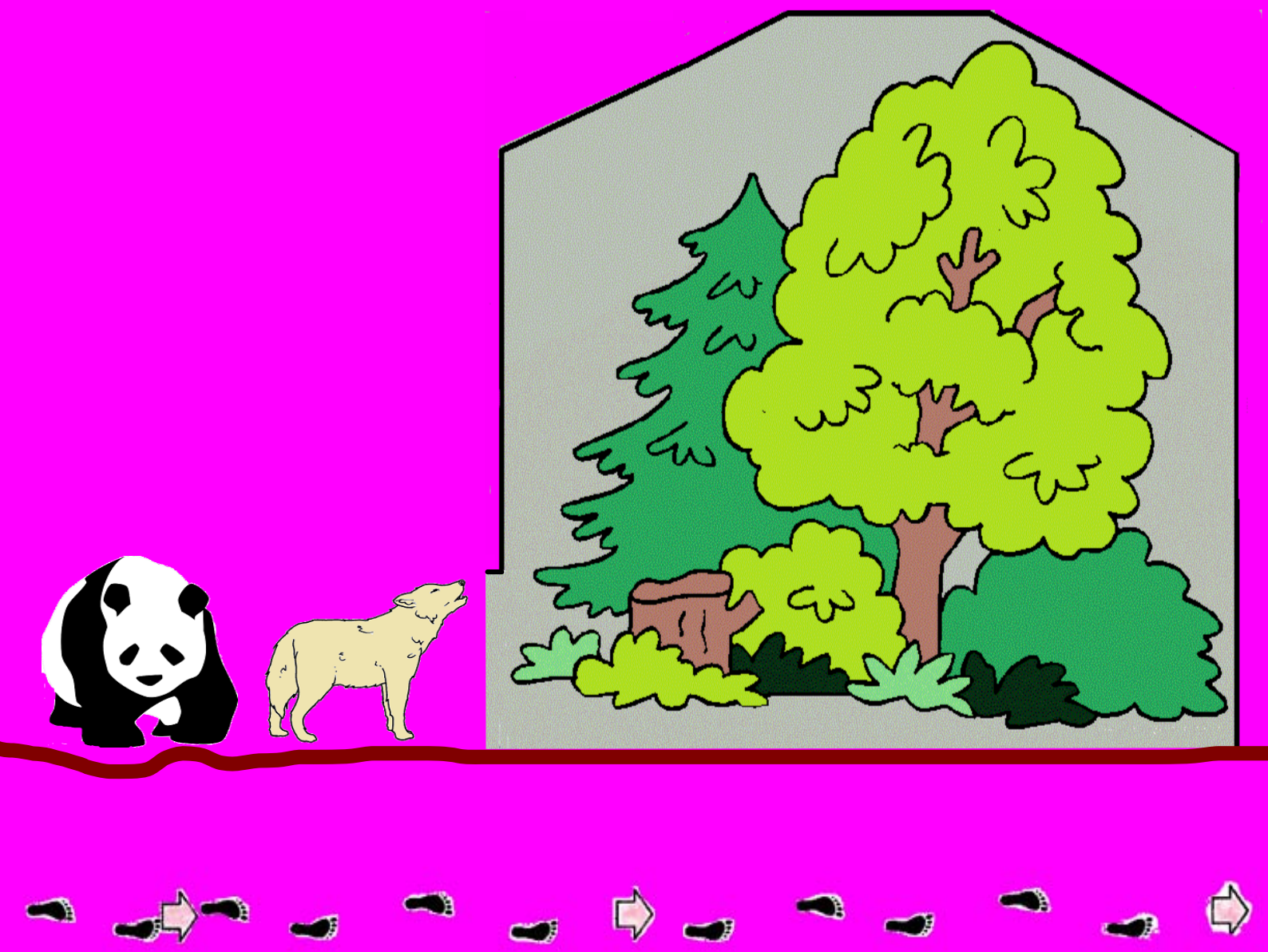
Indicadores del bienestar animal y programas de enriquecimiento en especies de mamíferos en cautividad

Animal welfare indicators and environmental enrichment programs in species of wild mammals in captivity

Ana Isabel Soriano Jiménez

INDICADORES DE BIENESTAR ANIMAL Y PROGRAMAS DE ENRIQUECIMIENTO EN ESPECIES DE MAMÍFEROS EN CAUTIVIDAD



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Charles Darwin apuntó:
"No serán las especies más fuertes las que sobrevivan, ni las más inteligentes, si no las más propensas a los cambios".

A lo largo de todos estos años, no puedo obviar a toda la gente que he conocido, de la cual he aprendido a sobrevivir y me ha permitido evolucionar.
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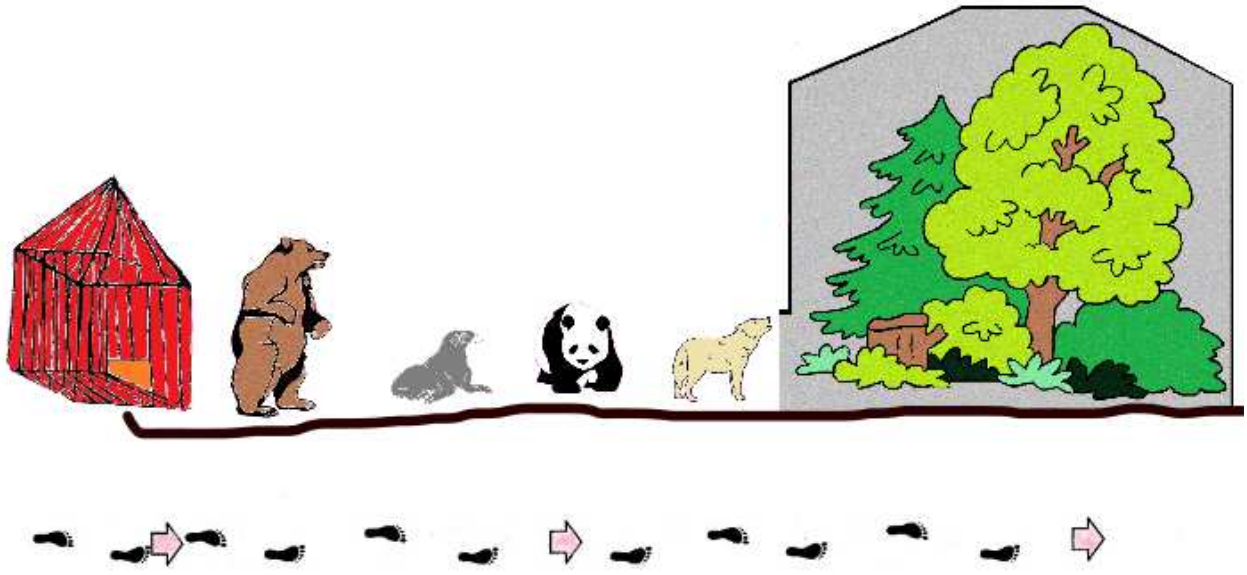
CONTENIDOS

1. INTRODUCCIÓN GENERAL



1. INTRODUCCIÓN GENERAL

Los zoos deberían ser instituciones integradas dentro de la comunidad científica y cuya toma de decisiones en relación a la vida salvaje se fundamentara de manera científica y técnica. Debido a la estabulación de sus colecciones de animales, los zoos se encuentran en una posición privilegiada para contribuir a un tipo de investigación orientada a la conservación (WAZA, 2005). La investigación biológica en los zoos es un aspecto reciente con apenas 50 años de proyección científica (Altmann-Langwald, 1996). Actualmente, el futuro de los zoos sólo se puede concebir si éstos contribuyen a la conservación de la biodiversidad y al desarrollo sostenible (Olney *et al*., 1994). Si los zoos quieren formar parte activa en la conservación deben afrontar las críticas de los grupos animalistas que defienden los derechos y el bienestar de los animales, los zoos deben adaptarse a las diferentes necesidades sociales y económicas cuando sea necesario, y explicar su misión de forma que se obtenga el apoyo del público. En nuestro país, cabe destacar la importancia de la redacción y el cumplimiento de la ley 31/2003, cuyo objetivo principal es la conservación de la fauna silvestre en los parques zoológicos debido al actual debate sobre la función y la existencia de dichos centros (Rodríguez-Guerra & Guillén-Salazar, 2007).

Actualmente los principales objetivos de los núcleos zoológicos se resumen en cuatro: la conservación, la investigación, la educación y el entretenimiento. La conservación de la fauna salvaje en cautividad no es posible sin una investigación científica apropiada y dicha investigación debería ir encaminada a potenciar la conservación de las especies (Hosey *et al*., 2009; Rees 2011). Los programas de conservación "ex situ" adquieren una gran importancia ya que, una de cada siete especies de vertebrados terrestres que están amenazados viven en cautividad (Conde *et al*., 2011).

Las especies más difíciles de mantener en cautividad quizás son aquellas que responden a algunas de las características que se mencionan a continuación: 1) Una dieta muy especializada que requiere un complejo manejo alimentario lo que en muchas ocasiones está asociado a grandes inversiones y

costes económicos [p.e. el oso panda (*Ailuropoda melanoleuca*) o los colibríes (O. Apodiformes)]; 2) Una baja tasa de reproducción y de cría que precisa de un manejo reproductor y genético muy especializado. Los factores que pueden influir sobre este aspecto son la incompatibilidad de la pareja reproductora, una estructura social desequilibrada, disponer de unas instalaciones inadecuadas para el parto y la cría, la experiencia maternal (ser primípara) o un desorden en los factores fisiológicos [p.e. los gorilas de llanura occidental (*Gorilla gorilla gorilla*) o los flamencos (O. Phoenicopteriformes)] entre otros; 3) Unos sistemas sociales complejos que requieren la modificación de la composición del grupo; 4) Una mayor complejidad neuronal y ratios de encefalización elevados pues suelen estar relacionados con una mayor susceptibilidad a las condiciones de cautividad por lo que se produce una dificultad en el alcance de niveles deseables de bienestar animal (p.e. los primates, los cetáceos, los pinnípedos, los carnívoros, las psitácidas y las rapaces) (Mason, 2010). En los zoos, la composición de las colecciones de animales ha estado formada más comúnmente por mamíferos de gran tamaño (felinos, elefantes y carnívoros) y primates; mientras que los menos habituales han sido, en el orden que se indica, las aves, los reptiles, los anfibios y los invertebrados (Rees, 2011).

A pesar de que existen numerosas definiciones para el término de "bienestar animal", la que mejor se adapta a la realidad de las condiciones de cautividad fue la definida por Barber & Mellen (2008), que es también la utilizada por la WAZA (2005). Según estos autores el bienestar animal es el grado de adaptación que poseen los individuos frente a los cambios del ambiente y que está determinado por la combinación de los indicadores de bienestar físico y psicológico. El bienestar físico se entiende como la ausencia de enfermedades físicas y/o fisiológicas que resultan (directa o indirectamente) de una inadecuada nutrición, ejercicio físico, estructura social u otras condiciones ambientales que impidan al animal responder apropiadamente. El bienestar psicológico se entiende como la capacidad que tiene un animal de expresar los comportamientos típicos de su especie frente a un estímulo y en especial si éste es repulsivo. El bienestar psicológico depende de varios factores como son las condiciones ambientales, el estado fisiológico, la fase de

desarrollo ontogénico, el contexto social en el que vive, todo ello puede contribuir o condicionar también el desarrollo de sus habilidades cognitivas (WAZA, 2005).

Se conocen varios tipos de indicadores del grado bienestar animal en condiciones de cautividad. Entre ellos cabe citar indicadores comportamentales como la ocurrencia de conductas anormales o aberrantes, el patrón diario de actividad, el uso del espacio que presentan los individuos de una especie y la proximidad entre los individuos ya sean de la misma o de diferente especie. Por otra parte, existen indicadores fisiológicos como los niveles de glucocorticoides en sangre, que a su vez se correlacionase con la conducta de los individuos. Se consideran conductas anormales aquellas que no son típicas de la especie y que por lo tanto, no se observan en los individuos en condiciones de libertad (Meyer-Holzapfel, 1968). Son comportamientos repetitivos causados por la frustración, asiduos intentos de adaptación al medio y/o una disfunción del sistema nervioso central (Mason, 2006). La estereotipia es un tipo de conducta anormal y se presenta en forma de patrones de comportamiento repetitivos e invariantes, sin un objetivo o función aparente (Mason, 1991). Las conductas anormales se observan en animales mantenidos en cautividad, en humanos con enfermedades o disminuciones mentales y en sujetos bajo los efectos de las drogas. Está asociada a un ambiente subóptimo en el que vive o ha vivido el animal y parece que su función podría ser amortiguar el efecto de los estímulos externos y reducir así, el miedo y el estrés (Lawrence & Rushen, 1993; Carlstead, 1998; Fernández, 2010).

El patrón de actividad diario de cualquier especie de mamífero en libertad es el producto de muchas generaciones de selección natural y de la adaptación a unas condiciones ambientales específicas. La cautividad impone a los mamíferos salvajes un ambiente que difiere ampliamente de aquel en el que han evolucionado. Para sobrevivir a las condiciones de cautividad, los sujetos deben adaptarse a estas diferencias y la evaluación de su conducta proporciona información acerca de ello (Carlstead, 1996). La comparación de los datos etológicos en cautividad con los observados en libertad, es un indicador de la

capacidad de adaptación de los sujetos a dichas condiciones (Snyder, 1975; Veasey *et al*., 1996; Hosey *et al*., 2009; Shivik *et al*., 2009). En consecuencia, el grado de similitud del patrón diario de actividad en los individuos de una especie mantenida en cautividad con el de libertad, es un indicador del grado de bienestar. Así mismo la evaluación del uso del espacio en cautividad aporta información sobre la utilización que hace el animal del área en la que vive y constituye un estudio complementario al de la conducta (Crockett, 1996) proporcionando una información útil para el diseño de futuras instalaciones (Gibbons *et al*., 1994) e indicadores sobre cuáles son las zonas más frecuentadas por los animales y qué hacen en ellas (alimentación, descanso y vigilancia, entre otras). Además, informa sobre: el grado de actividad de un animal, el uso que hace del mobiliario, las preferencias por determinados sustratos, la similitud con el uso del hábitat de los conspecíficos en libertad y la proximidad de los animales a individuos conspecíficos -de la misma instalación o de la instalación continua- y/o heterospecíficos -el público, los investigadores (Iredale *et al*., 2010) u otros animales (Ross *et al*., 2009). Conocido el uso del hábitat en los individuos de una especie dada, se pueden evaluar los posibles beneficios de la aplicación de un programa de enriquecimiento ambiental orientado a la optimización de la utilización del espacio en condiciones de cautividad (Kleiman *et al*., 2010). Un uso homogéneo del espacio está considerado también un indicador de bienestar animal (Shepherdson *et al*., 1993). Otro indicador es la proximidad y el contacto, ya sea entre individuos de la misma o de diferentes especies, aporta información acerca de la afinidad, la competencia, el parentesco y la compatibilidad entre los individuos (Zucker & Thibaut, 1995). Cuando se dispone de datos sobre variables fisiológicas el indicador del grado de bienestar animal, correlaciona los patrones de conducta y las variables fisiológicas, como son las hormonas del estrés, principalmente glucocorticoides (Möstl & Palme, 2002; Millspaugh & Washburn, 2004; Smith, 2004; Wielebnowski, 2005; Laws *et al*., 2007).

Los factores que influyen en el grado de bienestar animal en entornos cautivos son: las características y tamaño de la instalación, la preservación del comportamiento natural de la especie en las condiciones de cautividad -como

por ejemplo la estructura social- y la influencia del público (Hosey *et al*., 2009; Kleiman *et al*., 2010; Rees, 2011). .

Otro de los factores que influyen sobre el bienestar de los animales mantenidos en cautividad es la afluencia de público. La tarea de educación que se lleva a cabo en los zoológicos ha comportado hasta el momento que el público observe directamente a los animales y que éstos reciban a su vez todas las emociones que despiertan en los humanos, como gritos, aplausos, golpes en los cristales, los flash de las cámaras fotográficas, lanzamiento de comida, entre otros (Polakowski, 1987). En relación con este último comportamiento, en muchas ocasiones, durante las visitas a los zoológicos se puede observar cómo los animales mendigan el alimento al público de formas muy diferentes (Markowitz, 1982). Esta conducta aberrante pone en cuestión el bienestar de los animales ya que además de desequilibrar la dieta de los individuos se añade el ruido ambiental que puede convertirse en un factor de estrés (Hosey, 2000; Davey, 2005, 2007; Fernández *et al*., 2009).

Los programas de enriquecimiento nacen de la necesidad de incrementar el grado de bienestar de los animales cautivos (Markowitz, 1982; 2011). Estos programas aplicados a los animales domésticos son un buena herramienta para mejorar la productividad (por ejemplo en las granjas) y cuando se establecen para el manejo de la fauna salvaje de los zoológicos persiguen garantizar que las condiciones de cautividad favorecen la manifestación adecuada de los patrones de actividad diaria (Shepherdson, 2003; Hoy *et al*., 2010). En este último caso, los programas de enriquecimiento se empezaron a aplicar para mejorar el bienestar en especies de mamíferos y han estado en continuo desarrollo durante los últimos treinta años (Hoy *et al*., 2010). El grupo asesor de comportamiento y manejo (Behavioral and Husbandry Advisory Group) definen los programas de enriquecimiento como una técnica empleada para mejorar el cuidado de los animales en condiciones de cautividad teniendo en cuenta su biología comportamental y su historia natural. Por tanto, es un proceso dinámico en el cual los cambios en las instalaciones y en las prácticas de manejo tienen como objetivo la expresión del variado repertorio conductual

de los animales mediante la manifestación de los comportamientos típicos y las habilidades de la especie promoviendo así su bienestar animal (BHAG, 1999). Según Shepherdson (2001), los objetivos generales que pretenden alcanzar los programas de enriquecimiento son tres. El primero, consiste en mejorar el bienestar físico y psicológico de los animales de los zoológicos y de los acuarios mediante la diversificación del comportamiento y de sus conductas típicas de la especie para reducir la frecuencia de las conductas aberrantes, optimizar la utilización de las instalaciones en las que habitan los animales y mejorar la capacidad de afrontar los cambios del entorno. El segundo es promover la conservación de las especies amenazades favoreciendo su reproducción disminuyendo el estrés, fomentando la aparición de las conductas reproductoras específicas y aumentando la tasa de supervivencia de los animales que formen parte de los programas de reintroducción. Por último, despertar el interés del público y reforzar el papel educativo de los zoológicos fomentando un sentimiento de respeto y una adecuada actitud hacia los animales cautivos.

El 90,3% de los trabajos sobre el enriquecimiento ambiental, recae en los mamíferos y dentro de éstos el 47% sobre los primates y el 33% sobre los carnívoros. Dentro del orden Carnívora, los grupos más estudiados han sido los de la familia Felidae (46.3%) y la familia Ursidae (44.5%) (Law & Reid, 2010). Según Young (2003), existen seis tipos de programas de enriquecimiento ambiental: el social, el estructural, el alimentario, el ocupacional, el sensorial y el entrenamiento con refuerzo positivo. El enriquecimiento social es uno de los más importantes de entre todos los tipos de enriquecimiento y su principal objetivo es que los animales tengan la oportunidad de expresar las conductas sociales típicas de su especie (Winhall, 1998; Tennant & Bondenstaff, 1999), así como establecer relaciones positivas con el personal del zoo (cuidadores, veterinarios e investigadores) (Manciocco *et al.*, 2009). El enriquecimiento estructural pretende que tanto el diseño como el mobiliario de la instalación, recreen un hábitat lo más semejante posible al de su medio natural, con el objeto de que los animales desarrollen el patrón de actividad y comportamientos de su especie (Maple & Perkins, 1996; Spendrup & Larsson,

1997; Ames, 1999). El enriquecimiento alimentario consiste en modificar la dieta que tienen establecida. El objetivo es conseguir que tanto la presentación (frecuencia, horario y tiempo de procesamiento del alimento) como en el tipo de alimento (novedad, variedad y apetencia) sea lo más parecido posible al patrón alimentario en condiciones de libertad (Carlstead *et al*., 1991; Hare, 1995; Larsson & Tove, 1995; Liu *et al.,* 2006; Vasconcellos & Ades, 2007).

Una dieta equilibrada favorece el mantenimiento de un estado de salud óptimo que está directamente relacionado con el bienestar. El enriquecimiento ocupacional, consiste en la introducción de elementos en la instalación (que en adelante denominaremos "ítems") con el objeto de potenciar las capacidades cognitivas y motoras de los animales, mejorando así sus habilidades físicas y psicológicas (Altman, 1999; Wagstaff, 2004; Herreman & Holmes, 2005; Hessel & Golden, 2005). El enriquecimiento sensorial pretende estimular aquellos sentidos para los cuales los animales han sido adaptados biológicamente (Grice, 2004; Moore, 2005). Dependiendo de los sentidos implicados, se puede ser de tipo visual (televisión, ventanas o áreas abiertas a individuos de la misma u otra especie), gustativo (mediante la presentación de nuevos alimentos), olfativo (presentación de olores como perfumes, especias o las heces de otros animales), táctil (presentación de texturas diversas) y el auditivo (música y vocalizaciones, entre otros). Otra de las modalidades de enriquecimiento ambiental es el entrenamiento con refuerzo positivo (Claxton, 2011). El entrenamiento es un importante medio de enriquecimiento ya que estimula las capacidades tanto físicas como cognitivas de los animales (Laule & Desmond, 1998). El objetivo de este tipo de entretenimiento es interaccionar con el animal causándole el mínimo estrés y utilizando siempre la técnica del refuerzo positivo (Kranz, 1996). Según Ramírez (1999) son actividades que se realizan mediante esta técnica las que se especifican a continuación: establecer proximidad física entre animal y cuidador, separar a los individuos del grupo cuando es necesario, suministrar fácilmente la medicación, revisar de forma diaria el estado físico del animal (ojos, pelaje, oídos, garras, etc), intercambiar objetos entre animal y cuidador (como objetos lanzados por el público), recoger muestras (orina, saliva, pelo, sangre, etc), aprender a cómo cuidar de las crías

(Bloomsmith *et al.*, 2003; Rotherham, 2006) y reducir las conductas aberrantes (Coleman & Maier, 2010).

La evaluación de la efectividad del enriquecimiento constituye una de las últimas fases de los estudios sobre los programas de enriquecimiento ambiental (Hosey *et al.*, 2009). La evaluación es importante para determinar la eficacia de los entretenimientos, discernir entre ellos y valorar su inversión económica (materiales y tiempo de preparación, entre otros). Algunos estudios previos han demostrado situaciones en las que el enriquecimiento no ha tenido efecto alguno sobre los sujetos de estudio (Klomburg & Magiera, 1997; Hare, 2008; Rosier & Langkilde, 2011). Para determinar la eficacia de los programas de enriquecimiento es importante establecer unos objetivos y evaluar si se alcanzan, o no, con un entretenimiento determinado. Además, es necesario estudiar los efectos del enriquecimiento en la conducta de los animales con el objeto de conocer si existe un efecto positivo, negativo o nulo (Hosey *et al.*, 2009).

El manejo de las relaciones sociales en los zoos es uno de los factores más influyentes en el bienestar de los animales. Tanto los animales solitarios como los sociales tienen requerimientos sociales aunque sean puntuales y deben tenerse en cuenta. Cuando se trata de animales sociales se tiene que garantizar existencia de estructuras sociales (harenes, parejas, manadas o bancos) semejantes a las que presentan sus congéneres en libertad. En el caso de especies solitarias estrictas, con baja o nula tolerancia a la presencia de otros congéneres excepto en las épocas de celo, es importante controlar los factores de estrés producidos por la cercanía de otros conspecíficos y la posible influencia de los visitantes tanto a través de su patrón de actividad diario como de la aparición de conductas estereotipadas. En las especies sociales respetar y reproducir la estructura social determina un complejo manejo social dentro y entre las instituciones zoológicas. Los cambios en la composición social de los animales pueden ser debidos a varios factores: las relaciones materno filiales, la socialización de los animales durante la época de reproducción, la muerte de los individuos y la incompatibilidad de los sujetos por la competencia de la pareja u

otras causas (Young, 2003). El mantenimiento en cautividad de una inadecuada estructura social puede ser una fuente de estrés (Appleby & Hughes, 1997) y en consecuencia puede desencadenar la aparición de conductas aberrantes (Bernstein, 1991) y/o agresivas (Chamove & Anderson, 1989; Reinhardt, 1991; Law & Tatner, 1998; Davis *et al*., 2009), la pérdida de pelo (Beisner & Isbell, 2009), la disminución de la tasa de reproducción (Stevens, 1991; Pickering *et al*., 1992) y la aparición de enfermedades y parásitos (Steinmetz *et al*., 2005). Por consiguiente, el conocimiento del comportamiento social en las limitaciones impuestas por la cautividad es un elemento clave para garantizar el bienestar de los animales y una fuente potencial de enriquecimiento para mejorarlo en aquellos casos que lo requieran (Visalberghi & Anderson, 1993; Young, 2003).

La tendencia actual en los zoos es el diseño de instalaciones multiespecíficas con el objeto de potenciar las interacciones sociales tanto intra como interespecíficas imitando al máximo lo que sucede en el medio natural y potenciando así el enriquecimiento social (Veasey & Hammer, 2010). Este tipo de instalaciones tiene ventajas e inconvenientes. Las ventajas son el aumento del valor educativo de las instalaciones y de las interacciones sociales entre las especies. El principal inconveniente de estas instalaciones es el aumento de la complejidad del manejo de los grupos, que implica: 1) Mayor grado de competencia y agresión entre las especies; 2) Riesgo de hibridación entre especies próximas; 3) Mayor contagio de las enfermedades; y 4) Disminución del valor educativo de las instalaciones si las especies pertenecen a zonas biogeográficas diferentes (Rees, 2011). La mayoría de estudios sobre las instalaciones multiespecíficas se han realizado en mamíferos (Hjordt-Carlsen, 1995; Wade & Jado; 2006; Crotty, 2007) y sobretodo entre primates (Wojciechowski, 2004; Dalton & Buchanan-Smith, 2006; Buchanan-Smith et al., 2009).

En el presente estudio se abordan distintos aspectos relacionados con el bienestar animal (diagnóstico y mejora mediante programas de enriquecimiento ambiental) en cuatro especies de mamíferos: el oso pardo (*Ursus arctos*) (Cuadro 1), el oso panda gigante (*Ailuropoda melanoleuca*) (Cuadro 2), el león

marino de California (*Zalophus californianus*) (Cuadro 3) y el lobo ibérico (*Canis lupus signatus*) (Cuadro 4) todos ellos mantenidos en cautividad en el Zoo de Barcelona excepto el oso panda gigante, que vive en el Zoo de Atlanta. La memoria se organiza en tres capítulos de dos secciones cada uno. El Capítulo 1 está dedicado al estudio de los indicadores de bienestar en las dos especies de osos. El Capítulo 2 trata sobre el análisis de la efectividad de los programas de enriquecimiento en el oso pardo. Y el Capítulo 3 se centra en el estudio del comportamiento social en las dos restantes especies de mamíferos (el lobo ibérico y el león marino de California).

CUADRO 1. El oso pardo (*Ursus arctos*): la biología, la conservación, la relación con el hombre y el mantenimiento en cautividad.

Es un mamífero plantígrado del orden de los carnívoros y de la familia Ursidae. Su longevidad es de 25 a 30 años. Este animal presenta dimorfismo sexual, siendo el macho de mayor tamaño (su peso oscila entre los 90 y los 250 kg, la longitud corporal varía de 1.5 a 2.95 m y una altura en la cruz de hasta 1.3 m). Es una especie de carácter solitario. En invierno se aletarga en cuevas. El período de gestación tiene una duración de entre 180 y 250 días y los oseznos nacen con un peso de 350 g. Su alimentación es omnívora, presentando importantes variaciones estacionales. El hábitat es montañoso con preferencia por los bosques caducifolios y de coníferas. La distribución corresponde a Europa, noroeste de América del Norte, cercano Oriente y centro-oeste de Asia. (Rodríguez de la Fuente, 1978a; Fundación Oso Pardo & Reyero, 1998; Ward & Kinaston 1999; Zofío & Vega, 1999a).

La población en libertad que habita en la península ibérica se estima entre 70 y 90 ejemplares (Palomo *et al.,* 2007). El cambio climático, la transformación del hábitat por los incendios y la construcción de infraestructuras así como la caza furtiva son las mayores amenazas de esta especie. Según el atlas y libro rojo de los mamíferos terrestres de España (Palomo *et al*., 2007) el estatus de conservación del oso pardo es de "En peligro crítico". En los Pirineos centrales hay en la actualidad seis individuos procedentes de un reintroducción con ejemplares eslovenos, realizada entre 1996 y 1997. La Fundación Oso Pardo trabaja en diferentes proyectos de conservación "in situ" de esta especie con los programas LIFE, hábitat, huella y URSUS.

Durante toda la historia de la humanidad, el oso un animal grande y fuerte, ha sido admirado y temido, venerado y odiado. Sentimientos y sensaciones alrededor de un animal que nunca generó olvido ni despertó indiferencia. El que para muchas tribus fue el mejor guía espiritual, para no pocas gentes del campo representa la imagen del miedo a perder el ganado y/o las colmenas. Mientras el furtivo traduce su piel en importantes sumas de dinero, la sociedad de las grandes ciudades ve en él a ese entrañable amigo que todos quisimos tener y, de este modo, el oso se convierte en uno de los animales más atractivos de los zoos. Este afecto deriva de los cuentos y leyendas que refleja al oso como un ser bondadoso. Consecuencia de todo ello y de la infantilización de este úrsido, hacen la aparición los ositos de peluche y los personajes famosos en los dibujos animados como el oso Yogui, Baloo, Jackie y Nuca, Winnie de Pooh o el olímpico osito Misha que entre otros muchos han contribuido a crear en la sociedad una imagen de cariño hacia estos animales que el progreso mal entendido está a punto de extinguir (Fundación Oso Pardo & Reyero, 1998; Zofío & Vega, 1999a).

En el año 1976, van Keulen-Kromhout realiza la primera publicación sobre la conducta y el diseño de las instalaciones de los osos en cautividad poniendo de manifiesto la predisposición de esta especie a desarrollar conductas anormales. Existen varios libros que versan sobre la conservación y la conducta de los osos en cautividad (Ward & Kynaston, 1999; Brown, 2009; Poulsen, 2009).

CUADRO 2. El oso panda gigante (*Ailuropoda melanoleuca*): la biología, la conservación y el mantenimiento en cautividad.

El oso panda gigante es un mamífero del orden de los carnívoros y recientemente clasificado dentro de la familia Ursidae. Su longevidad es de 15 años en libertad, y de hasta 30 años en cautividad. El peso oscila entre los 70 y los 125 kg (sin marcado dimorfismo sexual), la longitud corporal varía de 1.2 a 1.5 m y una altura en la cruz de hasta 1.3 m. Es de carácter solitario. El período de gestación tiene una duración de entre 135 días y los oseznos nacen con un peso de 90-130 g. Es un animal omnívoro, come desde tallos y hierbas hasta aves, peces y roedores. Pero su alimento principal es el bambú.

Sus necesidades metabólicas le obligan a comer unos 14 kilos de bambú al día, en lo que tarda unas doce horas. Nativo de China central, el panda gigante habita en regiones montañosas como Sichuan y el Tíbet, hasta una altura de 3500 m (Schaller *et al.*, 1985; Lindburg & Baragona, 2004). Los censos de los años 2004 y 2005 demuestran que la población en libertad es de 1600 individuos y en cautividad de 188. La baja tasa de natalidad, la alta tasa de mortalidad infantil y la destrucción de su ambiente natural lo colocan bajo la amenaza de la extinción. La ley china es muy rígida en cuanto a su caza, esto ha contribuido a que disminuya la población por esta causa. La lista roja de especies amenazadas de la IUCN (2011) determina que el estatus de conservación del oso panda gigante es de "En peligro". La conservación "in situ" de esta especie consiste en la reforestación de los hábitats naturales de la especie y la creación de diferentes centros de reproducción en cautividad (Lindburg & Baragona, 2004).

El panda se conoció en Occidente en 1869, cuando un cazador llevó una piel al misionero jesuita francés Armand David. En 1936, Ruth Harkness llevó a los Estados Unidos un cachorro de panda, dando inicio a la pasión occidental por el animal. A partir de 1957, China comenzó a distribuir pandas como demostración de *buena voluntad*. El oso panda es el símbolo de WWF (fondo mundial para la protección de la naturaleza) desde 1961. Esta acción cesó por las leyes chinas de 1990 que consideraban que todo animal, incluyendo las células reproductivas era propiedad de China. Además los zoológicos interesados en obtener individuos en calidad de "préstamo", están sujetos a la firma de contratos sin garantías para ellos, por diez años a un coste de entre 1 y 2 millones de dólares americanos por año (Maple, 2000). En Europa sólo existen cinco zoológicos que cuentan con osos panda en sus colecciones: Zoologischer Garten Berlin (Berlín, Alemania), Tiergarten Schönbrunn (Viena, Austria), Zoo- Aquarium Madrid (Madrid, España), Edinburgh Zoo (Edimburgo, Reino Unido) y ZooParc de Beauval (Saint-Aignan, Francia).

Las publicaciones más recientes sobre el bienestar animal del oso panda en cautividad, han tratado sobre la dieta (Pfistermüller *et al.*, 2004; Tarou *et al.*, 2005), la reproducción (Zhang *et al.*, 2000, 2004; Sutherland-Smith *et al.*, 2004), la conducta (Liu et al., 2003; Powell *et al.*, 2006; Peng *et al.*, 2007), el uso del espacio (Owen *et al.*, 2005), los programas de enriquecimiento (Swaisgood *et al.*, 2001; Bloomsmith *et al.*, 2003; Hare *et al.*, 2003; Liu *et al.*, 2006) y el efecto del público (Wilson *et al.*, 2003). Existen varios libros que versan sobre la conservación y la conducta de los osos panda en cautividad (Maple, 2000; Seidensticker & Lumpkin, 2007).

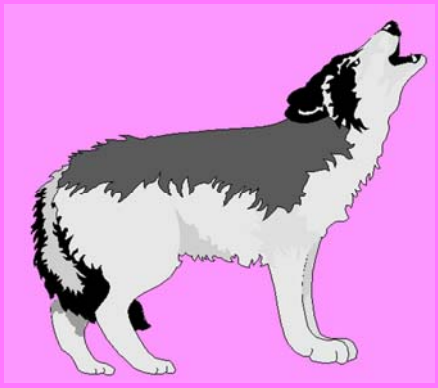
CUADRO 3. El lobo ibérico (*Canis lupus signatus*): la biología, la conservación, la relación con el hombre y el mantenimiento en cautividad.

El lobo ibérico pertenece a la subespecie *C. l. signatus* endémica a la península ibérica. Se trata de un mamífero del orden de los carnívoros y de la familia Canidae. Su longevidad es de 10 a 15 años. Este animal presenta dimorfismo sexual, los machos alcanzan entre 130 y 180 cm de longitud, y las hembras entre 130 y 160 cm. La altura en la cruz puede llegar a los 70 cm. Los machos adultos pesan generalmente entre 30 y 40 kg, y las hembras de 20 a 35 kg. Es una especie de carácter social. El período de gestación tiene una duración de entre 60 a 63 días y los lobeznos nacen con un peso de 300-500 g. El lobo ibérico es un carnívoro depredador, prefiere ungulados de tamaño medio, ya sean salvajes o domésticos, pero también se alimenta con frecuencia de carroña, conejos y liebres, insectos, frutos y hasta grano. Su hábitat es montañoso, mostrando preferencia por los bosques caducifolios y de coníferas. La distribución actual corresponde al cuadrante noroccidental de la península ibérica.

En la actualidad la población en libertad se estima en aproximadamente 1500 ejemplares. La caza, el uso de venenos, la persecución de los ganaderos y la pérdida de hábitats son las principales amenazas para esta especie (Zofío & Vega, 1999b; Grande del Brío, 2000). El atlas y libro rojo de los mamíferos terrestres de España (Palomo *et al.,* 2007) determina que el estatus de conservación del lobo ibérico se acerca a la categoría de "amenazado". Existen dos entidades que trabajan en diferentes proyectos de conservación "in situ" de esta especie como la Fundación Biodiversidad y la asociación para la conservación y estudio del lobo ibérico.

Desde el nacimiento de Roma, protagonizado por Rómulo y Remo, a la figura del sanguinario hombre-lobo, pasando por personajes de cuento como el "lobo feroz" en *Caperucita Roja* o en los *Tres Cerditos*; metáforas literarias como la de Hemann Hesse en *El Lobo Estepario*, o por oficios de dudoso y controvertido reconocimiento social como el del lobero –cazador de alimañas- o el de conservacionista –defensor del animal y su medio-, el lobo ha sido y es una animal casi mitológico que nunca ha generado desinterés social y que a lo largo de la historia ha venido jugando un doble papel de enemigo y aliado, dañino y benefactor (Rodríguez de la Fuente, 1978b; Zofío & Vega, 1999b).

La mayoría de los estudios realizados en la familia Canidae en condiciones de cautividad, han versado sobre el comportamiento (Kreeger *et al*., 1996; Bernal & Packard, 1997; Bestelmeyer, 1999; Frézard & Le Pape, 2003), el efecto de los visitantes en la conducta y en las hormonas (Pifarré *et al*., 2012), los programas de enriquecimiento (Allsopp, 1998; Cummings *et al*., 2007) y diferentes aspectos de las relaciones sociales: las interacciones agresivas (Kachuba, 1985; Fatjó *et al*., 2007), la preferencia por la pareja (Derix & van Hoof, 1995) y la dinámica social (Fox, 1973). Frank (1987) escribió un libro sobre los diferentes aspectos de la investigación del lobo en cautividad.



CUADRO 4. El león marino de California (*Zalophus californianus*): la biología, la conservación y el mantenimiento en cautividad.

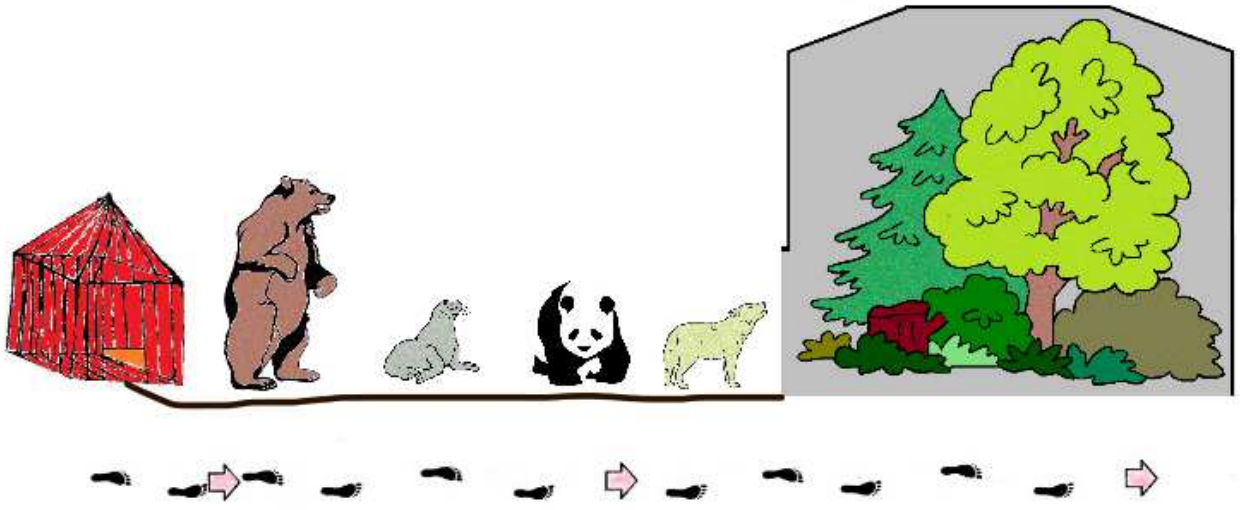
El león marino de California es un mamífero marino del orden de los pinnípedos y de la familia Otariidae. Su longevidad es de hasta 17 años. Es notorio su dimorfismo sexual, según el cual los machos pesan entre 300 y 380 kg (alcanzando unos 2.4 m de largo), mientras que las hembras apenas alcanzan de los 8 a los 120 kg (y miden de 1.8 a 2 m). Los machos adultos tienen una cresta sagital pronunciada. Es una especie de carácter social y con un sistema de apareamiento poligínico. Los machos son territoriales y tienen harenes de unas quince hembras cada uno. Usualmente se aparean entre mayo y junio y las hembras tienen una cría de 6 kg que nace en tierra o dentro del agua a los 12 meses de gestación. Se alimenta de peces y moluscos. Su hábitat es marino y se encuentra en los acantilados, las costas, los muelles y las boyas de balizamiento para la navegación. La distribución corresponde a las costas del norte del Pacífico desde Canadá hasta la península de Baja California en México.

La población en libertad es de unos 228.000 ejemplares. Las catástrofes ambientales (p.e. El Niño), la caza ilegal por la competencia con las industrias pesqueras, la acumulación de contaminantes como el DDT en la cadena alimenticia y la contaminación son las principales amenazas para esta especie (Riedman, 1991; Bonner, 1994; Perrin *et al.*, 2008). La lista roja de especies amenazadas de la IUCN (2011) determina que el estatus de conservación del león marino de California es de "preocupación menor". La conservación "in situ" de esta especie empezó a mediados del s.XX en EEUU y México con el tratado *Marine Mammal Protection Act of 1972*.

Los leones marinos han sido entrenados por la armada de los EEUU para la vigilancia submarina, la recuperación de objetos perdidos en el mar, la detección de minas y la localización de submarinos (Fetty, 2011).

Los leones marinos de California son "las focas" más famosas de los zoos, los circos y los parques acuáticos (IUCN, 2011). Las publicaciones científicas relacionadas con el bienestar animal de esta especie han versado sobre la reproducción (van Foreest, 1978; Dineley, 1981), las relaciones maternofiliales (Kastelein *et al.*, 1995; Hanson *et al.*, 2005) y los programas de enriquecimiento (Olivers, 1999; Herreman & Holmes, 2005). Los libros sobre esta especie tratan del manejo en cautividad (Grainger, 2005; Pywell, 2011).

2. OBJETIVOS



2. OBJETIVOS

La presente tesis doctoral tiene como objetivos analizar diferentes aspectos del bienestar animal en cautividad de cuatro especies de mamíferos en el Zoo de Barcelona y de Atlanta:

1. Estudiar dos indicadores de bienestar animal en cautividad en dos especies de úrsidos (Capítulo 1):

    a. Determinar el efecto de la estacionalidad en la duración, la ocurrencia y la intensidad de las conductas aberrantes en dos hembras de oso pardo (*U. arctos*) (Sección 1).

    b. Evaluar la influencia del público en la conducta y en el uso del espacio en dos especies de osos – el oso panda gigante (*A. melanoleuca*) y el oso pardo (*U. arctos*)- y su implicación en el manejo (Sección 2).

2. Evaluar la efectividad de distintos programas de enriquecimiento ambiental en el oso pardo (*U. arctos*) (Capítulo 2):

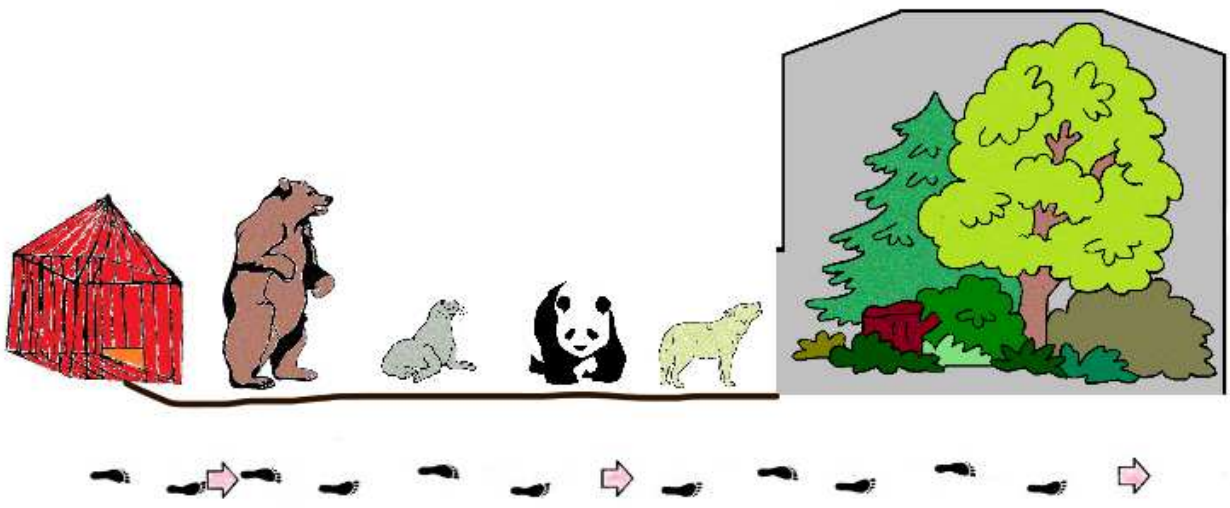
    a. Evaluar el efecto de un programa de enriquecimiento estructural en el bienestar de una pareja de osos pardos mediante el estudio del patrón de actividad diario y del uso del espacio (Sección 3).
    b. Evaluar la eficacia de un programa de enriquecimiento alimentario, ocupacional y sensorial en dos hembras y un macho de oso pardo, mediante la estandarización de cuatro modelos de efectividad (Sección 4).

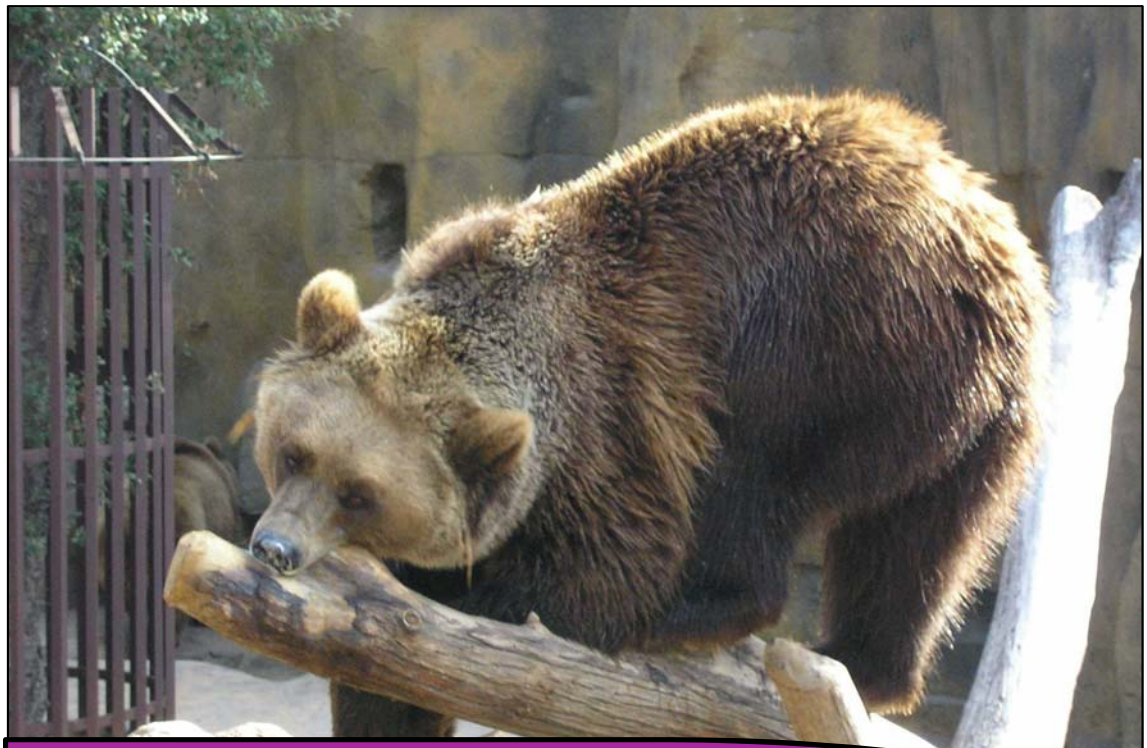
3. Analizar algunos aspectos del comportamiento social en cautividad de dos especies de mamíferos (Capítulo 3):

a. Efecto de la muerte del macho dominante en el patrón de actividad diario y el uso del espacio de una manada de lobo ibérico (*C. l. signatus*) (Sección 5).

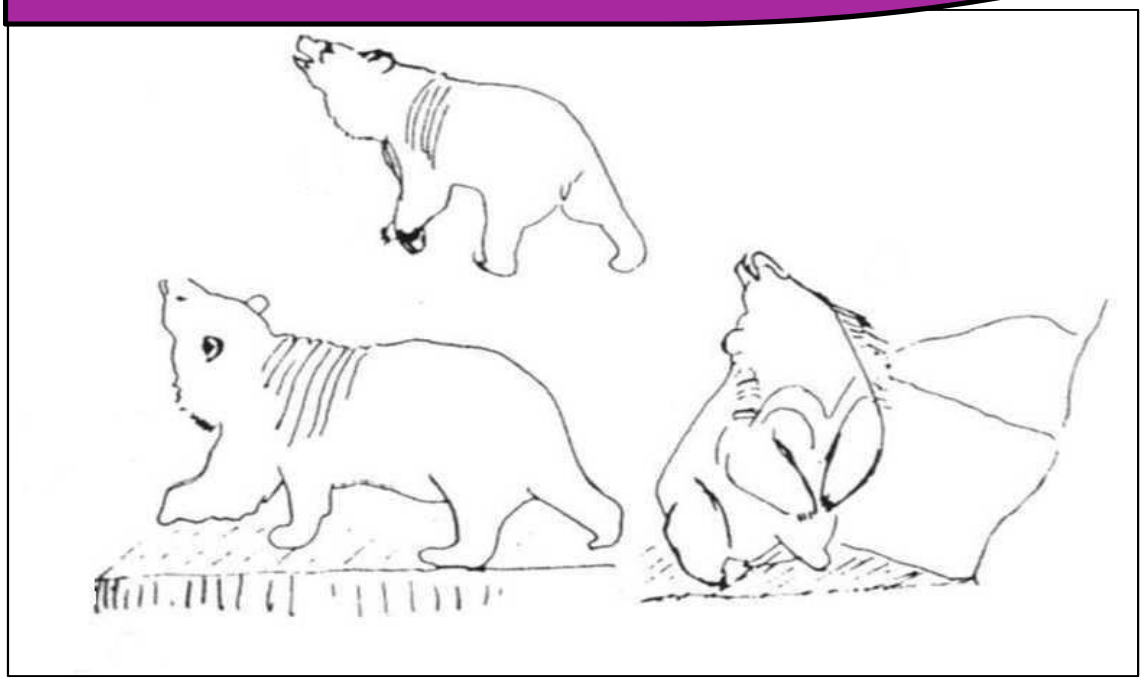
b. Comportamiento materno-filial en el león marino de California (*Z. californianus*) y su relación con el uso del espacio (Sección 6).

3. CAPÍTULO 1. INDICADORES DE BIENESTAR ANIMAL EN DOS ESPECIES DE ÚRSIDOS EN CAUTIVIDAD





3.1. SECCIÓN 1. A.I. Soriano, D. Vinyoles, C. Maté. (2012). Seasonal variation of the daily aberrant behavior of the two female brown bears (*Ursus arctos*) in the Barcelona Zoo. *Journal of Applied Animal Welfare Science*, submitted.



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Seasonal variations in the daily aberrant behavior of the two female brown bears (*Ursus arctos*) in the Barcelona Zoo

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Four species of bear are knowns that in their habitat natural manifest variable behaviors depending on the season. The objective of the present study was to assess if aberrant behaviors -as indicators of animal welfare- have annual and daily variations. Data were collected from two female brown bears (*Ursus arctos*) housed in the same facility at the Barcelona Zoo. Using a continuous sampling method, a total of 63 hours of behavior was observed and recorded per individual. The results indicate that the aberrant behavior varied according to the seasons during the year. The occurrence of aberrant behavior in two females brown bears during spring was higher meanwhile in autumn was lower and summer showed intermediate values. Old female had greater dedication to aberrant behavior in the morning, whereas the occurrence per session peaked in the evening for young female. Old female's aberrant behavior displays frequencies about 17%, whereas young female had a value about 5%.

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Four species of bear are known (Stirling, 1993; Brown, 2009) that, in their natural habitat, manifest variable behaviors depending on the season (Fundación Oso Pardo & Márquez, 1998; Roth, 1983; Roth & Huber, 1986; Stelmock & Dean, 1986), with the most notable differences demonstrated in food habits (Mace & Jonkel, 1986) and reproduction. Little research has addressed the impact or influence of seasons on the brown bear (*Ursus arctos*) in captivity, but the seasons having an influence on aberrant behavior is indicated (Ames, 1993; Carlstead & Seidensticker, 1991; Kolter & Zander, 1995). These abnormal behaviors are characterized because they are not observed in the typical behavior patterns of wild or free animals (Criswell & Galbreath, 2005; Meyer-Holzapfel, 1968).

Difficulty lies in defining stereotypies before unknowing the details about their causation. Stereotypies are defined as aberrant behavior observed in conditions of captivity characterized by morphologically identical movements repeated regularly and without any apparent motive (Mason, 1991; Mason & Rushen, 2006).

One of the important criticisms of this theory is that the stereotypies do have a real function if they represent symptoms of an illness or disequilibrated mental state (Hosey et al., 2009). Symptoms are overt characteristics of the normal homeostatic reactions of an organism trying to restore a disturbed equilibrium. In this sense, stereotypies are devises for adapting in an inadequate environment (Ödberg, 1978; Rees, 2011). The problem is knowing whether any external stimuli play a role in the abnormal behavior or if it is caused by internal neurological factors. Some authors have suggested that an appetitive behavior elicited in captivity gets repeated because it is no longer guided, whereas in nature it is continuously directed by various external stimuli; stereotypies have also been suggested to be rewarding themselves, such as reducing anxiety. In order to diminish the stereotypies there are the enrichment program techniques in order to motivating the lives of bears in zoos (Law & Reid, 2010).

Several studies have evaluated aberrant behavior in the Ursidae family because these animals are more susceptible to exhibiting this kind of behavior (Carslstead, 1998; van Keulen-Kromhout, 1976). Some studies in *U. maritimus* (Ames, 1993; Kolter & Zander, 1995) and *U. americanus* (Carlstead & Seidensticker, 1991) indicate seasonality in these species aberrant

behaviors. A large volume of research has focused on *U. maritimus*, and the most studied stereotypies are related to *pacing* (Wechsler, 1991, 1992) and the corresponding pharmacological treatment (Poulsen et al., 1995, 1996, 1997). Studies on *Tremarctos ornatus* (Fischbacher & Schmid, 1999) and *U. americanus* (Carlstead & Seidensticker, 1991) were also focused on *pacing*.

In other species, such as *Helarctos malayanus* (Cheng, 2001) and *U. thibetanus,* two types of stereotypies have been researched: motor and oral (Vickery & Mason, 2004). In a study on *Ailuropoda melanoleuca*, the authors classified 11 different types of stereotypies, mainly motor and oral (Lindburg et al., 2001). And finally, in a study on *Melursus ursinus*, the authors studied the effect of environmental enrichment on stereotypies in order to improve bear welfare (Anderson et al., 2010).

The objective of the present study was to determine if the duration, occurrence, and intensity of stereotypies vary according to the time of day and season, as observed on feeding and reproduction in the wild conditions.

MATERIALS AND METHODS

Animals and Installations

Two female European brown bears (*Ursus arctos arctos*) housed in the same facility at the Barcelona Zoo were used in this study. Both of the animals had come to the Barcelona Zoo from Parque de la Naturaleza de Cantabria (Cantabria, Spain) in November 2003. Young female was born in Cabárceno on March 1, 1994, and reared by her mother, but these details are not known for old female.

During the observation period, the two bears were housed together in a moat-style, semi-naturalized enclosure with a structure originally made from cement (see Figure 1) and a total area of 230 m^2. A wall divided the enclosure with an opening to connect the two parts. Each side had an aquatic zone for the animals to drink and bathe. The features in each of the enclosures were trees, bushes, several large stones, large overturned logs for climbing, and

several terraces at different levels with a natural substratum of gravel, sand, and bark. The indoor enclosures were cement cages out of sight from the public with a drinking trough and bath (total surface area of approximately 10 m^2 each) (Soriano et. al., 2006).

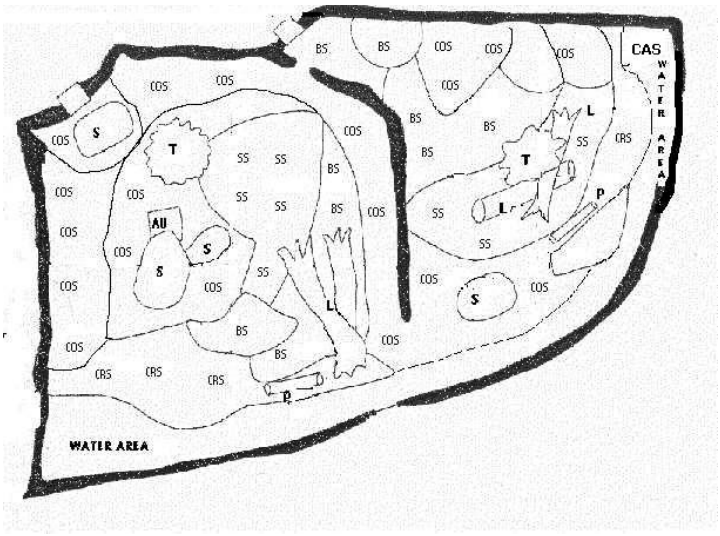

FIGURE 1 A plan of the brown bear enclosure. S=stones, T=tree, L=logs, BS=bark substrate, CAS= water fall, CRS=crushed stone substrate, SS=sand substrate, COS=concrete substrate, P=PVC pipe, AU= honey dispenser.

The study period was March to December 2004. The guidelines for allowing the bears out into their outdoor enclosures depended on the hours of daylight (between 9 am and 4 pm in the spring, to 8 pm in the summer and 7 pm in the autumn). The animals' diet consisted of fruit, vegetables, and meat once a day when they came into their indoor enclosures in the evening. Old female and young female slept in the interior enclosures alone. These animals were took part in two-day enrichment session.

Method

Data sampling was continuous recording of stereotypy behavior by both subjects (Martin & Bateson, 1991). The observation sessions were 1 hour in duration. A total of 63 hours of observation were recorded for both females.

The data collected in each session was 1) the season, spring, summer, or autumn, with a total of 21 h for each seasonal period; 2) the time of day, morning (from 9 am to 1 pm), midday (from 1 pm to 4 pm), or afternoon (from 4 pm to 5 pm in November and December, to 7 pm in March to October, and to 8 pm from June to September), with the same number of registered sessions for each period, though they varied with the daily hours of light.

Each bear displayed a different kind of stereotypy, and for this reason the data collection was different. Old female displayed aberrant bouts that consisted of biting the trunk. The morphology of this kind of stereotypy was the animal, in a four-legged position, partly introduced its mouth over the trunk and repeatedly opened and closed its mouth, tightening its jaw against the base of the furniture. Thus, the variables gathered during each session of observation for this female were: start time, end time, average duration of the aberrant bouts (duration), number of abnormal episodes per session (occurrence), and the time between one aberrant bout and the next (intensity).

Young female had a different type of stereotype, consisting of an aberrant turn of the head anti-clockwise in the vertical plane. The duration of this stereotype was very short, five seconds, and the variables to record were the time she started, the duration between one turn of the head and the next (intensity), and the number of episodes per hour (occurrence).

Data Analysis

All data analyses were performed using SPSS 15.0. Normality was assessed using Kolmogorov-Smirnov single-sample tests and logarithmic transformation of intensity. A rejection criteria of $p=0.05$ was applied to all tests. The relationship between numerical variables as the duration, occurrence, and intensity of the aberrant behaviors was obtained using the analysis of partial correlations. Two-way ANOVA test was used to determine the relation between numerical variables (duration, occurrence and intensity) with the season (spring, summer and autumn) and the time of day (morning, midday and afternoon). However, Kruskal-Wallis test was used to determine the relation between young female's intensity anormal behaviors with the seasonal cycle.

RESULTS

Table 1 shows the occurrence of the 137 aberrant episodes analyzed for old female and 4283 aberrant points for young female. The relationship between the duration, occurrence, and intensity of the aberrant behaviors was obtained using the analysis of partial correlations. When the occurrence diminished, the average duration of the episodes per session increased (r= -0.67, p<.05, N= 137) and the intensity increased (r= -0.3, p<.05, N= 137). Therefore, within a same session, episodes of greater duration corresponded with fewer episodes, whereas fewer episodes had greater intensity (less time passed between episodes), indicating that the aberrant behavior would become more continuous. However, we identified no relationship between the average duration of the episodes and intensity (r= -0.13, p>.05, N = 137).

TABLE 1

The occurrence of brown bear's aberrant behaviors

		OLD FEMALE	YOUNG FEMALE
		Mean ± SD	Mean ± SD
SPRING	Morning	1448.2 ± 255.8	47.5 ± 114
	Midday	1112.8 ± 389.7	42 ± 86.8
	Afternoon	684 ± 554.2	35.4 ± 41.4
SUMMER	Morning	596.4 ± 180.2	55.3 ± 137.4
	Midday	282.7 ± 243	43.9 ± 111.9
	Afternoon	244.7 ± 282.3	65.2 ± 193.3
AUTUMN	Morning	234 ± 259.4	70.7 ± 165.5
	Midday	213.3 ± 447.2	72.5 ± 174.1
	Afternoon	397.3 ± 389.6	49 ± 93

Table 2 shows that only the duration depended on time of day and season, the intensity depended on time of day and occurrence was not influenced. The highest aberrant's behavior duration was in spring and summer mornings meanwhile in autumn was in afternoon. The intensity is highest in midday (see Figure 2 and Figure 3).

TABLE 2

Old female's values for two-way ANOVA to determine the influence of season and time of day

	Duration (s)			Occurrence			Intensity (s)		
	F	df	p	F	df	p	F	df	p
Season	30.99	2, 54	0*	0.84	2, 54	0.44	1.49	2, 54	0.23
Time of day	4.24	2, 54	0*	1.39	2, 54	0.26	3.55	2, 54	0*
Season × time of day	3.10	4, 54	0*	0.44	4, 54	0.78	1.74	4, 54	0.15

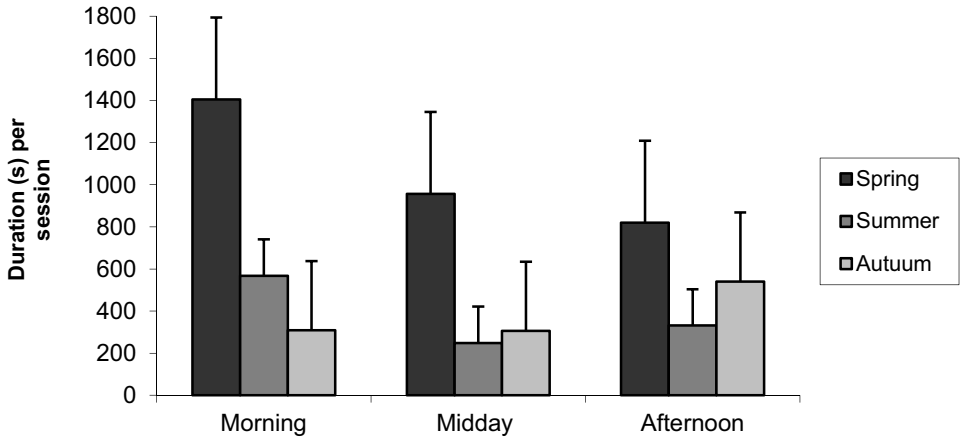

FIGURE 2 The mean (± SD) duration of old female's aberrant episodes by different daily and seasonal periods.

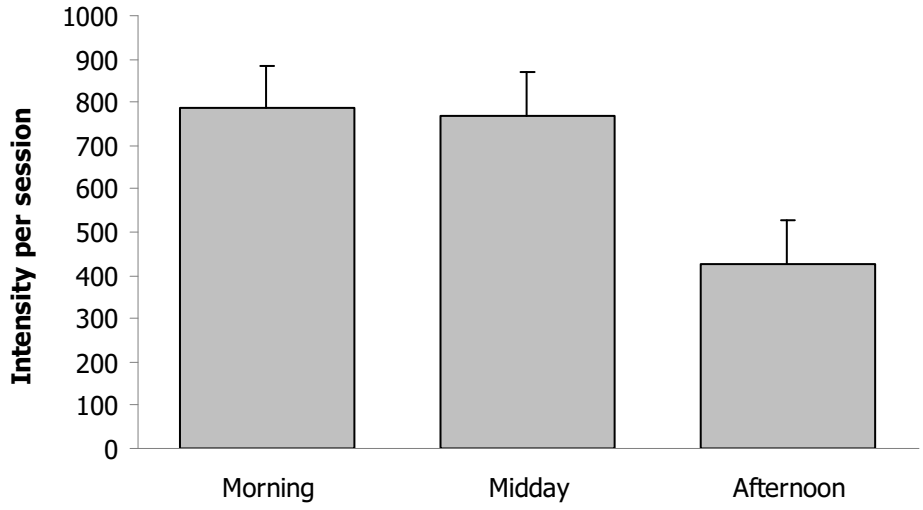

FIGURE 3 The mean (± SD) intensity old female's aberrant episodes by different daily periods.

In order to determine the relationship between the occurrence and the intensity for young female, a correlation between the two variables was obtained (r= -0,21, p<.05, N= 4283). Thus, greater occurrence coincided with greater intensity, as in the case we described for old female.

However, the occurrence of young female's per session not depended on the season (F (2,54)= 0.54, p>.05, N= 4283) and on the season* daily period (F (4,54)= 1.38, p>.05, N= 4283), only depended on the daily period (F (2,54)= 4.80, p<.05, N= 4283), as they were more frequent in the evening (Figure 4). The intensity only depended on the season ($H_{(2)}$ = 20.98, p<.05, N= 4283) and not on the time of day ($H_{(2)}$ = 2.58, p>.05, N= 4283); in spring they were shorter (greater intensity) and in autumn they were longer (Figure 5).

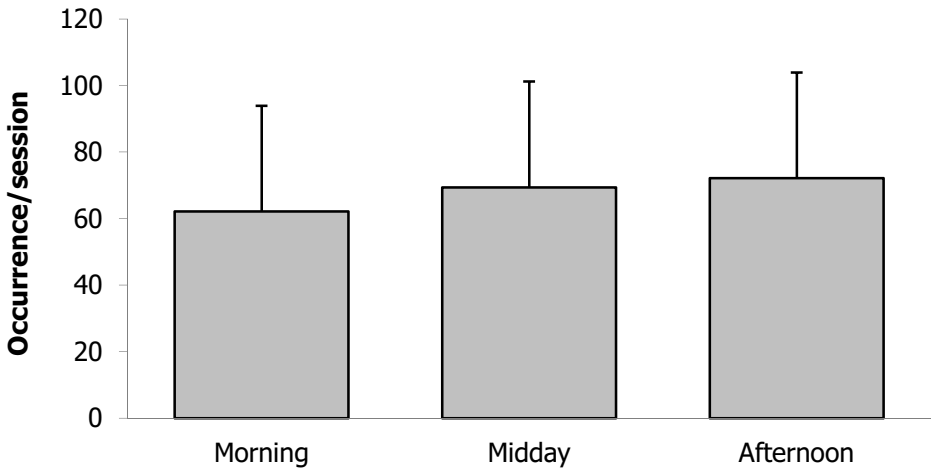

FIGURE 4 The mean (± SD) occurrence of young female's stereotype based on the time of day.

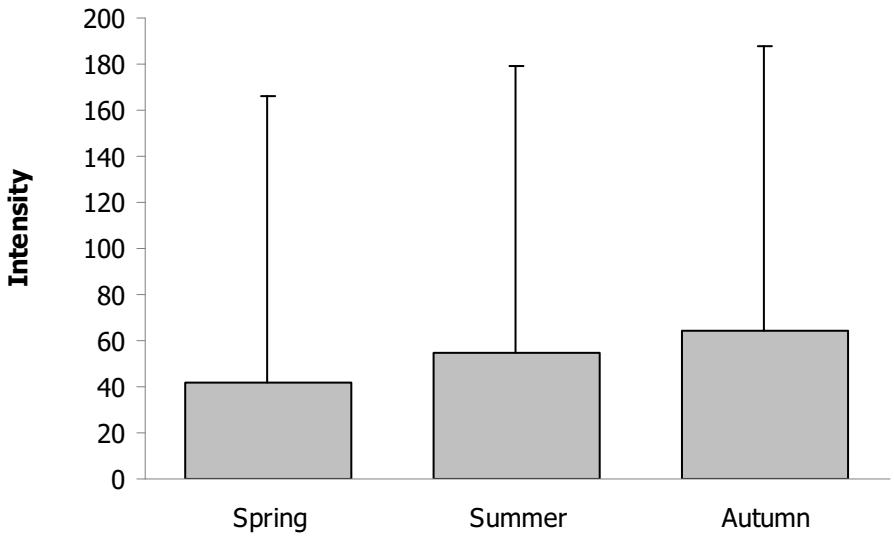

FIGURE 5 The mean (± SD) intensity of young female's stereotypies based on season.

DISCUSSION

Despite the two daily enrichment sessions aimed at improving the wellbeing of these animals, the present work shows that old female´s aberrant behavior displays frequencies superior to the 10% (17%) undesirable value espoused by Shepherdson (1989), whereas young female had a desirable value (5%).

The welfare of the Ursidae depends on many factors, including daily management and composition of the diet (Grandia et al., 2001; Larsson & Tove, 1995; Morimura & Ueno, 1999), enrichment programs (Hare, 1995), facility design (Soriano et al., 2006; Spendrup & Larsson, 1997), and public affluence (Montaudouin & Le Pape, 2005). All of these factors contribute to the occurrence of aberrant behaviors. Studying all of these aspects would be necessary to discern which conditions are suitable for the maintenance of these animals in the best captivity conditions (Swaisgood & Shepherdson, 2005) and for considering the reintroduction of individuals of this species, as proposed by Vickery and Mason (2003), because we are talking about a species in serious danger of extinction.

The design of the facilities should closely resemble the animals' natural habitat (Seidensticker & Doherty, 1996), and the use of cement should be minimized because this could

influence aberrant behavior, as seen in one of the bears in the present study. Other authors have indicated a crucial relationship between the size of the enclosure and the number of stereotypies manifested (Spendrup & Larsson, 1997).

The results of this study demonstrate that, in general, the aberrant behaviors of these two females varied according to the seasons, with a longer duration in spring, similar to observations made in the polar bear (*U. maritimus*) by Ames (1993) and Kolter and Zander (1995), and in contrast to the observations made in the American black bear (*U. americanus*) by Carlstead and Seidensticker (1991), who reported an elevated proportion of aberrant behavior during summer. The increased frequency of episodes observed in spring in the brown bear and polar bear could be related to the hormonal changes that take place during the zeal period, which increases the activity of adults (Fundación Oso Pardo & Márquez, 1998; Ward & Kynaston, 2003). Studying the winter period would have been interesting to identify variation in the aberrant behaviors at a time that entails diminished activity in this species in its natural habitat.

With respect to the daily variation of some aspects related to aberrant behavior, old female exhibited a peak in the average duration per session in the morning and young female an increase in the occurrence per session during the afternoon. The results indicated strong individual variation as both subjects remained equally active at any time of the day, similar to previous findings for the same species (Roth, 1983), without displaying peaks of activity-inactivity throughout the day as happens in other Ursidae species (Mainka & Zhang, 1994). Cheng (2001) and Weschler (1991) focused on two daily periods (morning and midday) in different species of bears. These investigators observed that a variation in the proportion of aberrant behavior occurred at midday, being greater in some cases and constant in others. However, we only observed an increase in the intensity at midday in old female. Vickery and Mason (2004) also observed a peak of aberrant behavior in two bears as occurring in the morning and afternoon. Comparing this study with ours, we found differences in the time of day in which the bears performed the behavior. Thus, old female had greater dedication to *biting the trunk* in the morning, whereas the occurrence per session peaked in the evening for young

female. This greater occurrence of aberrant behavior in the morning perhaps reflecting an increased motivation to locomote and explore at this time of day. In the wild, many diurnal species begin the day with an intense period of feeding or locomotion (Brown, 2009).This greater occurrence of aberrant behavior in the afternoon was associated with conditional learning (cause-effect) due to the manifestation of this behavior at the moment of acceding to the indoor facilities where the food is located, an aspect demonstrated in the works by Montaudouin & Le Pape (2005) and Wechsler (1991).

In order to guarantee the well-being of the captive animals and reduce aberrant behavior, considering factors that can be key in the appearance and fixation of stereotypy behaviors is necessary, including the origin and age of subjects before transfer. In the present study these factors were not considered, which may impact the appearance and persistence of these behaviors despite the application of an enrichment program.

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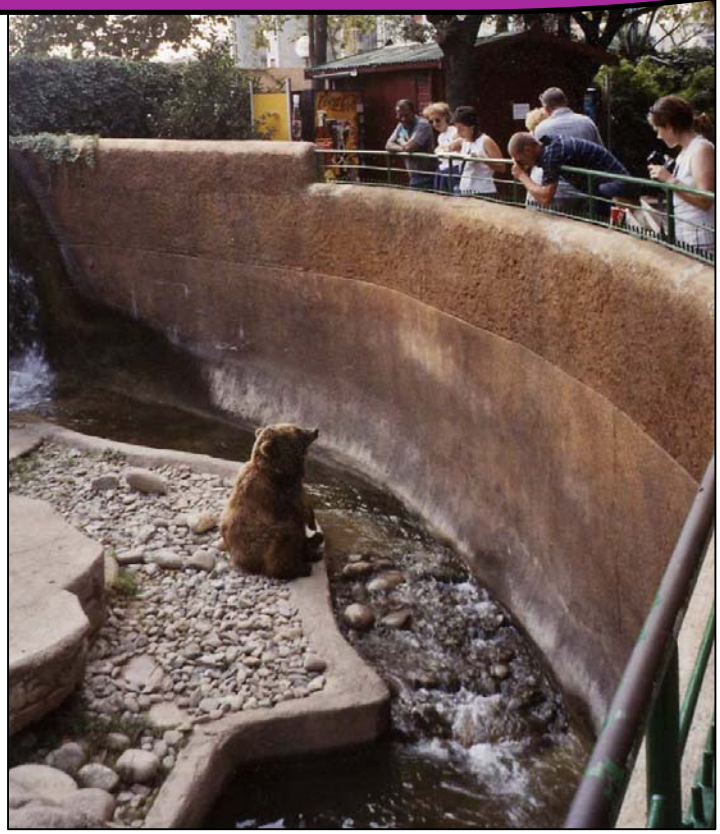
3.2. SECCIÓN 2. A.I. Soriano, D. Vinyoles, C. Maté. (2012). The visitors influence on the behaviour and the space use in two species of ursids: a management question? *Der Zoologische Garten*, submitted.



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DER ZOOLOGISCHE GARTEN

The influence of visitors on behaviour and on the use of space in two species of ursids: a management question?

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Abstract

The study of the influence of visitors on the behaviour of captive animals reflects a relatively recent concern that has emerged primarily over the past decade. An increasing effort is being made to determine whether the public can affect captive animal behaviour negatively, positively, or even neutrally. The subjects of this study were two pairs of bears: a pair of brown bears housed at Barcelona Zoo and a pair of giant pandas housed at Atlanta Zoo. A focal-animal sampling method was used for the study. Instantaneous samples were also recorded at 2-min intervals during 34 1-hour sessions for each individual. The total number of observation hours was 68. The results showed that in the presence of the public, the brown bears showed higher percentages of four behaviour patterns: vigilance, locomotion, stereotypic and stationary. With the public present, the pandas showed higher percentages of exploration, feeding, manipulation, and stationary behaviour. In addition, the pandas were more frequently not in sight with the public present. The pandas used their enclosure more homogeneously than the brown bears. All of these observations appear to suggest that the brown bears were more susceptible to the presence of visitors than the pandas. A possible reason for this difference is that the management of the brown bears was not adequate and that, unlike the pandas, the brown bears were not monitored to ensure their welfare. The data illustrated the importance of careful management and of visitor influence for captive brown bears and giant pandas.

Keywords: visitor influence; animal welfare; zoo management; behaviour; space use; *Ailuropoda melanoleuca*; *Ursus arctos arctos.*

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Introduction

Zoos and aquariums are making significant contributions to conservation by acting as mentors in socially relevant formal and informal education, thereby influencing people's attitudes and behaviour towards animals and environments. Education is a central role for all zoos and aquariums. This role includes the possession of a defined education policy and the formulation of a strategic development plan. The educational role consists of the interpretation of living collections to attract, inspire and enable people from all types of backgrounds to act positively in terms of conservation. Zoos offer informal (free-choice) education to their visitors and offer formal education by developing links with schools, colleges and universities (WAZA, 2005). In recent years, studies of the influence of the public on animal behaviour have become increasingly relevant. These studies conclude that the visitors can have a positive, neutral or negative effect on the welfare of captive animals (Davey, 2005, 2007; Farrand & Buchanan-Smith, 2005; Fernández et al., 2009; Hediger, 1969; Hosey, 2000, 2008; Kreger & Mench, 1995; Morgan & Tromborg, 2007).

Only two published studies report positive impacts by visitors on animal behaviour. Robson (2004) showed that stereotypies in elephants decreased in the presence of the public. Other studies presented by Glatson (1997), Houts (1999), Choo et al. (2011) and Claxton (2011) focused on visitors involved in enrichment programs. Relatively few studies cite neutral effects of visitors on the behaviour of captive animals. Kalthoff (2002) observed different species of animals in zoos and concluded that visitors did not influence the animals' activity patterns. O'Donovan et al. (1993) also demonstrated that the public did not affect the behaviour of a cheetah female with her cubs. However, most studies of the effect of visitors on the behaviour of captive animals determined that the presence of visitors caused the animals to be stressed.

The greatest number of studies of visitor influence have involved nonhuman primates (see, for example, Guillen-Salazar et al., 2002), but visitor influence has also been studied in other mammals, including felids (Cunningham, 2005), deer (Li et al., 2007), otters (Owen, 2004), and wallabies

(Pifarré et al., 2012). Studies of this type have even included birds (Keane & Marples, 2004).

In the family Ursidae, food begging represents the clearest example of the negative influence of visitors on the behaviour of captive animals. This pattern is not considered to be typical in ursids and might endanger the physical and psychological welfare of these omnivores (Markowitz, 1982; van Keulen-Kromhout, 1976). In this family, the negative effect of the public and the methods through which the animals can become accustomed to visitors over time have been studied in the American black bear by Jordan & Burghardt (1986). Only one study has been published on the effect of visitors on two different types of variables (the use of space and animal behaviour). Conducted on black-tailed prairie dogs, that study showed that if the number of visitors increased, resting increased and vigilance, feeding and locomotion decreased (Eltorai & Sussman, 2010).

The aim of this study was to determine if the influence of visitors on the behaviour and use of space in two species of bears in confinement depended on the characteristics of animal management. The subjects of the study were one pair of giant pandas (*Ailuropoda melanoleuca*) and one pair of brown bears (*Ursus arctos arctos*). All data were collected with the same recording methods and the same sampling techniques. The results of the present study can contribute to a better understanding of environment-behaviour interactions and show the importance of careful management and visitor education programs for the two species of bears.

Methods

Subjects and enclosures

The two brown bears (one male and one female) of this study were housed at the Barcelona Zoo, and the two giant pandas (one male and one female) were housed at Zoo Atlanta (see Table 1).

Table 1. Demographic information on each study subject.

Common name	Name	Sex	Birth date	Birth type	Rearing condition	Arrival date at zoo
European brown bear	Keiko	Male	June 1995	Wild-born	Hand	December 18, 1999
European brown bear	Miskha	Female	May 2000	Wild-born	Mother	December 28, 2000
Giant panda	Yang Yang	Male	September 9, 1997	Captive-born	Mother	November 5, 1999
Giant panda	Lun Lun	Female	August 25, 1997	Captive-born	Mother	November 5, 1999

During the observations, the two brown bears were housed individually in two moat-style, semi-naturalised enclosures especially designed for housing bears and constructed of cement. The two enclosures are separated by a wall with entrances to both enclosures. The yards vary in area. The area of the female's yard is 150 m^2, whereas the area of the male's yard is 230 m^2 . Each yard has a pool that allows the animals to drink and bathe. The features of each of the enclosures include trees, bushes, several large stones, large overturned logs for climbing and several terraces at different levels with a natural substratum of gravel, sand and bark (see Figure 1). The indoor enclosures are out of sight of the public and consist of cement cages with a drinking trough and a bath (with a total surface area of approximately 10 m^2) (see Soriano et al., 2006 for more details).

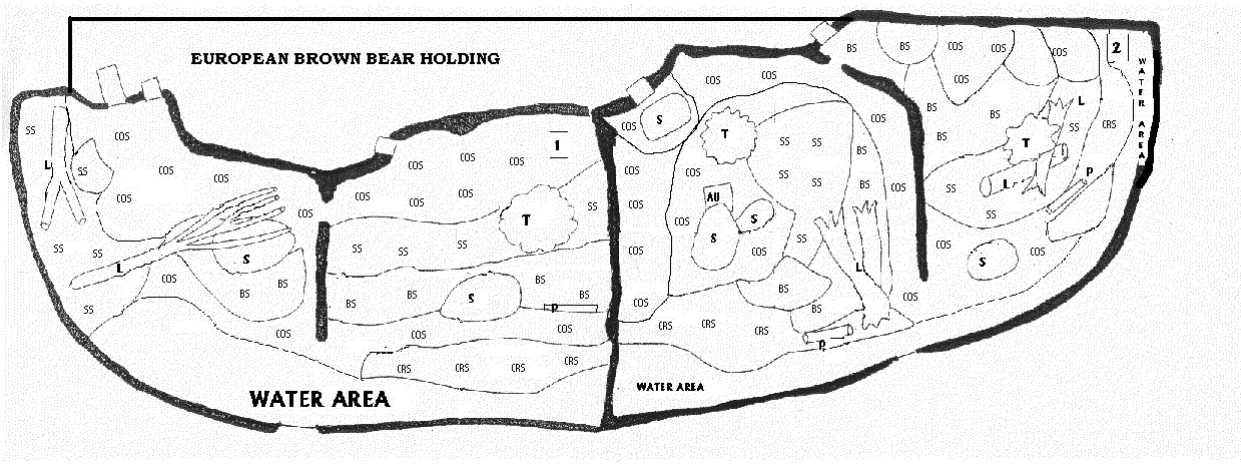

Figure 1 European brown bear holding area. 1= female's enclosure; 2= male's enclosure; S=stones; T=trees; L=logs; BS= bark substrates; CRS= crushed stone substrates; SS= sand substrates; COS= concrete substrates; AU = honey dispenser; P= PVC pipe.

The daytime enclosures in which the giant pandas were housed consisted of two areas, one indoors and the other outdoors. The two indoor daytime enclosures had an approximate surface area of 46 m^2 each and had two large front windows that allowed the public to observe the animals. These spaces were equipped with air conditioning and had several long logs placed vertically for climbing, a hammock for resting, a drinking trough and a cork substratum. The two outdoor daytime enclosures consisted of naturalised habitats with an approximate surface area of 495 m^2 each. A deep moat separated the animals from the public. The features of the enclosures included trees, bushes, platforms made of trunks for climbing, a grass substratum and a few shallow pools to serve as drinking troughs (see Figure 2). The indoor areas used at night were out of sight of the public and included cages in which the bears participated in various activities, such as training programs and studies of their cognitive abilities.

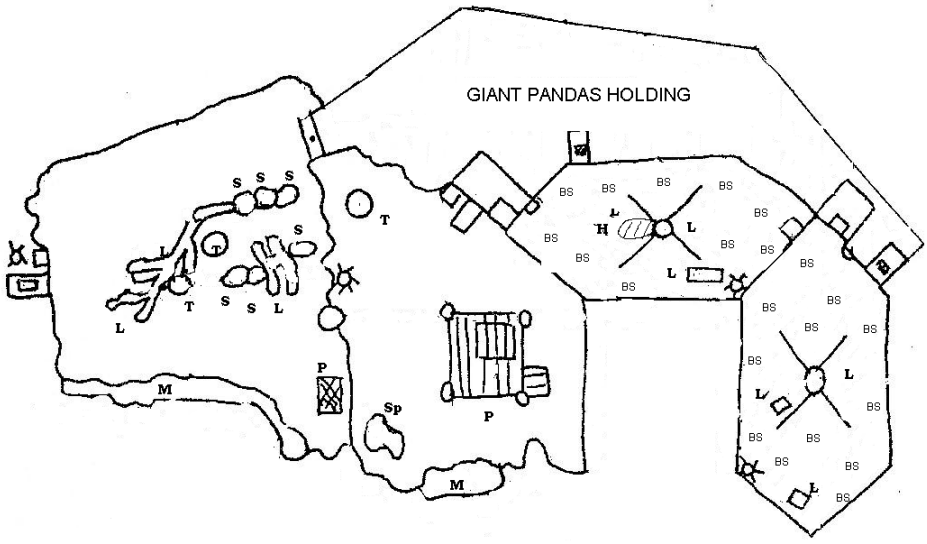

Figure 2 Giant panda holding area. S= stones; T= trees; L= logs; H= hammock; Sp= surface pool; P= platforms; M= moat; BS= bark substrate.

For the purposes of the study, the enclosures were considered to consist of two similar parts defined in terms of the proximity of the subjects to the visitors. The categories of the location variable were defined as *Front Location* if

the animals were in the areas close to the visitors and *Back Location* if the animals were in the areas farther from the public (Figure 3 and 4).

Daily management

The brown bears were housed individually in view of the conditions occurring naturally in the wild. The members of this species are solitary and only interact during the reproductive season. The schedule for the use of the outdoor enclosures by the female and the male depended on the hours of daylight (between 9:00 a.m. and 5:00 p.m. from October through February, between 9:00 a.m. and 6:00 p.m. during March, and between 9:00 a.m. and 7:30 p.m. from April through September). The female went out into the outdoor enclosures every day. The male went out on four alternating days (Tuesdays, Thursdays, Saturdays and Sundays) because the enclosure was occupied by another female brown bear on the other three days (Mondays, Wednesdays and Fridays). The bears' diet consisted of fruit, vegetables and meat. The animals were fed once a day when they entered their indoor enclosures in the evening. During the study, the animals participated in a weekly enrichment program in which we selected the enrichment items that were of most interest to them. This information was obtained with the aim of introducing a daily enrichment program.

The giant pandas were not kept together all day. The male and female usually shared enclosures during the morning and the afternoon. The air-conditioned areas enabled the subjects to be housed under comfortable conditions if the outdoor temperatures were extreme. The giant pandas entered the areas visited by the public between 9:30 a.m. and 4:30 p.m. The animals' diet consisted of biscuits rich in fibre, apples and peanut butter. Biscuits were given to the animals 5 times a day. Bamboo was provided throughout the day, with a large amount available at night. The giant pandas participated in an enrichment session and a training session each day.

Data collection

The study period for the brown bears extended from December 2001 through June 2002 during various seasonal periods. The observations of the giant pandas were conducted primarily during October 2002. A focal-animal sampling method was used, and instantaneous samples were also recorded at 2-min intervals during 34 one-hour sessions for each individual (Altmann, 1974). The total number of observation hours was 68 for the brown bears and 68 for the giant pandas. The observations were distributed over the daytime hours for the brown bears and between 9:30 a.m. and 4:30 p.m. for the giant pandas. The observation sessions for the brown bears occurred 48 hr after the day of their once-weekly enrichment program. The observation sessions for the giant pandas were held daily.

The following variables were recorded in this study for each subject: 1) the time of day: (morning (9:00-12:00 a.m.), midday (12:00 a.m.–2:00 p.m.) and afternoon (2:00-4:00 p.m.)); 2) visitor presence or absence (the "visitors" category was assigned if one or more visitors were present in front of the bears' enclosure, whereas "no visitors" was assigned if no visitors were in front of the enclosure); 3) the use of space by the bears in the enclosure (*Front Location* or *Back Location*; and 4) the daily activity pattern (the recorded behavioural categories are shown in Table 2). Interactions with humans by the brown bears included various forms of begging, such as begging while sitting or standing, or opening the mouth and moving the head from side to side. In the giant pandas, interactions with humans included significant changes in the frequency of other behaviours. Interactions with humans were observed in the pandas during their medical training sessions and involved the keepers. Stereotypic behaviour in the female brown bear consisted of locomotion in a fixed manner in space and time, whereas stereotypic behaviour in the male brown bear consisted of lateral biting.

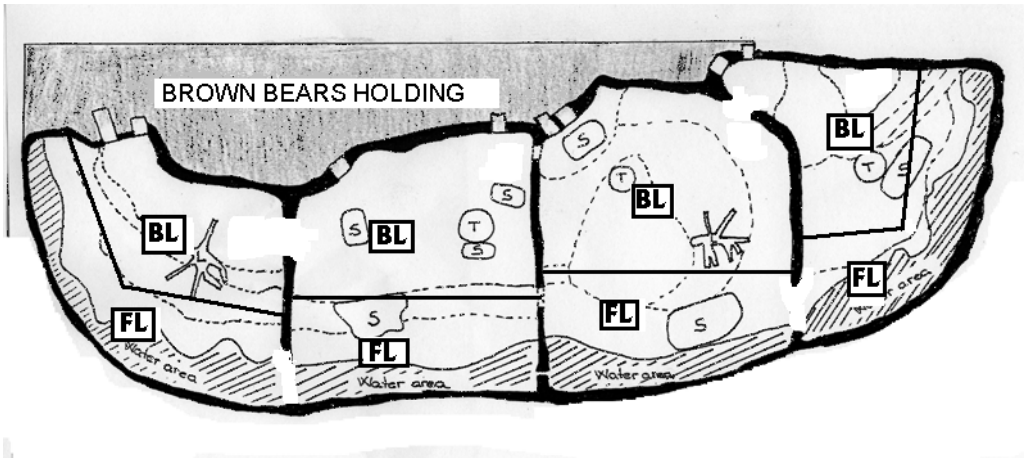

Figure 3 Brown bear holding area, showing the division between the front and back areas. S= stone; T= tree; L= log; BL= back location; FL= front location;---- uneven surface.

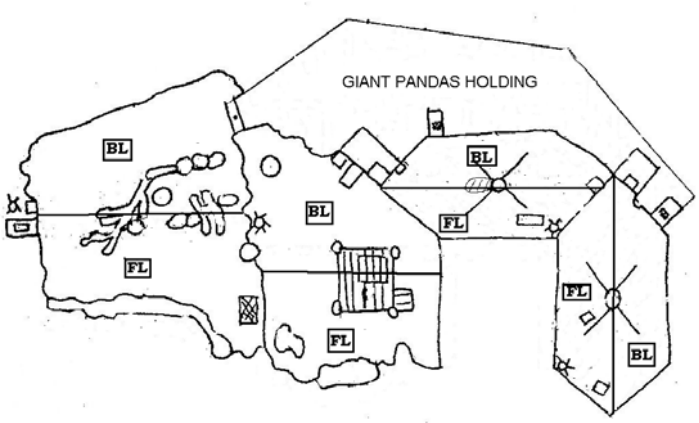

Figure 4 Giant panda holding area, showing the division between the front and back areas. S= stone; T= tree; L= log; BL= back location; FL= front location;---- uneven surface.

Table 2. Definition of the bear behavioural repertoire analysed in this study.

CATEGORIES	
Activity	
Exploration	The animal sniffs the air, the substratum, the food and objects in general.
Vigilance	The animal is in a state of alertness, with its head and ears raised and its eyes open.
Locomotion	The animal moves around the enclosure.
Scent Marking	The bear rubs any part of its body against the features in the enclosure.
Feeding	The animal consumes food; this also includes drinking.
Solitary play	Exaggerated, vigorous movements by the animal, such as jumping.
Maintenance	The animal grooms itself with its mouth and/or claws; it scratches itself, urinates, defecates or shakes its fur.

Manipulation	The bear scratches, bangs, bites or moves physical objects, both food and non-food, with its mouth and/or claws.
Interaction with humans	The bear sits or stands while watching humans.
Stereotypies	Behaviour having no apparent function or objective and showing a repetitive pattern in time and space.
Social interaction	Behavioural traits of an affiliative or agonistic nature between two individuals.
Inactivity	
Stationary	The bear rests sitting or lying down with its muscles relaxed.
Not visible	The bear or its behaviour cannot be seen.

Statistics

The statistical test used to evaluate behavioural differences between the brown bears and the giant pandas was based on contingency table analysis. The test calculated Pearson's χ^2 and the adjusted residual values (taking an absolute value of 1.96 of the test statistic as a reference based on a normal distribution and a significance level of 0.05) to determine whether the expected frequencies differed from the observed frequencies for the variables studied in the two bear species (Haberman, 1978). The same statistical tests were applied to analyse the effect of the qualitative variables (time of day, daily activity pattern, space use and visitor presence) on the behaviour of each bear species. The uniformity of the use of space was analysed with the spread-of-participation index (Shepherdson et al., 1993; Soriano et al., 2006). A value of 1 indicated minimum use of the facility; a value of 0 indicated that the use of space was totally uniform (Dickens, 1955).

Results

The occurrence (%) of the daily activity patterns at the three times of day was more equally balanced in the giant pandas than in the brown bears. The brown bears showed maximum frequencies of "locomotion" and minimum frequencies of "scent marking", whereas the giant pandas showed maximum frequencies of "stationary" and minimum frequencies of "solitary play". The

brown bears, unlike the giant pandas, showed "stereotypies" but not "social interactions". The giant pandas used the space more homogeneously than the brown bears. During data collection, visitor presence was more frequent than visitor absence for both species (Table 3).

Table 3 Occurrence (%) of the daily activity patterns, the use of space and the presence of visitors for each time of day for both species of bears.

	Brown bears			Giant pandas		
	Morning	Midday	Afternoon	Morning	Midday	Afternoon
Activity pattern						
Exploration	5.9	3.5	5.1	2.0	2.2	1.7
Vigilance	7.0	5.0	2.8	1.2	1.2	1.0
Locomotion	13.8	8.8	11.9	1.9	2.3	3.0
Scent Marking	0.1	0.1	0.1	0.1	0.1	0.3
Feeding	1.2	0.8	0.7	4.3	6.3	4.0
Solitary Play	0.4	0.4	0.7	0.1	0.0	0.0
Maintenance	1.0	1.1	0.5	2.9	1.7	1.8
Manipulation	1.3	0.8	0.5	4.3	7.5	7.8
Interaction with humans	0.2	0.1	0.2	0.7	0.2	0.4
Stereotypies	1.4	0.4	3.9	0.0	0.0	0.0
Social Interaction	0.0	0.0	0.0	0.6	0.8	0.7
Stationary	8.0	7.8	3.7	14.0	10.5	11.7
Not visible	0.4	0.5	0.8	1.5	0.6	1.3
Space use						
Front Location	7.3	7.4	7.8	15.2	17.9	12.1
Back Location	33.1	21.7	22.9	18.2	15.4	21.4
Visitor presence						
Visitors	25.7	20.1	22.5	26.3	28.3	24.8
No Visitors	14.7	9.1	8.2	7.1	5.0	8.7

In the presence of visitors, the brown bears showed significantly greater frequencies of "stereotypies", "stationary", "locomotion" and "vigilance" ($\chi^2_{(11)} = 30.50$, $p \leq 0.00$), whereas the giant pandas showed significantly greater frequencies of "exploration", "feeding", "manipulation", "stationary" and "not visible" with visitors present ($\chi^2_{(11)} = 82.20$, $p \leq 0.00$) (Fig. 5).

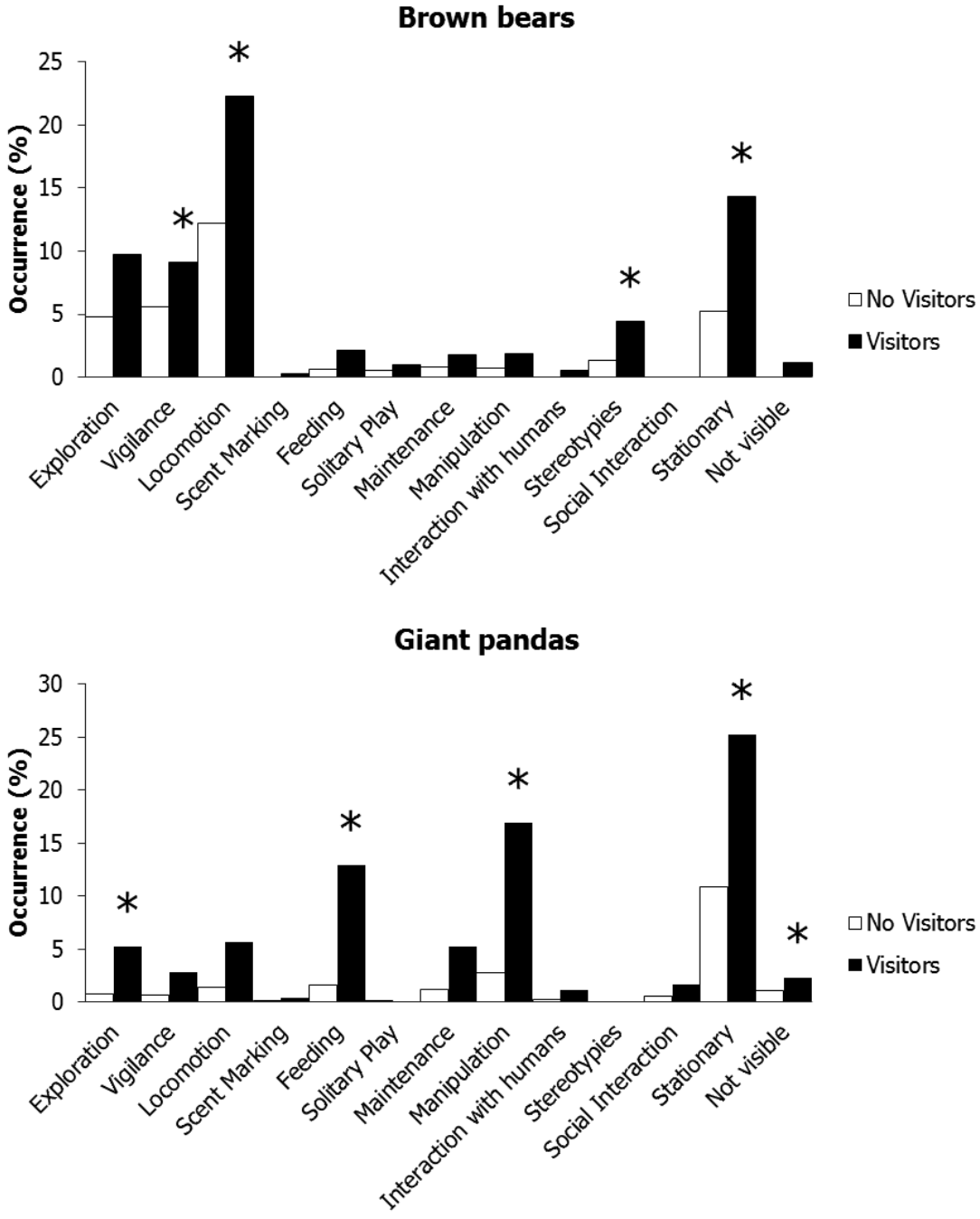

Figure 5 Occurrence (%) of the daily activity patterns for the two bear species in the presence and in the absence of visitors. Statistically significant differences ($P < 0.05$) are indicated by an asterisk.

In the presence of visitors, the brown bears and the giant pandas used the "back location" more frequently than the "front location" (brown bears: $\chi^2_{(1)} = 24.15$, $p<0.00$ and giant pandas: $\chi^2_{(1)} = 7.86$, $p<0.00$). In all cases, the brown bears used the "back location" more frequently (Fig. 6).

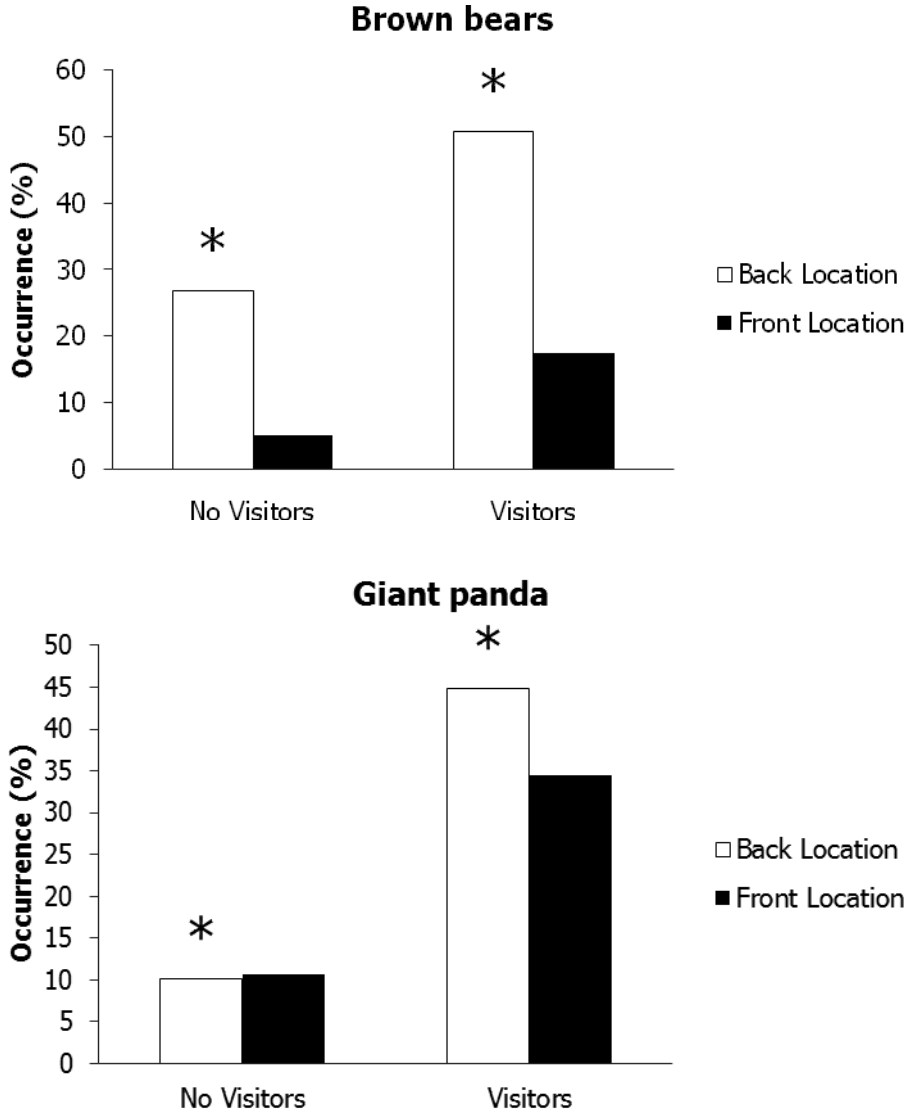

Figure 6 Percentage and statistical significance for each zone as a function of visitor presence for both bear species.

The data on the SPI index as a function of visitor presence showed a more homogeneous use of space by the giant pandas (the SPI was 0.13 in the presence of visitors and 0.02 in the absence of visitors) than the brown bears (the SPI was 0.49 in the presence of visitors and 0.69 in the absence of visitors).

Discussion

In this study, the daily activity pattern and the use of space in relation to visitor presence were used to compare the welfare of two species of bears from two different zoos.

The analysis of the daily activity patterns of the brown bears in this study showed an increase in stereotypies in the presence of visitors. A similar increase in stereotypes with visitors present was found in wallabies (Lockley & Leadbeater, 2005) and in certain species of primates (Cox, 1997; Guillen-Salazar et al., 2002; Mallapur et al., 2005; Carder & Semple, 2008). However, a increase in stationary behaviour was observed in the presence of visitors in Mexican wolves (Pifarré et al., 2012) and prairie dogs (Eltorai & Sussman, 2010) but not in different species of primates (Chamove et al., 1988; Todd et al., 2007) or in cheetah (O' Donovan et al., 1993). Moreover, the presence of visitors can be related to an increase in locomotion in certain species of primates (Hosey & Druck, 1987; Fa, 1989; Mitchell et al., 1992; Hague, 2005), as observed in this study for the brown bears. Cooke & Schillaci (2007) and Li et al. (2007) found a higher percentage of vigilance in the presence of visitors in primates and in a deer species, respectively, as also observed in the brown bears in this study but not in prairie dogs (Eltorai & Sussman, 2010). An increase in feeding in the presence of visitors has been observed in the Diana guenon (Todd et al., 2007), Asian small-clawed otters (Owen, 2004) and Mexican wolves (Pifarré et al., 2012). A similar increase was observed in the giant pandas. However, it is possible that this increase was due not to the provision of food to the animals by the visitors but because the unusual feeding habits of the giant pandas caused the visitors to spend more time looking for the animals in the exhibit. In both species of bears, the frequency of "not visible" behaviour increased in the presence of visitors. Such an increase can occur for two reasons. First, orangutans (Birke, 2002) and gorillas (Kuhar, 2008) were observed to spend more time hidden from the public in the presence of large numbers of visitors to avoid the noise produced by the visitors. In brown bears, the "not visible" behaviour category was only observed

to occur in the presence of visitors. Second, the occurrence of the "not visible" behaviour category had a different interpretation in the giant pandas. This behaviour occurred during training sessions, when the animals were at the access gates of the indoor areas with their backs to the visitors and facing their trainers. Cooke & Schialli (2007) and Li et al. (2007) found a higher percentage of vigilance in the presence of visitors in primates and in a deer species, respectively, as also observed in the brown bears in this study.

In previous studies of the use of space, certain primate species (Hosey & Druck 1987; Mitchell et al., 1992), prairie dogs (Eltorai & Sussman, 2010) and cockatoos (Keane & Marples, 2004) used front locations more often in the presence of visitors. These results differ from the findings of the current study for both species of bears. However, cheetah showed greater use of the back location, as did the bears in this study (O' Donovan et al., 1993). The proximity of animals to visitors depends on multiple factors, including the animal-human bond, the genetic factors affecting the social characteristics of the species, food conditioning associated with visitors and the daily management of the species.

The principal limitation of the study was that the two observation periods were not of the same duration and did not occur during the same periods of the year. Relatively little literature addresses the ethological characteristics of these animals in captivity or in the wild. In both species, it would have been of great interest to study not only the influence of the visitors on the behaviour but also the physiological effect of the visitors on certain hormones that indicate stress (e.g., cortisol). The latter topic has been examined in previous studies of other mammals by Pifarré et al. (2012) and Rajagopal et al. (2011). According to these studies, the number of visitors influences the adrenal activity of individuals in zoos. This effect could have undesirable consequences for *ex situ* conservation efforts in endangered species.

In conclusion, this study's examination of the indicators of the welfare of the giant panda in the presence of visitors produced the following findings: 1) the activity patterns of the giant pandas were relatively more balanced during the day and were more influenced by the daily management schedule (for example, the presentation of food and the training sessions) than by visitors; 2)

the giant pandas used the available space in the facility in a much more uniform way and therefore appeared better adapted to the improvements made in their conditions of captivity. It would be interesting to identify similar studies of this topic to allow comparisons of our study with previous results.

All of the findings of this study appear to suggest that the behaviour of the brown bears was more susceptible to the presence of visitors than that of the pandas. A possible reason for this difference is that the management of the brown bears was not adequate. Unlike the giant pandas, the brown bears had not been monitored to ensure their welfare. It can be concluded from this study that the following measures are necessary to improve the welfare of the brown bears: 1) a suitable design for the facility, 2) the establishment of a schedule for a social enrichment programme with the aim of facilitating reproduction, 3) an increase in the number of daily feedings and in the difficulty of access to the food, 4) an increase in the frequency of the enrichment sessions from monthly to weekly, and 5) an educational programme affecting the attitude of visitors towards the animals. To improve animal welfare in captivity, it is necessary to satisfy the physical and psychological needs of the animals. This goal is the responsibility not only of the staff directly involved in the management of the animals but also of the department in charge of educating the public, as enrichment programs can result in failure on days when visitor pressure is significant.

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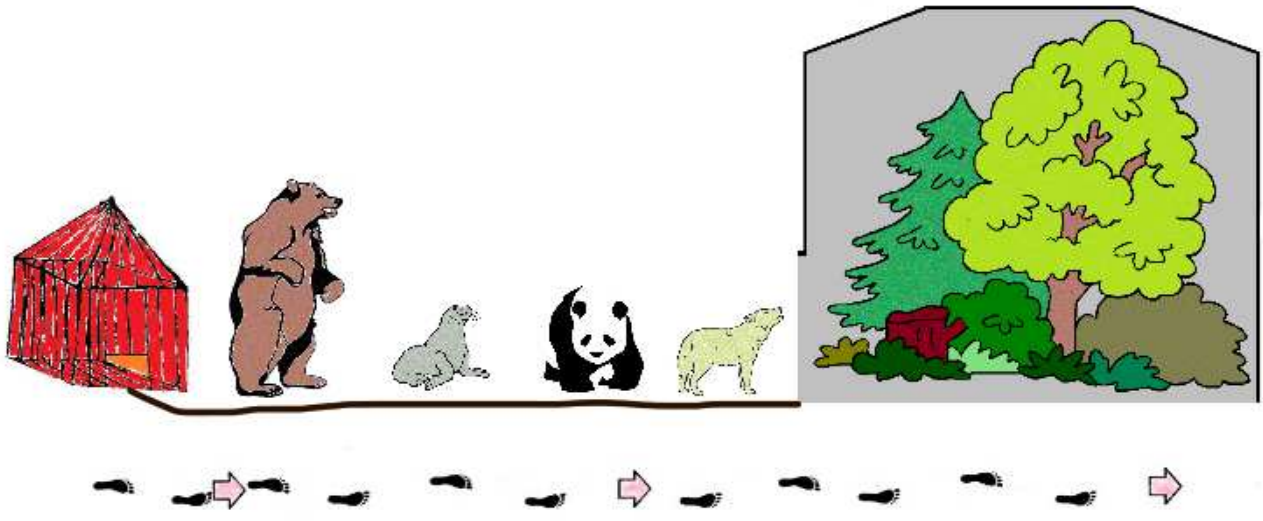
4. CAPÍTULO 2. EFECTIVIDAD DE LOS DISTINTOS PROGRAMAS DE ENRIQUECIMIENTO EN EL OSO PARDO



4.1. SECCIÓN 3. A.I. Soriano, C. Ensenyat, S. Serrat, C. Maté (2006). Introducing a semi-naturalistic exhibit as structural enrichment for two brown bears (*Ursus actos*). Does this ensure their captive well-being? *Journal of Applied Animal Welfare Science* 9(4): 299-314

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Introducing a Semi-Naturalistic Exhibit As Structural Enrichment for Two Brown Bears (*Ursus arctos*). Does This Ensure Their Captive Well-Being?

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In this study we used the daily activity pattern and use of space as indicators of change in the program of structural enrichment, implemented with 2 subjects of the species *Ursus arctos* in the Barcelona Zoo. We collected 930 sampling points in each study phase for each of the individuals: The samples were taken in a balanced way at different times of day. We observed a wider range of behavior in the male than the female. With respect to the indicators, we observed statistically significant differences in behavior in both individuals in the 2 study phases. Both individuals showed an increase in vigilance, maintenance, and inactivity when their enclosure was changed. In terms of the subjects' well-being, we considered the percentage of stereotyped behavior within acceptable limits. The percentage of activity observed in the male was very similar to that of individuals of this species in the wild. In terms of the use of space, we observed homogeneity only in the male during the enrichment program. The 2 individuals responded in different ways to the structural enrichment.

One of the five types of environmental enrichment is *structural enrichment* (Bloomsmith, Brent, & Schapiro, 1991). Consequently, many zoo biologists have begun to collaborate with architects and engineers to design exhibits that enhance the lifestyles of captive, nonhuman animals (Maple & Perkins, 1996). Numerous environmental variables contribute both individually and collectively to the well-being of captive animals. Some of these variables have been classi-

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fied as elements in the physical environment (Maple, 1979). Many of these elements have been used to improve the quality of life of captive bears: changing enclosure size and shape (Van Keulen-Kromhout, 1978; Winhall, 1998), building rest areas (Cowan, 1997; Poulsen & Price, 1997), and introducing some types of manipulable objects made with natural (Acuña, 1993) or artificial material (Cutting, 2002; Ford, 1995; Pfaff, 1999; Willms, 2001). The seminaturalization of exhibits and the increase in space for the bears were chosen to increase behavioral diversity and to provide a more educational and attractive enclosure for visitors (Murray, Waran, & Young, 1998).

The term *postoccupancy evaluation* (POE) is used in architectural language to mean the evaluation of a building once the facility is in use (Zimring & Reizenstein, 1980). POE has been described as a procedure that enables managers to make effective decisions about planning and designing environments (Ross & Lukas, 2003). Maple and Finlay (1987) described it as "the practice of using systematic methods to find out exactly what makes designed environments work well for their users." When a new animal facility is designed, many different users must be involved.

The main users are the animals (Riddle, Keeling, Alford, & Beck, 1982; Ross & Lukas, 2001). However, there are also other types of users (care staff, visitors, and researchers) who must be considered in the design of the environment. Care staff are probably second to the animals in terms of the length of time they spend in building. Zoo visitors expect a pleasant, agreeable, and entertaining experience (Wilson, Kelling, Poline, Bloomsmith, & Maple, 2003). Finally, other users (veterinarians, educators, and support staff) have important design needs for the facility. Ignoring care staff's needs will be detrimental to the animals' well-being (Shettel-Neuber, 1988).

Studies that have examined the effect of increasing the size of the enclosure on behavior (Chang, Forthman, & Maple, 1999; Goerke, Fleming, & Creel, 1987; Line, Markowitz, Morgan, & Strong, 1991; Little & Sommer, 2002; Spendrup & Larsson, 1997b), on the use of space (Kessel & Brent, 1996), or on a combination of both factors (Brent, Lee, & Eichberg, 1991; Hebert & Bard, 2000; Ogden, Finlay, & Maple, 1990; Price, 1992) have mainly focused on the primate order.

No previous studies have examined the effect of an increase in enclosure size on the behavior and use of space in the *Ursidae* family. Articles on this species that discuss entertainment mainly dealt with the effect of food enrichment on the behavior of brown bears (Grandia, Van Dijk, & Koene, 2001; Hare, 1995; Larsson & Tove, 1995; Morimura & Ueno, 1999) and on the relationship between the size of the enclosure and stereotyped behavior in these animals (Spendrup & Larsson, 1997a).

Therefore, this study is the only one on the effect of an increase in enclosure size on the *Ursidae* family. In addition, it is the only one that analyzed both behavior and use of space as indicators of the animal's well-being, using the calculation of an index of spatial homogeneity.

The aim of this study was to analyze the effect of structural enrichment on two captive bears in the Barcelona Zoo in Spain. The daily activity pattern and the use of space were used as indicators of change.

METHOD

The subjects were two bears (*Ursus arctos*) housed at the Barcelona Zoo. Bubu was a 10-year old female (in January 1997), who was captive born and mother reared. Keiko was a 1.5-year-old male (in January 1997), who was wild born and hand reared.

Baseline Phase

Housing and husbandry. During the baseline phase (BL), Bubu was housed with her mother, and Keiko was housed alone in 100-m^2 and 130-m^2 enclosures, respectively (see Figure 1). These animals went out into their exterior enclosures every day, as did the Tibetan bear and the American black bear who occupied the two adjacent bear enclosures. The bears were housed in concrete pits with various uneven exhibits and had a water area for drinking and bathing. Furnishings consisted of several large stones and trees in both exhibits and a large, felled log in Keiko's exhibit. Bubu and Keiko had auditory and olfactory contact with each other because their exhibits were contiguous. Indoor cages were out of view of visitors, as was the drinking trough and concrete substrate (approximately 10 m^2). The

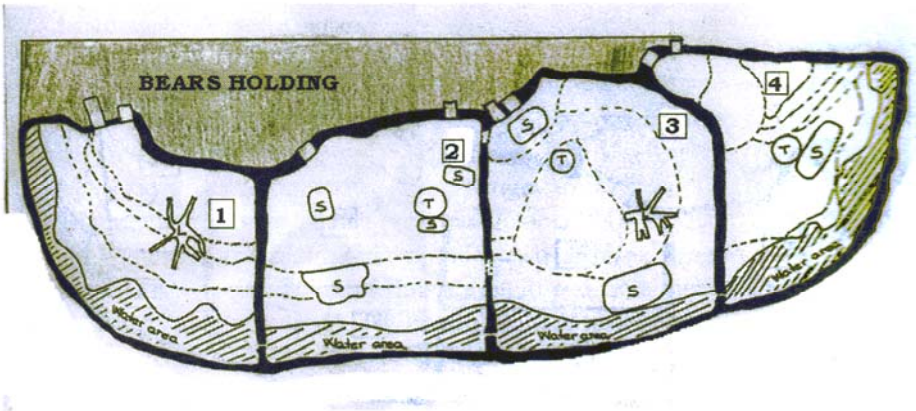

FIGURE 1 A plan of the old bear enclosures. 1 = *Selenarctos thibetanus* enclosure; 2 = *Ursus americanus* enclosure; 3 = *Ursus arctos arctos* enclosure; 4 = *Ursus arctos* enclosure; s = stone; T = tree; L = log; dashed line (- -) = uneven surface.

brown bears were housed individually because there was no interest in reproduction, as Bubu was a hybrid subject. They were on exhibit during daylight hours (9:00 a.m. to 8:00 p.m.). Bubu and Keiko were released into the outdoor enclosure daily. They were fed fruit, vegetables, and meat once a day in the afternoon when they were let into the indoor cages. These animals received a daily session with enriching items in the form of food.

Procedure. César González and collaborators from the ethology group Veterinarian Association for the Attention of Exotic and Wild Animals of the Autonomous University of Barcelona conducted the baseline observations. The bears were observed in the old exhibit in July and August 1997. The observation sessions began at 10:00 a.m. and ended at 8:00 p.m. Data were collected by different observers at different times of day. Observers had previously passed a reliability test, in which a concordance index was calculated (Martin & Bateson, 1986). Focal sampling methods and instantaneous scans were made at 10-min intervals over 22 days for each individual. In total, 75 hr of observation were undertaken for each of the subjects. Sessions were coded according to the time of day: mornings (10:00 a.m. to 1:00 p.m.), afternoons (1:00 p.m. to 4:00 p.m.), and evenings (4:00 p.m. to 8:00 p.m.); the location; and the activity each bear presented.

The study of use of space was carried out according to two different criteria in the division of the enclosure. First, the enclosures were divided into two similar parts in terms of the proximity of animals to the visitors (see Figure 2). Second, the location codes were "right location" when the animals occupied the right half of the enclosure and "left location" when the animals occupied the left half of the enclosure (see Figure 3). The activity categories that were coded are listed in Table 1.

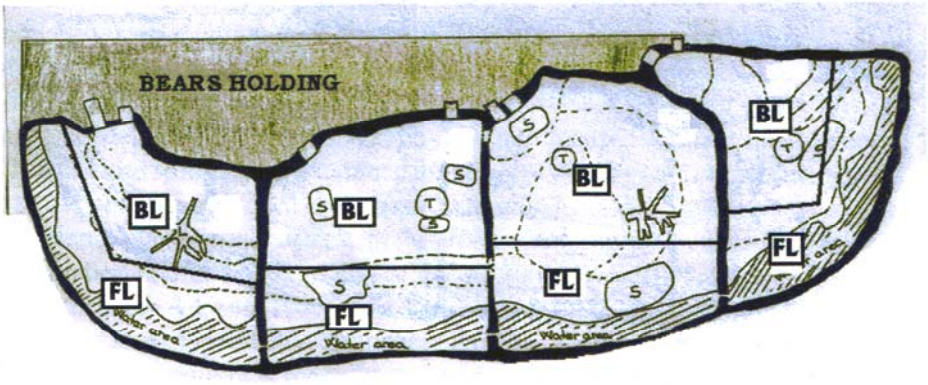

FIGURE 2 A plan of the enclosure showing the division into front and back areas. S = stone; T = tree; L = log; BL = back location; FL = front location; dashed line (- -) = uneven surface.

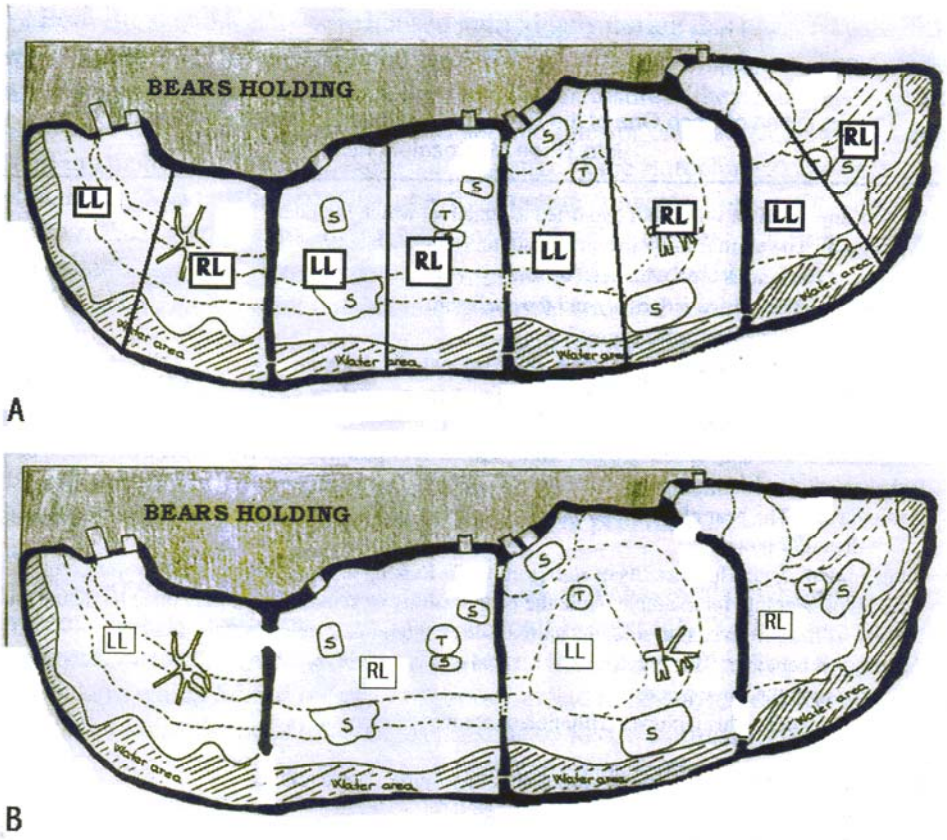

FIGURE 3 A plan of the brown bear enclosure showing the division into left and right areas. A = old exhibit; B = new exhibit; S = stone; L = log; T = tree; LL = left location; RL = right location; dashed line (- -) = uneven surface.

Postoccupancy Evaluation Phase

Housing and husbandry. The changes to the brown bears' enclosures in the Barcelona Zoo were carried out from October 2000 to March 2001. Each of the two new enclosures was formed by joining two of the existing four enclosures (see Figure 4). Therefore, the size of Keiko's enclosure increased by 150m^2; the size of Bubu's enclosure increased by 230m^2. In addition to doubling the surface available for the animals, different areas were made to increase the number of different surfaces. In addition to the cement floor, the new enclosure had areas with beach sand, gravel, and pine bark. New stones and logs were introduced as additional furnishings. The pump system was improved to prevent water from becoming stagnant, as it had been in the BL phase. For the animals' well-being, permanent enriching items were added, such as a honey dispenser and some fixed PVC tubes.

TABLE 1
The Definition of Each One of the Behavioral Categories and Their Classification Into Three Macrocategories

Activity is any behavior that is not classified as inactive, which includes:
Exploration: The animal sniffs the air, substrate, food or objects
Vigilance: The bear is alert with head up and eyes open
Locomotion: The animal moves around the enclosure
Scent marking: The bear rubs against logs
Feeding: The bear consumes food items, this also includes drinking
Solitary play: This mainly involves individual movement, such as vigorous, rigorous, exaggerated-like jumping
Maintenance: The animal self-grooms with mouth and/or paws, scratches, urinates, defecates, or shakes
Manipulation: The bear claws at, swipes at, nibbles at, picks up food, and nonfood items with mouth and/or paws
Human interaction: The bear sits or stands up while looking at humans; this includes different forms of begging, for example while the bear is sitting or standing up it may open its mouth and wave its head from side to side; the animal tries to communicate with the humans
Stereotyped behavior: This behavior has no goal and is repetitive, lasting for a constant time and occurring in the same places
Social interaction: This includes affiliation or agonistic behavior
Inactivity
Stationary: The bear rests lying or sitting with their musculature relaxed
Not Visible
Not visible: The bear or its behavior is not visible

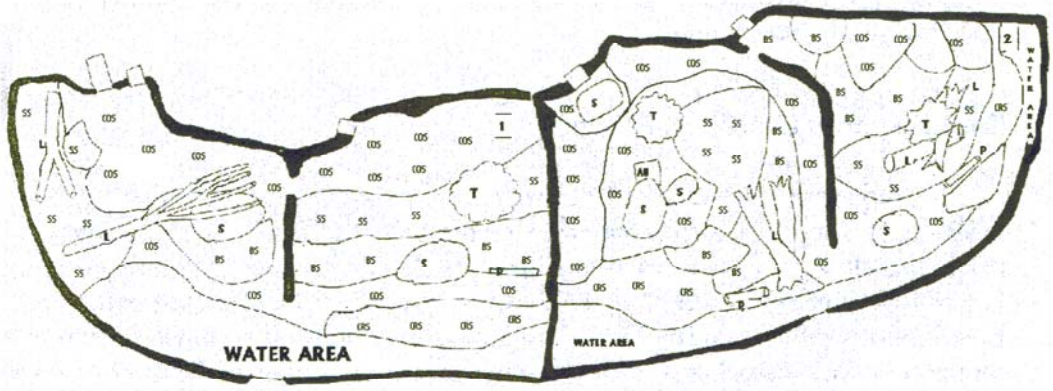

FIGURE 4 A plan of the new bear enclosures. 1 = Keiko's enclosure; 2 = Bubu's enclosure; S = stones; T = tree; L = logs; BS = bark substrates; CRS = crushed stone substrates; SS = sand substrates; COS = concrete substrates; AU = honey dispenser; P = PVC tube.

Both Bubu and Keiko were housed individually during this phase. Again there was no interest in reproduction because Bubu was a hybrid subject. The times at which the bears entered and left the exterior enclosures (they remained outside from 9:00 a.m. to 8:00 p.m.), the diet, and the interior enclosures were kept constant in all phases. However, there was a change in the Barcelona Zoo's collection plan. It was decided that, because of infrastructure considerations, only the species *Ursus arctos* would be maintained. Therefore, the Tibetan bear was removed from the collection, and a young female brown bear was introduced.

As a result, Keiko went into her exterior enclosure on Tuesdays, Thursdays, and Saturdays. On the other days, the young female brown bear went into the exterior enclosure. However, this female was not included in the study because there were no BL data available for her. Bubu also went into the exterior enclose on alternate days. He used the enclosure on Mondays, Wednesdays, Fridays, and Sundays. On the other days, the enclosure was used by the male American black bear. In this case, the animals did not undergo any enrichment program.

Procedure. Ana I. Soriano conducted all the behavioral observations in this present phase. Observations were made during June and July 2001. In this case, the observation sessions were 1 hr long and were carried out according to a monthly schedule in which 5 hr of monthly observation had to be carried out for each individual and for each one of the established time bands (mornings, 10:00 a.m. to 1:00 p.m.; afternoons, 1:00 p.m. to 4:00 p.m.; and evenings, 4:00 p.m. to 8:00 p.m.). Focal sampling methods and instantaneous scans were made at 2-min intervals over 15 sessions of 1 hr each for each individual. A total of 30 hr of observation was undertaken for each one of the individuals in the 2 months of the study while the animals were in the exterior enclosures (9:00 a.m. to 8:00 p.m.). Sessions were coded according to the same variables described in the BL phase.

The method of recording and sampling varied in the two study phases because the established objectives were initially different. However, it was decided that the data could be used to assess structural enrichment.

To compare the two study phases, the BL recording points were matched with those of the POE phase for each of the established time bands. In total, 930 recording points were obtained in each one of the phases and for each individual in the study.

Data Analysis

Using contingency tables, we analyzed the categorical data for behavior and use of space obtained in this study. These tables enabled us to determine whether there were statistically significant differences in the two study phases for the two dependent variables, by means of Pearson's chi-square calculation. This test sta-

tistic was used to determine in exactly which categories (behavior or location) the statistically significant differences could be found. This statistic has an absolute value of 2.96 for a normal distribution, assuming that the significance level is .05 (Haberman, 1978).

To analyze the effect of the enrichment program on a more homogeneous use of the space, a spread-of-participation index was used. A value of 1 indicated minimum use of the facility; a value of 0 indicated that the use of the space was totally homogeneous (Dickens, 1955; Shepherdson, Carlstead, Mellen, & Seindensticker, 1993).

RESULTS

Activity Differences Between BL and POE phases

Statistically significant differences in the two phases of the study for the two individuals are shown in Table 2. The detailed behavioral categories in which there were statistically significant differences (their values were either above or below the test statistic) are shown in Figure 5. Bubu spent more time engaging in the following behaviors: not visible, vigilance, locomotion, maintenance, manipulation, and inactivity; and spent less time engaging in explore, feeding, and social interaction in the POE observations than in the BL observations. Keiko spent significantly more time engaging in vigilance, maintenance, and inactivity and less time engaging in the following behaviors: not visible, explore, locomotion, feeding, solitary play, manipulation, and human interaction in the POE phase than in the BL phase (see Figure 6).

Location Differences Between the BL and POE Phases

Table 3 shows where there were statistically significant differences in the two study phases, the two area division systems, and the two individuals in this study.

TABLE 2
The Value of Pearson's Chi-Square, the Degrees of Freedom and the Significance Level for the Daily Activity Pattern of the Two Brown Bears

Statistic	*Bubu*	*Keiko*
Pearson chi-square	443.306	297.219
df	9	10
p	0*	0*

*Statistically significant difference.

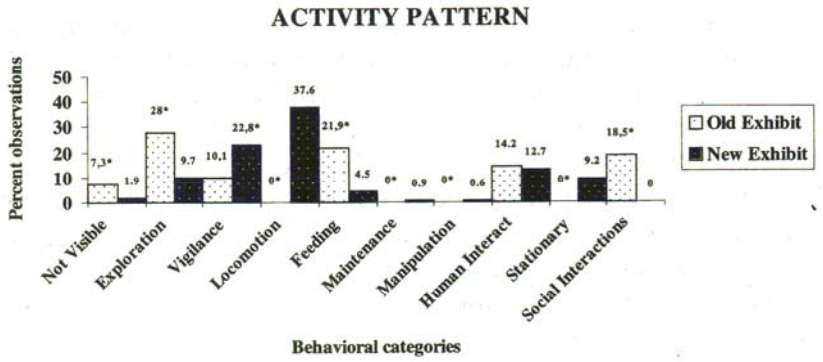

FIGURE 5 Bubu's percentage of activity observations in the two study phases.

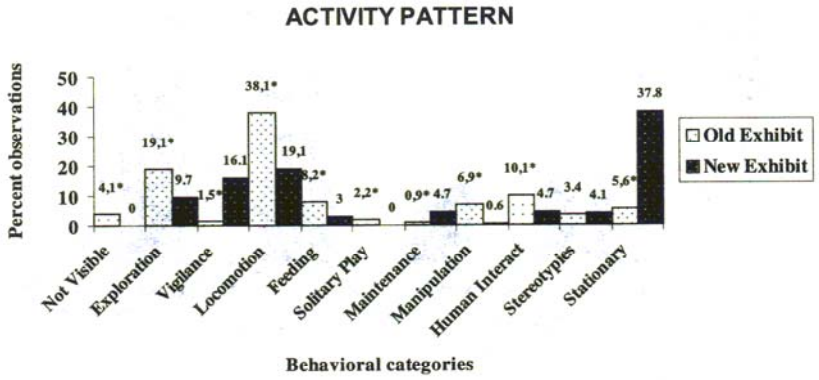

FIGURE 6 Keiko's percentage of activity observations in the two study phases.

TABLE 3
The Value of Pearson's Chi-Square, the Degrees of Freedom and the Significance Level for the Two Brown Bears' Use of Space

	Bubu		*Keiko*	
Statistic	*Front–Back Location*	*Right–Left Location*	*Front–Back Location*	*Right–Left Location*
Pearson chi-square	0.581	29.301	54.368	41.521
df	1	1	1	1
p	.446	0*	0*	0*

*Statistically significant difference.

Bubu's use of the front and back location did not differ significantly in the two phases (see Figure 7). However, her use of the right and left location differed significantly (see Figure 8). Keiko's front and back location differed significantly in the new enclosure (see Figure 7), although he spent significantly more time in the right location during the POE phase (see Figure 8).

The values of the spread-of-participation index for the two classifications of use of space and for the two subjects studied are shown in Table 4. There were no differences in terms of the homogeneity of Bubu's use of the front–back locations. However, homogeneity in the use of the right–left spaces was lost with enrichment. In the case of Keiko, an increase in homogeneity was seen only in the right–left locations.

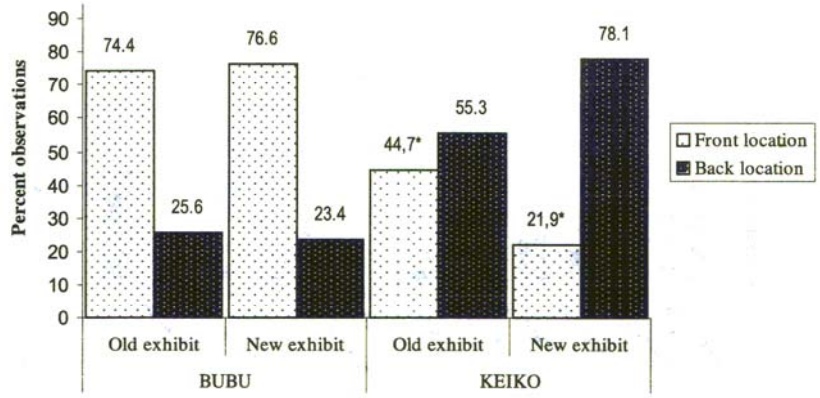

FIGURE 7 Bubu and Keiko's use of the front and back locations in the two study phases.

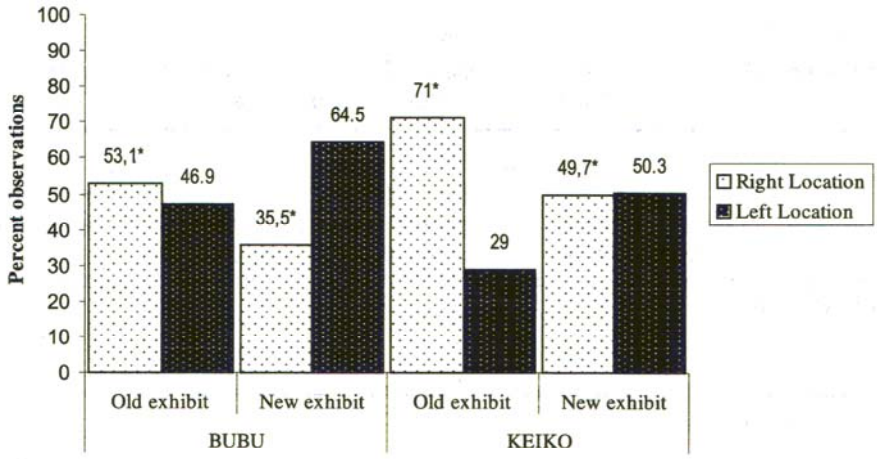

FIGURE 8 Use of right and left location by Bubu and Keiko in old and new exhibit.

TABLE 4
SPI Values for the Two Subjects and for the Two Classifications of Space

	Bubu		*Keiko*	
Location	*BL*	*POE*	*BL*	*POE*
Front–back	0.48	0.53	0.10	0.560
Right–left	0.06	0.29	0.35	0.006

Note. BL = baseline; POE = postoccupancy evaluation.

DISCUSSION

More behavioral categories (solitary play and stereotyped behavior) were observed in the male brown bear than in the female. This may have been due to several factors, such as sex, age of the individuals, and the type of birth (in the wild or in captivity).

Despite the time elapsed between the BL and POE evaluation periods and the death of Bubu's mother, the results show that brown bears spent more time engaged in vigilance, maintenance, and inactivity. The objective of structural enrichment was to attain increases in exploration, manipulation, maintenance, and solitary play.

Increases in exploration and manipulation were due to increased enclosure size and the introduction of new furniture and different substrates. An increase in the manipulation behavioral category was observed only for Bubu. The explore category was not increased with the new enclosure design.

Maintenance is an indicator of well-being because it contributes to controlling physiological functions. This indicator increased in the POE phase for the two subjects.

Solitary play contributes to the development of motor capabilities. The appearance of solitary play could be due to the youth of the male and the link between play and learning (Bekoff & Byers, 1998; Fagen, 1981). This behavior was observed in Keiko only during the BL phase.

The objective of physical enrichment was to attain decreased the following: not-visible behavior, stereotyped behavior, and human interaction.

Not-visible behavior is an indicator of an animal's adaptation to environmental factors such as architectural design and visitors' influence. Keiko's not-visible category was not observed during the POE evaluation because the new exhibit had no places in which Keiko could be out of sight. This was not the case for Bubu.

Stereotyped behavior is an indicator of well-being. Its presence indicates that the physical and physiological necessities of the animals are not fulfilled (Mason, 1991). It is the only behavior that did not change when Keiko's environment was

enriched. It was not observed in Bubu's behavioral repertoire. Shepherdson (1989) stated that more than 10% of stereotyped behavior is not acceptable. In this study, stereotyped behavior was observed only in the male, and the level was within acceptable values.

Human interaction is not desirable because it contributes to unbalancing the animal diet and is not part of the typical behavioral repertoire for this species. It is the only behavior that did not change after Bubu's environment was enriched. This behavior pattern decreased after Keiko's physical enrichment.

The seminaturalization of the exhibit was not enough to provide for both brown bears' well-being. Bubu's levels of inactivity increased only slightly (9.2%). This value was still far from wild brown bears' values. Keiko's well-being increased with the seminaturalistic exhibit because he was less active (42.2%) in the POE than in the BL phase (94.4%). Wild European brown bears have active behavior around 45% to 60% of the time in the summer period (Roth, 1983; Roth & Huber, 1986). Therefore, the physical enrichment program brought the male, captive brown bear's pattern of activity–inactivity closer to patterns of subjects in the wild.

Spendrup and Larsson's (1997a) studies of brown bears and Ames's (1999) studies of polar bears showed the importance of the size of the enclosure to these species. Both studies concluded that habitat size is linked to stereotyped behavior. The increase in the size of the enclosure in the Barcelona Zoo was not sufficient because the male continued to present stereotyped behavior. Therefore, as Spendrup and Larsson (1997a) indicated, other kinds of enrichment programs need to be implemented (food, sensory, and occupational) to improve the well-being of these animals.

Studies of structural enrichment in primates (Brent et al., 1991; Chang et al., 1999; Little & Sommer, 2002; Price, 1992) and its influence on behavior generally revealed a decrease in inactivity and an increase in feeding. In contrast, the exact opposite occurred with the Barcelona Zoo brown bears. Inactivity values were very low during the BL phase. These values increased in the POE phase. Feeding decreased in the POE phase, because the animals were submitted to a program of food enrichment during the BL phase.

The use of space during the two study phases was different for each individual, except in the case of Bubu's front and back locations during enrichment sessions. Keiko increased the use of the back area of her enclosure during the POE phase. There could be several reasons for this:

1. This location is at the greatest distance from the public.
2. It is close to the interior enclosure where the carers are and where there is more food.
3. It is the highest place in the enclosure, where the animal has the best view of the macroenvironment in which she lives.

A more homogeneous use of the space was observed only in the macho for the right–left location during the POE phase. This shows that increasing the size of the Barcelona Zoo's brown bear enclosure led to a decrease in spatial homogeneity, indicating that the bears have preferential areas within their habitat.

Renner and Lussier's (2002) study of the species *Tremarctos ornatus* indicated that structural enrichment increased the diversity of behavior and the use of space in this bear species. However, in our study the structural enrichment program caused an increase in behavioral diversity only in the female. In addition, spatial homogeneity was achieved only for the male in one of the uses of space divisions. This demonstrates that there is a different individual response to environmental enrichment programs, probably due to the sex, age, origin, and rearing conditions of subjects (Hare et al., 2003).

Readers should take into account that the brown bears' old and new exhibits are pits. This type of design influences the bears' well-being because their position is always subordinate to the visitors' position (Coe, 1985). Mammal exhibits must never be designed as pits because captive brown bears dislike a terraced and uneven floor enclosure. In their natural habitat of forests and mountains—where the view is blocked by many obstacles—this would tend to encourage the use of hearing and scent rather than sight (Van Keulen-Kromhout, 1978).

Having a seminaturalized exhibit with increased space is not enough to make a real improvement in captive brown bears' well-being (Beattie, Walke, & Sheddon, 1996). In addition, these two bears were in indoor cages several days a week. Therefore, the results demonstrate that they could not satisfy their daily needs. This type of management decreases the positive effects of structural enrichment. Achieving captive animal well-being is a combination of correct architectural exhibit design and correct daily management (Shettel-Neuber, 1988).

A limitation of this study that could have influenced the results was an excessive delay between the BL and POE phases. In addition, the objectives of the study were different in each of the two phases, so the recording and sampling methods were different. Moreover, the female was initially housed with her mother and subsequently was housed alone.

Future studies on this type of species in captivity should be aimed at improving the animals' well-being through introducing a daily routine that brings the behavioral indicators as close as possible to those of the same species in the wild. Thus, the objective is to boost the typical behavior of the species and to design a diet as similar as possible to the seasonal nature of the same species in a natural habitat.

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4.2. SECCIÓN 4. A.I. Soriano, D. Vinyoles, C. Maté (2012). Four models to assess the effectiveness of environmental enrichment: the brown bear (*Ursus arctos*) as a case study. *Zoo Biology*, submitted.

RESEARCH ARTICLE

Four Models to Assess the Effectiveness of Environmental Enrichment: the Brown Bear (*Ursus arctos*) as a Case Study

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Environmental enrichment programs seek to improve the well-being of animals in captivity, to promote species-typical behavior, and to decrease abnormal behaviors through changes in enclosure design or daily management. We designed, implemented, evaluated, and compared the effectiveness of different enrichment programs. The subjects studied included 1 male and 2 female brown bears (*Ursus arctos*) housed at Barcelona Zoo. The efficacies of 6 types of enrichment devices, including 4 feeding (sack of fruit, juicesicle, fishsicle, and live grasshoppers), 1 sensorial (deer feces), and 1 occupational device (ball), were evaluated over 9 enrichment sessions. We evaluated device enrichment using 2 criteria: the time invested on the animal-device interaction in enrichment sessions; and the device variation over time, which was analyzed through fluctuation, continuity, habituation, and device efficacy models. The new fluctuation model was observed for interactions with the juicesicle and deer feces (for the young female bear) and with the fishsicle (for the young female and male bears). The devices that were most used (sack of fruit) and less used (live grasshoppers) by the bears followed a continuity model, with important differences in the time that animals invested on interactions between these 2 devices. Other devices (juicesicle and ball) showed decreased enrichment efficacy with an increasing number of enrichment sessions and adjusted to a habituation model. None of the devices in this study showed the increased device efficacy model.

Keywords: animal-device interaction, fluctuation, continuity, habituation, increased device efficacy model

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INTRODUCTION

Environmental enrichment programs seek to improve animal well-being through the preservation of species-typical behaviors, development of conservation programs, and improvement of zoo visits by patrons in terms of education and enjoyment [Shepherdson, 2001]. In the 25 last years, enrichment techniques have been widely applied in many zoos for various animal species [Young, 2003], especially ursids [Law and Reid, 2010]. There are 6 types of environmental enrichment programs, many of which have been applied to ursids in captivity. These programs are classified as social (i.e., involving changes in animal group composition) [Winhall, 1997], structural (i.e., involving changes in enclosures or furniture) [Spendrup and Larsson, 1997; Soriano et al., 2006], feeding (i.e., involving changes in animal diet) [Hare, 1995; Larsson and Tove, 1995], sensorial (i.e., involving sensory stimulation), occupational (i.e., involving physical or psychological stimulation) [Altman, 1999], and training enrichment programs (i.e., involving zoo personnel interaction with educational or veterinary aims) [Bloomsmith et al., 2003; Rotherham, 2006].

The purpose of environmental enrichment evaluations is to determine whether an enrichment program or device improves the physical and psychological state of animals [Mellen and Sevenich, 1997; Morrow-Tesch, 1997; Oliva-Purdy, 1997; Morgan et al., 1998; Hawkins, 1999; 2006; 2009; Roberts, 2005]. Enrichment program evaluations may be divided into 2 types. The first group evaluates environmental enrichment in terms of daily activity patterns, abnormal behaviors, social interactions, and use of space. The second group classifies enrichment devices using various analytical parameters (latency, intensity, and duration, among others). Loss of device efficacy occurs due to learning through animal habituation [Platt and Novak, 1997; Plowman and Knowles, 2001; Kuczaj et al., 2002]. In other words, the animals lose interest in the device due to prolonged and repeated device exposure [Domjan, 2005].

Plowman and Knowles [2001] established a feeding, occupational, and sensorial enrichment program in 2 individuals of Sumatran tiger and observed a decrease in abnormal behavior on the first but not the second day. The objective of 2 studies about feeding enrichment programs in Asian small-clawed otters was to promote hunting behavior with live prey [Foster-Turley and Markowitz, 1982]. These studies found a decrease in abnormal behavior [Ross, 2002]. With regard to environmental enrichment of the Ursidae family, use of a feeding, sensorial, and occupational environmental enrichment program resulted in decreased stereotypical behavior and increased vigilance among giant pandas (*Ailuropoda melanoleuca*) [Tepper et al., 1999]. The percentage of activity observed in the male brown bear (*Ursus arctos*) was very similar to that of individuals of this species in the wild, and their use of space was more homogeneous after a structural enrichment program [Soriano et al., 2006]. Loss of interest in animal feeding devices has been reported in sloth (*Melursus ursinus*), American black (*U. americanus*), and brown bears (*U. ursinus*) over 6 sessions [Carlstead et al., 1991] and in sloth bears (*M. ursinus*) over 5 sessions [Anderson et al., 2010].

According to enrichment evaluations, enrichment devices may not always be effective [Rosier and Langkilde, 2011] or may be dangerous to animals due to the materials used for device construction

[Hare et al., 2007]. In other cases, the results obtained when environmental enrichment programs are used may not address the initially established objectives. For example, research in rhesus macaques showed that toy manipulation decreased with repeated toy presentation [Crockett, 1998]. Other studies found no decrease in abnormal behaviors, despite an increase in enclosure size [Line et al., 1991] or use of occupational and feeding enrichment [Line and Morgan, 1991]. Hawkins [1997] and Hogan et al. [2010], who studied different marsupial species with a feeding and occupational enrichment program, did not observe a decrease in stereotypical behavior or an increase in the activity or visibility of animals.

The aim of the present work was to determine the efficacy of different types of enrichment devices (feeding, occupational, and sensorial) in 3 brown bears (2 females and 1 male) housed at Barcelona Zoo. To achieve this goal, we monitored the time invested on the animal-device interaction during the enrichment sessions, and also analyzed the efficacy of the enrichment devices over time with 4 different models (fluctuation, continuity, habituation, and increase of device efficacy).

MATERIALS AND METHODS

Animals and housing conditions

The subjects included in this study were 3 brown bears (1 male, 1 old female, and 1 young female) housed at the Barcelona Zoo (Table 1).

TABLE 1. Demographic data for brown bears in the study at the Barcelona Zoo

Name	Sex	Birth date	Born	Rearing condition	Arrival date at zoo
Bubu	Female	January 1987	In captivity	Mother	Since birth
Keiko	Male	June 1995	In the wild	Hand	December 18, 1999
Miskha	Female	May 2000	In the wild	Mother	December 28, 2000

During the observations, the brown bears were housed singly in 2 semi-naturalistic, original concrete, and pit enclosures (Fig. 1). Each enclosure had a partition wall in the middle, with an opening for access between the 2 halves of each enclosure. The areas of the 2 yards were 150 and 230 m^2, respectively (Fig. 1). Each yard contained a water area for drinking and bathing. Furnishings consisted of trees, bushes, several large stones, large felled logs, and various elevated terraces at different heights with natural substrates of crushed stone, sand, and bark. Indoor cages, which were out of the view of visitors, were made of concrete substrate, with a drinking trough and bath (approximately 10 m^2 each) [see Soriano et al., 2006 for more details].

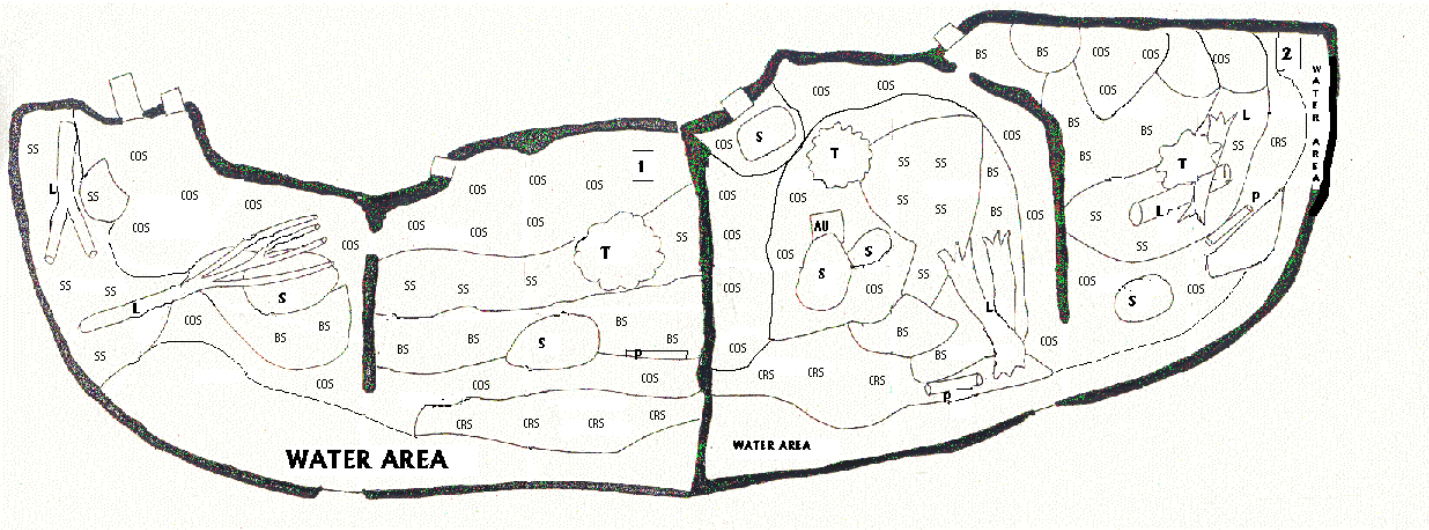

Fig. 1. Plan of enclosures for the young female (1) and the old female and male (2) brown bears. S = Stones, T = Tree, L = Logs; BS = Bark substrates; CRS = Crushed stone substrates; SS = Sand substrates; COS = Concrete substrates; AU = Honey dispenser; P = PVC tube.

The animals considered in the study were individually housed because as a species they are solitary and only interact during reproduction periods [Stirling, 1993]. The hours during which the bears were allowed into their outdoor facilities varied with the time of year (between 09:00 and 17:00 from December through February, between 09:00 and 18:00 in March, October and November, and between 09:00 and 19:30 from April through August). Enclosure 1 was used for the young female that went out on all of the days. Enclosure 2 was used for the male and the old female that went into the outdoor enclosure on alternate days of the week (Tuesdays, Thursdays, and Saturdays for the male; Mondays, Wednesdays, Fridays, and Sundays for the old female). The diet of the animals consisted of fruit, vegetables, and meat once a day when they came into their indoor facilities in the evening.

Environmental enrichment

From December 2001 through November 2003, the animals participated in a daily feeding, occupational, or sensorial enrichment program. The enrichment was classified by the objective: feeding enrichment applied to elements containing food; sensorial enrichment was imparted in the form of feces; and occupational enrichment was achieved with objects, such as balls. Different areas of the enclosure were randomly chosen in which to hide the devices. The enrichment session was begun by the keeper around 1 pm. The caretaker threw the item into the same zone as the visitors. The schedule of different kinds of devices for the sessions consisted of 31 elements, one for each day of the month, following the same pattern during all months of the study.

Four feeding-type devices were evaluated: “sack of fruit,” a burlap sack containing 1 kg of fruit tied with cord of esparto grass; “juicesicle,” a brick of frozen fruit juice; “live grasshoppers,” 15 live

grasshoppers; and "fishsicle," a 5-liter basket with 3 liters of water and 2 herrings or sardines congealed. One sensorial device was evaluated: "deer feces," 5 scattered handfuls of red deer feces. One occupational device was tested: "Boomer® ball," a ball. These devices were applied consecutively from days 1 to 6 for each month as follows: sack of fruit, juicesicle, live grasshoppers, fishsicle, deer feces, and ball.

Behavioral recording

Data sampling involved the continuous recording of animal-device interaction behavior by the 3 subjects according to Martin and Bateson [2007]. The observations included nine 1-hour sessions for the first 6 devices (1st to 6th day). A total of 99 hours were recorded, distributed as follows: 9 h (one item), 36 h (four items), and 54 h (six items) for the male, old female, and young female, respectively. The data collected for each subject and observational sessions were: enrichment type (sensorial, feeding, and occupational), enrichment device (sack of fruit, juicesicle, live grasshoppers, fishsicle, deer feces, and ball), and duration (in seconds) of the subject interacting with the device. The male was observed with the fishsicle. The old female was observed with the sack of fruit, juicesicle, live grasshoppers, and ball. The young female was observed with the sack of fruit, juicesicle, live grasshoppers, fishsicle, deer feces, and ball. Due to the study design, only the devices with the most number of sessions were studied. Holidays, weekends, and the deaths of the male and old female bears prohibited the study of more devices and sessions.

Enrichment models

To evaluate the different enrichment devices over 9 consecutive sessions, 2 factors were studied: the duration of the animal-device interaction in each enrichment session (designated the *animal-device interaction time*) and the enrichment device efficacy. Four models of enrichment device efficacy were used. The *fluctuation efficacy* (*fluctuation*) *model* states that a significant relation does not exist between the session order and the animal-device interaction time, which shows pronounced fluctuations over session order (high-range variation). The *continuous efficacy* (*continuity*) *model* states that a significant relation does not exist between the session order and the animal-device interaction time, which is more or less constant over time (low-range variation). The *loss of efficacy model* (*habituation*) *model* states that the animal-device interaction time decreases with increasing session order. In other words, session order is inversely correlated with the animal-device interaction time. The *increase of efficacy model* states that the animal-device interaction time increases significantly with session order. In other words, session order is directly correlated with the animal-device interaction time.

To differentiate between the fluctuation and continuity models, the coefficient of variation (CV, %) was used. This term is defined as: $CV = \sigma/X (\times 100)$, where σ is the standard deviation and X is the mean of the animal-device interaction time (in seconds) over the 9 enrichment sessions. A device showed a fluctuation model when CV was ≥75% and a continuity model when CV was <75%. All of the models

reflected the efficacy with respect to the time invested in the animal-device interaction (total duration [s] and %) during enrichment sessions.

Statistical analysis

All data analyses were performed with SPSS 15.0. A rejection criteria of $P = 0.05$ was applied to all tests. Lilliefor's test was used to verify the normal distribution of the results of each variable. Pearson's correlation was used to determine the relation between the (log) animal-device interaction time and the (log) session order over the 9 enrichment sessions for each animal.

RESULTS

Animal-device interaction times per session

Table 2 summarizes the results of the animal-device interaction times for the 3 animals for all devices. The sack of fruit had the greatest mean interaction time per session in both females. Bears showed the least interaction time with the ball, live grasshoppers, and deer feces. Overall, the greatest interaction time of animals was seen with the feeding devices (97.6% of total time in animal-device interactions), followed by the occupational (2.1%) and sensorial (0.3%) enrichment programs.

TABLE 2. Total time (s) invested on animal-device interactions, mean duration ± SD (s), and coefficient of variation (CV, %) for the 9 enrichment sessions applied for the 3 brown bears of this study

	Enrichment item	Total duration (s)	Mean duration ± SD (s)	CV (%)
OLD FEMALE	Sack of fruit	12131	1347.89 ± 684.921	50.81
	Juicesicle	5050	561.11 ± 570.5	101.7
	Ball	1099	122.11 ± 147.062	120.43
	Live grasshoppers	2027	225.22 ± 150.99	67.04
YOUNG FEMALE	Sack of fruit	7596	844.00 ± 563.955	66.81
	Juicesicle	5003	555.89 ± 512.136	92.13
	Ball	4504	500.44 ± 935.711	186.97
	Live grasshoppers	2664	296.00 ± 203.931	68.90
	Fishsicle	8467	870.80 ± 702.963	80.73
	Deer feces	781	86.78 ± 119.292	137.46
MALE	Fishsicle	1852	205.78 ± 179.904	87.42

In the case of the old female, the sack of fruit was the most entertained device (59.7% of total time), followed by the juicesicle (24.9%), live grasshoppers (10%), and ball (5.4%). Feeding devices (94.6%) occupied more time than occupational devices (5.4%). In the case of the young female, the maximum interaction time was observed with the fishsicle (29.2% of time), followed by the sack of fruit

(26.2%), juicesicle (15%), ball (15%), live grasshoppers (9.2%), and deer feces (2.7%). Feeding devices (81.8%) occupied more time than occupational (15.5%) or sensorial devices (2.7%).

Figures 2-4 show the results for the interactions times of each animal with the different devices in each enrichment session. The old female showed the longest and shortest interaction times with the juicesicle in the first session (1984 s) and fourth sessions (0 s), respectively, and with the ball in the first session (473 s) and sixth session (0 s), respectively (Fig. 4). The young female showed the longest and shortest interaction times with the fishsicle in the first session (2054 s) and fourth session (27 s), respectively; with the juicesicle in the seventh session (1829 s) and first session (156 s), respectively (Fig. 2); and with the ball in the first session (2873 s) and fifth session (12 s), respectively (Fig. 4).

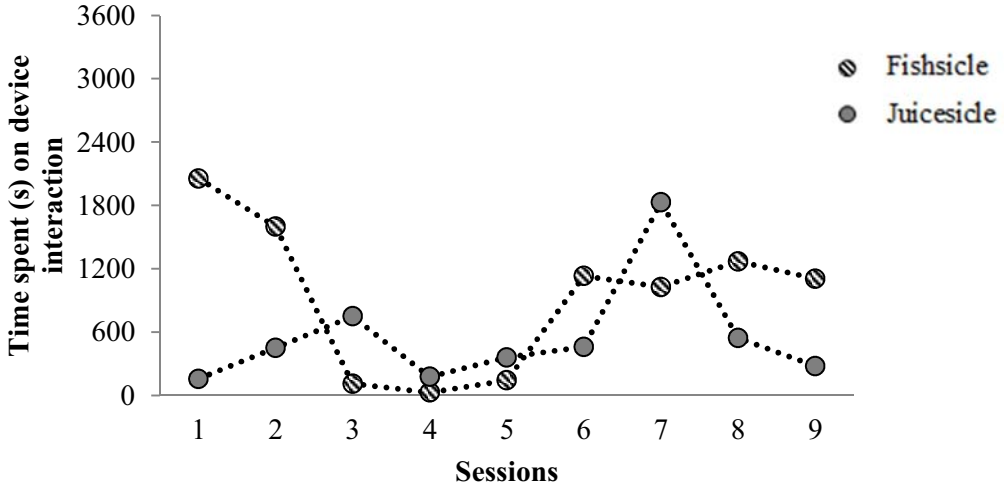

Fig. 2. Time spent on device interaction over 9 enrichment sessions with the fluctuation model (solid line: male; dashed line: young female).

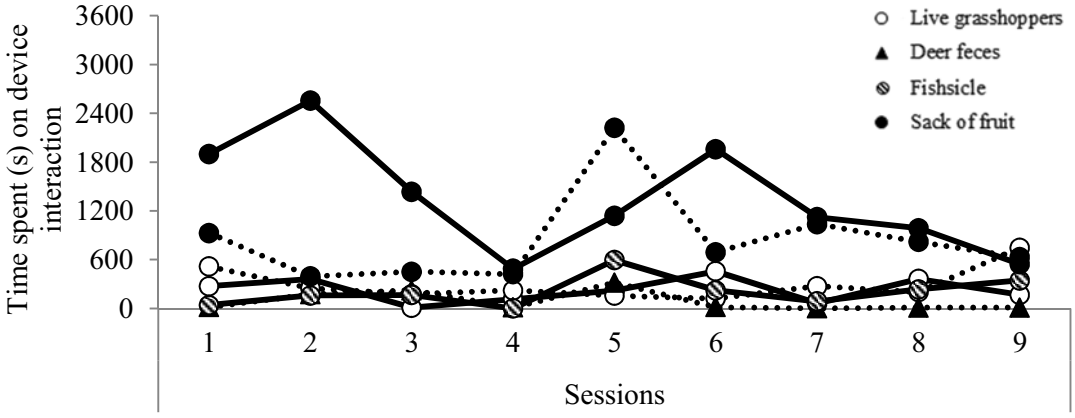

Fig. 3. Time spent on device interaction over 9 enrichment sessions with the continuity model (solid line: old female; dashed line: young female).

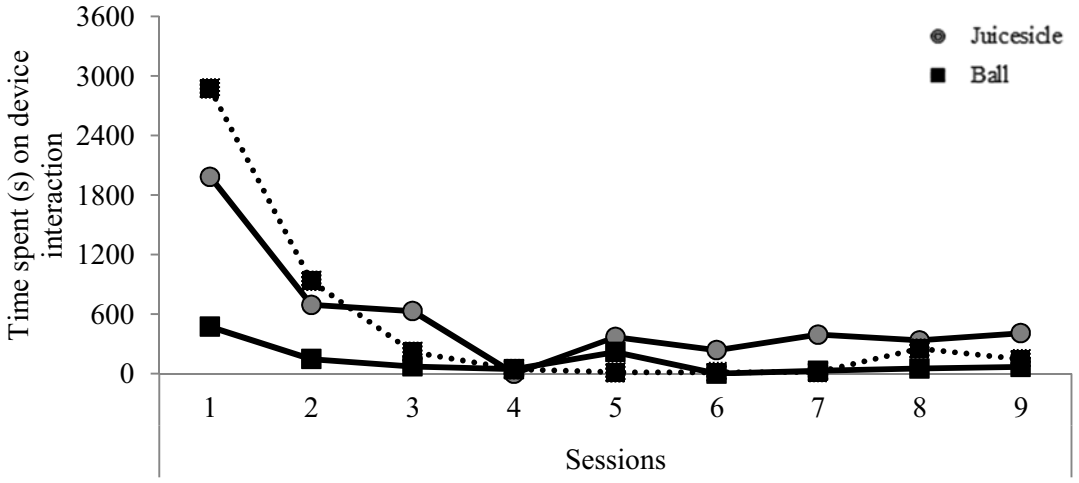

Fig. 4. Time spent on device interaction over 9 enrichment sessions with the habituation model (solid line: old female; dashed line: young female).

Enrichment device efficacy

The efficacy of the enrichment devices was evaluated according to fluctuation, continuity, habituation, and increase of device efficacy models (Figs. 2-4). None of enrichment devices evaluated in this study showed an increase of device efficacy model; in other words, no device showed progressively increased use over the 9 sessions of enrichment.

The fishsicle (for the male and young female) and the juicesicle and deer feces (for the young female) showed a fluctuation model (Fig. 2). The fluctuation model was characterized by marked oscillations in use over time and the lack of a significant correlation between the (log) animal-device interaction time (seconds) and the (log) session order (in all cases, $P > 0.05$). Some devices showed higher interaction times (fishsicle and juicesicle in the young female) and others showed lower interaction times (fishsicle in male and deer feces in young female) (Table 2, Fig. 2).

The sack of fruit and live grasshoppers for both females showed a continuity model (Fig. 3). The continuity model was characterized by more or less constant and sustained use over time and the lack of a significant correlation between the (log) animal-device interaction time (seconds) and the (log) session order (in all cases, $P > 0.05$). Some devices showed higher interaction times (sack of fruit) and others showed lower interaction times (live grasshoppers) (Table 2, Fig. 3).

The juicesicle for the old female only and the ball for both females showed a loss of efficacy model over enrichment sessions (Fig. 4). The loss of efficacy model was characterized by a significant negative relation between the (log) duration of the animal-device interaction (seconds) and the (log) session order (old female with juicesicle: r_p= -0.899; P = 0.034; old female with ball: r_p = -0.745, P = 0.002; young female with ball: r_p = -0.700, P = 0.036). In these cases, the animals showed a gradual loss of interest toward device enrichment.

DISCUSSION

Studies comparing the efficacy of feeding and sensorial enrichment devices in Goeldi's monkeys [Gibbs, 2003] and Sumatran tigers [Plowman and Knowles, 2001] have indicated that sensorial enrichment has less of an effect on animals than feeding enrichment. This observation is consistent with our results obtained in the young female brown bear. Studies evaluating differences between feeding and occupational enrichment devices in chimpanzees [Brent and Eichberg, 1991] and in three species of macaques [Crockett et al., 1989] showed that feeding devices are more entertaining for animals than occupational devices. This finding is also in agreement with results observed in both females of the present study.

Kessel and Brent [1998] determined that the time spent by a group of pigtail macaques with a toy (occupational) enrichment device was 27%. This percentage is higher than that obtained in occupational enrichment for the 2 brown bears in the present study. One explanation for this fact is that the 2 species reflect different evolutionary adaptations. Primates have biological adaptations to object manipulation, and their sensorial systems are mainly visual and auditory. In contrast, the sensory system in bears is predominately olfactory. It may be that the olfactory sense development of bears renders sensorial enrichment devices as more effective than occupational devices. However, this aspect was not addressed in the present study.

In our comparison of the durations of animal-device interactions, the only differences observed were in the popsicles: between the male and young female for the fishsicle, and between the young and old female for the juicesicle. Three previous studies examined occupational enrichment in a group of chimpanzees. Bloomsmith et al. [1990] found no differences between males and females but did find increased interest among young animals for balls. Brent and Eichberg [1991] observed that females had a greater interest for feeding puzzles than males. Similarly, in Platt and Novak [1997], females had a greater interest for a videotape and video game. Females and young animals seem to have a larger predisposition to device interaction than males, as the fishsicle case of this study would indicate; nevertheless, more studies are needed to address this issue. The females did not respond in different ways to feeding and occupational enrichment devices. However, differences in the response to the fishsicle were seen between the male and young female, as was also previously observed in structural enrichment for a couple of brown bears [Soriano et al. 2006].

After evaluating the environmental enrichment devices over sessions, we obtained a new model different from the 3 models that have been described in previous publications. The new fluctuation model described in this study showed increases and decreases (or vice versa) of device interest over time. This model was observed with the fishsicle for the young female and male, and with the juicesicle and deer feces for the young female.

The increased efficacy model is a panacea that could result in the other 3 models over time. It would be interesting to determine whether, over time, one model transforms into another, and whether such transformation is gradual; more studies about this concept are needed. We were unable to affirm that the enrichment efficacy increased over the 9 sessions for brown bears at the Barcelona Zoo, but this effect

was previously observed in feeding and other types of enrichment devices applied to a group of Goeldi's monkeys [Gibbs, 2003].

A habituation model was observed with an occupational device (ball) in both females and with a feeding enrichment device (juicesicle) in the old female. This model was also observed with some occupational devices in different species of primates [Paquette and Prescott, 1988; Bloomsmith et al., 1990; Line and Morgan, 1991; Brent and Belik, 1997; Platt and Novak, 1997; Kessel and Brent, 1998; Renner et al., 2000] and with feeding devices in 3 species of bears [Anderson et al., 2010; Carlstead et al.,1991], in leopards [Markowitz et al., 1995], and in different species of primates [Crockett et al., 1989; Brent and Eichberg, 1991; Bayne et al., 1993; Novak et al., 1998]. Unlike our observations of the model, habituation models have also been observed with some sensorial devices in other species of mammals [Calderisi, 1997; Clark et al., 2005].

The continuity evaluation model has only been described in a group of rhesus macaques for a feeding device [Line et al., 1991a]. In the present study, it was observed for the sack of fruit and live grasshoppers in both females. The brown bears were most entertained by the feeding-related enrichment devices, except for the live grasshoppers, especially those with some complexity for access to food (e.g., inside a sack or in a popsicle). This finding has also been observed in other primate species [Tripp, 1985; Vick et al., 2000; Maloney et al., 2006].

In this study, which was performed on concrete, the more natural live grasshopper device followed a continuity model and was associated with less interest. This observation is in contrast to observations among Asian small clawed river otters with live grasshoppers in front of cat food, dead crickets, and gelatin capsules [Foster-Turley and Markowitz, 1982] and rhesus macaques with wooden sticks in front of some dog toys [Line and Morgan, 1991]. In these previous studies, less interaction was found with the artificial elements than with the natural ones. More studies are needed to determine whether a relationship exists between enrichment origin and the effect on animals.

The schedule of device presentation influences enrichment efficacy, as shown by research in primates [Berrill, 2006], in 8 species of marine mammals and 2 species of birds [Kuczaj et al., 2002], and in some big cats [Plowman and Knowles, 2001]. The repetition and novelty of enrichment devices are important, as is the time elapsed between presentations of the same device. According to Plowman and Knowles [2001], device enrichment efficacy in big cats is larger when the time elapsed between the same device is 3 weeks. The present study used a 4-week schedule, which is the same as that applied previously in a feeding enrichment program for a female leopard, in which habituation was not observed [Markowitz et al, 1995]. Berrill [2006] proposed the removal of an enrichment device when the duration of the animal-device enrichment interaction decreases by 25% with respect to the first presentation.

We considered device enrichment to be effective when 2 conditions were met: 1) the device adjusted to a model of fluctuation, continuity, or efficacy increase over time, and 2) the time invested on the animal-device interaction was large (in this study, a maximum of 3600 s during the first hour of device presentation). The fluctuation model was observed under 2 conditions: with higher durations (i.e., greater efficiency) with the fishsicle and juicesicle for the young female; and with lower durations (i.e., less efficiency) with the fishsicle for the male and with the deer feces for the young female. Similarly, the

continuity model was observed with higher durations (i.e., greater efficiency) with the sack of fruit for both females, and it was observed with lower durations (i.e., less efficiency) with the live grasshoppers for both females.

Enrichment devices should also be evaluated for whether they improve animal well-being. Long-term evaluation is needed to remove devices from the routine when they do not elicit desirable changes in animal behaviors [Hogan et al. 2010]. These findings and others indicate that the schedule of device presentation may cause loss of enrichment efficacy [Quirke and O' Riordan, 2011]. When habituation to the device occurs, it must be replaced with another device or the presentation must be postponed [Anderson et al., 2010]. However, when a device follows a continuity model—which is related to the variety and novelty of the enrichment device—and a short duration is used, it is easier to modify the device qualitatively and quantitatively to increase the animal-device interaction time.

Future research must be done to evaluate enrichment programs and devices systematically, such that some relevant indicators about animal well-being may be established [Ross, 1999]. The integration of these animal welfare indicators into an index must allow intra- and inter-specific comparisons. Standardized sampling, analysis, and evaluation recording methods are needed for enrichment programs and their devices, to study models of enrichment program evaluation and the relationships among device type, presentation frequency, natural history of the species, and other variables, such as the presence of visitors, abnormal behaviors, social interactions, etc.

CONCLUSIONS

- Feeding enrichment devices entertained brown bears longer than occupational and sensorial devices.
- The most effective enrichment device was the sack of fruit, which was associated with longer interaction durations and with a continuity model.
- The new fluctuation model was observed with the juicesicle, deer feces (young female), and fishsicle (young female and male).
- The continuity model was observed with the live grasshoppers and sack of fruit for both females.
- The habituation model was observed with the ball (both females) and the juicesicle (old female).
- None of devices studied showed the increased device efficacy model.

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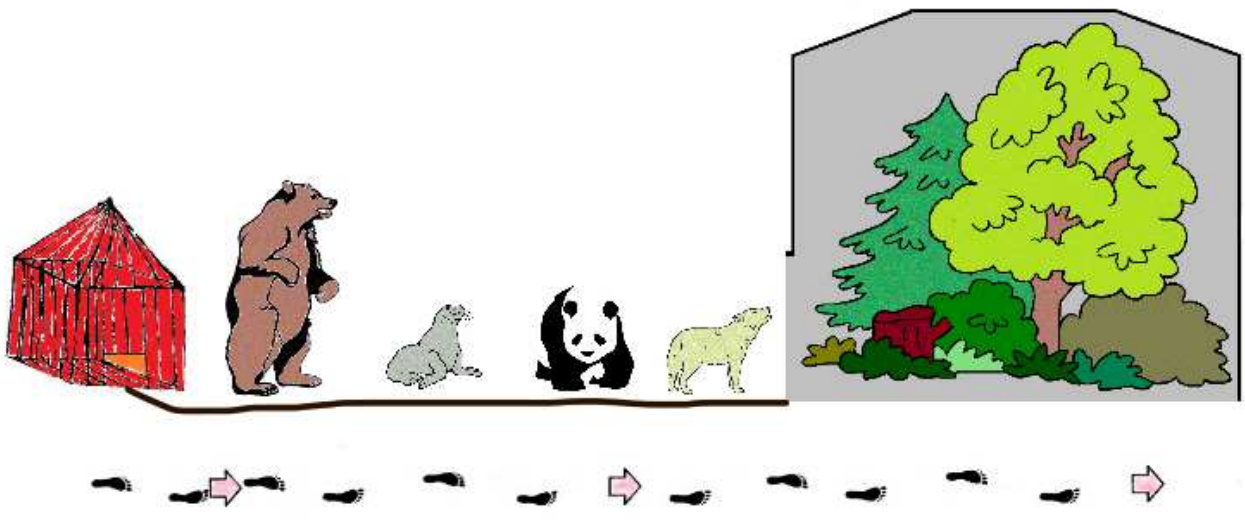
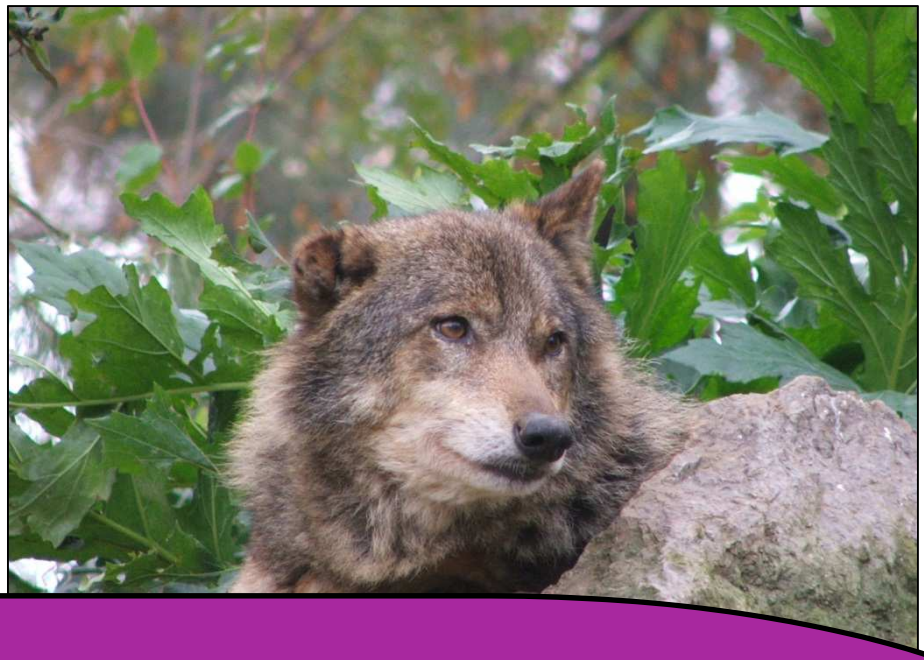
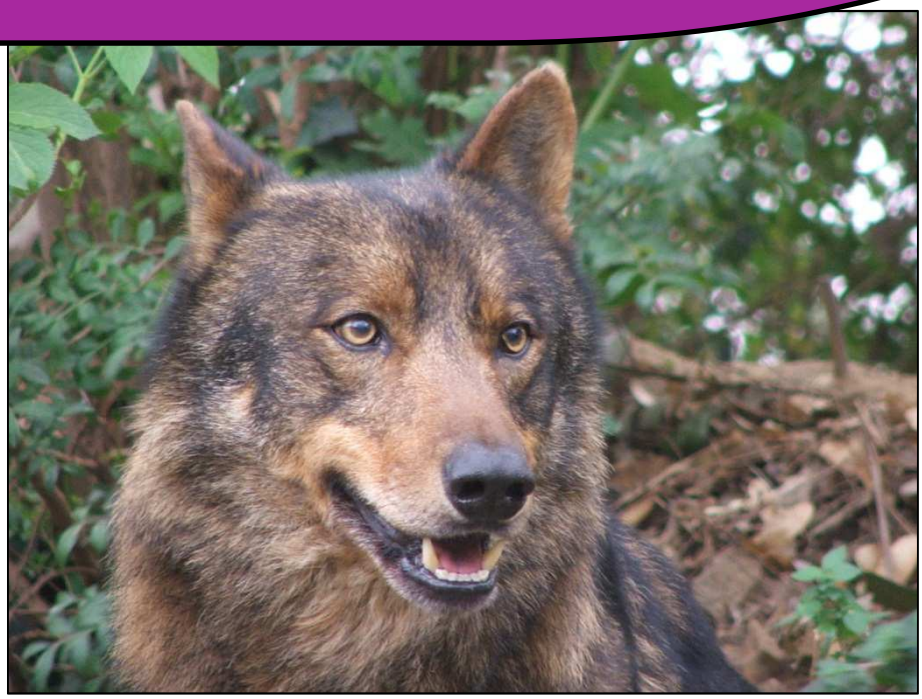
5. CAPÍTULO 3. COMPORTAMIENTO SOCIAL EN EL LOBO IBÉRICO Y EL LEÓN MARINO DE CALIFORNIA





5.1. SECCIÓN 5. A.I. Soriano, S. Serrat, C. Ensenyat, C. Riba, C. Mate (2006). Los cambios comportamentales y del uso del espacio asociados a la muerte del macho dominante de una manada de lobos ibéricos (*Canis lupus signatus*) en el Parque Zoológico de Barcelona. *Anuario de Psicología* 37(1-2): 141-155.



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Los cambios comportamentales y del uso del espacio asociados a la muerte del macho dominante de una manada de lobos ibéricos (*Canis lupus signatus*) en el Parque Zoológico de Barcelona

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La dinámica social es uno de los campos más estudiados de la familia Canidae en condiciones de cautividad. En este estudio se pretende determinar cómo la muerte del macho dominante de una manada de lobos alojados en el Parque Zoológico de Barcelona afecta al patrón de actividad diario y al uso del espacio del resto de coespecíficos. Los individuos objeto de estudio son dos machos y dos hembras de la especie Canis lupus signatus *alojados en una instalación naturalizada. Las observaciones se hicieron mediante un registro multifocal instantáneo cada 15 minutos. El número total de horas de observación fue de 55,5 para cada uno de los individuos tanto en la fase previa como en la fase posterior a la defunción del macho alfa. Los resultados obtenidos en el patrón de actividad diario muestran un aumento de las conductas de* Vigilancia, Mantenimiento *y* No Visible *y una disminución en la* Inactividad. *En cuanto al uso del espacio, aumenta la utilización de la zona* Centro Izquierda, *disminuye* Centro Anterior *mientras que no existen variaciones en* Izquierda Posterior. *Además la localización de los animales es menos homogénea tras la defunción.*

Palabras clave: *patrón de actividad diario, uso del espacio, Canis lupus signatus, muerte del macho dominante.*

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Social dynamics is one of the most widely studied fields in the Canidae family in captivity. This study aims to determine how the death of the dominant male in a pack of wolves at Barcelona Zoo affects the pattern of daily activity and the use of space of the rest of the members. The individuals under study are two males and two females of the species Canis lupus signatus *in naturalized surroundings. The observations were made using an instantaneous multifocal recording every 15 minutes. Each individual was observed for a total of 55.5 hours both prior to and after the death of the alpha male. The results for daily activity patterns show an increase in the behaviours of* Vigilance, Maintenance *and* Lack of Visibility *and a reduction in* Inactivity. *As regards the use of space, the use of the* left central *area increased, the use of the* front central *area decreased, while there were no differences in the use of the* rear left *area. The location of the animals was less homogeneous after the death of the alpha male.*

Key words: daily activity pattern, use of space, Canis lupus signatus, death of the dominant male

El lobo ibérico (*Canis lupus signatus*) es la única subespecie de Cánido existente en la Península ibérica. Su área actual de distribución se encuentra muy reducida respecto a la original a causa de la persecución deliberada por parte del hombre, la modificación del hábitat y la rarificación de las presas salvajes. En las últimas décadas la especie se ha recuperado notablemente en la mitad norte de la Península Ibérica donde mantiene un extensa y continua área de distribución, y además con tendencias claramente expansionistas, mientras las poblaciones del sur, reducidas y aisladas, presentan un futuro incierto (Grande del Brío, 2000; Palomo y Gisbert, 2002). De ahí, la importancia de su investigación y mantenimiento en cautividad con el objeto de apoyar los proyectos de conservación "in situ" que actualmente se están llevando a cabo.

Las manadas de lobos (*Canis lupus*) se han utilizado desde hace mucho tiempo de ejemplo para investigar las relaciones conductuales entre miembros de grupos sociales. La cuestión de la dominancia social y de la posición alfa ha ido cobrando importancia. Una manada de lobos está compuesta por un grupo de individuos que compiten constantemente por la dominancia y son el macho y la hembra alfa los que controlan este aspecto (Schenkel, 1947; Rabb *et al.*, 1967; Fox, 1971; Zimen, 1975, 1982). La denominación de alfa se asigna a un lobo de alto rango en una jerarquía de dominancia. El estudio de Fox (1971) trata la ontogenia del comportamiento de dominancia en diferentes camadas de lobos en condiciones de cautividad. Se formuló la hipótesis de que la reactividad emocional del cachorro dominante (el animal alfa en potencia) era notablemente distinta de la reactividad emocional de los individuos subordinados y, de esta manera, era posible seleccionar las características del temperamento de los lobos líderes y de los subordinados. Esta perspectiva supone que el rango es innato y que se configura a una edad temprana, de modo que existen determinados lobos destinados a dirigir la manada.

La mayoría de las investigaciones etológicas en condiciones de cautividad versan sobre la dinámica social de la manada en diferentes especies de Cánidos. El lobo gris (*Canis lupus*) es la especie de Cánido más estudiada y en condiciones de cautividad los temas más investigados son, sobre todo, los relacionados

con el comportamiento de dominancia (van Hooff y Wensing, 1987), de agresión (Fentress *et al.*, 1987; Moran, 1982; Kachuba, 1985), y los cambios en la dinámica social de la manada en diferentes épocas de reproducción (Rabb, 1967), con la introducción de nuevos individuos en el grupo (Fox, 1973; Fox *et al.*, 1974) o con el nacimiento de nuevos lobatos (Altman, 1987; Schotté y Ginsburg, 1987). Existen también investigaciones relacionadas con la alimentación de las crías por parte de los diferentes miembros de la manada (Fentress y Ryon, 1982; Paquet *et al.*, 1982), con el patrón de actividad diario durante las diferentes estaciones del año (MacDonald, 1980) y la descripción de las conductas relacionadas con la fabricación de los lechos para la crianza (Ryon, 1977). Los últimos estudios publicados sobre la especie *Canis lupus* en condiciones de cautividad describen cómo el tamaño de la instalación determina el patrón de actividad diario en dos manadas de lobo gris (Kreeger *et al.*, 1996) y la utilización de los patrones comportamentales y del uso del espacio como indicadores del bienestar animal en cautividad en seis manadas de lobos (Frézard y Le Pape, 2003).

Otra de las especies de Cánidos en las que se han llevado a cabo estudios en cautividad es *Canis lupus baileyi* por tratarse de un animal en grave peligro de extinción y con el objeto de conocer su biología para conseguir su conservación en el hábitat natural. En el año 1991 Servín estudia los cambios comportamentales de una manada de esta especie a lo largo de un año, teniendo en cuenta la época de reproducción. Bernal y Packard (1997) comparan las frecuencias de las conductas de una manada de lobo mejicano en condiciones de cautividad y otra mantenida en condiciones de semilibertad.

En el lobo rojo (*Chrysocyon brachyurus*) se ha llevado a cabo un estudio sobre los cambios comportamentales asociados a la reintroducción de tres machos en tres manadas diferentes de hembras con sus crías (Bestelmeyer, 1999).

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Este trabajo investiga los cambios comportamentales y del uso del espacio asociados a la muerte del macho dominante de una manada de lobos ibéricos (*Canis lupus signatus*) en el Parque Zoológico de Barcelona.

Material y método

Los sujetos estudiados son 4 individuos de lobo ibérico (*Canis lupus signatus*) alojados en el Zoo de Barcelona (ver tabla 1).

TABLA 1. INFORMACIÓN DEMOGRÁFICA DE LOS SUJETOS DE LA ESPECIE *CANIS LUPUS SIGNATUS*

Nombre	*Sexo*	*Edad (Dec 05)**	*Origen*	*Tipo de crianza*	*Fecha de llegada al zoo*
Lisa (LI)	Hembra	9 y 6m	Zoo Jerez (España)	Maternal	11 Octubre 1996
Claudia (CL)	Hembra	9 y 6m	Zoo Jerez (España)	Maternal	11 Octubre 1996
Junior (JU)	Macho	9 y 6m	Zoo Jerez (España)	Maternal	11 Octubre 1996
Flash (FL)	Macho	9 y 6m	Zoo Jerez (España)	Maternal	11 Octubre 1996

* y = año: m = mes.

Durante las observaciones, los lobos ibéricos estaban alojados en una instalación naturalizada (ver figura 1, página siguiente) de aproximadamente 940 m^2 y rodeada de una valla metálica cubierta de vegetación. La instalación exterior (figura 1.1) contiene vegetación típica del hábitat natural de la especie, tres piedras dispuestas en forma de dolmen como refugio, un área acuática para que los animales puedan beber y bañarse, y diferentes mecanismos de enriquecimiento ambiental como una liebre mecánica, cajas donde esconder el alimento y una estructura metálica en forma de L para dificultar el acceso de los animales a la comida. Los lobos construyen sus propios lechos para dormir y en medio de la instalación se puede observar un montículo en cuya parte superior hay una excelente visibilidad del ambiente exterior. La reserva fue diseñada como paridera (figura 1.2) y en la instalación interior (figura 1.3) hay tres casetas de madera a modo de dormitorios.

Estos animales son alimentados dos veces al día, por la mañana cada lobo come 1 kilogramo de carne magra cruda y por la tarde 1 kilogramo de carne cruda con hueso. Los sujetos objeto de estudio sólo están en la paridera durante la época de crianza de los lobatos y en las instalaciones interiores cuando los cuidadores u otro personal del Zoo necesitan acceder a las instalaciones exteriores por cuestiones de mantenimiento.

En cuanto a la dinámica social y a la dominancia de estos 4 sujetos se establece que Flash es el dominante por presentar un mayor porcentaje de conductas de carácter social y de marcaje del territorio.

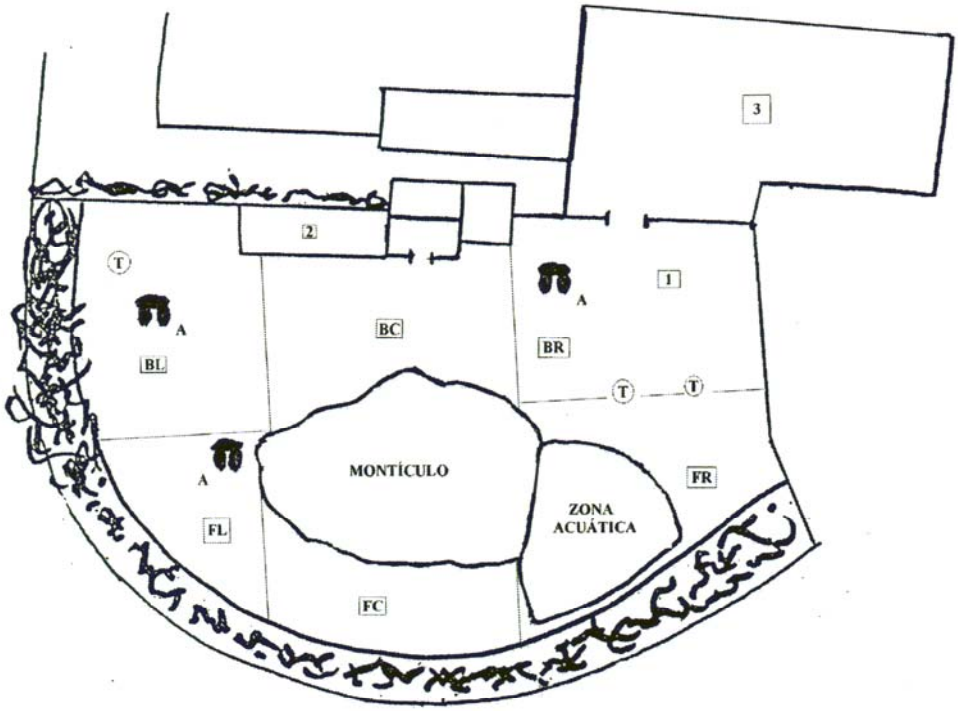

Figura 1. Esquema de la instalación naturalizada de los lobos ibéricos (1= Instalación exterior, 2= Reserva, 3= Instalación interior, A= Refugios de piedra, T= Árboles, BL= Izquierda Posterior, FL= Izquierda Anterior, BC= Centro Posterior, FC= Centro Anterior, BR= Derecha Posterior, FR= Derecha Anterior).

La muerte de Flash se produce en julio de 1997. En consecuencia, la fase previa (primera fase de estudio: Línea Base (LB)) se establece a su muerte entre mayo y julio de 1997, mientras que la fase posterior (segunda fase de estudio: Muerte del Dominante (MD)) se establece a la defunción entre agosto y diciembre del mismo año. Los animales fueron estudiados en diferentes estaciones del año y con un cambio en la composición de la manada.

Se aplicó un muestreo multifocal de sujetos con registro temporal instantáneo cada 15 minutos (Altman, 1974). En las dos fases de estudio, se registraron un total de 101 horas recogidas de forma equitativa durante las horas del día y para cada uno de los sujetos estudiados.

La información que se registraba en cada una de las sesiones de observación fue el periodo del día –*mañana* (entre 9:00 y 12:00 h), *mediodía* (de 13:00 a 15:00 h) y *tarde* (entre 16:00 y 18:00 h)–, el comportamiento y la localización para cada sujeto estudiado. La instalación exterior se dividió en seis partes de dimensiones similares y un montículo. Las diferentes zonas utilizadas para el estudio del uso del espacio fueron las siguientes: *Izquierda Anterior*,

Centro Anterior y *Derecha Anterior* son las zonas más próximas a los visitantes; *Izquierda Posterior*, *Centro Posterior* y *Derecha Posterior* en las que los animales están alejados de la zona destinada para el público; el *Montículo,* la zona más elevada de la instalación; la *Instalación Interior,* si los animales utilizaban esta zona; y *Localización Indeterminada,* cuando los sujetos no podían localizarse (ver figura 1). El etograma de la especie se detalla en la tabla 2.

TABLA 2: DEFINICIÓN DE CADA UNA DE LAS CATEGORÍAS CONDUCTUALES

ACTIVIDAD
Vigilancia: el lobo está alerta, con la cabeza y orejas levantadas y los ojos abiertos.
Locomoción: el animal se desplaza por la instalación.
Marcaje del espacio: el individuo orina con la pata levantada.
Alimentación: el sujeto consume alimentos, también incluye la acción de beber.
Juego solitario: incluye los movimientos exagerados y vigorosos del animal como pueden ser los saltos.
Mantenimiento: el lobo se acicala con su boca y/o garras, se rasca, orina, defeca o sacude el pelaje.
Manipulación: el animal araña, golpea, mordisquea o transporta elementos tanto alimentarios como no alimenticios ya sea con la boca y/o con las garras.
Interacción con humanos: el lobo sentado mira hacia los humanos. Incluye diferentes maneras de llamar la atención: por ejemplo, correr de forma exagerada en la misma dirección que las personas.
Interacción social: son todas aquellas conductas que implican la intervención de más de un individuo y son de carácter afiliativo, agresivo o sexual.
INACTIVIDAD
Estacionario: el sujeto descansa sentado o tumbado con su musculatura relajada.
NO VISIBLE
No visible: el individuo o su conducta no es visible.

Las pruebas estadísticas empleadas para el análisis de las variables cualitativas obtenidas fueron las tablas de contingencia con el cálculo de la χ^2 de Pearson y los residuos ajustados (tomándose como referencia el valor del estadístico de prueba 1,96 en valor absoluto, para una distribución normal y un nivel de significación de 0,05) (Haberman, 1978). Los valores de la χ^2 de Pearson se obtuvieron al contrastar los dos periodos de estudio (LB y MD) con la conducta y el uso del espacio para cada uno de los sujetos estudiados.

Para el estudio del uso del espacio se calculó el índice SPI (*Spread of Participation Index*) en cada uno de los animales y para cada una de las dos fases. Un valor de 1 en este índice indica una utilización mínima de la instalación y un valor de 0, señala que el uso del espacio es homogéneo para cada una de las divisiones del habitáculo (Dickens, 1974; Shepherdson *et al.*, 1993).

Para el tratamiento y análisis estadístico de los datos se ha usado el paquete estadístico *Statistical Package for the Social Sciences* (SPSS) versión 11.5 para Windows.

Resultados

Para el caso de Lisa, se observó que varias categorías comportamentales y algunas zonas de la instalación diferían para los dos periodos de estudio descritos (ver figuras 2 y 3).

Figura 2. Frecuencias observadas del patrón de actividad diario de Lisa para cada uno de los periodos de estudio.

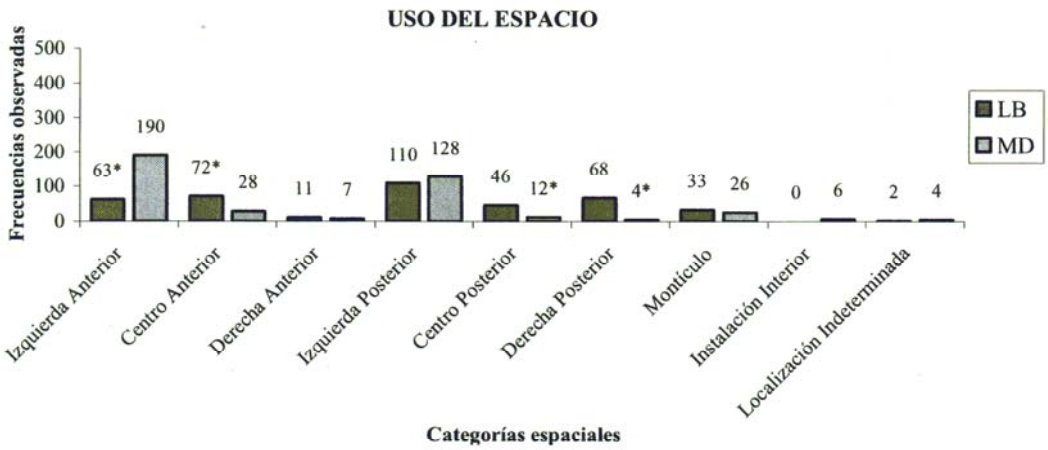

Figura 3. Frecuencias observadas del uso del espacio de Lisa para cada uno de los periodos de estudio.

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Durante la MD (o segunda fase de estudio, posterior a la muerte del macho), esta hembra presentó unos valores mayores con diferencias estadísticamente significativas en las conductas de *No Visible*, *Vigilancia*, *Alimentación* y *Mantenimiento* y unas frecuencias menores estadísticamente significativas en *Estacionario*. No se registraron diferencias significativas en las frecuencias de las categorías *Locomoción*, *Juego Solitario*, *Interacción Social*, *Interacción con Humanos* y *Marcaje del Espacio* (χ^2 [9]= 64,767, *p<0,05).

En cuanto al uso del espacio se observó cómo Lisa durante la MD mostró una utilización mayor de las zonas *Izquierda Anterior* y con una frecuencia significativamente menor ocupó las zonas *Derecha Posterior*, *Centro Anterior* y *Centro Posterior*. En cambio, no se observaron diferencias significativas para las zonas *Derecha Anterior*, *Montículo*, *Izquierda Posterior*, *Instalación Interior* y *Localización Indeterminada* (χ^2 [8]= 169,678, *p<0,05).

En Claudia se observaron diferencias estadísticamente significativas en el patrón de actividad diario y en el uso del espacio (ver figuras 4 y 5). Durante la MD se registraron unas frecuencias significativamente mayores en las conductas de *No Visible*, *Vigilancia*, *Juego Solitario*, *Mantenimiento* e *Interacción Social* y unos valores significativamente menores en *Alimentación* y *Estacionario*. No se observaron diferencias significativas en la *Locomoción*, *Manipulación*, *Interacción con Humanos* y *Marcaje del Espacio* (χ^2 [10]= 82,243, *p<0,05).

Figura 4. Frecuencias observadas del patrón de actividad diario de Claudia para cada uno de los periodos de estudio.

En la MD, se observó cómo Claudia usaba la *Localización Indeterminada* con una frecuencia significativamente mayor, y con un valor significativamente menor las zonas *Derecha Anterior* y *Centro Anterior*. En cambio, no se registraron diferencias significativas en las zonas *Derecha Posterior*, *Centro Posterior*, *Montículo* y *Derecha Posterior* (χ^2 [8]= 66,325, *p<0,05).

Figura 6. Frecuencias observadas del patrón de actividad diario de Junior para cada uno de los periodos de estudio.

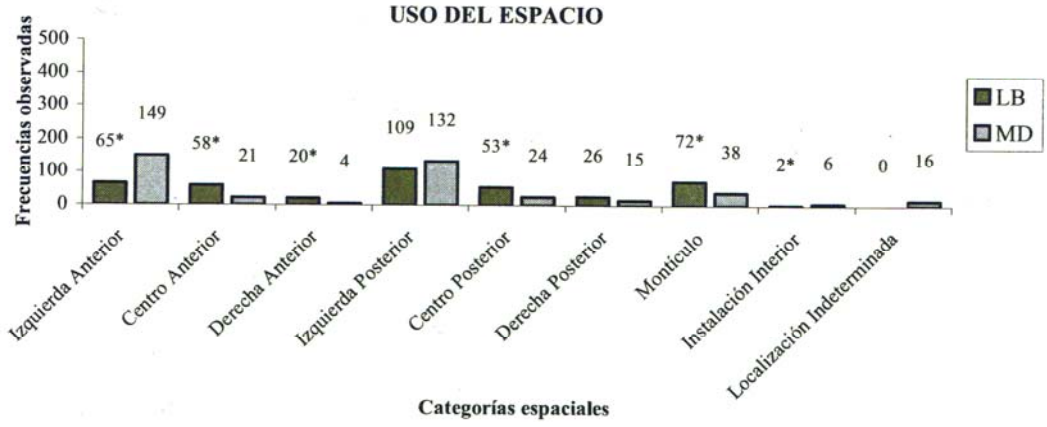

Figura 7. Frecuencias observadas del uso del espacio de Junior para cada uno de los periodos de estudio.

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En las figuras 8 y 9 se muestran las frecuencias de las conductas y del uso del espacio de Flash antes de su muerte. Este animal presenta un porcentaje mayor para la conducta de *Interacciones Sociales* (39 %) y para el *Marcaje del Espacio* (5%); en cambio Junior muestra un 12 % y un 0,1 % respectivamente.

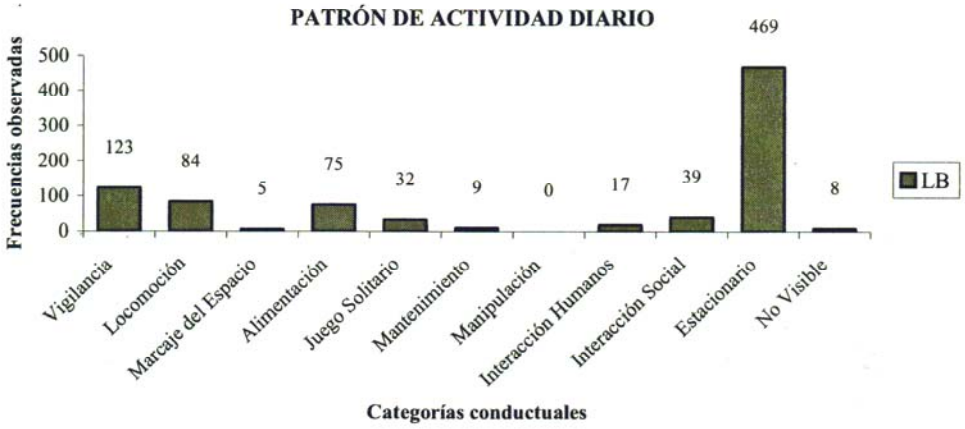

Figura 8. Frecuencias observadas del patrón de actividad diario de Flash para el periodo LB.

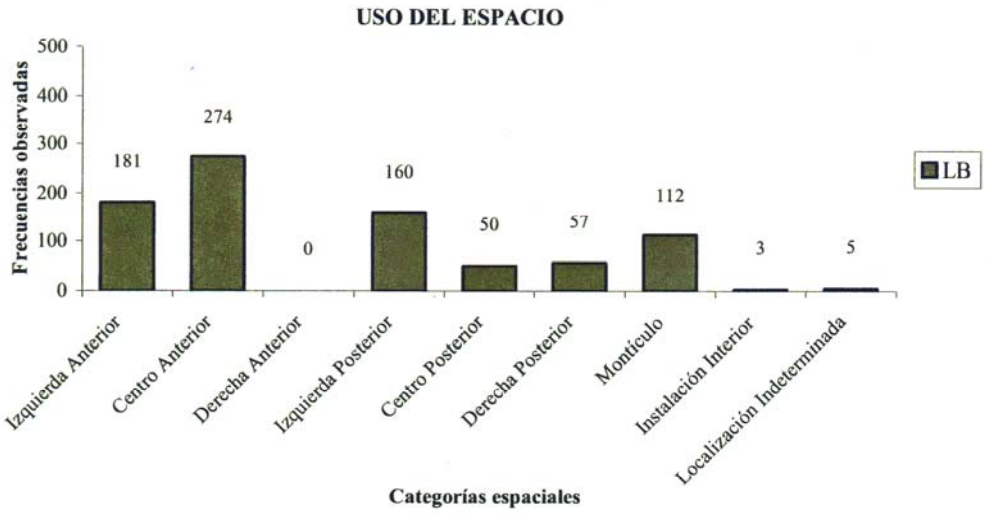

Figura 9. Frecuencias observadas del uso del espacio de Flash para el periodo LB.

En la Tabla 3 se muestra el índice utilizado para el estudio del espacio.

TABLA 3. VALORES DEL ÍNDICE SPI EN CADA UNA DE LAS FASES DE ESTUDIO Y PARA CADA UNO DE LOS SUJETOS ANALIZADOS.

	Lisa	*Claudia*	*Junior*	*Flash*
LB	0,31	0,241	0,24	0,44
MD	0,46	0,32	0,5	-

Discusión

Los indicadores de dominancia del macho alfa dentro de una manada de lobos son una mayor frecuencia de las interacciones sociales y del marcaje del espacio (Mech, 1999), por lo que el lobo llamado Flash se considera dominante por presentar unas frecuencias mayores en las conductas de *Marcaje del Espacio* e *Interacción Social* además de las conductas de *Locomoción*, *Alimentación*, *Juego Solitario, Interacción con Humanos* y *Estacionario* respecto al otro macho del grupo.

La desaparición del macho alpha del grupo tiene como consecuencia que el resto de los miembros de la manada presente una mayor frecuencia en las conductas de *Vigilancia* y una frecuencia menor en la conducta de *Estacionario,* debido posiblemente a la falta de la figura del individuo dominante que actúe como cohesión y equilibrio social dentro del grupo; en consecuencia, el resto de los animales es más susceptible a todos los estímulos procedentes del exterior. A su vez, la visibilidad de los individuos es menor porque aparece un notable aumento de la conducta de *No Visible* que puede ser debido al sentimiento de pérdida de un coespecífico, sentimiento que se ha descrito en algunas especies de animales sociales que establecen entre ellos relaciones muy cohesivas (Maté, 2005).

Otra de las conductas a destacar y cuya frecuencia aumenta con la muerte del individuo dominante es la de *Mantenimiento* debido posiblemente a que coincidió con la época de la aparición del pelaje de invierno y de ahí que fuera frecuente ver a los animales realizando este tipo de conductas.

Las conductas que no han sufrido ningún tipo de variación dentro de la manada después de la muerte del macho dominante son las de *Marcaje del Espacio* y de *Interacción con Humanos* posiblemente debido a que es una época de cambio de jerarquía donde todavía no está definida la figura del macho alfa y con ello el lenguaje que rige el marcaje sensorial. La conducta de interacción con humanos no sufre ninguna variación posiblemente debido a que es un comportamiento derivado de la cautividad y que no se ha visto influido por el cambio social que padeció el grupo.

El resto de conductas sufren variaciones individuales cuando se ha producido una disminución del número de individuos del grupo. El comportamiento de *Juego Solitario* e *Interacción Social* aumenta en Claudia y se mantiene

igual para el resto del grupo, posiblemente por que esta hembra pretende ser la dominante dentro de la manada y la que establece más a menudo relaciones con el resto de coespecíficos. La conducta de *Alimentación* aumenta en Lisa mientras que disminuye para Claudia, no sufriendo variaciones en el macho. La desaparición de la figura del macho dominante permite que Junior tenga mayor acceso a los recursos alimentarios, haciendo que Claudia pase menos tiempo alimentándose; pero, sin embargo, no se detectan diferencias para Lisa. La conducta de *Locomoción* permanece invariable para las dos hembras y disminuye en el caso del macho debido a que la mayor parte de su tiempo pasa a no estar visible. La conducta de *Manipulación* no se observa nunca ni en Lisa ni en Junior, sólo en Claudia y con una frecuencia muy baja no siendo trascendente en el estudio.

En cuanto al uso del espacio, con la desaparición del macho dominante se producen los siguientes cambios en los tres lobos. Aumenta el uso de *Izquierda Anterior* que es la zona de mejor visibilidad hacia el exterior de la instalación, disminuye la utilización de *Centro Anterior* que es la zona más próxima al público, mientras que *Izquierda Posterior* se utiliza de igual forma en los dos periodos de estudio.

En cuanto a los valores del *Spread of Participation Index* (SPI) se observa que con la muerte del macho dominante se produce una disminución estadísticamente significativa de la utilización del espacio en cada uno de los tres lobos ibéricos estudiados. Parece que los individuos pasan a estar más tiempo en zonas concretas de la instalación, posiblemente a causa de la ausencia de la figura del macho dominante como estabilizador de la manada y, en consecuencia, a una falta de adaptación a los estímulos ambientales externos recibidos.

La comparación con otros estudios de la misma especie y sobre el mismo tema no ha sido posible. Se han relatado diferentes actitudes mostradas por algunas especies sociales, como los delfines (Dudzinski *et al.*, 2003; Fertl y Schiro, 1994), ante la muerte de un coespecífico, pero no se han registrado de forma sistemática (Maté, 2005).

El patrón de actividad diario y del uso del espacio se utilizan como indicadores de bienestar animal en condiciones de cautividad. Lo más habitual es encontrar investigaciones que tratan sobre uno u otro aspecto de forma independiente, no siendo común la combinación de los dos, combinación que aporta una información mucho más detallada y enriquecedora (Martin y O'Reilly, 1988; Moran y Sorensen, 1984).

Los estudios etológicos en condiciones de cautividad y aplicados al bienestar animal pretenden determinar el nivel de adaptación de los individuos objeto de estudio al medio que los rodea. De este modo, se conoce el estado de bienestar de los sujetos, y si se considera necesario, se interviene con ellos para mejorar su calidad de vida. El bienestar animal significa que el repertorio conductual del animal es el típico de la especie característica indispensable para que los programas de conservación (como uno de los principales objetivos de los zoológicos) aumenten las probabilidades de éxito (AAZPA, 1973; Ganslober, *et al.*, 1995).

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La composición de la manada objeto de estudio no es la típica encontrada en condiciones de libertad. Los grupos de los lobos en condiciones naturales guardan una composición variable, en cuanto al número, sexo, edad y parentesco entre los individuos (Grande del Brío, 2000). En este caso, se trata de una estructura grupal atípica de la especie y, además, en condiciones de cautividad, hecho que posiblemente influye en el desarrollo vital de los sujetos objeto de estudio. Los resultados obtenidos en esta investigación no pueden ser generalizados a nivel de especie sino que son una descripción de lo ocurrido en un momento y lugar determinado.

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5.2. SECCIÓN 6. A.I. Soriano, R. González, C. Maté (2009). A study into the mother-pup relationship in three California sea lion *Zalophus californianus* mothers and pups at Barcelona Zoo. *International Zoo Yearbook* 43: 176-188.

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A study into the mother–pup relationship in three California sea lion *Zalophus californianus* mothers and pups at Barcelona Zoo

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The limited number of studies into maternal care in captivity carried out on California sea lions *Zalophus californianus* indicates that it is necessary to study their biology and behaviour in greater depth to improve management conditions and participate in the conservation of their genetic information and habitat. This study involved three adult ♀♀, two primiparous mothers and one that had already given birth, and their pups. The study period occurred from July to November 2003. Sampling was focused but data were collected continuously in 10 minute observation sessions. Twenty-four observation sessions were carried out for each individual, resulting in a total of 4 hours of observational data per animal evenly divided over three periods of the day (morning, midday and afternoon). The mother–pup location and play behaviours were not observed in the experienced mother; however, she spent more time in lactation than the primiparous mothers and her pup was more inactive. The use of space was similar for the three mother–pup pairs. The primiparous mothers started, received and finished more episodes with their pups than the experienced mother, which interacted with her pup more in the afternoon. The experienced mother's pup received more aggressive vocalizations than the primiparous mothers' pups.

Key-words: California sea lion; mother–pup activity pattern; primiparous mothers; social interactions; use of space.

INTRODUCTION

The California sea lion *Zalophus californianus* is characterized by having a capacity to adapt to conditions in captivity. This means that research into behaviour, physiology, learning and training, etc, may be more precise and informative than observational data collected under natural conditions. Many of the variables studied in captivity may not only provide more exhaustive knowledge about the biology of the species but they will also determine the optimal conditions for keeping these animals in captivity so that they have a high level of well-being (Kleiman *et al.*, 1996).

The reproductive behaviour of the species both in the wild and in this study group at Barcelona Zoo suggests that mating occurs between the end of May and mid-June, with parturition occurring after *c.* 345 days gestation. Female California sea lions experience delayed implantation, whereby the blastocysts do not attach to the uterus wall for a prolonged period. This delay may act as a timing mechanism, ensuring that all ♀♀ give birth within a few days of each other. Three maternal strategies have been described for pinnipeds (Bonner, 1984, 1994; Gentry & Kooyman, 1986; Oftedal *et al.*, 1987; Costa, 1991): aquatic nursing, foraging cycle (used by California sea lions) and fasting strategies. The major features of a foraging cycle are as follows. (1) Adult ♀♀ acquire a moderate store of energy in the form of blubber (subcutaneous fat) before they arrive at their traditional breeding site. (2) Adult ♀♀ fast 5–11 days post-partum, using the blubber stores to sustain lactation and maintain energy during the perinatal period. (3) Adult ♀♀ alternate foraging trips to sea with visits to land to nurse their pups. (4) The lactation period is relatively long, ranging from 4 months to

3 years. (5) Milk is high in fat relative to that of terrestrial mammals but generally lower in fat than that of other pinnipeds that use a fasting strategy (Boness & Bowen, 1996).

Ono *et al.* (1987) stated that the rapid growth of ♂ pups was owing to the fact that they fed 14·6% of the time (as opposed to 10·7% for ♀ pups). However, whether mothers feed ♂ and ♀ pups for different lengths of time has yet to be determined conclusively. There are two reports on studies into the time spent by mothers looking after their young in relation to the gender of the pup. Francis & Heath (1985) determined that ♀ pups wean later than ♂ pups. However, Boness *et al.* (1985) did not find differences in the mothers' behaviour in relation to the gender of the pups.

Numerous studies have been carried out into the rearing and caring behaviour of pinnipeds in the wild (Scheffer, 1958; Odell, 1981; Ridgway & Harrison, 1981; Bonner, 1984; Proverb, 1990; Gisiner & Schusterman, 1991; Renouf, 1991; Hanggi, 1992; Schusterman *et al.*, 1992; Melin *et al.*, 2000; Schulz & Don, 2004), which provide complementary information to the research carried out on these species in captivity.

Tedman & Bryden (1979) studied lactation patterns in pinnipeds and described two types of nursing strategies: short and long patterns. The short pattern is characterized by a single continuous lactation period of 15–60 minutes. The long pattern of suckling occurs for 1–2 hours, interrupted by periods of a few minutes of rest. Peterson & Bartholomew (1967) showed that California sea lions use the long pattern of lactation, usually started by the pup and including short periods of rest.

The most relevant data obtained from the wild for determining the type of maternal style are the average durations of the suckling sessions, which range between 17 and 23 minutes. The intervals between lactation range between 3 and 4 hours. The total daily time dedicated to 'taking care of the pup' (not defined further) also varies from 4 to 6 hours (Oftedal *et al.*, 1987). Different variables are known to affect the lactation of these subjects, such as available food resources, age, the mother's health and the birth of a new pup (Proverb, 1990).

There are few studies into maternal behaviour in California sea lions in captivity and these are mainly concerned with the successful survival of a pup (Otten & Andrews, 1976), describing the rearing period in a colony (Dineley, 1979, 1981) and managing a group with young (van Foreest, 1978; Valleriani, 1985). There are studies of the Grey seal *Halichoerus grypus* in captivity that research the lactation period and suckling (Kastelein & Wiepkema, 1988; Kastelein *et al.*, 1991, 1995).

To our knowledge, there are no studies into pinnipeds in captivity that have investigated the spatial relationship between mothers and pups.

The studies into care of offspring in other mammal species in captivity have focused basically on primates and one marine carnivore: anthropoid primates (Altmann, 1986), Gorilla *Gorilla gorilla* (Miller-Schroeder & Paterson, 1989), Chimpanzee *Pan troglodytes* (Davis *et al.*, 1981; Goff *et al.*, 1994), Rhesus macaque *Macaca mulatta* (Schapiro *et al.*, 1995) and the Sea otter *Enhydra lutris* (Hanson *et al.*, 2005).

We have not found any studies into marine mammals, in the wild or in captivity, that deal with the different aspects of caring for offspring, such as mother–pup nursing episodes, use of space and social interactions.

The aim of this study at Barcelona Zoo was to compare the maternal styles of three ♀ California sea lions with regard to their infant-care behaviour, use of space and social dynamics of the mother–pup nursing episodes. The original motivation for carrying out this study was to ensure that the pups were feeding well.

MATERIALS AND METHODS

Subjects

The subjects were three California sea lion mothers ['Spanky' (multiparous), and the primiparous ♀♀ 'Filippa' and 'Nora'] and their respective pups ('Lo', 'Gala' and

'Anubis') maintained at Barcelona Zoo. Only Spanky was wild-born and all the other animals were born in captivity and mother-reared (Table 1). At the start of this study, Spanky's pup Lo was 1 year old, while the other two pups, Gala and Anubis, were only a month old.

Exhibit location

The outside enclosure is *c.* 950 m^2, with a 20 m^2 reserve area that is used to isolate the animals for veterinary care, training sessions or exhibit modifications. The inside area is *c.* 30 m^2, is off public view and connects to the outdoors (Fig. 1). The highest part of the outside area separates the public from the pinnipeds and comprises a rocky area from which it is possible to observe the animals. The aquatic part of the habitat consists of a central pool 15 m × 7 m × 3 m deep, which has a small island in the middle. The terrestrial zone surrounds the pool and two slides connect the terrestrial zone to the pool.

The water in the pool is sea water brought into the zoo using a pump system and is maintained at *c.* 13 °C, pH 8 and a salinity of 26–28 g $litre^{-1}$.

Daily management

The study animals were maintained outside during the day, although in the afternoon the gates to the indoor area (where the sea lions usually spend the night) were opened.

The California sea lions were fed during training sessions, at which point the observations were stopped. Feeding times were at 0730, 1030, 1230 and 1530 hours.

Recording methods

Data were collected from July to November 2003, which is the 5 month period that includes the time of greatest maternal involvement.

To design the study and determine the study variables, 30 hours of initial observations were made by a single student from which all the behavioural categories that formed the ethogram (Martin & Bateson, 1986) were obtained. This initial study was necessary as no published information has been found, for this or any other pinniped species, which describes an ethogram in such detail.

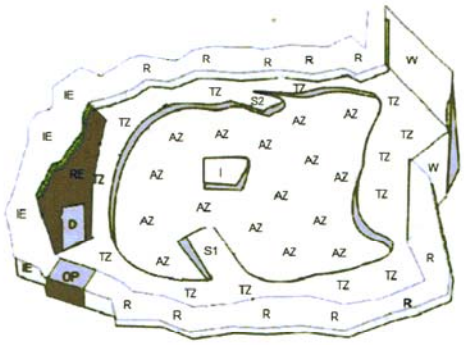

Fig. 1. Diagram of the California sea lion *Zalophus californianus* exhibit at Barcelona Zoo: AZ, aquatic zone; D, door; I, island; IE, indoor exhibit; OP, observation area; R, rocks; RE, reserve; S_1 and S_2, springboards; TZ, terrestrial zone; W, public viewing window.

NAME	SEX	DATE OF BIRTH	PLACE OF BIRTH	DATE OF ARRIVAL AT THE ZOO	PARENTS
MOTHERS					
Spanky	♀	1986	Wild-born Mexico	7 Oct 1999	unknown
Nora	♀	11 Jun 1999	Duisburg Zoo	7 Jun 2001	no information
Filippa	♀	24 Jun 1999	Osnabruck Zoo	24 Jun 1999	no information
PUPS					
Lo	♀	12 Jun 2002	Barcelona Zoo	–	Pototo/Spanky
Gala	♀	1 Jun 2003	Barcelona Zoo	–	Pototo/Filippa
Anubis	♂	8 Jun 2003	Barcelona Zoo	–	Pototo/Nora

Table 1. Demographic information for the California sea lions *Zalophus californianus* studied at Barcelona Zoo. Spanky was a multiparous mother who gave birth to her pup in 2002 (making Lo 1 year of age at the start of this study), while Nora and Filippa were both primiparous.

Social interaction	any intraspecific action in which a mother and her pup participate
Recognition	a mother and her pup making contact with their noses while vocalizing
Bonding	a mother and her pup making contact with any parts of their bodies (except noses) and always in an affiliative way
Locomotion	a mother and her pup moving from one part of the installation to another
Mother–pup location	a mother and her pup making an alternating series of deep vocalizations
Lactation	'a pup putting its nose in contact with its mother's mammary gland and suckling milk' (Oftedal *et al.*, 1987)
Aggressive vocalization	a mother and her pup uttering short, deep, strong vocalizations
Play	a mother and her pup chasing each other, nibbling each other and pushing each other with the exaggerated movements used in play
Inactivity	a mother and her pup lying down with their muscles relaxed and sometimes with their eyes shut
No social interaction	any social behaviour that is not of a mother–pup nature and/or of a solitary nature

Table 2. Definitions of the mother–pup behaviours observed in California sea lions *Zalophus californianus* at Barcelona Zoo.

Mother–pup behaviour was observed continually by the same student who carried out the preliminary study (Altmann, 1974) to obtain the duration (in seconds) of each maternal-behaviour interaction (called episodes). Sampling was focused but data were collected continuously in 10 minute observation sessions and recorded on paper report forms. The student was aware of the breeding status of the mothers (multiparous or primiparous) at the start of the study. Twenty-four observation sessions were carried out for each individual over the 5 month study period, resulting in a total of 4 hours of observational data per animal, evenly divided over three periods of the day (morning, midday and afternoon). These times were dependent on the opening times at Barcelona Zoo and no observations were made at night because of safety regulations. The variables that were documented during the mother–pup observations were time of day (morning: 1000–1300 hours; midday: 1300–1500 hours; afternoon: 1500–1700 hours), mother–pup interactions, location, subjects that initiated, received and finalized the social interactions and the average duration (in seconds) of the parental-care episodes.

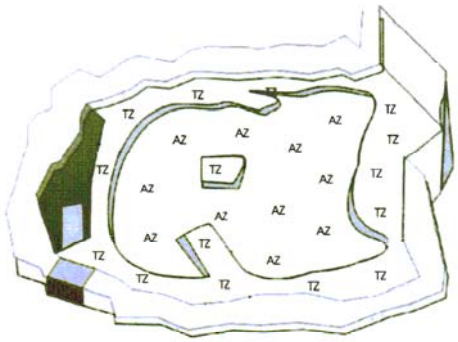

Fig. 2. Layout of the California sea lion *Zalophus californianus* pool system and exhibit with the Aquatic Zone (AZ) and Terrestrial Zone (TZ) identified for a study into the use of space by the mothers and their pups at Barcelona Zoo.

Several behaviour categories were documented (Table 2). In order to study the use of space, the enclosure was notionally divided into two zones: the aquatic zone and the terrestrial zone (Fig. 2).

Analysis

The Statistical Package for the Social Sciences (SPSS) version 11 · 0 for Windows was used to analyse data.

To determine the nature of the statistical analysis of the numeric variables in this study, the Kolmogorov–Smirnov normality test was used to determine that the episode durations did not follow a normal distribution. Non-parametric tests were, therefore, deemed the most appropriate to be applied for this study (Lehner, 1996).

The Mann–Whitney and Kruskal–Wallis tests were used to determine whether there were significant differences ($P < 0 \cdot 05$) in the time mothers spent on each of the behaviours, their use of the space and the time of day (Lehner, 1996).

	MOTHERS			PUPS		
	NORA MEAN ± SD (SECS)	FILIPPA MEAN ± SD (SECS)	SPANKY MEAN ± SD (SECS)	ANUBIS (♂) MEAN ± SD (SECS)	GALA (♀) MEAN ± SD (SECS)	LO (♀) MEAN ± SD (SECS)
Bond relations	3·2 ± 0·8	28·5 ± 30·4	15·2 ± 13·9	29·0 ± 33·9	3·0 ± 0·0	7·0 ± 0·0
Recognition	3·0 ± 0·0	14·8 ± 26·4	8·0 ± 0·0	3·3 ± 0·5	1·0 ± 0·0	50·0 ± 0·0
Locomotion	59·3 ± 46·5	47·1 ± 42·2	2·0 ± 0·0	18·0 ± 0·0	52·7 ± 65·3	10·0 ± 0·0
Mother–pup localization	6·6 ± 10·8	6·2 ± 2·5	0	6·2 ± 1·5	3·4 ± 1·7	3·0 ± 1·7
Lactation	134·8 ± 198·5	232·7 ± 239·1	343·8 ± 280·8	441·2 ± 186·7	310·7 ± 220·4	405·4 ± 205·8
Aggressive vocalization	2·0 ± 0	1·0 ± 0·0	2·0 ± 0	4·0 ± 1·4	0	0
Play	0	46·7 ± 18·8	0	52·5 ± 53·1	32·5 ± 19·1	0
Inactivity	233·7 ± 320·4	0	600·0 ± 0	68·0 ± 0·0	211·5 ± 296·3	575·0 ± 50·0
No interaction	600·0 ± 0·0	600·0 ± 0·0	600·0 ± 0	600·0 ± 0·00	553·8 ± 166·4	600·0 ± 0

Table 3. Mean ± SD of the duration (in seconds) of each mother–pup behaviour in six individual California sea lions *Zalophus californianus* studied at Barcelona Zoo: $n = 50$ (where n = number of observed episodes). Lactation and inactivity are the behaviours that lasted longest during the observation sessions. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀).

The other statistical analysis used for qualitative variables was the contingency table with the calculations of χ^2 analysis (Haberman, 1978).

RESULTS

Mother–pup episodes

The mean and standard deviation of the duration of each mother–pup behaviour for the three mother–pup pairs studied are shown in Table 3. The behaviours that lasted longest were inactivity and lactation (Table 3).

For the mothers, Spanky (multiparous) spent significantly more time on lactation and bond relations than Nora (primiparous) (Table 4). There were no statistically significant differences found between the two primiparous mothers (Nora and Filippa) for any of the variables. Meanwhile, for the pups, Anubis (♂) spent more time than either Gala or Lo (♀♀) in locating his mother (Table 4). Lo was significantly more inactive than Gala (Table 4).

The use of space

Spanky and her pup Lo used the terrestrial zone most while the adult ♀ Nora and Filippa's pup Gala used the aquatic zone more than the others (Table 5). However, no statistically significant differences were observed for use of space when comparing the mothers and pups (Table 6).

Time of day did not appear to affect the duration of mother–pup behaviours or the use of space for the individuals analysed in this study (Table 7).

The individuals that started, received and finalized the mother–pup episodes

The pinniped mothers received and finalized more episodes than they started while this was the exact opposite for their pups, which started more care episodes than they received or finalized. Comparing the mothering styles of the three pinnipeds, we can see that the primiparous mothers and pups (Nora and Anubis, and Filippa and Gala) started, received and finalized more mother–pup episodes than the experienced mother and her pup (Spanky and Lo) (Fig. 3).

The adult ♀♀ only interacted with their own pups. However, the pups interacted not only with their mothers but also with the other pups (Table 8).

Time of day had an effect on some individuals for starting, receiving and finalizing the mother–pup episodes (Table 9). Spanky and

	MOTHERS											
	NORA–FILIPPA				NORA–SPANKY				FILIPPA–SPANKY			
	Z	N1	N2	*P*	*Z*	N1	N2	*P*	*Z*	N1	N2	*P*
Bond relations	−1·63	2	2	0·10	−1·95	2	5	0·05**	−0·77	2	5	0·44
Recognition	−0·31	1	5	0·76	−1·00	1	1	0·32	−0·89	5	1	0·37
Locomotion	−0·11	3	7	0·91	−1·34	3	1	0·18	−1·54	7	1	0·12
Mother–pup location	−1·90	7	6	0·06	–	–	–	–	–	–	–	–
Lactation	−1·59	27	19	0·11	−2·46	27	6	0·01**	−1·63	19	6	0·10
Aggressive vocalizations	−1·00	1	1	0·32	0·00	1	1	1·00	−1·00	1	1	0·37
Play	–	–	–	–	–	–	–	–	–	–	–	–
Inactivity	–	–	–	–	−1·76	3	4	0·08	–	–	–	–
No interaction	0·00	6	6	1·00	0·00	6	32	1·00	0·00	6	32	1·00
	PUPS											
	ANUBIS–GALA				ANUBIS–LO				GALA–LO			
	Z	N1	N2	*P*	*Z*	N1	N2	*P*	*Z*	N1	N2	*P*
Bond relations	−1·22	2	1	0·22	0·00	2	1	1·00	−1·00	1	1	0·32
Recognition	−1·41	3	1	0·16	−1·41	3	1	0·16	−1·00	1	1	0·32
Locomotion	0·00	1	6	1·00	−1·00	1	1	0·32	−1·50	6	1	0·13
Mother–pup location	−2·47	6	8	0·01**	−1·96	6	3	0·05**	−0·31	8	3	0·75
Lactation	−1·42	17	13	0·15	−0·36	17	9	0·72	0·00	13	9	1·00
Aggressive vocalizations	–	–	–	–	−1·58	1	4	0·11	–	–	–	–
Play	–	–	–	–	–	–	–	–	–	–	–	–
Inactivity	0·00	1	2	1·00	–	–	–	–	−1·97	2	4	0·05**
No interaction	0·00	14	13	1·00	–	–	–	–	0·00	13	31	1·00

Table 4. Mann–Whitney *U*-test *Z*-values comparing the duration of mother–pup episodes between three mothers and three pups for California sea lions *Zalophus californianus* at Barcelona Zoo: **statistically significant differences $P < 0\cdot05$. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀). Spanky (multiparous) spent significantly more time on 'bond relations' and 'lactation' than Nora. Meanwhile, the ♂ pup Anubis spent significantly more time locating his mother than either of the ♀ pups. Lo was significantly more inactive than Gala.

her pup Lo were the only individuals that showed statistically significant differences in starting, receiving and finalizing the mother–pup interactions in relation to the time of the day: they interacted more in the afternoon (Figs 4–6).

The duration of mother–pup episodes depended on the individual that started or received the interaction (Table 10). When Nora started mother–pup episodes with her pup Anubis, she spent more time than the other two mothers on mother–pup location and lactation (Table 11). Filippa spent more time on the bond relations and recognition with her pup Gala (Table 11). Anubis was the pup that spent most time inactive, Gala spent most time on lactation and Lo spent most time playing (Table 11).

When Nora received the mother–pup episodes, she spent more time than the other two mothers in locomotion and bond relations. When Filippa received the mother–pup episodes, she spent more time than Nora on lactation and inactivity. Spanky spent more time than either Nora or Filippa on recognition, lactation and inactivity during received mother–pup episodes. Anubis was the pup who spent the most time in received episodes related to mother–pup location and lactation, Gala received the most bond relations and play and Lo received the most aggressive vocalizations (Table 12).

DISCUSSION

Few differences were observed among the mother–pup episodes, the use of space and the social interactions between the three mother–pup pairs studied at Barcelona Zoo. In the case of the older ♀, the differences

	MOTHERS			PUPS		
	NORA	FILIPPA	SPANKY	ANUBIS	GALA	LO
Aquatic Zone	36·2 ± 45·6	27·7 ± 34·5	2·00 ± 0·00	28·1 ± 40·1	49·5 ± 52·3	10·0 ± 0·00
Terrestrial Zone	112·7 ± 191·3	162·8 ± 209·1	267·8 ± 288·1	294·9 ± 258·2	176·8 ± 214·6	334·2 ± 259·0
No Interaction Zone	0	155·0 ± 296·7	0	0	0	0

Table 5. Mean ± SD [$n = 50$ (where n = number of observed episodes)] for each of the zones used by the six California sea lions *Zalophus californianus* in the study at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀). No statistically significant results were obtained for zone use by the sea lions in this study.

	MOTHERS											
	NORA–FILIPPA				NORA–SPANKY				FILIPPA–SPANKY			
	Z	N1	N2	*P*	*Z*	N1	N2	*P*	*Z*	N1	N2	*P*
Aquatic Zone	−0·48	5	15	0·63	−1·19	5	5	0·23	−1·41	15	1	0·16
Terrestrial Zone	−1·60	39	25	0·11	−1·85	39	17	0·06	−0·88	25	17	0·38
No Interaction Zone	–	–	–	–	–	–	–	–	–	–	–	–
	PUPS											
	ANUBIS–GALA				ANUBIS–LO				GALA–LO			
	Z	N1	N2	*P*	*Z*	N1	N2	*P*	*Z*	N1	N2	*P*
Aquatic Zone	−1·40	9	13	0·16	−0·17	9	1	0·86	−1·12	13	1	0·26
Terrestrial Zone	−1·74	28	22	0·08	−0·52	28	18	0·60	0·00	22	18	1·00
No Interaction Zone	–	–	–	–	–	–	–	–	–	–	–	–

Table 6. Mann–Whitney *U*-test *Z*-values comparing the use of the exhibit zones by three mothers and their pups in California sea lions *Zalophus californianus* at Barcelona Zoo. No statistically significant results were obtained for zone use in this study. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀).

	H	d.f.	*P*
MOTHERS			
Nora	0·11	2	0·95
Filippa	1·45	4	0·48
Spanky	4·26	2	0·12
PUPS			
Anubis (♂)	1·64	2	0·44
Gala (♀)	2·20	2	0·33
Lo (♀)	2·42	2	0·30

Table 7. Kruskal–Wallis values that show the effect of the time of day on the duration of behaviour and use of the space in mother–pup episodes for three California sea lion *Zalophus californianus* mothers and their pups at Barcelona Zoo.

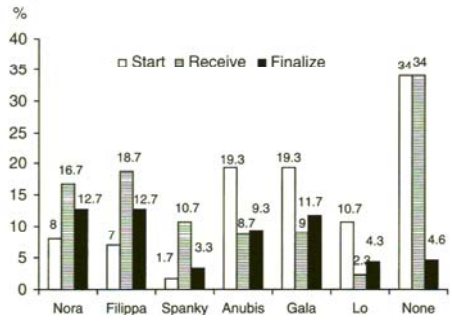

Fig. 3. Percentage of starting, receiving and finalizing mother–pup episodes for three California sea lion *Zalophus californianus* mother–pup pairs at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀).

observed could be the result of a combination of factors; for example, experience in rearing, a higher social status and her pup being 1 year older than the others.

The most common behaviour in the three mother–pup pairs studied was inactivity, which has also been observed in the wild. There are several probable causes for this, such as: (1) the animals may find it more difficult to move about in the terrestrial zone; (2) there are problems associated with releasing heat when the sea lions are out of the water; (3) inactivity is a strategy used to save energy during reproduction periods (Renouf, 1991).

In wild otariids, mothers have been observed to remain with their pups for *c.* 43% of the time and the age pups first enter the water at *c.* 28 days. During the pup's growth period, no differences were observed in the percentage of time spent with their mother but wild pups were observed to be more active and use the aquatic zones more (Renouf, 1991). However, the mothers at Barcelona Zoo spent more time (80%) with their pups, and the pups had entered the water by the age of 2 months. In the behavioural ontogeny, older pups were not more active nor did they use the aquatic zone more than the younger pups.

A study into lactation episodes in 23 California sea lion pups in the wild determined that the duration of the episodes was 10·7 minutes (642 seconds), which is 1·8% of daily activity (Oftedal *et al.*, 1987). In Cape fur seals *Arctocephalus pusillus pusillus*, the duration of lactation episodes was 16·3 minutes (978 seconds) (Carnio, 1982). These values are very different from those recorded at Barcelona Zoo, which had a mean duration of lactation of 5·18 minutes (311 seconds), half of that observed in the wild. However, the California sea lions at Barcelona Zoo were five times more active (10% of daily activity). These data show that individuals in captivity spend less time nursing and the repertoire of offspring-care behaviours is not as rich as in wild conspecifics. This is possibly because conditions in captivity are more controlled and, therefore, the mothers do not have to protect their offspring from possible predators or travel long distances looking for food. They are also not exposed to adverse weather conditions. It would appear that in the wild and for the species *Z. californianus*, the weaning age could be a function of latitude (Oftedal *et al.*, 1987).

In agreement with our study, Oftedal *et al.* (1987) show that nursing episodes can be started either by the mother or the pup; however, there seems to be evidence that it is the pup that finalizes feeding episodes (Fogden, 1971; Carnio, 1982; Macy, 1982) and determines its duration (Kastelein *et al.*, 1994). The only difference we observed was that in one of the primiparous mothers (Nora) the feeding episodes were longer when she

A		RECEIVE						
		MOTHERS			PUPS			
		NORA	FILIPPA	SPANKY	ANUBIS	GALA	LO	NONE
START	Nora				100			
	Filippa		9·5			90·5		
	Spanky						100	
	Anubis	86·2				10·3	3·4	
	Gala		93·1		3·4	3·4		
	Lo			100				

B		FINALIZE						
		MOTHERS			PUPS			
		NORA	FILIPPA	SPANKY	ANUBIS	GALA	LO	NONE
START	Nora	79·2			16·7			4·2
	Filippa		85·7			9·5		4·8
	Spanky			80			20	
	Anubis	32·8			41·4	3·4		22·4
	Gala		34·5			53·4		12·1
	Lo			18·8			37·5	43·8

C		FINALIZE						
		MOTHERS			PUPS			
		NORA	FILIPPA	SPANKY	ANUBIS	GALA	LO	NONE
RECEIVE	Nora	38			36			26
	Filippa		32·1			53·6		14·3
	Spanky			18·8			37·5	43·8
	Anubis	73·1			15·4	7·7		3·8
	Gala		74·1		14·8	11·1		
	Lo			57·1	28·6		14·3	

Table 8. Percentages of the social interaction analysis for California sea lions *Zalophus californianus* at Barcelona Zoo: A. Start–Receive; B. Start–Finalize; C. Receive–Finalize. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀). The adult ♀♀ Nora, Filippa and Spanky only interacted with their own pups (Anubis, Gala and Lo, respectively) and did not interact either with the other adult ♀♀ or with the other pups.

	ϑ^2	d.f.	*P*-VALUE
Start	52·48	12	0·001**
Receive	52·55	12	0·001**
Finalize	28·08	12	0·001**

Table 9. Chi-square values for individuals that started, received and finalized the mother–pup episodes in relation to the time of the day for California sea lions *Zalophus californianus* at Barcelona Zoo.

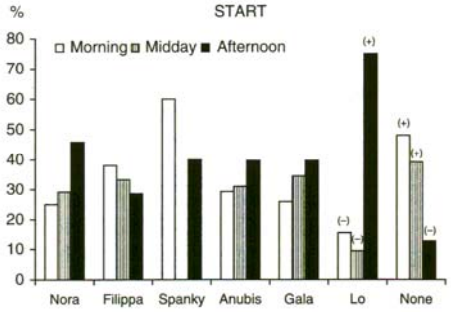

Fig. 4. Percentage of mother–pup episodes started by each California sea lion *Zalophus californianus* at different times of the day in a study at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀).

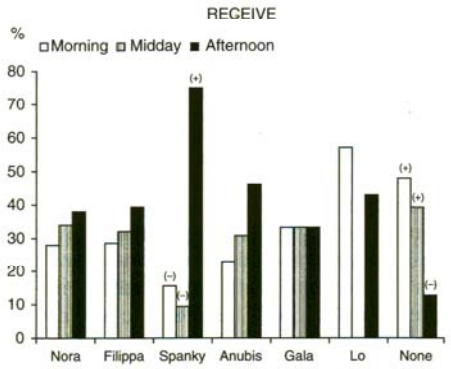

Fig. 5. Percentage of mother–pup episodes received by each California sea lion *Zalophus californianus* at different times of the day in a study at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀).

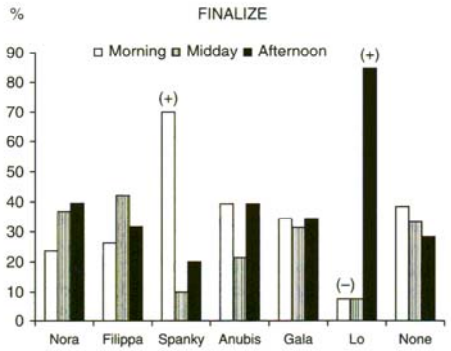

Fig. 6. Percentage of mother–pup episodes finalized by each California sea lion *Zalophus californianus* at different times of the day in a study at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀).

	H	d.f.	*P*-VALUE
Start	56·96	5	0·001**
Receive	59·10	5	0·001**
Finalize	5·72	5	0·33

Table 10. Kruskal–Wallis values that show the effect of the individual that started, received and finalized the mother–pup interactions on the duration of each episode for California sea lions *Zalophus californianus* at Barcelona Zoo.

started them (Table 11), while in the experienced mother (Spanky) they were longer if the pup (Lo) started them (Table 12).

A study on Grey seal pups in captivity showed that the nursing episodes were more frequent at night than during the day (Kastelein & Wiepkema, 1988). This result cannot be compared with the California sea lions in our study because they were not observed at night.

Another limitation of our study was the observation of whether the pinniped pups had a preferred nipple or whether they alternated nipples for nursing. All studies to date seem to show that otariids choose the nipple they nurse from by chance (Peterson & Bartholomew, 1967; Bryden, 1968; Bester, 1977; Tedman & Bryden, 1979; Kovacs, 1986). We did

	MOTHERS			PUPS		
	NORA ($n = 24$)	FILIPPA ($n = 21$)	SPANKY ($n = 5$)	ANUBIS ($n = 58$)	GALA ($n = 58$)	LO ($n = 32$)
Bond relations	5·0 ± 0·0	28·5 ± 30·4	22·0 ± 22·6	19·0 ± 29·4	3·0 ± 0·0	9·7 ± 6·3
Recognition	3·2 ± 0·5	17·7 ± 29·5	0	0	2·0 ± 1·4	29·0 ± 29·7
Locomotion	6·0 ± 0·0	17·2 ± 6·6	0	63·3 ± 39·6	64·1 ± 56·9	6·0 ± 5·6
Mother–pup location	6·4 ± 7·7	3·8 ± 1·9	2·0 ± 0·0	0	0	5·0 ± 0·0
Lactation	306·5 ± 415·1	66·0 ± 4·2	0	250·7 ± 241·1	277·6 ± 233·0	0
Aggressive vocalization	2·0 ± 0·0	1·0 ± 0·0	0	4·0 ± 1·41	0	0
Play	0	0	2·0 ± 0·0	61·7 ± 45·7	35·8 ± 22·5	587·5 ± 35·3
Inactivity	81·5 ± 19·1	0	0	303·0 ± 420·0	35·8 ± 22·2	0

Table 11. Mean+SD of the durations of the mother–pup behaviours when they were started by each of the California sea lions *Zalophus californianus* at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀): n = number of observed episodes.

	MOTHERS			PUPS		
	NORA ($n = 50$)	FILIPPA ($n = 56$)	SPANKY ($n = 32$)	ANUBIS ($n = 26$)	GALA ($n = 27$)	LO ($n = 7$)
Bond relations	19·0 ± 29·4	3·0 ± 0·0	9·7 ± 6·3	5·0 ± 0·0	28·5 ± 30·4	22·0 ± 22·6
Recognition	0	2·0 ± 1·4	29·0 ± 29·7	3·2 ± 0·5	17·7 ± 29·5	0
Locomotion	63·3 ± 39·6	60·0 ± 55·2	6·0 ± 5·6	6·0 ± 0·0	15·3 ± 6·6	0
Mother–pup location	0	5·5 ± 2·9	5·0 ± 0·0	6·4 ± 7·7	3·9 ± 1·9	2·0 ± 0·0
Lactation	250·7 ± 241·1	279·3 ± 231·2	380·8 ± 230·9	306·5 ± 415·1	40·5 ± 40·3	0
Aggressive vocalization	0	0	0	2·0 ± 0·0	1·0 ± 0·0	3·3 ± 1·5
Play	0	41·2 ± 20·5	0	9·0 ± 0·0	61·7 ± 45·7	0
Inactivity	303·0 ± 420·0	421·0 ± 0·0	587·5 ± 35·3	81·5 ± 19·1	2·0 ± 0·00	0

Table 12. Mean+SD of the durations of the mother–pup behaviours received by each of the California sea lions *Zalophus californianus* at Barcelona Zoo. The mother–pup pairs are as follows: Nora (primiparous) and Anubis (♂); Filippa (primiparous) and Gala (♀); Spanky (multiparous) and Lo (♀): n = number of observed episodes.

not gather any conclusive information on this process at Barcelona Zoo.

From the results of our study, we could not determine whether the duration of nursing episodes was longer in the older pup and there is also not enough published information on otariids to show this (Renouf, 1991). However, in different species of phocids conflicting results have been found on whether 1 year-old pups nurse for more time (Tedman & Bryden, 1979; Stewart, 1983; Kovacs, 1986).

The primiparous pairs in this study showed greater behavioural diversity (eight episodes) of offspring care than the experienced mother and her older pup (seven episodes). It was evident that the younger pups required more care and attention from their mothers; as a consequence, the average duration of the parental-care episodes was longer. However, the older pup should have been weaned by this time but its mother continued with her parental attentions. This could be because the pup born this year died (Reeves *et al.*, 2002) and/or because ♀ pups are weaned later than ♂ pups (Ono *et al.*, 1987).

It has been found in California sea lions that the larger and faster-growing ♂ pups spent a larger proportion of their time suckling (14·6%) than ♀ pups (10·7%) (Ono

et al., 1987). In our study, the pups born in the same year were of different genders and no difference was found in the time spent on nursing (40%). The only difference between the pups was that the ♂ spent more time locating his mother than the ♀ pup.

Gentry (1975) determined that play between otariid pups is more common in the ♂♂ than in the ♀♀. This is in agreement with the results found for Anubis (♂), which was the pup that started the most play episodes.

Another limitation of our study was that the pup (Lo) of the experienced mother (Spanky) was 1 year older than the pups of the primiparous mothers and, therefore, the differences found could be the result of the age of the pup and not the experience of the mother. The differences in maternal styles observed in our study seemed to be related to maternal experience and the age of the mothers and also the age of the pups. Therefore, more studies into this behavioural aspect are necessary, both in the wild and in captivity, in order to corroborate the previous hypotheses.

It is necessary to carry out more studies both in wild and in captive California sea lions as it was not possible to compare whether the social interactions (individuals that started, received and finalized episodes) were similar to the interactions in the wild or whether the sea lions used the aquatic zone more or less than they would in their natural habitat.

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PRODUCTS MENTIONED IN THE TEXT

SPSS: statistical analysis package (version 11.0, for Windows), manufactured by SPSS Inc., Chicago, IL 60606, USA.

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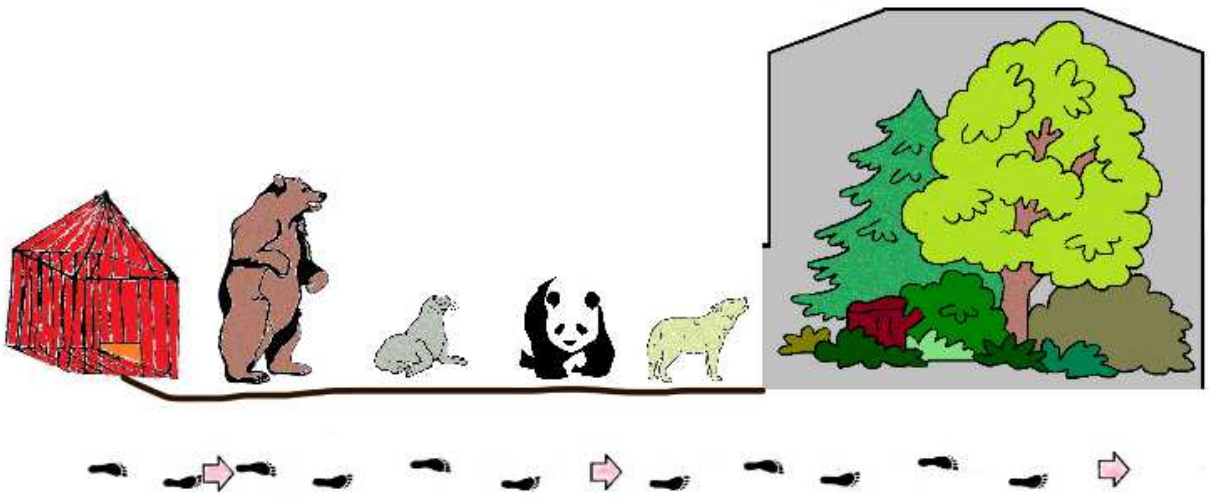
6. RESUMEN DE LAS PUBLICACIONES EN CASTELLANO



6. RESUMEN DE LAS PUBLICACIONES EN CASTELLANO

VARIACIONES ESTACIONALES EN EL PATRÓN DIARIO DE CONDUCTAS ABERRANTES DE DOS HEMBRAS DE OSO PARDO (Ursus arctos) *EN EL ZOO DE BARCELONA*

A.I. Soriano, D. Vinyoles, C. Maté (2012): Journal of Applied Animal Welfare Science (submitted).

En su hábitat natural, son cuatro las especies de osos conocidas por manifestar conductas que varían a lo largo de las estaciones del año. El objetivo de este estudio fue evaluar si las conductas aberrantes –como indicadoras del bienestar animal- presentan variaciones estacionales y diarias. Los datos se obtuvieron de dos hembras de oso pardo (*Ursus arctos*) alojadas en la misma instalación del Zoo de Barcelona (Orma y Echea). El método de registro de la conducta fue continuo, con un total de 63 horas de observación para cada uno de los individuos. Los resultados indicaron que las conductas aberrantes variaron en función de las estaciones del año. La ocurrencia de las conductas aberrantes en ambas hembras de oso pardo fue mayor durante la primavera mientras que en otoño fueron menores y en invierno mostraron valores intermedios. La hembra más longeva presentó una mayor dedicación a la conducta aberrante durante las mañanas mientras que la ocurrencia por cada sesión de la hembra joven mostró un pico durante la tarde. La frecuencia de las conductas aberrantes en la hembra longeva fue del 17%, mientras que el valor en la osa joven fue del 5%.

LA INFLUENCIA DEL PÚBLICO EN LA CONDUCTA Y EN EL USO DEL ESPACIO DE DOS ESPECIES DE ÚRSIDOS: ¿UNA CUESTIÓN DE MANEJO?.

A.I. Soriano, D. Vinyoles, C. Maté (2012): Der Zoologische Garten (submitted).

En la última década han cobrado especial importancia los estudios sobre la influencia del público en la conducta de los animales. Cada vez más, se está determinando que el público además de afectar negativamente al bienestar de los animales también puede tener un efecto positivo o neutro. Los sujetos objeto de estudio fueron dos parejas de osos: una de oso pardo (*Ursus arctos arctos*) –alojada en un zoo europeo- y otra de oso panda (*Ailuropoda melanoleuca*) -alojada en un zoo americano-. El método de registro utilizado fue focal, mientras que el método de registro fue instantáneo a intervalos de 2 min durante 34 sesiones de observación de 1h de duración por cada individuo y el total de horas de observación para cada una de las especies fue de 68 h. Los resultados demostraron que, en presencia de público, la pareja de osos pardos tuvieron mayores porcentajes en la conducta de vigilancia, locomoción, estereotipias y estacionario, mientras que en la pareja de pandas, dominaron las conductas de exploración, alimentación, manipulación, estacionario y no visible. El uso del espacio de los osos pandas fue más homogéneo que en los osos pardos, éstos en presencia de público hicieron un mayor uso de la instalación al contrario que los osos pandas. Todo parece apuntar que la conducta de los osos pardos es más susceptible a la presencia de los visitantes que la de los pandas, posiblemente debido a que su manejo no es tan adecuado ni ha sido tan estudiado como el de los osos pandas.

LA SEMINATURALIZACIÓN DE LA INSTALACIÓN DE LOS OSOS PARDOS (Ursus arctos) *DEL ZOO DE BARCELONA COMO PARTE DE UN PROGRAMA DE ENRIQUECIMIENTO ESTRUCTURAL: ¿ES SUFICIENTE PARA ASEGURAR SU BIENESTAR ANIMAL?*

A. I. Soriano, C. Ensenyat, S. Serrat, C. Maté (2006). Journal of Applied Animal Welfare Science 9 (4): 299-314.

En este estudio se utilizó el patrón de actividad diario y el uso del espacio como indicadores del posible cambio por la implementación de un programa de enriquecimiento estructural, a dos sujetos de oso pardo (*Ursus arctos*) en el Zoo de Barcelona. Se recogieron 930 puntos de registro en cada fase de estudio (Fase 1: línea base y Fase 2: evaluación del programa de enriquecimiento estructural) y para cada uno de los animales. Los registros fueron equitativos en relación a los períodos del día. Además se observó una mayor diversidad conductual en el macho que en la hembra. Con respecto a los indicadores, se obtuvieron diferencias estadísticamente significativas en el patrón de actividad diario de ambos sujetos para las 2 fases de estudio. Con el cambio de las instalaciones, ambos individuos mostraron un aumento de la vigilancia, el mantenimiento y la inactividad. En términos del bienestar animal de los sujetos, se pudo considerar que el porcentaje de las estereotipias estuvo dentro de unos límites aceptables. El porcentaje de actividad observado en el macho fue similar al de sus conspecíficos en libertad. Durante el enriquecimiento estructural, sólo se observó en el macho una mayor homogeneidad en el uso del espacio. Los dos individuos respondieron de forma diferente al enriquecimiento.

CUATRO MODELOS PARA EVALUAR LA EFECTIVIDAD DE LOS PROGRAMAS DE ENRIQUECIMIENTO AMBIENTAL: EL OSO PARDO (Ursus arctos) *COMO CASO DE ESTUDIO*

A.I. Soriano, D. Vinyoles, C. Maté (2012). Zoo Biology (submitted).

El objetivo de los programas de enriquecimiento es mejorar el bienestar de los animales en cautividad mediante los cambios en las instalaciones y/o en el manejo diario con el objeto de promover las conductas típicas de la especie y reducir las conductas aberrantes. Para conseguir este objetivo fue necesario no sólo diseñar e implementar los diferentes programas de enriquecimiento sino también evaluar y determinar su efecto. Los individuos objeto de estudio fueron un macho y dos hembras de oso pardo (*Ursus arctos*) que habitaron del Zoo de Barcelona. Se evaluaron seis ítems de enriquecimiento: cuatro de tipo alimentario (saco con fruta, brick de zumo congelado, bloque de hielo con pescado y saltamontes vivos) uno sensorial (heces de ciervo) y uno ocupacional (pelota) a lo largo de nueve sesiones de enriquecimiento. La evaluación de los ítems de enriquecimiento se realizó mediante dos criterios: el tiempo invertido por los animales en la interacción con los ítems y la variación en el uso de los ítems a lo largo de las sesiones, la cual fue analizada mediante los modelos (fluctuación, continuidad, habituación y ganancia) de eficacia del enriquecimiento. El nuevo modelo de la fluctuación se observó para las interacciones con el brick de zumo congelado y las heces de ciervo (en la hembra joven) y con el bloque de hielo con pescado (en la hembra joven y el macho). Tanto los ítems de enriquecimiento más utilizados (saco con fruta) como los menos utilizados (saltamontes vivos) siguen un modelo de continuidad, en el que se observan diferencias respecto a la duración de la interacción del animal al comparar estos dos ítems. Otros entretenimientos (brick de zumo congelado y pelota) mostraron un modelo de habituación (pérdida de la eficacia) en el que el tiempo invertido por el animal disminuye a lo largo de las sesiones. Ninguno de los ítems de enriquecimiento de este estudio siguió un modelo de ganancia de la eficacia.

LOS CAMBIOS COMPORTAMENTALES Y DE USO DEL ESPACIO ASOCIADOS A LA MUERTE DEL MACHO DOMINANTE DE UNA MANADA DE LOBOS IBÉRICOS (Canis lupus signatus) *EN EL PARQUE ZOOLÓGICO DE BARCELONA*

A. I. Soriano, S. Serrat, C. Ensenyat, C. Riba, C. Maté (2006). Anuario de Psicología 37 (1): 141-155.

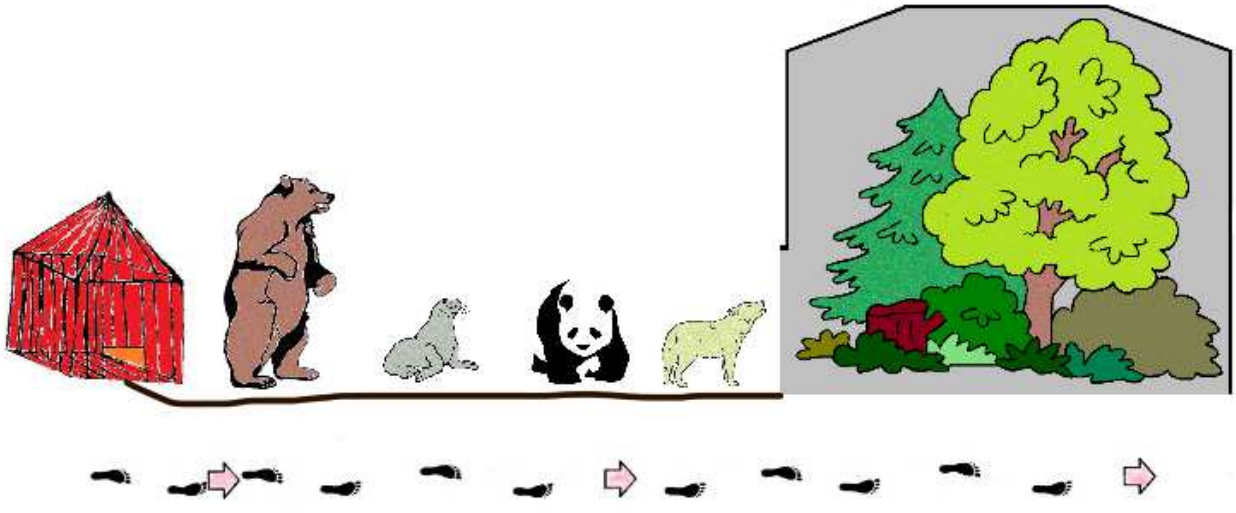
La dinámica social es uno de los campos más estudiados de la familia Canidae en condiciones de cautividad. En este estudio se pretende determinar cómo la muerte del macho dominante de una manada de lobos alojados en el Parque Zoológico de Barcelona afecta al patrón de actividad diario y al uso del espacio del resto de conspecíficos. Los individuos objetos de estudio son dos machos y dos hembras de la especie *Canis lupus signatus* alojados en una instalación naturalizada. Las observaciones se realizaron mediante un estudio multifocal instantáneo cada 15 minutos. El número total de horas de observación fue de 55,5 para cada uno de los individuos tanto en la fase previa como en la fase posterior a la defunción del macho alfa. Los resultados obtenidos en el patrón de actividad diario muestran un aumento de las conductas de *Vigilancia* y *Mantenimiento* y *No Visible* y una disminución en la *Inactividad*. En cuanto al uso del espacio, aumenta la utilización de la zona *Centro Izquierda*, disminuye *Centro Anterior* mientras que no existen variaciones en *Izquierda Posterior*. Además la localización de los animales es menos homogénea tras la defunción.

RELACIONES MATERNOFILIALES EN TRES MADRES Y TRES CRÍAS DE LEÓN MARINO DE CALIFORNIA (Zalophus californianus) *EN EL ZOO DE BARCELONA*

A. I. Soriano, E. González, C. Maté (2009). International Zoo Yearbook 43: 176-188.

El limitado número de estudios sobre la conducta maternal en cautividad realizados en el león marino de California (*Zalophus californianus*) indican que es necesario el estudio en detalle de su biología y su conducta con el objeto de contribuir al manejo de los animales y a la conservación de su información genética y del hábitat de la especie. Este estudio incluyó tres hembras adultas, dos de ellas madres primíparas y una no primípara, y sus crías. El período de estudio fue de Julio a Noviembre de 2003. La regla de muestreo fue focal y la de registro continua. La duración de las sesiones de observación fue de 10 minutos. Se analizaron veinticuatro horas de observación por cada uno de los individuos, resultando un total de 4 horas de observación por cada uno de los animales repartidas de forma equitativa para los tres períodos del día (mañana, mediodía y tarde). La localización de los individuos y las conductas lúdicas no se observaron en la madre experimentada, aunque invirtió más tiempo en la lactancia que las madres primíparas y su cría se observó más tiempo inactiva. El uso del espacio fue similar en las tres parejas maternofiliales. Las madres primíparas iniciaron, recibieron y finalizaron más episodios con sus crías que la madre experimentada que interactuó más con su cría durante la tarde. La cría de la madre experimentada recibió más vocalizaciones agresivas que las crías de las madres primíparas.

7. INFORME DE LAS DIRECTORAS



7. INFORME DE LAS DIRECTORAS

Como Directoras de la Tesis Doctoral realizada por:

Ana Isabel Soriano Jiménez, presentamos el siguiente informe sobre la contribución de la doctoranda en las publicaciones en coautoría presentadas en la tesis:

SECCIÓN 1

A.I. Soriano, D. Vinyoles, C. Maté. Seasonal variation of the daily aberrant behavior of the two female brown bears (*Ursus arctos*) in the Barcelona Zoo. *Journal of Applied Animal Welfare Science*. Submitted.

Contribución de la doctoranda: participación en el diseño del trabajo, realización del muestreo, realización de los análisis, redacción de la primera versión del manuscrito y revisiones posteriores.

Contribución de los otros autores: DV, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito; CM, concepción del trabajo, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito.

"Journal of Applied Animal Welfare Science" tiene en la última edición disponible del *Journal Citation Reports* (JRC) correspondiente a 2010, un índice de impacto de 0.593. Esta revista se encuentra en el número 84 de 145 en el área de ciencias veterinarias.

SECCIÓN 2

A.I. Soriano, D. Vinyoles, C. Maté. The visitors influence on the behaviour and the space use in two species of ursids: a management question? *Der Zoologische Garten*. Submitted.

Contribución de la doctoranda: participación en el diseño del trabajo, realización del muestreo, realización de los análisis, redacción de la primera versión del manuscrito y revisiones posteriores.

Contribución de los otros autores: DV, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito; CM, concepción del trabajo, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito.

"Der Zoologische Garten" no aparece como revista citada en el *Journal Citation Reports* (JRC). Esta es una revista alemana que se publica desde 1859 por el zoo de Berlín.

SECCIÓN 3

A.I. Soriano, C. Ensenyat, S. Serrat, C. Maté (2006) Introducing a semi-naturalistic exhibit as structural enrichment for two brown bears (*Ursus actos*). Does this ensure their captive well-being? *Journal of Applied Animal Welfare Science* 9(4): 299-314.

Contribución de la doctoranda: participación en el diseño del trabajo, realización del muestreo, realización de los análisis, redacción de la primera versión del manuscrito y revisiones posteriores.

Contribución de los otros autores: CE, participación en el diseño del trabajo; SS, participación en el diseño del trabajo; CM, concepción del trabajo, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito.

"Journal of Applied Animal Welfare Science" tiene, en la última edición disponible del *Journal Citation Reports* (JRC) correspondiente a 2010, un índice de impacto de 0.593. Esta revista se encuentra en el número 84 de 145 en el área de ciencias veterinarias.

SECCIÓN 4

A.I. Soriano, D. Vinyoles, C. Maté. Four models to assess the effectiveness of environmental enrichment: the brown bear (*Ursus arctos*) as a case study. *Zoo Biology*. Submitted.

Contribución de la doctoranda: Participación en el diseño del trabajo, realización del muestreo, realización de los análisis, redacción de la primera versión del manuscrito y revisiones posteriores.

Contribución de los otros autores: DV, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito; CM, concepción del trabajo, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito.

"Zoo Biology" tiene, en la última edición disponible del *Journal Citation Reports* (JRC) correspondiente a 2010, un índice de impacto de 0.663. Esta revista se encuentra en el número 79 de 145 revistas en el área de ciencias veterinarias, y en el número 97 de 145 en lo que se refiere a revistas especializadas en zoología.

SECCIÓN 5

A.I. Soriano, S. Serrat, C. Ensenyat, C. Riba, C. Mate (2006) Los cambios comportamentales y del uso del espacio asociados a la muerte del macho dominante de una manada de lobos ibéricos (*Canis lupus signatus*) en el Parque Zoológico de Barcelona. *Anuario de Psicología* 37(1-2): 141-155.

Contribución de la doctoranda: participación en el diseño del trabajo, realización del muestreo, realización de los análisis, redacción de la primera versión del manuscrito y revisiones posteriores.

Contribución de los otros autores: SS, participación en el diseño del trabajo y realización de los análisis; CE, participación en el diseño del trabajo; CR, participación en el diseño del trabajo y revisiones posteriores; CM, concepción del trabajo, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito.

"Anuario de Psicología" no aparece como revista citada en el *Journal Citation Reports* (JRC). Esta es una revista de ámbito nacional que desde 1969 se publica por la facultad de psicología de la Universidad de Barcelona.

SECCIÓN 6

A.I. Soriano, R. González, C. Maté (2009) A study into the mother-pup relationship in three California sea lion *Zalophus californianus* mothers and pups at Barcelona Zoo. *International Zoo Yearbook* 43: 176-188.

Contribución de la doctoranda: participación en el diseño del trabajo, realización de los análisis, redacción de la primera versión del manuscrito y revisiones posteriores.

Contribución de los otros autores: RG, realización del muestreo; CM, concepción del trabajo, participación en el diseño, en la supervisión del trabajo y la redacción del manuscrito.

"International Zoo Yearbook " tiene, en la última edición disponible del *Journal Citation Reports* (JRC) correspondiente a 2010 un índice de impacto pendiente de computerizarse.

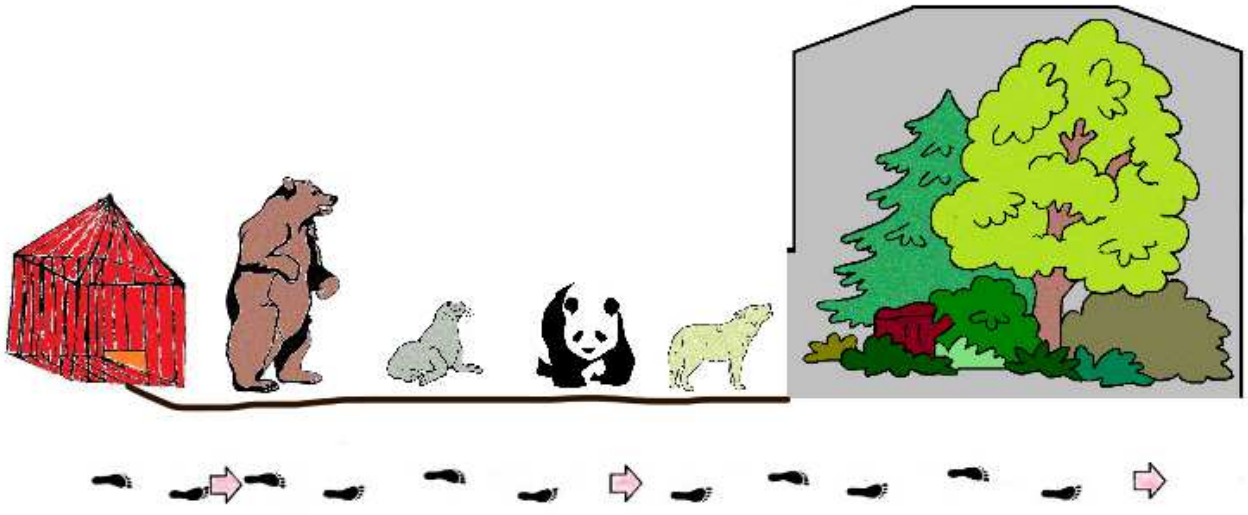
De la misma manera se informa que ninguno de los coautores participantes en los artículos que componen esta tesis ha utilizado, implícitamente o explícitamente, estos trabajos para la elaboración de su propia tesis doctoral.

Barcelona, a 15 de Septiembre de 2012

Dra. Carme Maté García
Agència d' Ecologia Urbana

Dra. Dolors Vinyoles Cartanyà
Departamento de Biología Animal
Facultad de Biología (UB)

8. DISCUSIÓN GENERAL



8. DISCUSIÓN GENERAL

A lo largo de los años, los objetivos y diseño de los zoos han ido evolucionando. Los zoos centenarios tienen generalmente su origen en colecciones particulares que cuando se abrieron al público solían mostrar a los ejemplares en jaulas, ordenadas más o menos con criterios taxonómicos. Desde hace unas décadas, los zoológicos se han transformado, mostrando las colecciones en dioramas, más o menos descriptivos del contexto ecológico y biogeográfico. En el siglo XXI, los zoos deberían convertirse en verdaderos centros de conservación de la biodiversidad con instalaciones de inmersión (Zimmerman *et al*., 2007). No obstante, en este proceso de cambio se cuestiona la razón de ser de los zoos sobretodo cuando no siempre garantizan el bienestar de los animales. A pesar de que durante las últimas tres décadas se haya reforzado el importante papel que pueden desempeñar los zoos en la conservación, no todos enfocan sus esfuerzos y recursos para alcanzarlo. Dicho objetivo está estrechamente relacionado con la realización de tareas de investigación en condiciones de cautividad. La conservación en los núcleos zoológicos no se puede alcanzar sin antes proporcionar a los animales las condiciones de vida adecuadas que garanticen su bienestar, así como tampoco se pueden plantear programas de conservación sin un buen asesoramiento científico y sin la colaboración de un buen equipo de expertos en dichos programas. En contra de la justificación de la función educativa de los zoos, están los nuevos métodos pedagógicos surgidos con el desarrollo de las nuevas tecnologías, el auge del ecoturismo y la creciente sensibilidad de la sociedad por el bienestar de los animales, lo cual contribuye a que la justificación de la cautividad de los animales con fines educativos se ponga en tela de juicio. En los zoos españoles, el entretenimiento del público se potencia más que el resto de los objetivos y no se pone tanto énfasis ni se destinan suficientes recursos en los otros pilares básicos como son la conservación y de la investigación. Para cambiar la función recreativa tradicional de los zoos españoles hacia un compromiso relevante en la conservación, la investigación y la educación, éstos deberían cumplir con lo estipulado por la ley 31/2003 *de conservación de la fauna silvestre en los parques zoológicos* (Rodríguez-Guerra & Guillén-Salazar,

2007). Desde que esta ley entró en vigor, todavía no se ha observado ningún avance significativo, probablemente debido a que el cumplimiento de los nuevos objetivos y requisitos requiere una profunda revisión de la actividad tradicional que desempeñan los zoos (Rodríguez-Guerra, 2006). Un informe (*The EU Zoo Inquiry, 2011*) elaborado por dos ONGs europeas destaca que el 72% de los más de 4.000 parques zoológicos europeos son deficientes, mantienen a sus animales en condiciones inadecuadas y no cumplen en su objetivo de conservar la biodiversidad. Esto contrasta con la dinámica emprendida por los zoos norteamericanos, que parecen tener los más altos estándares de bienestar animal del mundo así como la implicación en los programas de conservación de las especies más amenazadas del planeta. El principal objetivo de los zoos del futuro debería ser la conservación de la biodiversidad con la participación en programas de conservación tanto "ex situ" como "in situ" (Fa *et al*., 2011).

Los trabajos realizados en este estudio ponen de manifiesto que el bienestar de los animales en cautividad depende de múltiples factores y que puede ser mejorado por diferentes vías. Los indicadores del grado de bienestar animal utilizados en este estudio fueron el patrón de actividad diario, la ocurrencia de conductas aberrantes, el grado de homogeneidad en el uso del espacio y los tipos de interacciones sociales entre los miembros de un grupo bajo el efecto de diferentes condiciones capaces de alterarlo como la presencia del público, la implementación de programas de enriquecimiento (estructural, alimentario, sensorial y ocupacional) y los cambios en la composición social de un grupo ya sean provocados por la muerte o por el nacimiento de los individuos.

La valoración del bienestar animal requiere de diversas aproximaciones, una de ellas plantea la comparación del patrón de actividad diario en condiciones de cautividad con respecto al que muestran en su hábitat natural. Los resultados obtenidos muestran que el porcentaje de la actividad en verano del macho de oso pardo en cautividad fue semejante al de libertad. También se obtuvieron porcentajes similares a los observados en la naturaleza respecto a la conducta lúdica de las crías macho del león marino de California. Los estudios

realizados tanto en libertad como en otros zoos, deberían tenerse en cuenta más a menudo, ser los referentes para determinar el bienestar animal en cautividad ya que proporcionan información útil acerca de la composición y la naturaleza de los grupos de animales, aportando información básica para el diseño y el tamaño de la instalación, la variación estacional de la actividad, las necesidades climatológicas y las enfermedades más habituales de la especie (Snyder, 1975; Veasey *et al*., 1996; Hosey *et al*., 2009; Shivik *et al*., 2009).

Por otra parte, el estudio de las conductas aberrantes también es una herramienta que sirve para determinar el grado de bienestar animal en el sentido contrario, pues la observación y cuantificación de dicha conducta cuestiona el bienestar animal. Las conductas aberrantes de las dos hembras de oso pardo de este estudio, mostraron una variación estacional coincidiendo con lo observado en el oso negro americano del estudio de Carlstead y Seidensticker (1991), siendo éstas dos las únicas publicaciones que existen hasta el momento sobre este tema. Serían necesarios más trabajos sobre la variación diaria y estacional de estos comportamientos, con el objeto de disminuir este tipo de conductas mediante la mejora de su manejo en cautividad, tal y como propone Rees (2011). Las variaciones diarias y estacionales permiten cambiar y/o introducir nuevos factores en el manejo diario de los animales como por ejemplo: la variación horaria de la presentación de la comida o del enriquecimiento, el cambio de la composición de la dieta en función de la estación del año, la variación artificial de las condiciones climáticas de la instalación, etc. Para ello se deben tener en cuenta los ritmos circadianos y los ritmos estacionales propios de cada especie (Roots, 2006). En los zoos, la mayor actividad del personal se realiza durante el día, de este modo, no ha resultado ni resulta fácil, detectar las conductas aberrantes de los animales nocturnos y/o crepusculares, cuya actividad se muestra en las horas de menor presencia de personal y por tanto, son más difíciles de detectar y en consecuencia, de tratar y erradicar. El estudio de este tipo de animales es cada vez más accesible gracias al desarrollo de las últimas tecnologías (web cams, cámaras de visión nocturna, iluminación especializada para la inversión de la noche y el día, entre otros).

El tercer indicador analizado en este estudio fue el uso del espacio, que resultó más homogéneo en el oso panda y en el oso pardo tras aplicar un programa de enriquecimiento estructural. En cambio en el lobo ibérico, el uso del espacio fue más heterogéneo cuando la composición social de la manada de lobo ibérico cambió tras la pérdida del macho alfa. La heterogeneidad en el uso del espacio indica, en la mayoría de los casos, un mayor grado de bienestar de los animales y ha sido utilizado para este fin en diferentes especies de mamíferos (Dickens, 1955; Shepherdson *et al*., 1993). El índice más utilizado hasta la fecha (SPI: *Spread of Participation Index*) nos aporta una información unidimensional y/o bidimensional de la zona de la instalación que más utiliza el animal (Dickens, 1955) pero existe otro índice (EI: *Electivity Index*) más moderno que permite estudiar el uso tridimensional que hacen los animales de las diferentes zonas de una instalación, incluyendo su mobiliario (Ross *et al*., 2009). Este último índice nos proporciona una información más detallada sobre el uso del mobiliario que realizan los animales, presentándose por consiguiente como una herramienta útil tanto para diseñar cambios estructurales en instalaciones antiguas como para la creación de nuevas.

El otro indicador investigado en este estudio fue la influencia del público y depende de varios factores: 1) Los intrínsecos a los animales y los que más influencia ejercen sobre su bienestar, como por ejemplo, el diseño de la instalación y las diferentes técnicas de manejo [la alimentación, la socialización, el enriquecimiento, el entrenamiento y los horarios de exposición al público, entre otros, como ponen en evidencia los resultados de este estudio y de muchos otros (ver, por ejemplo, Davey, 2007; Fernández *et al*., 2009)]; 2) Los intrínsecos al zoo como son los programas educativos y los paneles informativos que deberían modificar el hábito de dar comida a los animales (así como gritar, lanzar objetos, tocar, etc.) y que ejercen una gran influencia en el bienestar de los animales (Farrand & Buchanan-Smith, 2005). Deberían aquí incluirse también la existencia de ciertas rutinas incorrectas, como la de recompensar a los animales cada vez que acceden a las instalaciones interiores a última hora del día (coincidiendo con el momento en que los animales tienen a su disposición gran parte de la comida de su dieta), ya que este manejo

potencia la aparición de las conductas aberrantes produciéndose la resolución de una conducta apetitiva -consumo de comida- (Timberlake & Silva, 1995). Otros factores dentro de este apartado son los ruidos ocasionados por obras, actividades de mantenimiento y jardinería, que pueden afectar al bienestar de los animales (Owen *et al*., 2004; Powell *et al*., 2006); 3) Extrínsecos al zoo pero previsibles como son el número de visitantes que recibe y que, en muchos casos, está relacionado con más comida y más ruido (Kuhar, 2008; Choo *et al*., 2011).

En el presente estudio, la influencia del público fue evaluada en dos especies diferentes de osos que habitaban en dos zoos cuyo manejo, formación y condiciones económicas [el coste anual para el personal y la alimentación de una pareja de osos pardos en cautividad puede estar alrededor de unos 30.000 € mientras que el mismo valor para una pareja de osos panda puede llegar a ser el triple (Maple, 2000)] también fueron diferentes. El manejo de los osos pardos del zoo de Barcelona se podría definir como "básico" caracterizándose por un programa de enriquecimiento diario y una dieta en una sola toma, en una instalación seminaturalizada de tipo foso y un dormitorio de escasas dimensiones. El público no recibe ninguna indicación de cómo actuar delante de la instalación de estos animales. El manejo de los osos pandas se podría definir como "complejo" e incluyó: una instalación exterior, una instalación interior y un dormitorio climatizados, un programa de enriquecimiento y otro de entrenamiento, una dieta distribuida en diferentes tomas y un manejo social que permitía la socialización del macho y la hembra durante ciertas horas al día. El público del zoo de Atlanta tiene prohibido comer, beber o fumar en la instalación de estos animales y además parecen más respetuosos con los animales ya que no gritan, no dan golpes ni llaman la atención de los animales. Evidentemente, el diferente tipo de manejo de estos animales condiciona su grado de bienestar y, en consecuencia, su grado de susceptibilidad a la influencia de los visitantes, un hecho que ya había sido observado por Mallapur y cols. (2004) y por Carder y Semple (2008), en otras especies de mamíferos.

Por otra parte, la cantidad de visitantes se relaciona también con la ocurrencia e intensidad de las conductas aberrantes que presentan los

animales, con su grado de actividad y sus niveles de agresividad (Guillén-Salazar *et al.*, 2002; Pifarré *et al.*, 2012). La presencia de visitantes ejerce una clara influencia en el bienestar de los animales y se podría aminorar con varias actuaciones, como por ejemplo, utilizar a los voluntarios para cambiar actitudes en aquellas instalaciones donde existe una mayor afluencia de público y/o donde se lanza más comida, colocar vallas de protección para evitar los golpes en los cristales de las instalaciones de tipo diorama y el contacto directo entre los visitantes y los animales, etc. En muchas ocasiones un buen manejo puede verse truncado si no existe una buena educación e información del público así como una buena predicción y planificación de los días de afluencia masiva de visitantes. Para evitar un conflicto de intereses entre el bienestar de los animales y el ocio de los visitantes, es necesario realizar investigaciones sobre el comportamiento del público teniendo en cuenta diferentes variables como el tiempo que éste invierte en cada una de las instalaciones, las emociones que en él despierta cada una de las especies y los recorridos que se realizan con más asiduidad, con el objeto de hacer las visitas más interesantes y educativas, además de ayudar en los estudios de márquetin de estas instituciones (Margulis *et al.*, 2003; Ross & Gillespie, 2009).

Otro de los aspectos abordados en este estudio ha sido la efectividad de los programas de enriquecimiento. Los estudios realizados hasta el momento han sido más numerosos en primates y en carnívoros, quizás por tratarse de los taxa que más especies exhiben en los zoos, y por ser también éstos los grupos de animales más susceptibles a desarrollar conductas anormales (Shyne, 2006). Los programas de enriquecimiento ayudan a mejorar el bienestar de las especies en condiciones de cautividad pero es necesario que dichos programas estén acompañados de un buen manejo diario de los animales (Markowitz, 2011). De acuerdo con Hosey y cols. (2009) los resultados de este estudio sugieren también que los programas de enriquecimiento deberían ir acompañados de un diseño idóneo de la instalación, una composición adecuada del grupo, una dieta equilibrada, un cuidado veterinario y un programa de entrenamiento para que el efecto del enriquecimiento sea máximo. El futuro de los programas de enriquecimiento y, basándonos en lo que ya apuntan las

últimas investigaciones, tiende a centrarse en la evaluación de los ítems de enriquecimiento y en cómo los animales se habitúan, o no, provocando una pérdida de interés (Plowman & Knowles, 2001; Anderson *et al*., 2010; Hoy *et al*., 2010). En el presente estudio, para estandarizar los resultados, se han descrito cuatro modelos sobre la eficacia de los ítems que componen los programas de enriquecimiento a lo largo del tiempo: ganancia, habituación (pérdida de la eficacia), fluctuación y continuidad. Es necesario que se realicen más investigaciones con el objeto de determinar si estos cuatro modelos podrían extrapolarse a otras especies, a otros ítems de enriquecimiento y quizás conseguir una metodología única para la fase de evaluación. Además, en este punto, sería conveniente que todos los estudios sobre la evaluación de los ítems de enriquecimiento siguieran unas mismas fases de estudio, conocidas como SPIDER (*S: setting goals; P: Planning; I: Implementing; D: Documenting; E: Evaluating; R: Readjusting*) para poder realizar comparaciones y obtener un máximo rendimiento de los resultados obtenidos (Ross, 1999; Sevenich & Mellen, 1999; Rees, 2011). Además se podría elaborar una base de datos sobre la evaluación de los programas de enriquecimiento para cada especie y/o taxón para determinar cuáles son los ítems que mejor funcionan, junto con otras variables que pueden ser de valiosa información teniendo en cuenta que existen variaciones individuales dentro de la misma especie. El acceso a la base de datos lo tendrían todas las instituciones que trabajan con animales en cautividad como zoos, laboratorios y centros de recuperación, y sería una apreciable fuente de información que ahorraría trabajo a los investigadores, a los cuidadores y que mejoraría sustancialmente el bienestar de los animales. En este estudio, la seminaturalización de la instalación en la que se albergaban los osos pardos, pareció no ser suficiente para mejorar el bienestar de estos animales, a pesar de obtenerse un cambio positivo en el patrón de actividad diario y en el uso del espacio del macho; este programa de enriquecimiento sólo tuvo un efecto neutro en el caso de la hembra (habría sido de esperar que ambos ejemplares hubieran salido beneficiados del enriquecimiento para poder considerar que éste fue efectivo). En otras especies de mamíferos, sin embargo, sí se observó una mejora en su bienestar tras la aplicación de un

enriquecimiento estructural (Brummer *et al*., 2010; Clark *et al*., 2012), lo que pudo estar influido por el hecho de haberse realizado a corto plazo a diferencia del presente estudio (realizado a largo plazo y con información más detallada obtenida diariamente).

Otro de los requisitos a tener en cuenta para mejorar el bienestar de los animales en cautividad es el factor social. En condiciones de libertad, y a diferencia de la cautividad, los individuos presentan dos tipos de interacciones sociales: 1) Intraespecíficas, ya sea entre los miembros del mismo grupo o entre individuos pertenecientes a diferentes grupos (competidores o aliados); 2) Interespecíficas: las presas, los depredadores y/o los competidores por un mismo recurso. En los zoos más modernos se intenta que estas interacciones sean lo más semejantes posible a las que se producen en el medio natural, lo que conlleva diseñar instalaciones multiespecíficas capaces de garantizar el bienestar de los animales mediante un tipo de enriquecimiento social. Evidentemente, en este tipo de instalaciones el manejo diario y las investigaciones son más complejos que los grupos que permanecen solos. Pero, por otra parte, dentro de este apartado se contempla también el efecto que puede tener la muerte o desaparición de alguno de los miembros del grupo sobre el resto de individuos. Este aspecto ha sido abordado en la presente memoria mediante el estudio de una manada de lobo ibérico tras la muerte del macho alfa. En los zoos, cuando ocurre la desaparición de uno de los miembros dentro de un grupo, lo más idóneo sería observar si sucede lo mismo que en condiciones de libertad, donde en algunos mamíferos se ha descrito un período de luto (Maté, 2005). Las nuevas incorporaciones, por remplazo, suelen provenir de otros centros zoológicos o de zoos- con los que se participa en programas de cría en cautividad. Según los resultados del estudio realizado en el lobo ibérico, la desaparición del macho alfa produjo, cambios en la estructura y la dinámica del grupo debido a las modificaciones que se produjeron en el status de algunos de sus miembros, coincidiendo con lo descrito por otros autores en condiciones de libertad (Whilde & Marples, 2010). Los estudios tanto en libertad como en cautividad sobre el efecto de la muerte de los animales en

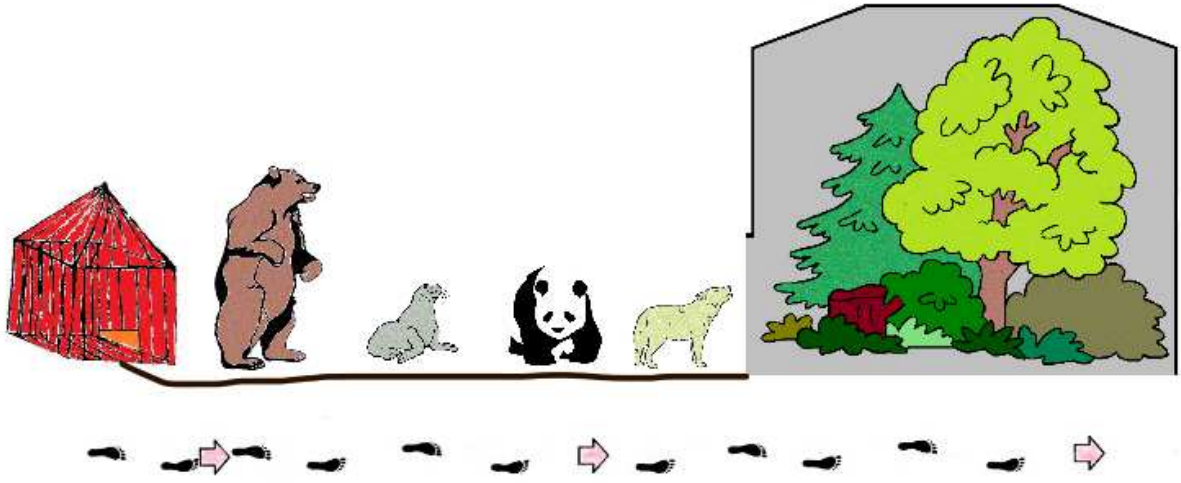
el resto del grupo son escasos y deberían realizarse más investigaciones en este ámbito (Dudziski *et al*., 2003; Warren & Williamson, 2004; Less *et al*., 2010).

En los estudios que integran la presente memoria no se llevaron a cabo correlaciones entre los indicadores del grado de bienestar animal y los indicadores hormonales del estrés (glucocorticoides), aunque investigaciones recientes ponen de manifiesto su relevancia y su frecuente aplicación en un futuro muy próximo. Existen publicaciones que relacionan los factores etológicos con factores hormonales, y que éstos últimos muestran variaciones en función de la estacionalidad (Huber *et al*., 2003), la afluencia de público (Rajagopal *et al*., 2011; Pifarré *et al*., 2012), la aplicación de programas de enriquecimiento (Carlstead *et al*., 1993; Liu *et al*., 2006; Shivik *et al*., 2009) y las variaciones en la composición de los grupos –muerte y/o nacimientos- (Doyle *et al*., 2008). Por otra parte, los factores que determinan el bienestar animal comprenden, además de los aspectos analizados en esta memoria, requerimientos climatológicos determinados, una dieta equilibrada, la estimulación física y/o psicológica y ciertos cuidados veterinarios. La clave para garantizar el bienestar de los animales radica en estudiar minuciosamente las necesidades físicas y psicológicas de los mismos a través del estudio de la historia natural de las especies, así como de los trabajos realizados en otros zoos.

El comportamiento de los animales viene condicionado por una parte genética o instintiva -que sería la porción menos variable y por tanto más comparativa- y una parte ambiental o de aprendizaje, mucho más difícil de controlar y por lo tanto de cotejar. Las diferencias que se presentan entre las condiciones impuestas por la vida en cautividad y las que se presentan en el hábitat natural de una especie van a condicionar, en mayor o menor medida, la expresión del repertorio comportamental de dicha especie. En condiciones de libertad la conducta de un animal resulta de una combinación equiparada entre la parte ambiental y la parte genética. Sin embargo, en condiciones de cautividad (con frecuencia inadecuadas), la parte ambiental tenderá a adquirir una mayor influencia sobre la conducta que la parte instintiva. Cuando la conducta de componente genético no se puede expresar de forma adecuada en

condiciones de cautividad (p.e., el comportamiento reproductor y el comportamiento de caza), ello conduce a la frustración y, en consecuencia, a la aparición de conductas aberrantes (Hosey *et al.*, 2009). Por ello, si bien es cierto que los factores que influyen en el bienestar animal deberían tenerse en cuenta a la hora de albergar ejemplares en condiciones de cautividad, por otra parte (y teniendo en cuenta la cantidad de factores que influyen su conducta bajo tales condiciones), la comparación de resultados con datos obtenidos en condiciones de libertad debería realizarse con mucha cautela.

9. CONCLUSIONES



9. CONCLUSIONES

Conductas aberrantes en el oso pardo (Ursus arctos)

- Las conductas aberrantes en las hembras de oso pardo analizadas representaron por término medio entre un 5 y un 17% de su actividad diaria (superando, en este último caso, el máximo aceptable en términos de bienestar animal, y que se sitúa en un 10%).
- La frecuencia de conductas aberrantes en las dos osas del Zoo de Barcelona varió en función de la estación del año.
- La frecuencia de las conductas aberrantes en ambas hembras de oso pardo fue mayor durante la primavera (asociado a un período de mayor actividad relacionado con la época de celo) mientras que en otoño fueron menores y en invierno mostraron valores intermedios.
- Una de las osas presentó una mayor frecuencia de conductas aberrantes durante las mañanas, mientras que en la otra de las osas estudiadas la ocurrencia de las mencionadas conductas mostró un pico durante la tarde (coincidiendo con la proximidad de la hora de la comida).

Influencia del público en dos especies de úrsidos

- En presencia de los visitantes, los osos pardos mostraron un aumento estadísticamente significativo de la vigilancia, la locomoción, las estereotipias y la inactividad.
- En presencia de visitantes, los osos pandas mostraron un aumento estadísticamente significativo de la alimentación, la manipulación, la inactividad y la conducta de no visible.
- El uso del espacio de los osos pardos fue menos homogéneo que en los osos pandas independientemente de la presencia o ausencia de público.
- Los osos pandas utilizan las zonas anterior y posterior de forma similar.

- En presencia de los visitantes, los osos pardos mostraron un uso del espacio más homogéneo que sin público y en ambos casos, utilizaron más las zonas posteriores que las anteriores.

***Enriquecimiento estructural en el oso pardo* (U. arctos)**

- Con el enriquecimiento estructural se consiguió un aumento de las conductas de vigilancia, mantenimiento e inactividad en los dos sujetos, lo que no se interpreta como una mejora del bienestar.
- En la hembra no se observaron estereotipias y la frecuencia de estereotipias del macho no registró variaciones con el cambio manteniéndose dentro de los limites aceptables (<10%).
- Con la remodelación de la instalación únicamente el macho de oso pardo alcanzó un nivel de actividad similar al observado en sus coespecíficos en libertad para la misma época del año (verano) y mostró un uso más homogéneo del espacio disponible.
- Los dos ejemplares de oso pardo (un macho y una hembra) estudiados respondieron de forma diferente al enriquecimiento estructural.

***Modelos de evaluación de los ítems de un programa de enriquecimiento alimentario, ocupacional y sensorial en el oso pardo* (U. arctos)**

- Los ítems de enriquecimiento alimentario fueron más usados por los osos pardos que los de tipo ocupacional y sensorial.
- El ítem de enriquecimiento más eficaz fue el saco con fruta que presentó modelo de eficacia basado en la continuidad.
- El nuevo modelo de fluctuación se observó con el brick de zumo congelado y las heces de ciervo (en la hembra joven) y con el bloque de hielo con pescado (en la hembra joven y en el macho).
- El modelo de continuidad se observó en los saltamontes vivos y en el saco con fruta para el caso de las dos hembras de oso pardo.

- El modelo de habituación se observó con la pelota (para las dos hembras) y con el brick de zumo congelado (en la hembra mayor).
- Para ninguno de los ítems estudiados se observó el modelo de ganancia de la eficacia del ítem.

Cambios en la estructura social de una manada de lobo ibérico **(Canis lupus signatus)** ***por la muerte del macho alfa***

- La desaparición del macho alfa provocó un aumento en la frecuencia de la conducta de vigilancia, mantenimiento y no visible, así como una disminución de la conducta estacionaria en el grupo, lo que se interpreta como un proceso de cambio para restablecer la estructura social (grado de cohesión y equilibrio social entre los individuos).
- La desaparición del macho alfa provocó un aumento de la frecuencia de "no visible", coincidiendo con lo descrito bajo las mismas circunstancias en varias especies de animales sociales tanto en cautividad como en libertad.
- La desaparición del macho alfa provocó una utilización menos homogénea del espacio disponible por parte de los individuos del grupo, que pasaron a permanecer más tiempo en zonas concretas de la instalación.

Interacciones maternofiliales en el león marino de California **(Zalophus californianus)**

- La conducta de inactividad fue la más observada durante los episodios de interacciones maternofiliales entre tres hembras y sus crías de león marino de California en el Zoo de Barcelona, manteniéndose en porcentajes similares a los obtenidos en condiciones de libertad.
- Las madres de león marino de California de este estudio permanecieron un 80% del tiempo con sus crías, lo que sugiere una mayor dedicación en sustitución de otras actividades que no pueden desarrollarse en condiciones de cautividad.

- En condiciones de cautividad, las crías inician su actividad en el medio acuático a los dos meses de su nacimiento, dos veces más tarde que en libertad.
- La duración de los episodios de lactación y el repertorio conductual de los animales en cautividad, fueron menores que los observados en libertad.
- En el Zoo de Barcelona, la duración de los episodios de lactancia en las crías macho y hembra no mostró diferencias estadísticamente significativas, al contrario de lo observado en condiciones de libertad donde se muestran diferencias entre las crías machos y hembras.
- La cría macho del Zoo de Barcelona, presentó más episodios lúdicos que la hembra de su misma edad, al igual que lo observado en libertad.

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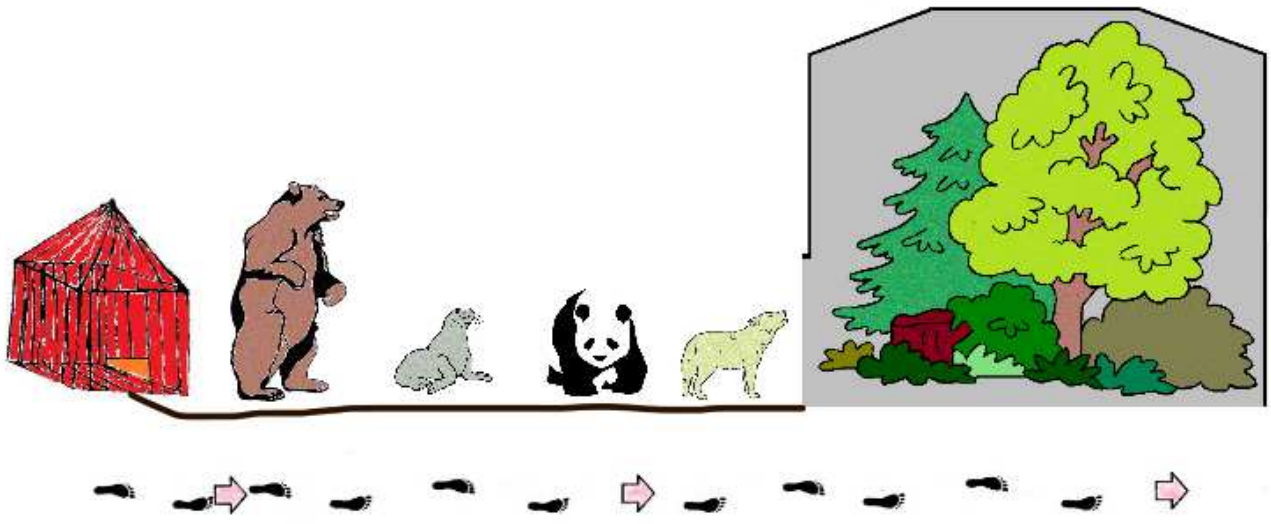

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En la actualidad, los cuatro objetivos de los zoos modernos son la educación, la investigación, la conservación y el ocio. Esta tesis se centró en la evaluación de algunos indicadores de bienestar animal en cuatro especies de mamíferos en condiciones de cautividad (el patrón de actividad diario, la ocurrencia de conductas aberrantes, el uso del espacio y las interacciones sociales). Los principales resultados obtenidos en este estudio pueden resumirse en: 1) Las conductas aberrantes de dos hembras de oso pardo (*Ursus arctos*) mostraron variaciones estacionales, al igual que lo observado en las conductas típicas de la especie en condiciones de libertad; 2) En el oso pardo (*U. arctos*) la presencia de público provocó un aumento en la ocurrencia de estereotipias y un uso del espacio más homogéneo, mientras que en el oso panda gigante (*Ailuropoda melanoleuca*) no se observaron estereotipias ni una influencia del público en el uso del espacio; 3) La seminaturalización de las instalaciones de dos individuos de oso pardo (*U. arctos*), un macho y una hembra, provocó que únicamente el macho alcanzara un nivel de actividad similar al observado en sus conspecíficos en libertad y para la misma época del año (verano), haciendo un uso más homogéneo del espacio disponible. Los dos ejemplares de oso pardo (un macho y una hembra) estudiados respondieron de forma diferente al enriquecimiento estructural; 4) El estudio de la eficacia de un programa de enriquecimiento alimentario, sensorial y ocupacional en tres individuos de osos pardo (*U. arctos*), puso de manifiesto cuatro modelos de evaluación de dichos programas: el modelo de la ganancia, el de la habituación, el de la continuidad y el la fluctuación de la eficacia del ítem; 5) La muerte del macho alfa en una manada de lobos ibéricos (*Canis lupus signatus*) provocó un aumento de las conductas de "vigilancia" y "no visible" así como un uso del espacio menos homogéneo; 6) Las interacciones maternofiliales entres madres y tres crías de león marino de California (*Zalophus californianus*) en cautividad, mostraron varias semejanzas con las que presenta la especie en libertad (los individuos se mantuvieron inactivos durante la mayor parte del tiempo y las crías macho presentaron mayores episodios lúdicos que las hembras).

Los factores que influyen en el bienestar de los animales de este estudio deberían tenerse en cuenta para garantizar que las condiciones de cautividad son adecuadas para los animales. Estos factores son las condiciones sociales de la especie, el tamaño y el diseño idóneo de la instalación,la composición de la dieta, la estimulación física y/o psicológica, la influencia del público y los cuidados veterinarios. La clave para garantizar el bienestar de los animales, radica en estudiar minuciosamente las necesidades físicas y psicológicas de los mismos a través del conocimiento tanto de la historia natural de las especies, como de los trabajos realizados en otros zoos.