interacted with their enclosure features more. The Sparkwell pack however spent just over half of their activity resting, and most of their activity occurred near the edge of their enclosure where anticipation of keepers and visitors could be monitored.

Many studies have been carried out on the effects of enclosure and spatial associations (Taylor-Holzer & Fritz 1985; McCreery 2000; Romero & Aureli 2007) however more research is needed on enclosure utilisation in captive wolves when considering modifying an enclosure. Building the enclosure is the most expensive and labour intensive element in any captive wolf project, it is also the least open to later change (Frank 1987).

Captive wolves do not alter their overall activity level in relation to the size of their enclosure (White 2001). This could then imply that even if the enclosures are large enough to mitigate aggression, the strong social bonds that form the pack hold the members in close contact. Therefore information on the optimum environment for safety and stability in the pack could improve the quality of life for captive wolves and increase the safety factor for the personnel working with the wolves (White 2001). Through understanding and minimising the stimulus for heightened aggression levels, it may be possible to reduce the need for staff to come into direct contact with the wolves to separate individuals or attend to injuries. Such information could be generalised to increase the success of captive breeding programs for the highly endangered Mexican wolf (*C. lupus baileyii*) and the red wolf (*C. rufus*). A guideline for the optimum environment for a captive pack could also be utilised in grey wolf reintroduction efforts that employ a ‘soft release’ method (White 2001).

It appears however that instead of putting resources into larger enclosures for captive wolves, zoos or breeding centres need to instead house smaller packs in relatively large enclosures, as increasing the size of the enclosures does not necessarily remove aggressive behaviours, rather it relies on the social bonds between members. With the association indices results, this could help in identifying that perhaps to improve the overall welfare of the Sparkwell pack would be to actually separate members into smaller packs. From the data it would appear that Lizzy, Prettyface and Lady P should be housed as one pack, and Ivy, Sarah, Parker and Sooty housed as another pack.

In the case of Sparkwell pack, perhaps a properly drained den could be made available in the larger enclosure so as to provide an escape route from harsh weather conditions and to utilise the second enclosure more. Perhaps a future prospect would be to extend the wolf and bear enclosure so that they are linked; this would portray a true picture of the wild and natural species in the same habitat. This can be seen in Wolf Park, in the United States of America, where wolves are able to carry out normal hunting behaviours as they are placed with their natural prey, bison, on a regular basis in a huge enclosure area, allowing for adequate escape for the prey species and yet wolves are able to exhibit wild behaviour. Bow stretch behaviour is seen for example, where the wolves are testing their prey (Goodmann *et al.* 2002). The future lynx enclosure at Sparkwell could perhaps play apart if the wolf pack were European, as this would perfectly display England’s once native wildlife. The issue of space plays an important part.

Frezard and Le Pape (2003) also emphasise the importance of spatial choice and social group management. This was through the behavioural diversity being little affected by the enclosure, instead being highly related to the composition of the pack.

Morgan & Tromborg (2007) suggest that perhaps the greatest stressors in populations of captive animals are those over which the animal has no control and from which they cannot escape. The importance of controllability in animal welfare is a complex subject, and one that is problematic for study. Even so many investigators have argued that control is essential for animal well-being. Another aspect of captivity that may be stressful to animals is its predictability. It may be essential however to introduce animals to a certain amount of unpredictability, in the case if the aim of maintaining animals in captivity is conservation and reintroduction. Choice and control are probably the two most significant criteria for improving animal welfare (Frezard & Le Pape 2003).

Enclosure designs and enrichment focusing on carnivores ranging tendencies (e.g. providing more space, multiple den sites, greater day-to-day environmental variability and more control over exposure to aversive or rewarding stimuli) could be particularly effective means of improving welfare (Clubb & Mason 2007).

Behaviour

Most of the agnostic behaviours observed in the Sparkwell pack were directed at the pariah animal, Lady P. It is likely that in the wild these repeated attacks could cause the wolf to leave the pack or to die (Mech 1970). The welfare however could be improved by providing narrow shelters at the particular places the wolves are attacked, in which the wolves can protect themselves from these attacks (Frezard & Le Pape 2003).

Socialised Vs unsocialised

In the example of Wolf Park, the animals have purposely been socialised to humans in the aim of providing education for the public and to be a research facility. This is also found in the UK Wolf Conservation Trust, where the wolves are more likely to carry on uninterrupted interactions in the presence of visitors. This is thought to be because humans are acceptable social companions, allowing researchers to observe film and handle, manipulate and move wolves to experimental locations with a minimal amount of stress to the individuals and little disruption to the pack social order. When wolves are not socialised and require medical care for example, the first obstacle is catching them. These methods might aggravate the animals' condition or make it appear vulnerable and more likely to be harassed after treatment by its pack members. Socialised wolves however, are more easily approached, routine maintenance is effectively achieved and the wolves may receive routine medical care and some emergency treatments without traumatic methods of capture and restraint. Overall the stress

and disruption caused by human presence and activity are therefore significantly decreased.
Where the opportunities for handlers exist, this system has much to offer in improving management, research and general husbandry of captive wolves in our care (Klinghammer and Goodmann 1985). Socialisation creates additional opportunities to enrich the wolf's environment, this is because socialised individuals can be leash trained and allowed to explore the world beyond the enclosure and this perhaps could allow some limited hunting behaviour (Klinghammer & Goodmann 1987). Because the trust wolves are ambassadors, they have mental stimulation as they go for woodland walks, shows, to schools and seminars. The walks allow for limited hunting behaviour – such as voles and also catching the scent of deer. Because there is so much space in the trusts enclosures, the wolves can interact with other wildlife such as voles, mice and ground nesting birds such as pheasants. The three packs at UKWCT also swap enclosures every four months. This allows for environmental enrichment as it is a change of environment and allows for territory marking.

Future research

As a future idea it would be interesting to see how the wolf packs at the UKWCT utilise their enclosures in relation to the other packs in the breeding season of January to March.
In the future the UKWCT are looking into including a water feature, as are DZP. Wolves love water; to achieve this though a filtration system would be required a wolves would defecate in the feature. The juveniles play with the water troughs, and in the winter they play with the ice that develops on the troughs and the frost on the grass.
Other questions that arise for potential captive wolf research in the future:

- How does space influence pack behaviour?
- If juvenile wolves can not disperse, how does this affect pack dynamics? (could also look into age effects on pack dynamics)
- What effect does captivity have on the omega wolf?

- What mental stimulation is used to enrich the lives of captive wolves?

Applications

It may be possible to apply my findings, and future findings, to several different fields related to wolf ethology. Refuges and zoos could put to use a guideline for the number of wolves and area needed per wolf in enclosure design for future. Again, at the moment it appears that limited resources need to be incorporated into building more separate enclosures to facilitate smaller packs, rather than into enlarging present pens when considering the aggression levels of resident wolves. This can be seen in the UKWCT, as they have three separate enclosures with smaller packs. Once a threshold for aggression is found, such facilities could optimise the utility of their resources and increase the health and safety of both wolves and caretakers.

Another field that could benefit form the observations of this trend is conservation biology. Wolf reintroduction efforts are often more successful when a 'soft release' tactic is used to introduce the animals to their new surroundings. The correlation between number of wolves and aggression levels suggest that the fewer founding wolves housed together during the acclimation period, the lower the aggression level and consequently the stress level. With a lower aggression and stress level, the translocated wolves stand a better chance of forming strong bonds with each other and becoming a viable wild wolf pack once released. Such knowledge can also be put forward into captive breeding programs for endangered species and subspecies of wolves. Other ethologists and facilities may be able to generalise this trend to other social pack animals that institute a strict hierarchy such as: golden jackals, Ethiopian wolves, dingoes, African wild dogs, and mongoose (Morell 1996)

Improvements

The modified SPI permitted the use of unequal zones and had several advantages as zones of varying sizes were assigned based on enclosure resources useful to the animals, such as the mound in the UKWCT two packs. As a future study, enclosure features such as boundaries, shade, hiding places and vegetation types could be assigned zones (provided that their total area or volume can be reasonably estimated). This would allow for more consistent observations and larger zones can still result in accurate estimates of enclosure utilisation. Even though smaller zones will give more accurate results, they are practically more difficult to work with (Plowman 2003).

Conclusions

With further research, the results of this study could be applied to planning enclosure design, resource allocation and pack composition. It is important to realise the need for housing of familiar co specifics, the wolf is a wide-ranging, highly socialised carnivore and therefore a pack in captivity is extremely hard to manage when members in captivity go missing. Reintroduction and captive breeding efforts for the endangered Red wolf and Ethiopian wolf could benefit from correct enclosure design as this will eliminate abnormal behaviour. Possibly other socially hierarchical species, such as the highly endangered African wild dogs could benefit.

The keeping of naturally wide-ranging carnivores should be either fundamentally improved or phased out.

Acknowledgments

I would like to thank the UK Wolf Conservation Trust for the wonderful work experience with such magnificent animals, and for the time that was able to be set aside to study the Juveniles and North American pack, and the help and information that was provided. Many thanks to the staff at Dartmoor Zoological Park for accommodating this study.

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