

The effects of dietary variation and ecology on the relationship between body size and reproductive strategy in extant mammalian carnivores

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Short title

Dietary Effect on Size and Reproduction in Carnivores.

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Abstract:

Diet has a profound impact on the relationship between body mass and reproductive strategy in mammals, and the implications have been of particular interest in recent years. Previous studies have indicated that diet strongly shapes the way that body mass drives reproductive strategy in herbivores and omnivores, but not in carnivores. One suggested explanation for this result is that the differences in resource distribution between invertebrate feeding carnivores (hypocarnivores) and vertebrate feeding carnivores (hypercarnivores) combine to produce a non-significant result when they are analysed as a single unit. In this study, we investigate how dietary and locomotor differences in carnivores influence the relationship between body mass and reproductive strategy within the context of phylogeny, using a reproductive strategy index and performing a phylogenetically informed analysis of covariance (PANCOVA) on 101 evolutionary trees. We examine this question in two distinct ways. First, we separate carnivores by diet (hypocarnivores, mesocarnivores, and hypercarnivores). Second, we separate carnivores based on their mode of locomotion to determine how ecology may affect this relationship irrespective of diet. For all diet categories we find that the effect of diet is significant when taken individually but is not significant when carnivores are investigated as a single unit. When examining locomotion categories individually, we find that statistically significant trends exist for all groups but volant carnivores. When analysed as a single unit the effect is significant. These results suggest future work should investigate ecological differences to understand the variation in reproductive strategies among carnivores. In the end, the aspects of diet investigated here do not influence the relationship between body mass and reproductive strategy in carnivorous mammals, while ecology does. This suggests that evolution in carnivore reproductive strategy is driven by distinctly different factors than those in omnivorous or herbivorous mammals.

Keywords: Evolution, Life history, Mammals, Diet, Mammalogy, Reproduction

Introduction:

Diet has had a significant impact on the evolution and radiation of mammals, as indicated by the sheer diversity of mammalian dentitions (Pineda-Munoz et al., 2016; Price et al., 2012; Weller, 1968). Diet also plays a primary role in determining body mass and other physiological characters of mammalian species (Pineda-Munoz et al., 2016; Price and Hopkins, 2014). Additionally, mammalian body size appears to strongly influence reproductive strategy (Famoso et al., 2018; Werner and Griebler, 2011; Charnov, 1990; Tuomi, 1980). Large mammals tend to be *K*-selected (low numbers of offspring with a greater degree of parental care), while small mammals tend to be *r*-selected (high number of offspring with a lower degree of parental care, or absence of parental care altogether). The relationship between body size and reproductive strategy in mammals is well understood (Famoso et al., 2018; Price and Hopkins, 2014; Wilder et al., 2012; Tuomi, 1980), but the effect that diet has on this relationship is not well known. Diet influences extrinsic ecological factors such as resource distribution, competition,

41 lifestyle, and longevity (Sibly and Brown, 2007). Each of these constraints influences body size
42 and, potentially, reproductive mode in mammals.

43 Previous studies comparing diet to body mass suggest that herbivorous mammals tend to large
44 size, while omnivores are intermediate, and carnivores tend to be the smallest mammals (Price
45 and Hopkins, 2014). The basal trophic state in mammals is carnivory, specifically insectivory,
46 and the earliest mammals were relatively small (Price et al., 2012; Holliday and Steppan, 2004;
47 Bengston, 2002). Additionally, omnivory likely developed when carnivores diversified their
48 diets, and this generalist diet led to herbivory (Price et al., 2012). Large bodied animals have a
49 variety of benefits, including a relative reduction in metabolic energy requirements. This
50 reduction in metabolic rate creates increased food abundance for large bodied animals, which
51 can consume low quality, hard to digest food items (Hopkins, 2018; Price and Hopkins, 2015).
52 Large size also provides protection from predators (Weterings et al., 2018). While large
53 carnivores are rare compared to large herbivores, their size allows consumption of a wider array
54 of prey species than small carnivores can (Wolf and Ripple, 2016).

55 Carnivory is a unique ecological challenge, as their food supply relies not only on the relative
56 abundance of species, but on the ability of the carnivore to kill and consume another animal
57 (Bengston, 2002). Small to medium sized carnivores invest more time and energy hunting and
58 capturing prey, while large carnivores consume more per feeding while investing less in
59 procurement of food (Rizzuto et al., 2018). This dichotomy is because smaller carnivores only
60 obtain a portion of their daily requirements per feeding, and so are constantly on the hunt; in
61 contrast, large carnivores satisfy their daily requirements much more easily (Rizzuto et al.,
62 2018). Because carnivores tend to be the smallest mammals, it is expected that they would be
63 most likely to favour *r*-selection, while herbivores would favour *K*-selection, and omnivores
64 would fall between. Famoso et al. (2018) analysed the effect of diet on the relationship between
65 body mass and reproductive strategy in mammals and showed that diet has a significant impact
66 on this relationship in herbivores and omnivores but not in carnivores. Although the observed
67 relationship was not significant in carnivores, it did indicate the lowest tendency for *K*-selection
68 with increasing size of all the animals studied. Herbivores demonstrated the greatest trend toward
69 *K*-selection with increasing size, and omnivores presented a trend with increasing size which was
70 to be more *r*-selected than herbivores and more *K*-selected than carnivores.

71 Feeding adaptations in herbivorous mammals are largely restricted to the dentition and
72 musculature of the jaw, while in carnivores these adaptations include the postcranial skeleton and
73 musculature (Davis and Golley, 1963). Locomotion is fundamentally connected to postcranial
74 morphology and is a critical component of ecology (Gutarra et al., 2023, Hildebrand 1960).
75 Locomotion relates to substrate preference (aquatic, terrestrial, volant, etc.) and, for carnivores,
76 mode of predation (Pancioli, et al., 2017). However, morphology restricts the breadth of an
77 animal's movement, as seen in seals: highly mobile swimmers with difficulty moving on land

78 (Panciroli, et al., 2017; Taylor, 1989). Locomotion mode may also constrain size, as seen in
79 volant and fossorial mammals, for whom small body size helps meet their physical demands
80 (Van Valkenburgh, 1987). Thus, a carnivore's locomotor mode limits the prey it can feasibly
81 capture (Van Valkenburgh, 1987). Carnivores also show important differences in the proportion
82 of meat, that is, vertebrate flesh, in their diets. Carnivores that eat less than 30% meat, with
83 nonvertebrates constituting most of their diet, are termed hypocarnivores, while mesocarnivores
84 eat between 50-70% meat, and hypercarnivores eat at least 70% meat (Roemer et al., 2009;
85 Holliday and Steppan, 2004; Van Valkenburgh, 1989). Although hypocarnivores eat less than
86 30% meat, they still require that meat to survive, which sets them apart from herbivores (Van
87 Valkenburgh, 1989). Many omnivorous species may also be described as mesocarnivores or
88 hypocarnivores (Holliday and Steppan, 2004; Van Valkenburgh, 1989). Carnivorous mammals
89 may preferentially consume other vertebrates, invertebrates, or may ingest both indiscriminately.
90 We frame this study on carnivore dietary compositions and differences in ecology as denoted by
91 locomotion, investigating the way these factors affect the reproductive biology of carnivorous
92 mammals.

93 We seek to understand how diet influences the relationship between body mass and
94 reproductive strategy in carnivorous mammals, in addition to how ecology may affect this
95 relationship. Our hypothesis is that resource distribution and nutritional availability may differ
96 for carnivores based on their diets, producing distinct relationships between mass and
97 reproductive strategy by dietary composition and prey preference. These varying relationships
98 within carnivores would explain why the relationship between body mass and reproductive
99 strategy is not significant for carnivores as a group. If this explanation is the case, then we should
100 find significant relationships between body mass and reproductive strategy in carnivorous
101 mammals when we break out lineages by dietary composition. We consider three specific dietary
102 compositions (hypocarnivore, mesocarnivore, and hypercarnivore). Additionally, if diet does not
103 have a profound influence on the relationship between body mass and reproductive strategy in
104 carnivores, it can be hypothesized that ecology is the primary driving force behind the observed
105 pattern. To this end we consider four categories of locomotion (terrestrial, fossorial, volant, and
106 aquatic). If ecology impacts the relationship between body mass and reproductive strategy, then
107 we should find significant relationships between body mass and reproductive strategy when we
108 break out lineages by locomotion. Our null hypothesis is that there is no distinction in the way
109 that diet or locomotion and body mass drive reproductive strategy in carnivores, so there should
110 be no significant relationships in the regression analyses.

111 **Methods and Materials:**

112 We define carnivores as an ecological grouping rather than a phylogenetic one, and in this
113 regard we can analyse predatory taxa that do not fall within the carnivora, such as whales and
114 bats. We build upon the data set and R code from Famoso et al. (2018), which related diet and
115 body mass to reproductive strategy. Original life history data for Famoso et al. (2018) was
116 downloaded from the PanTHERIA database (Jones et al., 2009). Famoso et al. (2018) defined
117 Reproductive Strategy Index (RSI) as principal component one extracted from a principal

118 components analysis (PCA) run on three variables: offspring per year, percentage of the year
119 dedicated to parental care, and sexual lifespan. RSI explains 64.13 percent of the variance in the
120 reproductive data, making it a robust measure of reproductive strategy. Famoso et al. (2018)
121 presented information on body size and life histories of female animals belonging to 561 species
122 of mammal. We removed Herbivores and Omnivores from the data set to focus on primarily
123 carnivorous mammals, and we added information for each species about its carnivorous diet
124 using data from Price et al. (2012). A total of 206 carnivorous species were then separated into
125 three subcategories based on specific diet: hypocarnivore (carnivores with meat composing less
126 than 30% of their diets), mesocarnivore (carnivores with meat composing 50-70% of their diets,
127 and hypercarnivore (carnivores with meat composing over 70% of their diets). The number of
128 species examined varied by category, with 155 species being hypocarnivorous, 25
129 hypercarnivorous species, and 28 mesocarnivorous species. To account for any effects of
130 phylogenetic relatedness on the relationship between diet and body size for each diet category,
131 we performed a phylogenetically informed analysis of covariance (PANCOVA) on these data
132 using the caper package version 1.0.1 (Orme et al., 2018) in R version 4.1.2 (R Core
133 Team, 2021). Following Famoso et al., (2018), we used 101 mammalian phylogenetic trees
134 created by Fritz, Bininda-Emonds, and Purvis (2009). Our code was prepared with the intent of
135 comparing both phylogenetically informed least squares (PGLS) regressions within each specific
136 diet grouping, plotting the body mass and reproductive strategy index on continuous
137 evolutionary contour maps in phytools version 1.0-1 (Revell, 2022), and checking for statistical
138 significance in PANCOVAs between the diet categories over 101 iterations, each of which
139 considered the evolutionary signal for a different phylogenetic tree. We modified code from
140 Famoso et al. (2018) (supplemental file). To determine the effect that aquatic and volant
141 mammals had on the significance in the results of the PANCOVA due to their unique
142 evolutionary histories, bats and whales were removed entirely from an iteration of the complete
143 analysis. A second complete analysis, built on a modification of the first, compared carnivores
144 based on their mode of locomotion. For this comparison, the species were categorized in terms of
145 locomotion mode for which sufficient samples were available (terrestrial, fossorial, aquatic, and
146 volant) and the analysis was conducted on these categories according to the procedures described
147 above. Again, the number of species considered in the analysis varied by category: 108 terrestrial
148 species, 18 aquatic species, 10 fossorial species, and 67 volant species. Given the nature of the
149 analysis based on locomotion, only one was performed with aquatic and volant animals included
150 as excluding these would eliminate two locomotion categories of interest. Arboreal animals were
151 included in the data set, and are shown in the figure, but were excluded from analysis due to poor
152 sample size. Locomotion was considered independently of diet to determine how ecological
153 differences may affect the relationship between body mass and reproductive strategies in
154 carnivorous mammals.

155 Values for slope, intercept, p -values, and standard errors for each stat were obtained from the
156 outcomes of the 101 iterations in each analysis. Results obtained through testing PGLS
157 regression intercepts against each other, and the general carnivore trend were denoted
158 PANCOVA result 1, while PANCOVA result 2 was obtained by testing both PGLS slopes and

159 intercepts against each other and the general carnivore trend. The median p -values for slope and
160 intercept across all analyses were then taken from the lists of results and reported in Tab. 1-3.
161 Median slope and intercept values from repeated PGLS were then used to plot regression lines
162 (Fig. 1-3) which are more representative of the data than single standard PGLS regression lines
163 alone. Median values for PANCOVA results were considered in the final interpretations.

164 **Results and Discussion:**

165 While we found a difference in the relationship between body mass and reproductive strategy in
166 three subcategories of carnivore when separated based on diet (hypocarnivore, mesocarnivore, or
167 hypercarnivore), the overall model is not statistically significant when slopes and intercepts of
168 subcategory PGLS regressions are tested against each other and the general carnivore trend
169 which disregards diet information ($p = 0.8044$). When bats and whales are removed from the
170 analysis, so only terrestrial carnivores are considered, there is a striking decrease in the p -value
171 of the effect of diet on the relationship between body mass and reproductive strategy (p
172 $= 0.0745$), though focusing on terrestrial carnivores does not yield a statistically significant result
173 for the model as shown in (Tab. 2). While unique trends appear to exist, the median results of
174 PANCOVA analyses run on 101 phylogenetic trees indicate that differences according to diet are
175 not enough to exclude this observation from being an artifact of random chance (Fig.1). The
176 PANCOVA results and other statistics obtained from the analysis are shown in Tab. 1-2.
177 Running the analysis on carnivorous mammals predicated on locomotion returned a significant
178 result for the overall model ($p = 0.008$), as detailed in Tab. 3. Significant results were observed
179 for terrestrial, fossorial, and swimming animals but not for volant animals (bats). The results for
180 terrestrial mammals were noteworthy as p -values for the slopes and intercepts of this group
181 returned apparent zeroes, indicating a high degree of confidence in the generated regression. The
182 slope for volant carnivores was found to be not statistically different from zero, which may relate
183 to a narrow range of body size likely related to adaptations for flight (Fig.3). Confounding
184 factors related to the unusual modes of parental care, locomotion, and ecosystem energetics
185 found in flying or aquatic carnivores are likely responsible for the observed discrepancies and
186 limiting the diet analysis to terrestrial carnivores eliminates these variables (Fig.2). Diet does not
187 appear to have a significant impact on the relationship between body mass and reproductive
188 strategy in carnivorous mammals. However, ecology as denoted by locomotion seems to
189 significantly impact the relationship between body mass and reproductive strategy in carnivores.
190 Inferences were made based on median P -values returned when PANCOVA analysis was
191 performed on 101 mammalian family trees for the variables in question. Similar methodology
192 was used in (Bolt et al., 2022). We emphasize that the uncertainty produced from each individual
193 iteration was not considered when making these inferences, so any interpretations in this regard
194 should be made with a degree of caution.

195 When the relationships between body mass and reproductive strategy are compared on the basis
196 of diet between herbivores, carnivores, and omnivores a significant result is observed for
197 herbivores and omnivores, but not for carnivores though the overall model is significant (Famoso
198 et al., 2018). It was presumed that the reason for the deviation seen in carnivores was a

199 difference in resource distribution and availability between carnivores that preferentially feed on
200 other vertebrates and those that feed primarily on invertebrates (Famoso et al., 2018; Carbone et
201 al., 1999). We have found that diet does not impose a significant influence on the way that body
202 mass drives reproductive strategy in carnivores, but that ecological differences observed among
203 carnivores do impose a significant influence on this relationship. One reasonable explanation for
204 our results is that carnivores represent a more basal dietary state, subsisting on easily digested
205 and highly nutritive animal protein that is homogeneous in nutritional value across prey species.
206 It could be that dietary nutrition varies more based on the relative amounts of meat consumed,
207 and that these differences could be offset by factors such as frequency of feeding or the
208 nutritional value of invertebrate or plant materials that supplement the diet. Locomotion
209 introduces another variable as the kinds of foods that animals can obtain is contingent upon their
210 mode of locomotion. For example, a bat has access to a selection of prey species that is distinctly
211 different than those available to a marine mammal. It appears that the effect diet has on the
212 relationship between body mass and reproductive strategy in carnivores is subtle, with
213 differences in ecology shaping this relationship.

214 Differences in reproductive biology observed in various locomotor groups can likely be
215 attributed to a combination of morphological deviation from a generalized terrestrial body plan,
216 biological constraints such as body size, and the unique ecosystem energetics experienced by
217 some groups. For example, in insectivorous bats there seems to be no correlation between
218 reproductive strategy and body mass, which suggests that the evolution of reproductive biology
219 in bats is driven by factors unrelated to body mass. However, terrestrial mammals demonstrate a
220 very strong correlation between body mass and reproductive strategy suggesting that these are
221 fundamentally connected in terrestrial carnivores. It may be that diet began affecting this
222 relationship in a significant way when carnivores diversified their diets to include larger amounts
223 of plant material, and certainly a transition to herbivory led to a change in focus from food
224 collection to food processing. Because the relationship between body mass and reproductive
225 strategy appears to operate independently of diet in carnivores, we can infer that the evolutionary
226 biology of carnivores is driven by different factors than those seen in omnivores or herbivores.
227 These ideas are reinforced by the restriction of morphological adaptations to diet in herbivores to
228 the teeth and jaws, while in carnivores they include the postcranial musculoskeletal system
229 (Davis and Golley, 1963). Additionally, in carnivores it appears that dental morphology reflects
230 diet, but may be shaped more by competition for food among sympatric carnivores, which results
231 in resource partitioning (Van Valkenburg, 1989). For example, polar bear teeth are not
232 significantly different in form than those of a grizzly bear, despite polar bears being much more
233 carnivorous, suggesting that in the absence of competition, the ancestral tooth form was retained
234 in polar bears despite dietary changes (Van Valkenburgh, 1989). It is worth noting that
235 behavioural adaptations like pack hunting can increase the efficacy of a predator beyond its
236 physical means and can serve to expand or improve diet (Taylor, 1989). Behavioural adaptations
237 in carnivores can also allow a carnivore to rear more offspring per litter than would otherwise be
238 possible (Oftedal and Gittleman, 1989).

239 Terrestrial carnivores returned p -values so small they were represented as “0” for both slope
240 and intercept which suggests a high degree of confidence. The strong connection between body
241 mass and reproductive strategy in terrestrial carnivores is likely reflective of physical demands of
242 supporting extra weight during pregnancy in addition to energetic demands faced by these
243 animals. Energy requirements increase significantly during pregnancy which is due to a
244 combination of increased metabolic rate and increased activity levels (Oftedal and Gittleman,
245 1989). Litter size has a strong positive correlation to body mass in mammals which speaks to the
246 importance of litter size when it comes to maternal expense, and the ability of larger mammals
247 with lower metabolic rates to care for greater numbers of offspring. The energetic requirements
248 for producing a litter drastically exceed the energy deposited in foetal tissues and involves the
249 production of mammary, uterine, and placental tissues. Carnivores are generally altricial and
250 require extensive parental care to survive which is related to the energy deposited in foetal
251 tissues by the mother during gestation (Oftedal and Gittleman, 1989). Precocial ungulate
252 neonates contain 20-40 percent more energy than what has been observed in the tissues of
253 neonate domestic carnivores. Additionally, carnivore milk tends to be more nutritively rich than
254 ungulate milk (Oftedal and Gittleman, 1989). A domestic cat that has a litter of 5 kittens will
255 spend about twice the energy of a cat with 2 kittens during intense lactation (Oftedal and
256 Gittleman, 1989). These limitations can be buffered by behavioural adaptations as in some
257 species conspecific individuals may cooperate in the feeding, defence, and transport of young.

258 Adaptations to flight place restrictions on body size, and this may explain why the observed
259 slope for volant carnivores was not statistically different from zero (Fig. 3), as a narrow range of
260 body mass is demonstrated by insectivorous bats. A variety of reproductive strategies are present
261 in insectivorous bats: delayed ovulation, delayed implantation, sperm storage, and reproductive
262 synchrony with the environment (Altringham, 2001). In each case the reproductive strategy
263 seems to circumvent pregnancy during hibernation and facilitate birth during the most productive
264 time of the year when food is most abundant. This maximizes survivability for both mother and
265 offspring as reproduction is energetically expensive. Energy transfer from mother to offspring
266 through milk production and feeding is costly for bats as well. Bats tend to “burn hot” even for
267 small mammals, which is part of the reason why they are such effective vectors for disease as
268 they are perpetually running a fever, but this elevated body temperature combined with small
269 size may necessitate the need to prevent gestational overlap with hibernation or periods of prey
270 scarcity to avoid starvation. It is worth noting that the group of herbivorous bats classically
271 referred to as the Megachiroptera are much larger than their insectivorous counterparts, the
272 Microchiroptera which likely reflects energetic differences between herbivorous and carnivorous
273 lifestyles. The size discrepancy between megachiropterans and microchiropterans is likely also
274 related to the necessity for maneuverability in predatory bats rather than strictly size limitation
275 related to flight. It turns out that bats are generally K strategists, which likely reflects the burden
276 that carrying and rearing altricial young exacts on these creatures. Bats tend to fly with their
277 young clinging to them which for a small flying carnivore is physically laborious (Altringham,
278 2001).

279 Marine environments represent a unique set of conditions both physically and energetically. In
280 marine ecosystems, the largest animals are carnivores with whales representing some of the
281 largest animals to ever exist (Bianucci et al., 2019). The incredible size of marine carnivores can
282 be attributed to a combination of low energy feeding mechanisms, an abundant and stable food
283 supply of high-quality animal protein, and the unique physical conditions of occupying an
284 aquatic habitat (Goldbogen et al., 2019). In general, mammals that are adapted to an aquatic
285 lifestyle are larger than their terrestrial relatives. Mustelids are one group in which aquatic
286 species are significantly larger than terrestrial species, an adaptation believed to reduce heat loss
287 in the aquatic environment (Estes, 1989).

288 Future research should consider behavioural adaptations or adaptations to various
289 environmental conditions with respect to the relationship between body mass and reproductive
290 strategy in carnivores. A statistically significant result might be found in carnivores when the
291 effects of ecological characteristics such as feeding strategy or degree of social behaviour on the
292 relationship between body mass and reproductive strategy are tested. We find that diet does not
293 significantly influence the way in which body mass drives reproductive strategy in carnivores,
294 however ecology seems to strongly influence this relationship.

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Table 1 — Statistical results for the three carnivore diet categories and accompanying PANCOVA results. Values ≤ 0.05 are taken to be statistically significant. Slopes, intercepts, t -values and p -values are medians from 101 random replicates. The Standard Errors of the Slopes and Intercepts reflect variation in values among the 101 random replicates.

	Value	Standard Error	t -value	p -value
Slope (Overall Model)	-0.1960	0.005967863	-6.039	<0.0001
Intercept (Overall Model)	1.1876	0.03347238	1.512	0.1320
Hypocarnivore Slope	-0.2427	0.00049481	-6.921	<0.0001
Mesocarnivore Slope	-0.4662	$1.025 \cdot 10^{-10}$	-12.476	<0.0001
Hypercarnivore Slope	-0.2274	0.00031171	-3.693	0.001201
Hypocarnivore Intercept	1.4329	0.00253749	2.684	0.008086
Mesocarnivore Intercept	3.0333	$6.253 \cdot 10^{-10}$	8.114	<0.0001
Hypercarnivore Intercept	1.1432	0.00296614	1.456	0.158819
PANCOVA result 1	NA	NA	NA	0.8613521
PANCOVA result 2	NA	NA	NA	0.8043951

Table 2 — Statistical results for the three specific diet subcategories of carnivores when bats and whales are removed from the data set. Values ≤ 0.05 are taken to be statistically significant. Slopes, intercepts, t -values and p -values are medians from 101 random replicates. The Standard Errors of the Slopes and Intercepts reflect variation in values among the 101 random replicates.

	Value	Standard Error	t -value	p -value
Slope (Overall Model)	-0.1318	0.005967863	-4.521	<0.0001
Intercept (Overall Model)	1.0235	0.03347238	1.756	0.0816
Hypocarnivore Slope	-0.2053	0.000113197	-7.890	<0.0001
Mesocarnivore Slope	-0.1976	$9.5000 \cdot 10^{-12}$	-3.130	0.0064
Hypercarnivore Slope	-0.2188	$6.1944 \cdot 10^{-11}$	-5.305	<0.0001
Hypocarnivore Intercept	1.4144	0.000485875	6.939	<0.0001
Mesocarnivore Intercept	1.4673	$7.7605 \cdot 10^{-12}$	3.566	0.0025
Hypercarnivore Intercept	1.3976	$6.1663 \cdot 10^{-10}$	3.799	0.0011
PANCOVA result 1	NA	NA	NA	0.1485993
PANCOVA result 2	NA	NA	NA	0.0541655

Table 3 — Statistical values obtained for mammalian carnivores when categorized on the basis of locomotion. Values ≤ 0.05 are taken to be statistically significant. Slopes, intercepts, t -values and p -values are medians from 101 random replicates. The Standard Errors of the Slopes and Intercepts reflect variation in values among the 101 random replicates.

	Value	Standard Error	t -value	p -value
Slope (Overall Model)	-0.1966	0.0063871	-6.0366	<0.0001
Intercept (Overall Model)	1.1914	0.0366161	1.5147	0.1314
Terrestrial Slope	-0.2231	$2.76986 \cdot 10^{-5}$	-13.7031	0
Fossorial Slope	-0.1508	$5.0773 \cdot 10^{-12}$	-3.4793	0.0083
Aquatic Slope	-0.5450	0.0038437	-2.9889	0.0087
Volant Slope	-0.1072	0.0018691	-1.0171	0.3129
Terrestrial Intercept	1.5380	$9.4086 \cdot 10^{-5}$	13.4174	0
Fossorial Intercept	0.9933	$2.6150 \cdot 10^{-11}$	5.3845	0.0006
Aquatic Intercept	3.9187	0.0534845	1.4290	0.1722
Volant Intercept	-0.0191	0.0034335	-0.0584	0.9117
PANCOVA result 1	NA	NA	NA	0.001463948
PANCOVA result 2	NA	NA	NA	0.008043177

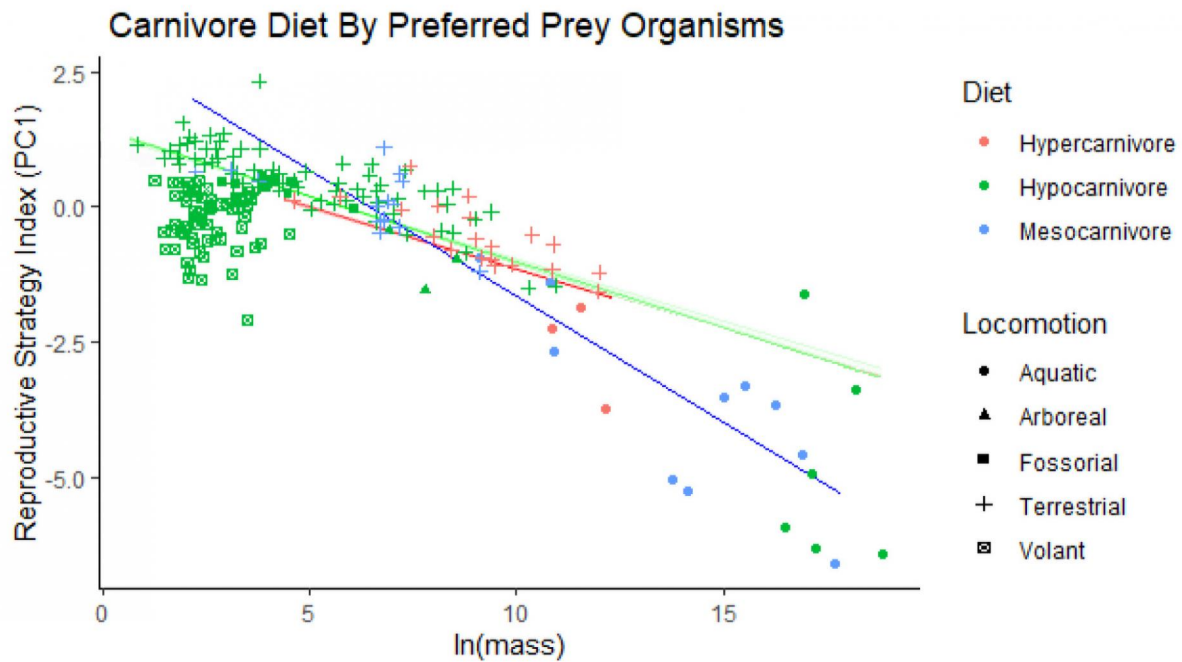


Figure 1 — Regression lines relating the natural log of body mass to the reproductive strategy index of carnivorous mammals based on dietary composition, after phylogenetic correction. Colours denote diet with the green line representing hypocarnivores, blue representing mesocarnivores, and the red representing hypercarnivores. While a general trend exists for lower reproductive rates in larger animals, the degree to which this occurs varies based on diet. The image shows solid lines based on the median coefficients and faded lines represent where 101 iterations were plotted.

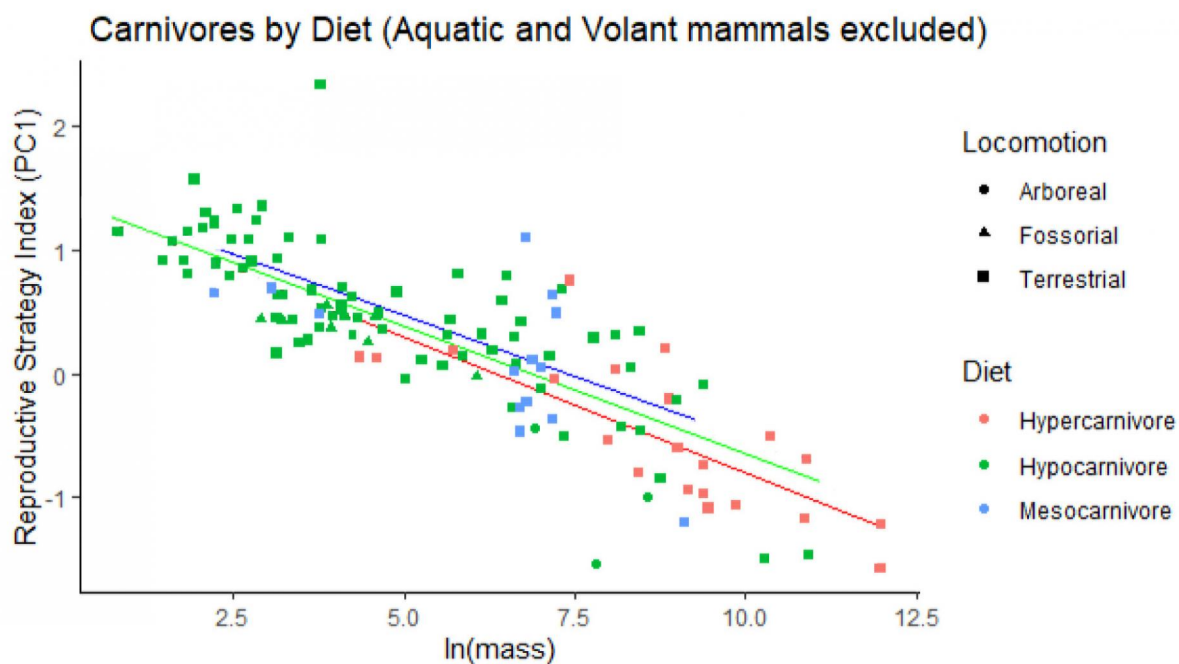


Figure 2 — A modification of Fig. 1, excluding whales and bats. The image shows regressions plotted based on median slopes and intercepts, generated through analysis of 101 phylogenetic trees. Faded lines represent the 101 individual iterations while solid lines represent the median coefficients.

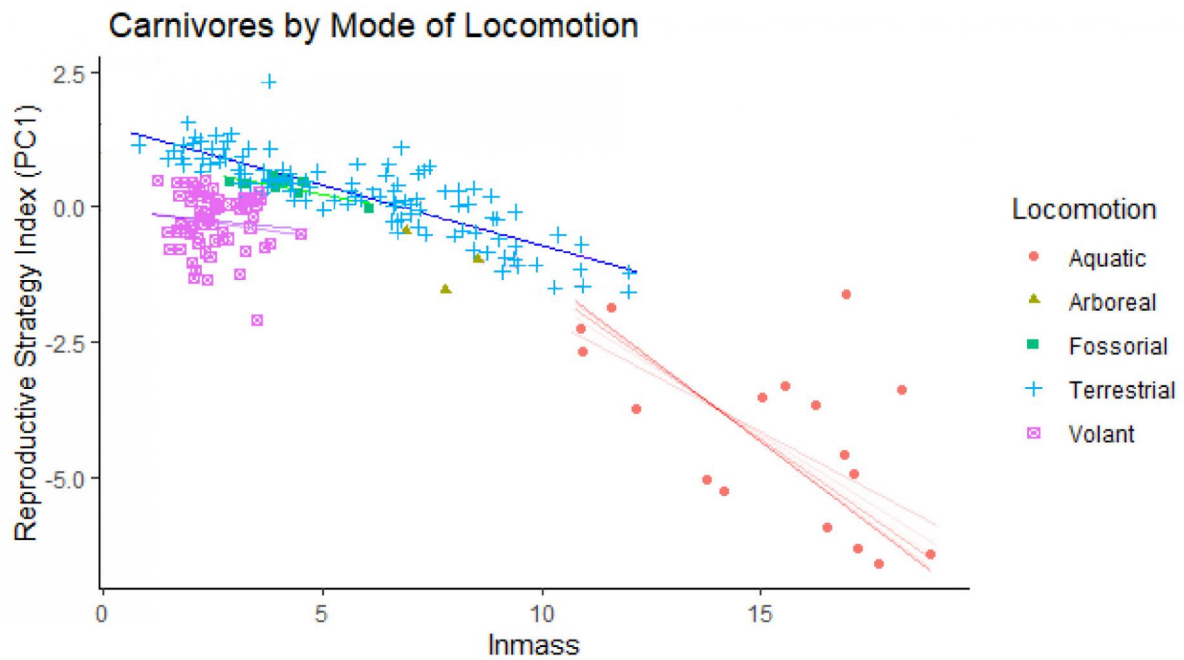


Figure 3 — The relationships between diet and body mass based on carnivore locomotor guilds irrespective of diet. The green line represents the regression for aquatic animals, the yellow line represents the regression for fossorial animals, the blue line represents the regression for terrestrial animals, and the purple line represents the regression for volant animals. Arboreal animals are represented by red circles but were not considered in this study. Lines were plotted based on median slope and intercept values generated through the analysis of 101 phylogenetic trees. Solid lines represent the median coefficients for slope and intercept while the faded lines represent each of the 101 iterations

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Tables

Table 1 - [Download source file \(24.86 kB\)](#)

Table 1 — Statistical results for the three carnivore diet categories and accompanying PANCOVA results. Values ≤ 0.05 are taken to be statistically significant. Slopes, intercepts, t-values and p-values are medians from 101 random replicates. The Standard Errors of the Slopes and Intercepts reflect variation in values among the 101 random replicates.

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Table 2 — Statistical results for the three specific diet subcategories of carnivores when bats and whales are removed from the data set. Values ≤ 0.05 are taken to be statistically significant. Slopes, intercepts, t-values and p-values are medians from 101 random replicates. The Standard Errors of the Slopes and Intercepts reflect variation in values among the 101 random replicates.

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Table 3 — Statistical values obtained for mammalian carnivores when categorized on the basis of locomotion. Values ≤ 0.05 are taken to be statistically significant. Slopes, intercepts, t-values and p-values are medians from 101 random replicates. The Standard Errors of the Slopes and Intercepts reflect variation in values among the 101 random replicates.

Figures

Figure 1 - [Download source file \(6.98 MB\)](#)

Figure 1 — Regression lines relating the natural log of body mass to the reproductive strategy index of carnivorous mammals based on dietary composition, after phylogenetic correction. Colours denote diet with the green line representing hypocarnivores, blue representing mesocarnivores, and the red representing hypercarnivores. While a general trend exists for lower reproductive rates in larger animals, the degree to which this occurs varies based on diet. The image shows solid lines based on the median coefficients and faded lines represent where 101 iterations were plotted.

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Figure 2 — A modification of Fig. 1, excluding whales and bats. The image shows regressions plotted based on median slopes and intercepts, generated through analysis of 101 phylogenetic trees. Faded lines represent the 101 individual iterations while solid lines represent the median coefficients.

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Figure 3 — The relationships between diet and body mass based on carnivore locomotor guilds irrespective of diet. The green line represents the regression for aquatic animals, the yellow line represents the regression for fossorial animals, the blue line represents the regression for terrestrial animals, and the purple line represents the regression for volant animals. Arboreal animals are represented by red circles but were not considered in this study. Lines were plotted based on median slope and intercept values generated through the analysis of 101 phylogenetic trees. Solid lines represent the median coefficients for slope and intercept while the faded lines represent each of the 101 iterations

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Code for running diet analysis with and without aquatic and volant species.

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