Body Size

Body Size: Introduction

Body size has a wide range across felid species. From the small domestic house cat to the comparatively large lion, body mass and body dimensions (height, width, and length) differ drastically.

While overall body sizes differed within our target species, the majority of body structural components relative to size (i.e., limbs, paws, head, etc.) were similar. See Tail Length Relative to Body Size for one example that does not follow this claim. The divergence in body size may be attributed to selective pressures for specialized hunting abilities. This hypothesis is supported by the relationship between predator and prey body size. As predators increase in size, their preference and hunting ability for larger prey increase (Gittleman 1985). Also, results from Felidae forelimb studies demonstrate a positive correlation between prey size and skeletal/muscular components of the forelimbs. Large cat predators were shown to have longer olecranon processes, robust radi and metacarpals, and larger humeral and radial articulation. All of these traits help the larger predator to withstand the forces of larger struggling prey. Smaller cats that hunt smaller prey do not meet as much resistance in their prey's capture. Instead, these smaller predators must be nimble with paws capable of catching smaller, elusive prey. Smaller predators have been documented to have elongated phalanges relative to metacarpals. This was hypothesized to provide a velocity advantage for catching the small prey (Meachen-Samuels 2008).

Hypothesis: The divergence in body size in our target species is due to selective pressures for specialized hunting abilities.

Lion (Panthera leo)

Male lions range in weight from 325-470 lbs, while female lions weigh 265-360 lbs (FCF). The approximate mean body mass was calculated to be 350 lbs (Diniz-Filho et. al 2009). The body length of an adult ranges from 7.8 ft to 11 ft and the height measured from the top of the shoulder to the ground ranges from 3 1/2 ft to 4 ft (FCF).

Body Size Relation to Prey

While they differ in their hunting strategy when compared to other Felidae (hunt cooperatively in groups), the actual killing of the prey is completed by a sole individual. They mainly prey on large ungulates such as zebra, gazelles, and impalas (Harrington 2004). Their larger prey struggle and resist the lion's predatory advances with greater force. Thus, a successful lion must be able to subdue its larger prey with its own sheer force. The lion has been documented to have longer olecranon processes, robust radi and metacarpals, and larger humeral and radial articulation. Also, their humeral epicondyles are larger relative to smaller predatory cat species. The humeral epicondyles are the origins of many forelimb muscles that aid in the grasping of large prey (Meachen-Samuels 2008).

However, if large prey availability is low, lions will hunt smaller prey (Harrington 2004).

Tiger (Panthera tigris)
The range of body weight for the tiger differs according to the subspecies (i.e. Amur, Sumatran, etc.) However, averaged across subspecies, the average weight for males is 350-570 lbs, while females weigh 220-300 lbs (FCF). The approximate mean body mass was calculated to be 360 lbs (Diniz-Filho et al. 2009). The head-body length ranges from 4 1/2 to 9 feet, and the height measured from the top of the shoulder ranges from 3 to 3 1/2 feet (Dacres 2007).

**Body Size Relation to Prey**

Tigers are solitary hunters. Their major prey sources include large ungulate species (i.e. hog deer, black buck, water buffalo, etc.) (Dacres 2007). Similarly to lions, tigers must subdue the resistive forces of larger prey. As large prey specialists, they share the same skeletal/muscular features as lions. Please see "body size relation to prey" for lions for more detail.

Also, tigers have the same advantage as lions when it comes to hunting smaller prey when large prey availability is low (Dacres 2007).

**Caracal (Caracal caracal)**

The approximate mean body mass is 26.5 lbs (Diniz-Filho et al. 2009). The adult caracal measured from nose to the base of the tail is 23 to 42 inches long and 18 inches tall at the shoulder. It is larger than most domestic cats. (The average house cat is 18 inches in length). The legs are tall, and its hind legs are disproportionately muscular and long. Females weigh 21 to 24 lbs (9.5-11 kg), while males weight 25 to 40 lbs (11.5 to 18 kg) (Phillips 2009).

**Body Size Relation to Prey**

Caracals are solitary hunters. While they hunt prey that are 2-3 times their body size, their overall prey size in comparison to the lion and tiger are much smaller. The bulk of its diet is made up of hares, rodents, and birds (Zoo Exhibit, IUCN).

Interestingly, the caracal's geographic range overlaps that of the lion and tiger. Thus, we hypothesize caracals were constrained by these larger predators to only hunt smaller prey (larger predators outcompeted the caracal for access to larger prey). Over time, the caracal became specialized to capture the available resource: smaller prey. Their elongated phalanges relative to their metacarpals provide a velocity advantage which may aid in the capture of smaller, elusive prey (Meachen-Samuels 2008).

**Phenotypic Evolution**
As discussed above, body size is important for the hunting abilities of each species. Also, body size plays an important role in protection. Large body size enables the species to fend off predators, while small body size allows species to hide and avoid detection by predators (Gittleman 1985).

Found in Late Oligocene deposits in France was a fossil similar in size to the modern ocelot (40 cm high at the top of the shoulder). This fossil was classified as the earliest ancestor of cat species and was named *Proailurus lemanensis*. Estimated to be 30 million years old, *Proailurus lemanensis* supports the hypothesis that smaller body size is an ancestral trait (Turner et al).

Illustrated in the phylogeny we constructed above, the large body size exhibited in lions and tigers is hypothesized to have arisen within the genus Panthera.

This trait is hypothesized to be adaptive because larger body size allowed species to monopolize more prey species (due to their ability to catch larger prey, while also hunting smaller prey if necessary).

Sexual dimorphisms for body size have been documented in these species. Generally, males are larger than females (see individual sections for body size for exact numbers). These differences in body size between sexes may be due to sexual selection. Larger body size (and mane size in lions) has been documented to positively effect an individual’s success rate in male-male competition and female choice (West and Packer 2002).

**Development/Gene Regulation**

The exact genes regulating the body size of this group is not known nor has it been researched within this family. However, many genetic studies in other mammalian species have illustrated body size evolution is a complex process involving many genes. An estimated number of 6,000 genes cause variation in body size in mice. In humans, mutations in 241 genes are known to cause large effects on body size (Kemper 2012). Also, the impact of hormones on body size has been investigated in species of primates. While earlier studies suggested a higher level of insulin-like growth factor (IGF-1) was correlated with larger body size, more recent studies have proved the interaction between hormones and
body size is not as straightforward. Instead, multiple hormonal processes, as well as other genetic mechanisms, are most likely responsible for size differences between and among species (Bernstein et. al 2007).

Due to the similarities in body structural components relative to body size, we hypothesize the difference in body size can be attributed to mutations in regulatory regions. While primary literature supporting this hypothesis is lacking, we believe these differences may have arisen via the mechanism of heterochrony. A regulatory region within larger felid species may have a mutation that allows the earlier expression of genes for body growth. This mutation would have provided the individual an advantageous body size capable of outcompeting others for resources. Thus, individuals with these regulatory mutations may have had better survival, more opportunity to mate, and the allele carrying this regulatory mutation would have risen to fixation within the population.

References


PHOTOS:

This photo was taken in January 2007 by Nick and Melissa Baker in the Serengeti. Thanks go to Alex, our guide, and Green Footprint Adventures. See [http://www.flickr.com/photos/nickandmel/419801669](http://www.flickr.com/photos/nickandmel/419801669)

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