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A scoring system to evaluate physical condition and quality of life in geriatric zoo mammals

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Abstract

The decision to perform euthanasia in geriatric zoo mammals is usually a highly complex procedure involving ethical, medical, emotional and sometimes political factors. However, subsequent necropsies show that the pathological changes of organs and/or the musculoskeletal system are often already advanced. Therefore, we hypothesise that euthanasia is often delayed to the detriment of the animal's welfare. The purpose of this study was to facilitate and establish an initial, objective, decision-making framework for the euthanasia of geriatric zoo mammals. A scoring-system to assess the physical condition and quality of life in ageing zoo mammals is presented, based on retrospective and prospective investigation of 70 geriatric zoo mammals in five European zoos. Medical records and necropsy reports were studied in retrospective cases. Symptoms were monitored and recorded in prospective cases. Radiographic investigations under general anesthesia or at necropsy were performed additionally. A significant association between symptoms and pathological findings revealed that 36.9% (n = 24/65) of examined animals (n = 41/65) had pathological alterations to the musculoskeletal system and 26.2% (n = 17/65) suffered from neoplasia. Based on the individual reports, 28 veterinarians from different fields of veterinary medicine concluded that these animals had mild to severe pain, discomfort and a significantly reduced quality of life, thus strongly reducing welfare. The proposed scoring system includes all of these factors and offers a simple and reliable tool to support decision-making for euthanasia in geriatric zoo mammals.

Keywords: *aged zoo mammals, animal welfare, euthanasia, pathology, scoring system, symptom*

Introduction

In the last years of the 20th century zoos became increasingly focused on conservation (through captive breeding), research and education. This has been due in part to changing public attitudes towards zoos and the appropriate methods of keeping wild animals in captivity (Young 2003). In addition, the captive conditions of zoo animals have improved and animal longevity has been increased. As a result, problems arising from the management of long-lived species and age-related diseases are increasing. Some of the problems may be difficult to diagnose and treat, thereby potentially compromising animal welfare (Kitchener 2004). In many cases, the subjects are apparently healthy, but aged zoo animals at necropsy are found to suffer from a range of health problems that may not have been apparent while they were alive (Richardson 2000). Animals in captivity invariably live longer than their wild counterparts (Nowak 1999; Richardson 2000; Erwin *et al* 2002). Enabling zoo animals to live in better conditions for a long period is presently viewed as important. However, zoos often unwittingly condemn their animals to long, painful lives. In certain instances this may benefit the conservation of genetic lineages. However, in other instances, the already well-represented animal occupies much needed space long beyond making a significant contribution to the breeding programme. A good zoo strives to improve the quality of its animals' lives, not necessarily their length of life (Richardson 2001).

Suffering is an unpleasant state of mind that disrupts the quality of life. It is the mental state associated with unpleasant experiences such as pain, malaise, distress,

Table 1 Retrospective and prospective cases (n = 70) of this study with the relative age (%) in comparison with the longevity seen in free-ranging and captive animals.

Species	Sex	Age	Longevity in free-ranging animals	Relative age in comparison with the longevity in free-ranging animals (%)	Record of longevity in captive animals	Relative age in comparison with the longevity in captivity (%)
Brown bear (*Ursus arctos*)	M	27	22.5	120	47	57.44
Brown bear (*U. arctos*)	F	28	22.5	124.4	47	59.57
Brown bear (*U. arctos*)	F	28	22.5	124.4	47	59.57
Brown bear (*U. arctos*)	M	32	22.5	142	47	68.08
Brown bear (*U. arctos*)	F	22	22.5	97.8	47	46.80
Brown bear (*U. arctos*)	F	29	22.5	128.8	47	61.70
Brown bear (*U. arctos*)	F	23	22.5	102.2	47	48.90
Brown bear (*U. arctos*)	F	33	22.5	146.6	47	70.20
Brown bear (*U. arctos*)	F	33	22.5	146.6	47	70.20
Polar bear (*Ursus maritimus*)	M	25	27.5	90.9	45	55.55
Polar bear (*U. maritimus*)	F	26	27.5	94.5	45	57.77
Polar bear (*U. maritimus*)	F	30	27.5	109.1	45	66.66
Polar bear (*U. maritimus*)	M	27	-	-	45	60.00
Sun bear (*Helarctos malayanus*)	F	24	-	-	35	68.57
Sun bear (*H. malayanus*)	M	21	-	-	35	60.00
Spectacled bear (*Tremarctos ornatus*)	M	29	-	-	39	74.35
Spectacled bear (*T.ornatus*)	F	21	-	-	39	53.84
Tiger (*Panthera tigris*)	M	10	9	111.1	26	38.46
Tiger (*P. tigris*)	F	15	9	167.7	26	57.69
Tiger (*P. tigris*)	M	17	9	188.9	26	65.38
Tiger (*P. tigris*)	F	18	9	200	26	69.23
Tiger (*P. tigris*)	F	14	9	155.5	26	53.84
Leopard (*Panthera pardus*)	F	20	12.5	160	23	86.95
Leopard (*P. pardus*)	M	17	12.5	136	23	73.91
Leopard (*P. pardus*)	F	13	12.5	104	23	56.52
Leopard (*P. pardus*)	M	19	12.5	152	23	82.60
Leopard (*P. pardus*)	M	17	12.5	136	23	73.91
Leopard (*P. pardus*)	M	14	12.5	112	23	60.86
Leopard (*P. pardus*)	M	22	12.5	176	23	95.65
Snow leopard (*Panthera uncia*)	M	19	12.5	152	21	90.47
Snow leopard (*P. uncia*)	F	18	12.5	144	21	85.71
African lion (*Panthera leo*)	F	16	14	114.3	30	53.33
African lion (*P. leo*)	F	18	14	128.6	30	60.00
African lion (*P. leo*)	M	17	14	121.4	30	56.66
African lion (*P. leo*)	F	17	14	121.4	30	56.66
Wolf (*Canis lupus*)	F	11	11.8	93.2	17	68.75
Wolf (*C. lupus*)	F	9	11.8	76.3	17	56.25
Okapi (*Okapia johnstoni*)	F	13	-	-	33	39.39
Okapi (*O. johnstoni*)	F	18	-	-	33	54.54
Musk ox (*Ovibos moschatus*)	F	15	22	68.2	-	-

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Table 1 (continued)

Species	Sex	Age	Longevity in free-ranging animals	Relative age in comparison with the longevity in free-ranging animals (%)	Record of longevity in captive animals	Relative age in comparison with the longevity in captivity (%)
Masai giraffe (*Giraffa camelopardalis tippelskirchi*)	M	23	-	-	36	63.88
Masai giraffe (*G. camelopardalis tippelskirchi*)	F	21	-	-	36	58.33
Masai giraffe (*G. camelopardalis tippelskirchi*)	F	18	-	-	36	50.00
Sable antelope (*Hippotragus niger*)	F	14	-	-	22	63.63
Greater kudu (*Tragelaphus strepsiceros*)	M	16	7.5	213.3	23	69.56
Greater kudu (*T. strepsiceros*)	M	16	7.5	213.3	23	69.56
Camel (*Camelus bactrianus*)	F	19	37.5	50.6	50	38.00
Camel (*C. bactrianus*)	F	16	37.5	42.6	50	32.00
Camel (*C. bactrianus*)	M	25	37.5	66.6	50	50.00
Camel (*C. bactrianus*)	M	18	37.5	48.0	50	36.00
Camel (*C. bactrianus*)	M	16	37.5	42.6	50	32.00
Grevy's zebra (*Equus greyvi*)	F	19	9	211.1	40	47.50
Chapman's zebra (*Equus quagga chapmani*)	F	20	9	222.2	40	50.00
Chapman's zebra (*E. quagga chapmani*)	F	31	9	344.4	40	36.00
Greater Indian rhinoceros (*Rhinoceros unicornis*)	F	25	-	-	45	32.00
Black rhinoceros (*Diceros bicornis*)	M	36	-	-	45	80.00
Black rhinoceros (*D. bicornis*)	F	39	-	-	45	47.50
Black rhinoceros (*D. bicornis*)	M	21	-	-	45	50.00
Brazilian tapir (*Tapirus terrestris*)	M	19	-	63.3	35	77.50
Brazilian tapir (*T. terrestris*)	F	16	-	53.3	35	55.55
African elephant (*Loxondata africana africana*)	F	48	60	80.0	-	-
Woolly monkey (*Lagothrix lagotricha*)	F	21	-	-	30	86.66
Green monkey (*Cercopithecus aethiops*)	F	24	-	-	-	46.66
Spider monkey (*Ateles geoffroyi* spp)	F	25	-	-	48	54.28
Spider monkey (*A. geoffroyi* spp)	M	17	-	-	48	45.71
Crab-eating macaque (*Macaca fascicularis*)	M	19	-	-	37	35.41
Crab-eating macaque (*M. fascicularis*)	F	20	-	-	37	87.50
Crab-eating macaque (*M. fascicularis*)	M	28	-	-	37	80.00
Crab-eating macaque (*M. fascicularis*)	F	29	-	-	37	52.08
Crab-eating macaque (*M. fascicularis*)	F	19	-	-	37	35.41

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Table 2 Symptoms observed in all animals, frequency and groups of observed symptoms including the factor of multiplication.

Symptom	Frequency of observed symptom (%)	Symptom group	Multiplication factor	Species showing symptom observed
Vomiting	11-33%	1	2	All species
Dysorexia	11-33%	1	2	All species
Cachexia	11-33%	1	2	All species
Anorexia	11-33%	1	2	All species
Weakness	11-33%	1	2	All species
Apathy	11-33%	1	2	All species
Dehydration	5-6%	2	1.5	All species
Dyspnoea	1-4.5%	3	1	All species
Coughing	1-4.5%	3	1	All species
Diarrhoea	5-6%	2	1.5	All species
Reluctance to move	11-33%	1	2	All species
Pain when standing up	11-33%	1	2	All species
Lameness	11-33%	1	2	All species
Muscle atrophy	5-6%	2	1.5	All species
Polyuria/polydipsia	5-6%	2	1.5	All species
Lesser role in hierarchy	5-6%	2	1.5	All species
Hypersalivation	1-4.5%	3	1	All species
Reduced bathing	1-4.5%	3	1	Bears
Increased bathing	1-4.5%	3	1	Bears
Social pressure	1-4.5%	3	1	Primates
Bite wounds	1-4.5%	3	1	Primates
Isolation from group	1-4.5%	3	1	Primates

Table 3 Pathologies classified in three pathological groups found in different familae of animals (n = 65) of this study.

Familae	Neoplasia (n = 17)	Dysfunction of the musculoskeletal system (n = 24)	Other pathology (n = 24)
Ursidae	Bile duct carcinoma, hepatocellular carcinoma, pancreatic adenocarcinoma and duodenal adenocarcinoma (1)	Arthrosis and spondylarthropathy, moderate to severe (5)	Pancreatic necrosis, severe myocarditis, bronchopneumonia, enteritis, colitis and glomerulonephritis (1)
Felidae	Metastasing pancreatic adenocarcinoma, duodenal adenocarcinoma, bile duct carcinoma, chondroma, phaechromocytoma, metastising chondrofibrosarcoma, leiomyoma cervix, lymphosarcoma, leukaemia and omental squamous cell carcinoma (1)	Arthrosis, severe (2), spondylarthropathy (2)	Infarction, stomach perforation, pyelonephritis and necrotising hepatitis (1)
Canidae	Haemangiosarcoma (1)	Spondylarthropathy (1)	-
Camelidae	Cholangiosarcoma (1)	Arthrosis, moderate to severe (3)	Sand impaction (1)
Giraffidae	-	Fracture, distal phalanx (2), deformation of claws (1)	Kidney infarct (1), abomasal congestion (1)
Elephantidae	-	Arthritis, severe (1)	-
Equidae	-	Trauma of the cannon bone, laminitis and fracture of the pelvis (1)	-
Capridae	-	-	Anomaly of teeth, severe (1), pneumonia, severe (1)
Rhinocerotidae	-	Arthrosis, moderate to severe (2)	Pancreatitis (1), impaction (1)
Moschidae	Ileal adenocarcinoma (1)	-	-
Bovidae	-	Arthrosis, severe (1)	Bronchopneumonia, severe (1)
Cebidae	Squamous cell carcinoma of stomach (1)	Fracture, distal phalanx (1)	Infected skin lesion (1)
Cercopithecidae	-	-	Bite wound, chronic colitis, chronic gingivitis/periodontitis, chronic, hernia, liver amyloidosis and hepatitis (1)

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Table 4 Animal card filled out by veterinarian for each retrospective and prospective case (n = 65) to evaluate pain, discomfort and quality of life with the aid of observed symptoms and pathological findings.

Reference number: **Species:** **Age:** **Name:** **Sex:**				
Symptom				
☐ Vomiting	☐ Dehydration	☐ Reluctance to move	☐ Isolation from the group	☐ Recumbency
☐ Dysorexia	☐ Dyspnoea	☐ Pain when standing up	☐ Social pressure	
☐ Cachexia	☐ Coughing	☐ Lameness	☐ Bite wounds	
☐ Anorexia	☐ Diarrhoea	☐ Muscle atrophy	☐ Influenced by the season	
☐ Weakness	☐ Increased bathing	☐ Polyuria/polydipsia	☐ Spring/Summer	
☐ Apathy	☐ Decreased bathing	☐ Lesser role in hierarchy	☐ Autumn/Winter	
Pathology				
☐ Pancreas	☐ Respiratory system	☐ Kidney and Adrenal glands		
☐ Pancreatic adenocarcinoma	☐ Bronchopneumonia	☐ Chronic nephritis		
☐ Pancreatic necrosis	☐ Trauma	☐ Pyelonephritis		
☐ Hepatobiliary system	☐ Oral disease	☐ Phaechromocytoma		
☐ Hepatocellular carcinoma	☐ Abscess	☐ Gastrointestinal tract		
☐ Hepatitis	☐ Periodontitis	☐ Squamous cell carcinoma of the stomach		
☐ Cyst	☐ Anomalous teeth	☐ Adenocarcinoma of the duodenum		
☐ Bile duct carcinoma	☐ Genital system	☐ Colitis		
☐ Cholangiosarcoma	☐ Leiomyoma of cervix	☐ Gastritis		
☐ Vomiting	☐ Cardiovascular system	☐ Perforation of the stomach		
☐ Arthrosis	☐ Cardiac insufficiency	☐ Squamous cell carcinoma of the omentum		
☐ Spondyloarthropathy	☐ Haemangiosarcoma	☐ Skin		
☐ Arthritis	☐ Infarction	☐ Infected skin lesion		
☐ Erosion				
☐ Synovialitis				
☐ Fracture				
☐ Chondrofibrosarcoma				
☐ Chondroma				
☐ Deformation of claws				
☐ Laminitis				

The scaling for evaluating pain, discomfort and quality of life ranges from 0 to 10.
For pain and discomfort 0 signifies none and 5 and 10 signify moderate and severe, respectively. For quality of life 0 signifies good with 10 signifying very bad.

injury and emotional numbness (Gregory 2004). In the present study we focused on pain, because pain, probably more than any other state, directly reduces welfare (Duncan 2004). Generally, it is very difficult to determine the appropriate point to perform euthanasia. Besides the medical aspect, the zoo veterinarian must take into consideration the differing interests of zoo managers and staff, visitors, animal welfare organisations, sponsors and, perhaps, the needs of respective breeding programmes (eg European Endangered Species Programme). The final decision to perform euthanasia is influenced greatly by the general clinical condition of the animal. In this regard, the correct interpretation of clinical symptoms in zoo animals plays a central role in the evaluation of the animal's welfare. Persistence of clinical signs, in spite of medical treatment, should rapidly give rise to discussions on the future quality of life in the individual. In some cases, a change of drug may be helpful, in certain circumstances a surgical intervention under general anesthesia may be indicated while in other cases the decision for euthanasia must be taken. Treatment invariably raises many questions about its efficacy and each veterinarian must exercise the highest standards of animal welfare (EAZA 1999; WAZA 1999). Interventions invariably cause stress and are a risk for the animals. Additionally, this mobilises personnel and material, is time consuming, and generates costs.

Based on the correlation of symptoms, professional perceptions and necropsy results we propose an initial scoring-system to evaluate physical condition and quality of life in geriatric zoo mammals, with the aim of improving the decision-making process for euthanasia at an appropriate time.

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Table 5 Observed symptoms significantly associated with pathological findings in this sample.

Symptom	Pathology	*P*-value
Vomiting	Neoplasia	$P = 0.02$
Apathy	Neoplasia	$P = 0.007$
Anorexia	Neoplasia	$P = 0.01$
Lameness	Arthrosis	$P < 0.000001$
Pain when standing up	Spondyloarthropathy	$P = 0.009$

Table 6 Frequency of the three pathological groups of this study in correlation with an age of animals ≥ 100% of the life expectancy in the wild (%) and in correlation with an age ≥ 50% of the maximal age in captivity (%).

Pathology	Animals (n = 29) with an age ≥ 100% of the life expectancy in the wild (%)	Animals (n = 62) with an age ≥ 50% of the maximal age in captivity (%)
Neoplasia	36.6	25.0
Dysfunction of the musculoskeletal system	39.0	34.4
Other pathology	24.4	40.6

Table 7 Frequency of all animals in this study with the same group of pathology in correlation with an age ≥ 50% of the maximal age in captivity (%).

Pathology	Animals (n = 29) with an age ≥ 100% of the life expectancy in the wild (%)	Animals (n = 62) with an age ≥ 50% of the maximal age in captivity (%)
All animals with neoplasia	73.3	81.0
All animals with dysfunction of the musculoskeletal system	75.0	81.8
All animals with other pathologies	60.0	84.6

Materials and methods

Animals

This study included 70 aged, zoo mammals belonging to 24 different species (Table 1). Sixty-five animals died or were euthanised between 1979 and 2005 in five European zoos and five animals were still alive at the time of manuscript submission. Only cases whose symptoms (Table 2) were documented reliably and which had pathological reports were chosen for this study. Sixty animals were retrospective cases and 10 were prospective.

The zoo animals' ages are expressed as a percentage of the reported maximal age in the wild when available and the maximal reported longevity in captivity. (Haltenorth 1977; Grzimek 1993; Nowak 1999; Cat Specialist Group 2004; International Association for Bear Research and Management 2004).

Symptoms

The term 'symptom' is a general term that includes both clinical symptom and behavioural changes. A variable factor of multiplication which depends on the frequency of the symptoms observed is allocated in the scoring system. The frequency is defined whereby the most frequent symptoms are those that are shown by most animals and we create three groups. Frequency between 11 and 33% for each symptom obtained a factor 2 (group 1), frequency between 5 and 6% for each symptom obtained a factor 1.5 (group 2) and frequency between 1.0 and 4.5% for each symptom obtained a factor 1 (group 3).

Retrospective and prospective cases

For retrospective cases, participating zoos' medical records were used and persons (veterinarians, keepers) involved in the care of the animals concerned were interviewed in order to characterise precisely symptoms that the animals had shown prior to euthanasia or natural death. The symptoms which were taken into consideration were defined as those which predominated during the final year of life. The symptoms are, therefore, based on observations reported by keepers and veterinarians and, thus, a degree of subjectivity in the judgment of clinical signs has to be considered. Whereas some signs, such as lameness or vomiting, are easy to detect and quantify, others are less straightforward and harder to quantify or qualify. The term 'pain when standing up' for example, was used when a strenuous effort was necessary for the animal to get to its feet; this observation may, however, vary depending on the interpretation of the individual in question. In addition, the necropsy report was analysed for each case.

For the prospective cases, a similar procedure was performed in six bears (*Ursus arctos* and *U. maritimus*), one giraffe (*Giraffa camelopardalis tippelskirchi*), one okapi (*Okapia johnstoni*) and one camel (*Camelus bactrianus*); symptoms were monitored, and, after euthanasia or death, necropsy was performed either on site or at the Institute for Animal Pathology at the University of Berne. Each prospective case was examined radiographically, five of which under general anesthesia, including four adult brown bears (*U. arctos*) and one polar bear (*U. maritimus*).

Prior to necropsies, post mortem radiographic examination (Siemens Polydoros 100 system, with a performance of 80 kW at 100 kV) was performed on four animals: one giraffe (*G. camelopardalis tippelskirchi*), one okapi (*O. johnstoni*), one Bactrian camel (*C. bactrianus*) and one brown bear (*U. arctos*).

Pathologies

Pathological findings were classified per system or per organ including pancreas, hepatobiliary system, musculoskeletal system, respiratory system, genital system,

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lymphatic system, cardiovascular system, kidney and adrenal gland, gastrointestinal tract, skin, oral diseases including teeth, and trauma. Pathologies were classified into three groups: neoplasia, dysfunction of the musculoskeletal system and other pathologies (Table 3). Further, we subdivided neoplasia into two groups: 'neoplasia of visceral organs' and 'neoplasia of non-visceral organs'. Neoplasia and dysfunction of the musculoskeletal system were the most common diseases recorded in our study.

Evaluation of pain, discomfort and quality of life

A data card was created for each animal (n = 65), including species, name, age, symptoms and diagnosed pathologies followed by three scales for evaluation of pain, discomfort and quality of life (Table 4). Each scale was graduated from zero (no pain, no discomfort, good quality of life) to ten (high level of pain, high level of discomfort, poor quality of life). The sum of the three scales gave the general assessment factor (from 0 to 30). Twenty-eight veterinarians evaluated these data cards. Groups were created according to each veterinarian's degree of speciality: zoo veterinarian (n = 12), residents (n = 7) (two in clinic and five in pathology), veterinary pathologists (n = 2), interns (n = 2), surgeons (n = 3) and anaesthetists (n = 2). Two data cards were provided in duplicate in each set of 65 cards in order to maintain objectivity in veterinarians' evaluation. No veterinarians were informed that cards had been duplicated.

Scoring system

The proposed scoring system is based on the scoring system '4 a vet' (association 4avet) which was created to evaluate pain in small companion animals and is used at the Veterinary Faculty of the Berne University. It was adapted to evaluate the physical condition and quality of life of geriatric zoo mammals. It includes five parts (Table scoring system). The first part is the 'history assessment' with age and clinical symptoms. The second part 'therapy' contains the response to the therapy with specific and tentative therapy. The third part is the 'evaluation of pain, discomfort and quality of life'. The fourth part contains the 'radiographic examination'. The fifth part contains the 'additional assessment' including breeding interest, gender, ability to reproduce and hindrance to the new breeder. In the results section we differentiate the evaluation without or with 'radiographic examinations'.

Statistics

Descriptive statistics include frequency tables, measures of central tendency and spread, and the respective graphs. The association between the specific symptoms and pathologies was assessed using cross-tabulation and the chi-square test or, when any of the expected cell frequencies were below 5, the Fisher's Exact test. In addition, odds ratios (OR) with 95% confidence intervals were calculated. All statistical procedures were performed with NCSS 2001 software (Number Cruncher Statistical Systems, Kaysville, UT, USA) and Microsoft Excel. The overall level of statistical significance was set to $P < 0.05$.

Results

Symptoms and pathology

The symptoms included in group 1 (frequency between 11 and 33%) were shown in 95.7% of the cases (n = 67/70). The animals showing one symptom (20% [n = 14/70]), two symptoms (30% [n = 21/70]), three symptoms (22.9% [n = 16/70]) or four symptoms (11.4% [n = 8/70]) represented 84.3%. The animals showing either five symptoms (5.7% [n = 4/70]), six symptoms (4.3% [n = 3/70]), seven symptoms (2.9% [n = 2/70]) or eight symptoms (2.9% [n = 2/70]) represented 15.7%. We found significant associations between five symptoms and five pathologies (Table 5). In the following we will focus on the results of the five most frequently observed symptoms.

Vomiting

In this sample vomiting was observed in bears, felids and one tapir (*Tapirus terrestris*). This symptom was significantly associated with neoplasia ($P = 0.02$; OR = 6.2) ie in 29.4% of all animals with neoplasia (n = 5/17). Only 6.3% of all animals (n = 3/48) without tumours, vomited.

Anorexia

In this sample anorexia was observed in all species and was a consistent finding in bears and felids (72.2%). This symptom had a significant association with neoplasia ($P = 0.01$; OR = 4.3) ie occurring in 52.9% of all neoplastic animals (n = 9/17). 20.8% of all animals (n = 10/48) without neoplasia showed anorexia.

Apathy

In this sample apathy was observed mainly in bears and felids (87.5%, n = 8/9) and was significantly associated with neoplasia ($P = 0.007$; OR = 8.2) ie occurring in 35.3% of all animals (n = 6/17) with neoplasia. Only 6.3% of all non-neoplastic animals (n = 3/48) showed apathy.

Lameness

In this sample lameness was the symptom with the highest observed frequency and was recorded in all species. It was seen in 37.1% of all animals studied (n = 26/70). Lameness had a significant association with dysfunction of the musculoskeletal system ($P < 0.000001$; OR = 27.8) and arthrosis ($P < 0.000001$) ie 75% of all animals (n = 18/24) with dysfunction of the musculoskeletal system showed lameness as did 100% of all animals (n = 14/14) with arthrosis. This compares with only 9.8% (n = 4/41) of animals that didn't have dysfunction of the musculoskeletal system and were lame and 15.7% (n = 8/51) that were lame without showing arthrosis.

Pain when standing up

In this sample we found a significant association between pain when standing up and spondylosis/spondylarthrosis ($P = 0.009$; OR = 8.9) ie 62.5% of all animals (n = 5/8) with spondylosis/spondylarthrosis had pain when standing up. This compares with only 15.8% of all animals (n = 9/57) without spondylosis, showing pain when standing up.

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Age and pathology

Animals with neoplasia represented 26.2% (n = 17/65) of the total set, animals suffering from dysfunction of the musculoskeletal system represented 36.9% (n = 24/65) and animals suffering from other diseases represented 36.9% (n = 24/65) (Table 6 and 7). In the group 'neoplasia' 50% of the animals (n = 5/10) with 'neoplasia of visceral organ' and 87.5% of the animals (n = 6/7) with 'neoplasia of non-visceral organ' had an age equal to or greater than 100% of the life expectancy seen in the wild. In the group 'other pathologies', 100% of the animals (n = 7/7) with an age equal to or greater than 100% of the life expectancy in the wild suffered from either dysfunction of the cardiovascular system or dysfunction of the liver or kidneys.

Radiographic examination of anaesthetised animals

Four brown bears (*U. arctos*) and one polar bear (*U. maritimus*) showed mild lameness, gait abnormalities or paraparesis, and one brown bear (*U. arctos*) showed severe lameness. Radiographs showed non-existant to mild osteoarthritic changes in the elbow joints of four bears. In the brown bear (*U. arctos*) with severe lameness, severe osteoarthritis was diagnosed in both elbow joints. Regarding the hip joint, five bears with mild lameness showed no radiographic alterations while the radiographs of the brown bear (*U. arctos*) with severe lameness revealed severe osteoarthritic alterations. The stifle joint in one brown bear (*U. arctos*) was not examined. Three bears had mild to moderate osteoarthritis in the stifle joint and the bear with severe lameness had moderate osteoarthritic changes. Furthermore, three bears showed enthesiophytes in the right patella, proximally. One bear showed enthesiophytes in the left patella, proximally and another showed enthesiophytes in the left patella both proximally and distally. One stifle in a brown bear (*U. arctos*) with gait abnormalities showed changes consistent with osteochondromatosis. The same bear showed an extra articular bone lesion consistent with an enostosis-like lesion in the tibia. Radiographs showed mild osteoarthritic changes to the tarsal joint in three bears, mild to moderate osteoarthritic alteration in four and in two others moderate osteoarthritic change. Two bears with lameness and/or gait abnormalities showed enthesiophytes, one dorsally in the right metatarsus and the other in the plantar ligament. In one bear with lameness, marked, cuff-like, periarticular mineralisations were detected in the left tarsal joint (Föllmi *et al* in preparation).

Evaluation of pain, discomfort and quality of life

The scoring for pain, discomfort, quality of life and general assessment between the groups of veterinarians differed. In the 'zoo veterinarians' group the median score was 8 for pain (on a scale of 1 to 10), 8 for discomfort (on a scale of 1 to 10), 8.5 for quality of life (on a scale of 1 to 10) and 24 for the general assessment (on a scale of 0 to 30). The scores were very similar in the 'pathologists' and in the 'residents' groups with median scores of 7 and 7.5 for pain; 8 and 8 for discomfort; 8 and 8.5 for quality of life and 23 and 24 for the general assessment, respectively. The scores obtained by the 'interns', 'surgeons' and 'anaesthetists' were 5, 6 and 6 for pain; equal at 7 for discomfort and quality of life, and 18, 19 and 18.5 for the general assessment, respectively.

In the 'zoo veterinarians' group the control with duplicate cards showed low variation in the general assessment with a mean difference of 0.9. In the 'residents' the mean difference was 1.6, while in the 'anaesthetists' it was 2.2 and 2.5 for 'pathologist', 'intern' and 'surgeon' groups.

Scoring system

The section 'results of the scoring system' was established as follows: for each symptom observed in an animal five points were allocated and multiplied with a variable factor (as defined under 'Symptoms'). An evaluation of the therapy could not be established for each case. Therefore, a mean value of five points was allocated for each question concerning efficacy and disappearance of symptoms during treatment. The result of the zoo veterinarian with the highest evaluation as well as that of the zoo veterinarian with the lowest evaluation of pain, quality of life and discomfort was used to calculate each animal's mean. Minus five points were allocated to the part 'additional assessment', and 15 points to the part 'radiographic examination'. A mean was calculated for each animal. On this basis, treatment can be recommended when the result obtained lies between one and 30 points for result without additional examination, and one and 45 points with additional examination. The prognosis is considered to be doubtful when the score is between 31 and 51 or 46 and 66, respectively. Euthanasia should be considered with scores over 51 and 66, respectively.

Discussion

The aim of this study was to develop a systematic approach for defining the appropriate time to euthanise a geriatric zoo mammal. For this purpose, we studied retrospective and prospective cases from five different European zoos in order to evaluate a correlation between symptoms and pathological findings. Additionally, 28 veterinarians evaluated the pain, discomfort and quality of life of these animals. Combining these results the study presents a scoring procedure to allow the zoo veterinarian to evaluate an old animal's general condition and, if necessary, to support the decision for euthanasia.

In these geriatric zoo mammals, similar symptoms were described independently of the zoo and the species. Of the five predominant clinical symptoms, vomiting, anorexia and apathy had a significant association with neoplasia whereas lameness, pain when standing up and anorexia were significantly associated with 'dysfunction of the musculoskeletal system'. These five symptoms were very frequent. Neoplasia was diagnosed in 26.2% of all examined animals, but if we consider only those species for which life expectancy in the wild is known, this value reaches 37.9% (with an age equal to or greater than 100% of the life expectancy in the wild). Dysfunction of the musculoskeletal system was recorded in 36.9% of all examined animals, but this rose to 41.4% when only species

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with known maximal age in the wild were considered. Other diseases were diagnosed in 36.9% of all examined animals, but this dropped to 20.7% once only species with known maximal age in the wild were taken into account. The groups 'neoplasia' and 'dysfunction of the musculoskeletal system' represented 63.1% of all animals in this study, but this value reached 79.3% considering only species with known maximal age in the wild.

As far as neoplasia is concerned, it is known that age influences the risk of onset (Kennedy & Strafuss 1976; Port *et al* 1981; Gage 1999; de Magalhaes & Toussaint 2002; Nimmervoll *et al* 2005). The present study showed that an animal with symptoms and with an age equal to or greater than 100% of the maximal age reached in wild animals had a 33.3% chance of developing neoplasia. In addition, tumours were either malignant (82.3%, n = 14/17) and/or surgery was impossible due to their localisation (recurring leiomyoma of the cervix, chondroma of thoracic vertebrae).

Aged animals are often afflicted with dysfunction of the musculoskeletal system (Jack & Thacker 1985; George *et al* 1990; Canfield & Spencer 1993; Kompanje & Klaver 1998; Kompanje *et al* 2000; Colman & Binkley 2002; Erwin *et al* 2002; Morbeck *et al* 2002; Nichols & Zihlman 2002; Kitchener *et al* 2003, Kitchener 2004). Degenerative skeletal lesions represent a major proportion of aged zoo mammal pathologies. In a study involving 27 bear skeletons of different bear species that were approximately 15 years of age, 96% showed evidence of skeletal pathology (Kitchener 2004). Lions (*Panthera leo*), tigers (*Panthera tigris*), gorillas (*Gorilla gorilla*), orangutans (*Pongo pygmeus*), babirusas (*Babyrousa babyrussa*) and pygmy hippos (*Hexaprotodon liberiensis*) suffer from similar problems as bears, but to varying degrees (Kitchener 2004). The pathological alterations were considered significant and, in human terms, would be regarded as very painful (Kitchener *et al* 2003; Gregory 2004). In the present study, animals suffering from arthrosis and/or spondylarthropathy represent 66.7% (n = 16/24) of all animals with musculoskeletal dysfunction. Lameness and difficulty when standing up have a significant association with arthrosis and spondylarthropathy, implying that these animals are in pain. In such cases treatment has only palliative effects.

As far as other pathologies are concerned, the results show that age has an effect on the development of pathology, such as, for instance, pancreas or liver necrosis or dysfunction of the kidney or cardiovascular system.

The median score for the general assessment of pain, discomfort and quality of life was 24 (scale from 0 to 30) in the 'zoo veterinarians' group. This means that the pathological findings were assumed by the veterinarians to be of moderate to severe clinical significance, implying a high degree of pain and discomfort as well as a poor quality of life. The pathologists and the residents made a similar estimation. The anaesthetists, interns and surgeons had a lower median score of 18.5. One reason for this difference is perhaps that they are unused to working with zoo or wild animals.

Thorough observation of the clinical signs is very important as they provide significant information on the animal's general condition. When an old animal displays symptoms, it is often too late for effective treatment. Our study shows that an animal with an age equal to or greater than 100% of the maximum age attained in the wild, with one or more symptoms, had a poor prognosis. If a treatment turns out to be ineffective it should be stopped and euthanasia considered as the animal has a high (79.3% according to this study) risk of suffering from neoplasia or dysfunction of the musculoskeletal system.

Combining the results, a scoring system is proposed to evaluate the general condition and quality of life of geriatric zoo mammals. The scoring system includes five parts: the first part refers to the 'history assessment' with points attributed to age and symptoms. The symptoms have a variable factor of multiplication, which depends on their frequency. This variable factor has been created to allow for differentiation of the value of the symptom according to its frequency. The second part includes the 'therapy' with points for the efficacy of treatment. For instance treatment for neoplasia, osteoarthritis, chronic nephritis, cardiac insufficiency or stomach perforation has poor efficacy or is difficult to apply. The third part refers to the 'evaluation of pain, discomfort, and quality of life' and represents a subjective evaluation performed by the examining veterinarian, based on the observed symptoms, therapy, radiology, other potential information and on the experience of the veterinarian. The fourth part involves the 'radiographic examination'. In this part the radiographic examination of the joints is included, considering that dysfunction of the musculoskeletal system represents a major problem in geriatric animals (37%). Finally, the fifth part refers to the 'additional assessment' which includes further factors such as breeding interest, gender, and ability to reproduce.

For the establishment of the section 'results of the scoring system', in the part 'history assessment' we allocated five points for each symptom observed. This value was defined due to the fact that the degree of symptom was described with words and not with numbers in the medical records. In all retrospective and prospective cases of this study, the efficacy and/or response to treatment played an important role in the euthanasia decision. Consequently, in the 'therapy' part of the scoring system, five points were allocated for the efficacy of the treatment and five points for the disappearance of symptoms. In the part 'additional assessment' an animal can receive positive or negative points depending, for example, on its breeding interest or its gender. A male black rhinoceros (*Diceros bicornis*) that is a proven breeder, has much more 'value' than, for example, a male European wolf (*Canis lupus*), which is over-represented in the population. In the part 'radiographic examination' points were given based on the type of alteration in a joint, the number of joints affected in each animal and the localisation in the joint.

The mean total score for each animal was 52.72. Therefore, based on this sample set, we would recommend euthanasia

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when the total score is over 51 points. An animal's prognosis with a score between 31 and 51 is considered doubtful. In this category we had few animals (n = 5/65) which had treatment options and euthanasia might not have been justified at this moment, for example a bear with colitis or a leopard with pyelonephritis. Therefore, we cannot justify euthanasia in all cases with a score from 31 to 51 but we would suggest treatment for all animals with a score below 30.

The scoring system was tested on nine animals for evaluation. Based on these results five animals were euthanised. Three animals had a score between 67 and 102 without radiographic examination and two animals had scores of 81 and 140 with radiographic examination. Subsequent necropsy and pathological findings proved that euthanasia was justified in all five cases. Based on the results of the scoring system four animals are still alive. Three animals have a score between 20 and 28 without radiographic examination. One animal with a score of 42 without radiographic examination is in the 'doubtful'category. This animal will be re-evaluated on a regular basis.

In conclusion, a geriatric zoo mammal showing one or more of the symptoms described has a reduced quality of life. With the support of the proposed scoring system, the general condition of the old animal can be systematically and rapidly evaluated. Furthermore, it allows evaluation of therapeutic efficacy at any stage in the proceedings. This scoring system provides a decision aid to the veterinarian for appropriate euthanasia in geriatric zoo mammals.

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