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1 **Title**

2 Nutraceutical supplementation increases mobility in aged captive non-domesticated felids.

3

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17 **Abstract**

18 **Background –**

19 Musculoskeletal diseases (MSDs) are an increasing issue as the lifespan of captive animals
20 increases. Extracts of green-lipped mussels have been linked to alleviation of MSDs in
21 domestic carnivores. Understanding their efficacy in non-domestic felids could provide
22 another tool in improved welfare of aged individuals in collections.

23

24 **Methods –**

25 A within subject study design quantified steps per minute in each of 18 cats of 13 species
26 before and after addition of Antinol™ to their diets. The age structure of four commonly kept
27 subspecies of non-domestic cats was quantified to provide a demographic context to the need
28 for managing aged individuals.

29

30 **Results –** Each of the 18 cats exhibited a higher rate of steps per minute after addition of
31 Antinol in their diet. A paired t-test showed that at the group level the rate of steps after
32 uptake was significantly higher than before addition of Antinol to the diet.

33

34 **Limitations –** While our results showed a strong significant increase, further studies that
35 incorporate a placebo, more individuals, and more detailed metrics of mobility would provide
36 a more detailed evidence-base for practitioners.

37

38 **Conclusion –** Nutraceuticals may yield benefits to aged individual felids including species
39 kept widely in European collections. Their use warrants further, detailed research in
40 collections.

41 **Keywords**

42 AntinolTM, Felidae, green-lipped mussel extract, musculoskeletal disease, osteoarthritis

43 **Introduction**

44 Captive felids suffer a range of health issues and novel diseases that are not typically
45 observed in their wild counterparts¹. Specifically, the longer lifespan, and the reduced activity
46 and behavioural repertoire of captive felids can lead to a range of musculoskeletal diseases
47 (MSDs). Although the boundary between standard physiological ageing and MSDs is
48 somewhat subjective, if there is pain, loss of mobility or functional impairment MSDs can be
49 considered present^{2,3,4}. In older domesticated cats, MSDs can be highly prevalent: degraded
50 cartilage commonly leads to osteoarthritis, while more widespread degeneration of the joints
51 is categorised as degenerative joint disease, both of which fall under the umbrella term of
52 MSDs. MSDs are also one the most prominent issues within captive felids, being associated
53 with a large proportion of deaths within some age-classes of some species (e.g., geriatric
54 jaguars^{5,6}), in addition to having considerable welfare implications in chronic conditions².
55 Long-term studies suggest that mortality because of MSDs is common across a range of
56 species in captivity, including jaguars^{5,6}, Amur leopards⁷ and Asiatic lions⁸. The presence and
57 welfare impact of MSDs, specifically degenerative joint diseases, are not restricted to larger
58 species, with the similar trends also having been observed in smaller species, including
59 domestic cats^{9,10,11}.

60

61 Despite MSDs being a well-known issue among aged felids, there is limited research into the
62 efficacy of different treatments for these diseases. However, empirical evidence for some
63 successful methods of treatment does exist, including surgery, medication, environmental
64 manipulation, and nutraceutical supplementation. Surgery has been conducted on Bengal
65 tigers¹², and snow leopards¹³, bilateral denervation of the coxofemoral joints in the former
66 case, osteochondral autograft transfer in the latter. In each case surgery led to medium to
67 long-term benefits, with few side effects. Environmental manipulation, including switching to

68 carcass feeding in Asiatic lions¹⁴ and social housing conditions in tigers¹⁵, has been
69 associated with improved locomotor activity and a wider range of behaviours, both of which
70 can increase range of motion, mobility and maintain muscle strength, with a view to reducing
71 the functional impairment associated with MSD. Medication is another option for treatment
72 of long-term conditions. Different medications have been proven to be an effective treatment
73 for osteoarthritis in domestic cats^{16, 17, 18, 19}, but there are concerns related to pharmaceutical
74 intervention. For example, there are concerns about side-effects of long-term use of
75 pharmaceuticals^{20, 21} although these may be less widespread than some fear^{22, 23}. Further, some
76 of the pharmaceuticals that are very commonly used to treat MSDs have been developed for
77 use in humans, for example tramadol and gabapentin,^{24, 25} can have prohibitive costs or may
78 not be widely licensed³. Another option for treatment of MSDs are nutraceuticals
79 (supplements added to the food), which unlike surgery are non-invasive, and which compared
80 to pharmaceuticals are relatively inexpensive, although evidence for their efficacy, while
81 promising, is sparse even in domestic cats^{26, 27} while to our knowledge there is only one
82 published study on their use in non-domesticate felids. In this study, Arabian leopards and
83 cheetahs with pre-existing conditions both showed increased activity and orthopaedic status
84 after addition of SteadfastTM, an eggshell membrane supplement, containing components such
85 as collagen, hyaluronic acid, glucosamine, chondroitin sulphate, durmatan sulphate,
86 desmosine, amino acids, and peptides²¹, to their food²⁸. However, this study was based on a
87 very small sample size in only two species. There is a significant gap in our knowledge of the
88 treatment efficacy of nutraceutical interventions for MSDs across the felid family.

89

90 Domesticated species represent a useful analogue for understanding health issues in wild and
91 non-domesticated captive animals. They offer a more amenable, flexible system to study the
92 effects of a given treatment, and therefore an opportunity to transfer knowledge of treatment

93 efficacy to larger, less abundant, and less tractable species. The evidence-base for
94 nutraceutical use in treating MSDs in domestic animals could therefore inform treatment in
95 other closely related non-domesticated species housed zoo collections or sanctuaries. Omega-
96 3 polyunsaturated fatty acids (n-3 PUFAs) are a widely used nutraceutical for human and
97 animal health conditions, yet evidence for their efficacy is limited and results have been
98 mixed^{29,30,31}. One group of nutraceuticals which have shown promise are extracts of green-
99 lipped mussel (GLM) (*Perna canaliculus*), which are thought to act via anti-inflammatory
100 activity stimulated by a suite of lipids present in the supplement³². GLM extracts have been
101 shown to alleviate symptoms of osteoarthritis and degenerative joint diseases in both
102 domestic dogs^{33,34,35,36} and cats^{29,31}. In the context of non-domesticated captive felids, the
103 latter result is of particular interest. For example, the *Panthera* genus is very similar
104 anatomically to the domestic cat, with studies into the thoracic limb³⁷ and the pelvic limb³⁸ of
105 lions showing the main anatomical differences being subtle, mostly relating to shape changes
106 to allow for increased load during hunting. Given the conserved anatomy among felids,
107 supplementation with GLM extracts may have similar effects in non-domesticated cats,
108 including big cats, to those observed in domestic cats. One specific product based on GLM is
109 AntinolTM, which has shown beneficial effects in domesticated dogs^{39,40}. This nutraceutical
110 performs well in treating MSDs, specifically osteoarthritis, relative to non-steroidal anti-
111 inflammatory drugs³⁹, is safe and effective in combination with medication^{40,41} and is known
112 to be safe at high levels⁴². As yet, however, its potential for treating MSDs in felids generally,
113 but specifically in captive, non-domesticated felids is unknown.

114

115 Here, we use a within subject study design to investigate whether the nutraceutical AntinolTM
116 is effective in reducing joint pain and the effects of MSDs in aged non-domesticated cats. To
117 do so, we measure steps per minute before and after treatment with Antinol in a collection of

118 aged captive non-domestic cats. We predict that we will see an increase in steps per minute
119 after receiving Antinol, as green-lipped mussel extracts have previously been associated with
120 increases in subjective measures of activity in domestic cats^{29,31}. To provide further context
121 for the scope of the problem of MSDs in older non-domesticated captive felids, we examine
122 and report on the age distribution of felids in European collections as reported in the
123 Zoological Information Management System⁴³ (ZIMS; Species 360 2023) focusing on four of
124 the most widely kept species/sub-species: African (*Panthera leo*) and Asian lions (*Panthera*
125 *leo persica*), Amur tigers (*Panthera tigris altaica*), and Sumatran tigers (*Panthera tigris*
126 *sumatrae*).

127

128 **Methods**

129 *Study Site*

130 The study was completed at the Big Cat Sanctuary (BCS), based in Kent, United Kingdom.
131 The collection under observation contained 18 individuals representing 13 species of a range
132 of sizes. Individuals varied in their sex and age (Table 1). All cats kept at the sanctuary were
133 either actively or previously involved in international breeding programmes.

134

135 *Ethical Statement*

136 The changes to the already existing dietary supplement regime of the animals (described
137 below) were part of ongoing husbandry developments and were conducted under supervision
138 and with the authority of two veterinary surgeons who oversee the collections at BCS. The
139 data collection was non-invasive and presented no changes to the daily routine of the animals
140 involved.

141

142 *Experimental design*

143 A within-subject design was used to examine the mobility of each individual cat before and
144 after treatment with a nutraceutical supplement, Antinol, which is based on an extract of
145 green lipped mussels containing a range of 3-omega fatty acids. Data on each cat was
146 collected in two phases, each of which lasted a total of six days (before supplementation:
147 23rd-28th August 2022; and after supplementation: 18th-23rd October 2022). Data were
148 collected 8 weeks apart to allow Antinol to take affect (4-6 weeks being the estimated time
149 for the supplement to take effect, based on manufacturer's documentation⁴⁴ Antinol The
150 Executive Summary 2023). The Antinol used in this trial was bought by the research project
151 team.

152

153 Following data collection during the pre-treatment phase, the focal cats received Antinol non-
154 invasively, as a dietary supplement. Capsules were placed inside small food pieces that were
155 then introduced into the animal's enclosure to provide enrichment. The number of capsules
156 given to each individual was dependent on their body weight with one capsule being
157 administered per 20kg of body mass⁴⁴. Capsules were given daily for six weeks. To record
158 whether all animals received the medication keeping staff completed a compliance form to
159 record each day. Prior to and during the study, all individuals were on Carnivit and Flexadin
160 supplements.

161

162 *Data Collection*

163 Animals were observed from outside the enclosures between 09:00 and 16:00 each day. The
164 objective was to collect one hour of activity for each cat in each of the before- and after-
165 Antinol supplementation blocks. Each day, all enclosures were systematically visited, and if
166 the cat was already active, recording took place for as long as that activity continued.

167 However, if the cat began activity upon observer arrival no data was collected for several
168 minutes to allow the cat to habituate to the presence of human beings. Food motivation may
169 also play a role in increased activity or speed, so feeding times and days were kept at a fixed
170 schedule throughout, with data being collected for each individual on both feeding and non-
171 feeding days to get a representative average.

172

173 The number of steps per minute of observation time was our metric for comparison and all
174 data were collected through video analysis. All recordings were collected using a camcorder
175 (Sony Handycam HDR CX240E, 1280x720/25p) or a GoPro Hero 6 at 30fps with 1080p
176 resolution. The baseline level of inactivity in cats made general activity patterns operationally
177 impractical as a response variable. To collect data on steps per unit time the number of steps
178 was totalled for every period of activity recorded. A step was defined as each time the front
179 left foot was raised and then returned to the ground, and a period of activity defined as the
180 time-window in which the cat was actively in motion. For each time window the number of
181 steps taken was divided by the number of seconds within the time window to obtain a
182 consistent measure of steps per unit time. For the purposes of analysis, we converted this
183 number into steps per minute and took the mean steps per minute across all quantified time
184 windows for each cat for each of the two data collection periods. This gave us, for each cat,
185 an average steps per minute in each of the before and after supplementation data collection
186 periods.

187

188 In studies of chronic pain, the caregiver placebo effect can have a strong effect^{45,46} and so we
189 quantified the level of inter-observer reliability between the primary data collector (MN),
190 who knew which treatment the data related to, and one independent observer (JB) who was
191 blind to treatment. For each cat, the independent observer (JB) scored the steps per minute on

192 two randomly selected video clips of a maximum of 30 seconds in duration, one clip per cat
193 from each of the pre- and post-treatment phases. The two clips were scored blind to
194 treatment. The scores obtained were compared to those scored by the primary data collector
195 (MN) by means of a Pearson's correlation.

196

197 *Data Analysis*

198 All data met the assumptions of a paired t-test, which was therefore used to analyse the data
199 in the software R⁴⁷.

200

201 ZIMS was interrogated for demographic data on two widely kept species, *Panthera leo* and
202 *Panthera tigris*, including data on two subspecies of each (*P. leo* and *P. leo persica*; *P. tigris*
203 *altaica*, *P. tigris sumatrae*) within captive collections held within Europe. Age pyramids for
204 each were constructed and for each we calculated the median age and proportion of the
205 population of 15 years or older (often used as a definition of geriatric in big cats).

206

207 **Results**

208 Group-level analysis revealed an overall significant increase ($t=-7.80$, $df = 17$, $p<0.001$;
209 Figure 1) in steps per minute (SPM) after treatment (113.28 ± 4.3) versus before treatment
210 (98.2 ± 3.24). Every individual cat in the study experienced an increase in steps per minute
211 regardless of species, age, sex, or body mass (Table 1 and Figure 1).

212

213 **Table 1:** Taxonomic and demographic data on cats included in the study along with mean
214 pre- and post-supplementation steps per minute (SPM). 'Relative change' was calculated by
215 $(\text{post-supplementation SPM}/\text{pre-supplementation SPM}) \times 100$. [TABLE FOLLOWS ON
216 NEXT PAGE]

217

218 Inter-observer reliability between the main dataset and the subset of observations scored by a
219 second observer blind to treatment was extremely high ($r = 0.99$, $N = 36$, $p < 0.001$).

220

221 Analysis of ZIMS demographic data highlighted non-pyramid shaped population structures,
222 with many aged cats of each of the four sub-species we investigated (figure 2). The ‘top
223 heavy’ nature of these plots suggests that for each of these commonly kept subspecies there
224 was a high proportion of aged cats. For each of the four subspecies, the median age category
225 and proportion recorded in ZIMs as being geriatric (15+ years of age) was as follows: African
226 lion, median = 9-10 years, 0.20 of total population geriatric; Asian lion, median = 10-11
227 years, 0.12 of total population geriatric; Amur tiger, median = 8-9 years, 0.12 of total
228 population geriatric; Sumatran tiger, median = 9-10 years, 0.21 of total population geriatric.
229 These data suggest a high median age for each, and high proportion of geriatric cats, and
230 therefore higher risk of MSDs, in European collections.

Species	Name	Body mass(kg)	Sex	Age	Total footage before (min)	Total footage after (min)	Mean steps min ¹ pre-supp (S.E.)	Mean steps min ¹ post-supp (S.E.)	Relative Change
Lion	Kasanga	220	Male	12	63.96	62.28	72.37 (1.66)	85.37 (1.66)	118.0
White Lion	Ngozi	190	Male	8	60.23	61.28	84.26 (1.79)	94.04 (1)	111.6
White Tiger	Baikal	140	Male	11	61.12	66.02	88.33 (1.7)	99.96 (0.73)	113.2
White Lion	Imara	130	Female	8	60.23	61.28	80.37 (1.5)	92.68 (3.76)	115.3
Amur tiger	Amasia	113	Female	9	57.05	67.28	91.1 (1.1)	97.34 (1.13)	106.9
Sumatran Tiger	Puna	75	Female	17	61.35	69.32	96.34 (2.6)	109.46 (1.51)	113.5
Sumatran Tiger	Kirana	75	Female	15	63.68	52.14	92.08 (1.46)	111.84 (0.79)	121.5
Jaguar	Neron	70	Male	4	60.72	58.28	102.72 (2.94)	124.06 (1.33)	120.8
Jaguar	Athena	60	Female	18	63.05	38.2	88 (0.9)	96.98 (1.29)	110.2
Amur Leopard	Xizi	40	Female	16	59.85	41.32	111.82 (1.57)	135.15 (1.28)	120.9
Snow Leopard	Yarko	40	Male	10	43.62	54.06	92.45 (1.25)	115.62 (1.27)	125.1
Puma	Valentina	40	Female	14	61.45	62.01	111.57 (1.41)	113.53 (0.78)	101.8
Puma	Yahzi	30	Female	11	64	34.54	94.22 (1.42)	111.39 (1.14)	118.2
Eurasian Lynx	Petra	18	Female	19	55.02	37.41	101.83 (1.98)	111.18 (1.21)	109.2
Serval	Samia	10	Female	12	61.04	58.38	115.02 (1.84)	123.06 (1.93)	107.0
Serval	Jua	10	Female	9	61.37	60.51	104.61 (2.28)	120.02 (1.09)	114.7
Fishing Cat	Aquarius	10	Male	10	15.58	24.45	118.57 (6.53)	155.9 (5.15)	131.5
Jungle Cat	Jack	10	Male	10	57.17	23.39	121.85 (1.43)	141.47 (2.75)	116.1

231 **Discussion**

232 The treatment of aged and geriatric animals in living collections is controversial, often
233 requiring a trade-off between the welfare of the individual and the long-term sustainability of
234 the reproductive population⁴⁸. However, it is an issue that curatorial teams, population
235 managers, and veterinary professionals will need to tackle with increasing frequency⁴⁹. As
236 husbandry and veterinary practice improves, the lifespans of captive animals will increase,
237 and there will be an associated need to maintain their quality of life. Specifically, the risk of
238 reduced welfare resulting from age-related musculoskeletal diseases (MSDs) such as
239 osteoarthritis will become higher^{1,49} and will require management of the affected populations
240 and/or individuals. Our investigation of the ZIMS dataset shows that the median ages of four
241 widely kept subspecies of big cats is at, or approaching, ten years of age, and that between 10
242 and 21% of individuals in the European population of each are 15 years of age or older. These
243 data highlight that the European populations of big cats are aged, and combined with our
244 observational study suggest that nutraceutical supplements could be an important addition to
245 the toolkit that veterinary professionals have available with aim of maintaining quality of life
246 in these animals. Specifically, in 18 aging felids of different age and sex, across 13 species of
247 different size, the addition of dietary nutraceutical supplements was associated with a
248 consistent and significant increase in a key metric of individual mobility (the steps per unit
249 time of those cats). We discuss the implications of these findings, and their potential role in
250 the field below.

251

252 These results can start to fill a major gap in research surrounding MSDs in big cats, with very
253 few studies investigating pain, how to measure it, or how to alleviate it within the taxon.
254 Most of the research into the efficacy of nutraceutical treatment has so far focussed on
255 domesticated dogs^{33,34,35,36} and cats^{29,30,31}. Our results are consistent with this growing body

256 of research and illustrate that green-lipped mussel extracts yield beneficial outcomes in
257 captive non-domesticated felids. The 13 species included in this study represent a broad range
258 of species of different size, geographic distribution, and included individuals of different sex,
259 and age. The fact that the rate of steps per minute increased across all individuals in this
260 range of species highlights the potential transferability of this supplement, and the possibility
261 of it being a more general treatment for musculoskeletal problems in a broader range of taxa
262 outside of domesticated carnivores and non-domesticated big cats.

263

264 The caregiver placebo effect can be a strong factor in studies of chronic pain, particularly in
265 felids^{45,46}. Ideally all data collection would have been performed blind such that the observers
266 would not know which clips corresponded to pre- vs. post-supplementation, and future
267 research should consider the inclusion of a control group if sample size permits. Although we
268 cannot entirely rule out the possibility of it influencing our results, our analysis of inter-
269 observer reliability suggests that the data collected are robust to the placebo effect. Green-
270 lipped mussel extracts have been shown to lead to objective improvements in other taxa
271 either alone⁵⁰, or in conjunction with other supplements²⁹. In the latter case, a 2010 study²⁹
272 highlighted the possible positive effects of GLM extracts in cats, but their supplements also
273 included higher than usual levels of eicosapentaenoic acid (EPA), and docosahexaenoic acid
274 (DHA), both of which may also be beneficial in the treatment of MSDs. Similarly, in our
275 study we cannot rule out the possibility that the increased mobility of cats was not due to
276 interactions between GLM extracts and Flexadin, which was also administered throughout
277 the data collection period. Flexadin has shown beneficial impacts in domestic cats and
278 dogs^{51,52}, but the diet of non-domestic felids in captivity contains a higher proportion of its
279 active ingredient (undenatured type II collagen) than their domestic counterparts, suggesting
280 that while an interactive effect is possible, it is unlikely to entirely explain our results.

281 Important extensions of our research would be to include blinded data collection to reduce the
282 likelihood of the caregiver placebo effect, using other objective measures of MSDs severity,
283 and to remove other supplements from the diet entirely to isolate the effects of the focal
284 supplement.

285

286 Steps per minute was used as a metric of mobility for operational reasons, but through further
287 detailed observations, alternative measures could provide further insight into how the effects
288 of Antinol are manifest in the study species. Stride frequency has a significantly lower
289 metabolic cost compared to other movement centred metrics such as stride length⁵³ and it is
290 therefore likely that stride frequency would be one of the first parameters to improve as the
291 symptoms of MSDs ease. Other metrics that could be used to may be more objectively
292 measured, relating to the gait of the treated animals³ (e.g., peak vertical force), or subjective
293 measures such as orthopaedic assessment scores or more behaviour-oriented data³. Further
294 research investigating the effects of nutraceutical supplementation on a suite of these metrics
295 could provide a more holistic view the benefits and potential drawbacks of Antinol treatment.

296

297 During the first data collection block, the temperature ranged between 25-30 degrees Celsius,
298 whereas in the second stint it was lower at 10-15 degrees Celsius. Although understudied in
299 non-human animals, there is evidence that lower temperatures and changes in barometric
300 pressure can increase the severity of MSDs, specifically osteoarthritis in humans^{54,55} although
301 this evidence is not unequivocal⁵⁶. In this case we might expect this temporal variation in
302 temperature to make it harder to detect, rather than amplify, any beneficial impacts of
303 Antinol. In domestic cats, activity levels may be negatively associated with temperature such
304 that higher temperatures result in reduced physical activity⁵⁷. Whether this trend applies to
305 captive non-domestic cats from such a range of climates is unclear, as is the question of

306 whether the range of temperatures under which the study was conducted would have an
307 effect. If such a trend were consistent across species, we might expect the higher
308 temperatures to reduce overall movement in the pre-supplementation treatment, but how this
309 would affect our output metric of steps per unit time is difficult to ascertain. So, while the
310 temperature difference between data collection periods remains a possible contributing factor
311 to our results, we think it unlikely that steps per unit time would increase uniformly across
312 such a range of species in response to this difference.

313

314 The longer lifespans and associated increased frequency of novel diseases means that
315 stakeholders within collection management have divergent views of how to deal with the
316 issues presented by housing aged animals⁴². Broadly speaking there exist three options for
317 managing the increased longevity of captive animals. First, we revise our views and review
318 our policies on which animals should be kept in captivity if we judge that the increased
319 lifespan of large-bodied, long-lived animals causes a significant compromise to the welfare of
320 those animals⁵⁸. Second, if the focus of captive population management is purely to keep
321 sustainable, reproductive populations, aged animals could be euthanized at the point in time
322 at which they no longer contribute to that population and a clear decision-making process and
323 audit trail exists⁵⁹. Finally, we could develop a set of treatments and tools that allow us to
324 maintain an acceptable level of quality of life in aged individuals beyond their reproductive
325 contribution to the population. Our results suggest that if some collections and population
326 managers wish to pursue the third option, then nutraceutical supplementation could provide
327 another tool to help alleviate age-related conditions in these animals.

328

329 **Acknowledgements**

330 We would like to thank the staff of the Big Cat Sanctuary for their time and expertise.

331

332 **Footnotes**

333 There are no conflicts of interest related to this study.

334

335 **Data Availability Statement**

336 A flat sheet of all data used in the analyses within this study will be available from the

337 Liverpool John Moores University data repository upon acceptance of the paper.

338

339 **Author Contributions**

340 **Conceptualization:** Jon Bielby, Matthew Norfolk, Luiza Figueiredo Passos, Adam Reddon,

341 Matthew Rendle.

342 **Data acquisition:** Matthew Norfolk, Luiza Figueiredo Passos.

343 **Formal analysis:** Jon Bielby, Matthew Norfolk, Luiza Figueiredo Passos, Adam Reddon.

344 **Writing – original draft:** Jon Bielby, Matthew Norfolk.

345 **Writing – review & editing and final approval of submitted draft:** Jon Bielby, Matthew

346 Norfolk, Luiza Figueiredo Passos, Adam Reddon, Matthew Rendle.

347

348 **Figure legends**

349 **Figure 1:** Group median (\pm IQR) of steps per minute before and after addition of supplement

350 to the diet. Each separate line joining the before and after treatment represents an individual

351 cat.

352

353 **Figure 2:** Age pyramids from ZIMS data from European collections on the following sub-
354 species of big cats: **A.** African lions (*Panthera leo*), **B.** Asian lions (*Panthera leo persica*), **C.**
355 Amur tiger (*Panthera tigris altaica*), **D.** Sumatran tiger (*Panthera tigris sumatrae*). The
356 lengths of the bars represent the number of individuals within each one-year age category for
357 each of male (yellow bars on the left) and female (green bars on the right) cats separately.
358 Deviation from a pyramid shape suggests a high prevalence of aged cats.

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