

# Locomotor Anatomy of Gray Langurs (*Semnopithecus entellus*)

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## I. INTRODUCTION

Gray langurs (*Semnopithecus entellus*), colobines known for infant killing, are less appreciated for their locomotor versatility. Ripley's (1967) path-breaking field study found that leaping is only one aspect of their locomotor profile. Like many terrestrial cercopithecines such as vervets, baboons and macaques, gray langurs are proficient movers on the ground. However, little anatomical information has been available on *S. entellus* beyond muscle descriptions (Ayres 1948) and limb bone indices (e.g. Napier and Napier 1967). This study presents new research on both hard and soft tissues derived from dissection of whole animals. We compare langurs with vervet monkeys (*Cercopithecus aethiops*), which represent a generalized Old World monkey (Schultz 1970). We test the hypothesis that langurs have the basic Old World monkey ground plan similar to vervets.

## II. MATERIALS and METHODS of DISSECTION

Our study of langur and vervet monkeys combine analyses of all body segments and muscle groups with skeletal dimensions.

We use standardized methods in dissection of whole animals to provide quantitative information on body segments (head/trunk, tail, fore- and hind limbs), limb segments (arm, forearm, hand, thigh, leg, and foot) and individual muscles (e.g. Grand 1977; Zihlman et al. 2011). One on side of the body, the forelimb is detached from the trunk at the shoulder joint and weighed, the hind limb, at the hip joint. The tail is weighed as a unit. Each limb is then separated into segments and weighed. Tissues are separated and weighed: muscle, bone, skin. On the other side, each muscle with its tendon is detached and weighed.

Whole body segments are calculated relative to total body mass; within limb segments relative to total limb mass. Muscles are grouped according to function and relative percentages are calculated. Bones are cleaned and measured and intermembral, brachial, and crural indices, determined. Relative proportions of hand and foot bones are determined by taking the lengths of tarsal, third metatarsal and phalanx to total foot length, and hand proportions are determined on comparable functional segments.

## III. RESULTS

**Relative segment masses.** Whole body segments are similar in the langur and vervet, although the langur tail is relatively lighter (**Figure 1a**). Within limb segments, the langur arm is relatively lighter than the vervet, but the forearm and hand are heavier. The langur thigh accounts for less of the hind limb mass, whereas the leg and foot are relatively heavier (**Figure 1b**).

**Relative muscle groups.** The percent of elbow, wrist, and extrinsic digital flexors to extensors are similar in langur and vervet, as are the plantar-/dorsiflexors and digital flexors to extensors. The differences become apparent in knee extensors/flexors: extensors are relatively heavier in langurs, whereas in the vervets these muscles are nearly equal. Langurs have heavier foot invertors (**Figure 2**).

**Bone length indices.** Intermembral and crural indices of the two species overlap. The brachial index does not: langur average is 108 (range 105-114), the vervet 95 (93, 97) (**Table 1**). The relative proportions of foot bones are similar. In the hand, however, langur metacarpals are relatively longer than in vervets (**Figure 3**).

## IV. DISCUSSION

Gray langurs, traditionally classified as "arboreal folivores," are equally at home on the ground and in the trees. Ripley emphasized that their locomotor behavior shows competence at both ends of the spectrum. Gray langurs and vervets share some musculo-skeletal features, part of the Old World monkey "ground plan." The distribution of body mass to whole body segments is similar in langurs and vervets, although the langur tail is relatively lighter. The muscle group ratios of the elbow, wrist and extrinsic digits are also similar in the langur and vervet. The langur intermembral and crural indices overlap with vervets, though the brachial index is distinct (cf. Napier and Napier 1967; this study).

In the trees, langurs make long spectacular leaps between branches, and on the ground can attain relatively high speeds (Grand 1976). The differences in anatomical features of langurs may contribute to their facility in making long bounding leaps. Within the limbs, segment mass proportions overlap somewhat, but langurs have a slightly different pattern in that mass is shifted distally. Hence, the forearm and hand, and leg and foot are relatively heavier in the langur. In the langur's hind limb, more mass to the invertors assist in turning the sole of the relatively heavier foot inward to conform to cylindrical branch shapes. The heavier langur quadriceps of the thigh provide powerful knee extension. Emphasis on invertors and quadriceps likely contribute to the vertical climbing behavior described by Ripley (1967), in which animals ascended 60' trees with no low branches, by hind limb propulsion, and descended with hind limbs acting as brakes. Powerful knee extension assists in vertical climbing and is a fundamental function in leaping that – in this case – is not readily translated from the intermembral index. Their heavier distal segments may assist in control of rotation during leaps (Dunbar 1994).

No field studies on gray langurs have documented leaping frequencies, or distance traveled using leaping. However, McGraw's 1998 quantitative study of locomotor repertoires of sympatric species of colobines and cercopithecines in the Taï Forest revealed that overall colobines *do* leap more than cercopithecines, that body mass and leaping frequency are not highly correlated, and that leaping is generally associated with travel more than foraging.

## V. SUMMARY and CONCLUSIONS

**Langur and vervet anatomies are remarkably similar in most respects, with the following exceptions:**

- **Langurs proportionately have lighter arms, thighs and tails compared to vervets.**

- **Langurs have heavier knee extensors and foot invertor muscles compared to vervets.**

- **Langur brachial index is higher than vervets.**

- **Langur hand metacarpals are proportionately longer than vervets, although there are no differences in the foot bone proportions.**

**These preliminary data on *S. entellus* and *C. aethiops* show an overlap in mass distribution and limb indices. Subtle differences suggest a possible variation in the Old World monkey "ground plan" that may reflect leaping behaviors characteristic of gray langurs.**

Table 1. Sample of Adults.

Specimen ID	Sex	Body Mass (g.)	Intermembral Index	Brachial Index	Crural Index
<i>Semnopithecus entellus</i>	Male	23438	82	108	91
<i>Semnopithecus entellus</i>	Male	18438	82	105	89
<i>Semnopithecus entellus</i>	Female	11000	84	105	88
<i>Semnopithecus entellus</i>	Female	10545	82	114	91
<i>Cercopithecus aethiops</i>	Male	6450.0	82	93	91
<i>Cercopithecus aethiops</i>	Female	3500.0	79	97	98

Figure 1a. Percent Segment Proportions to TBM.

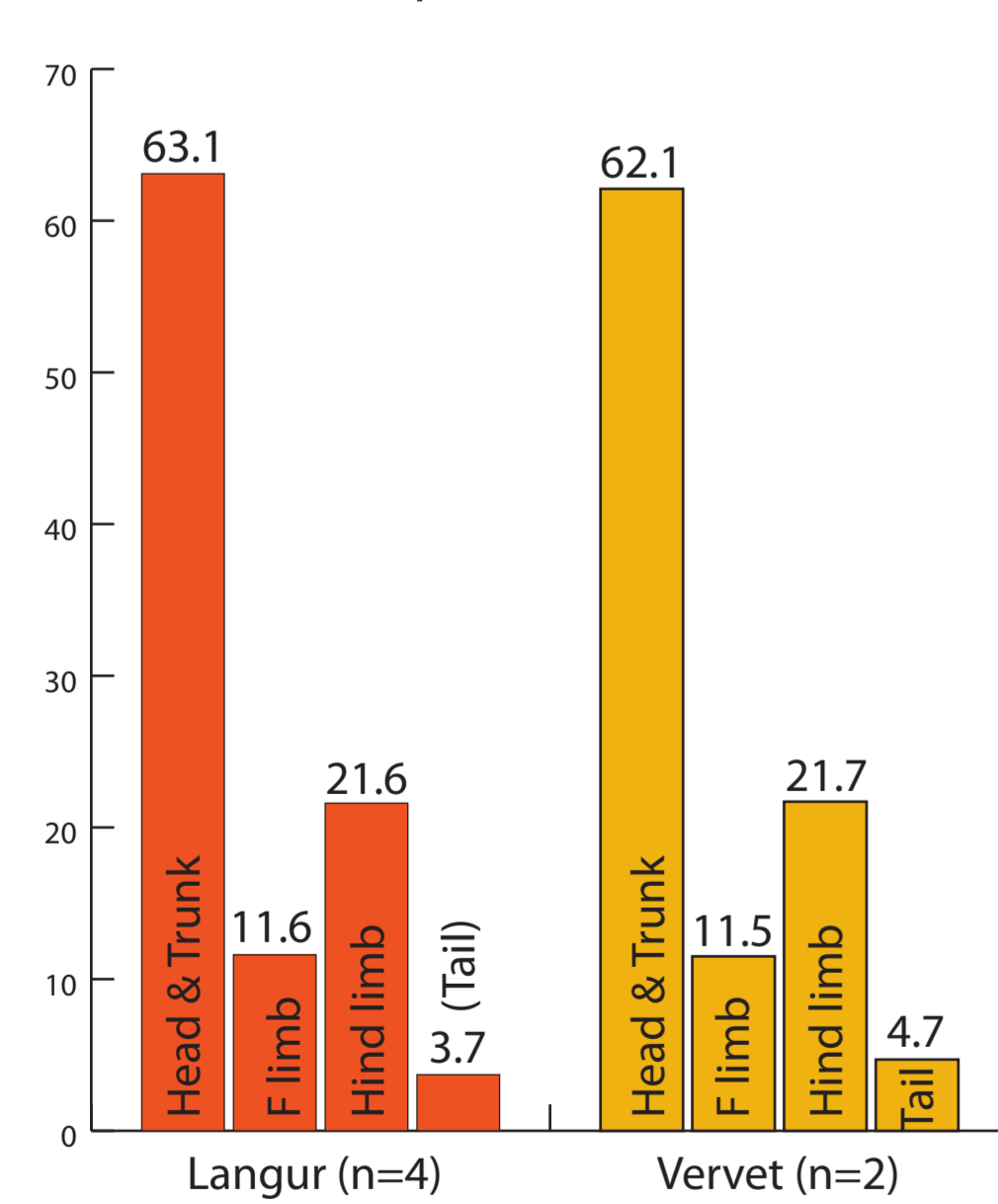


Figure 1b. Percent Segment Proportions to Total Limb Mass.

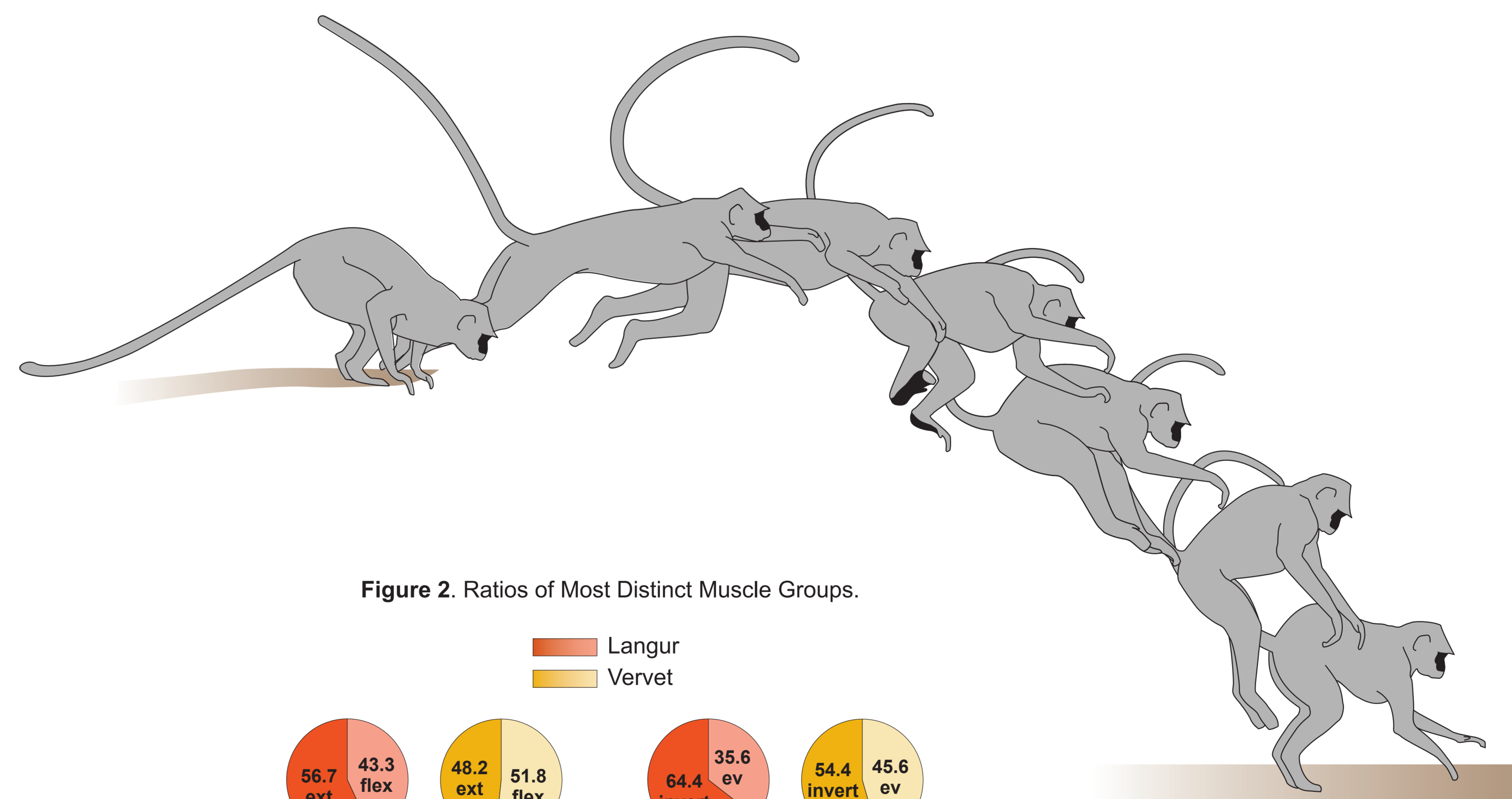
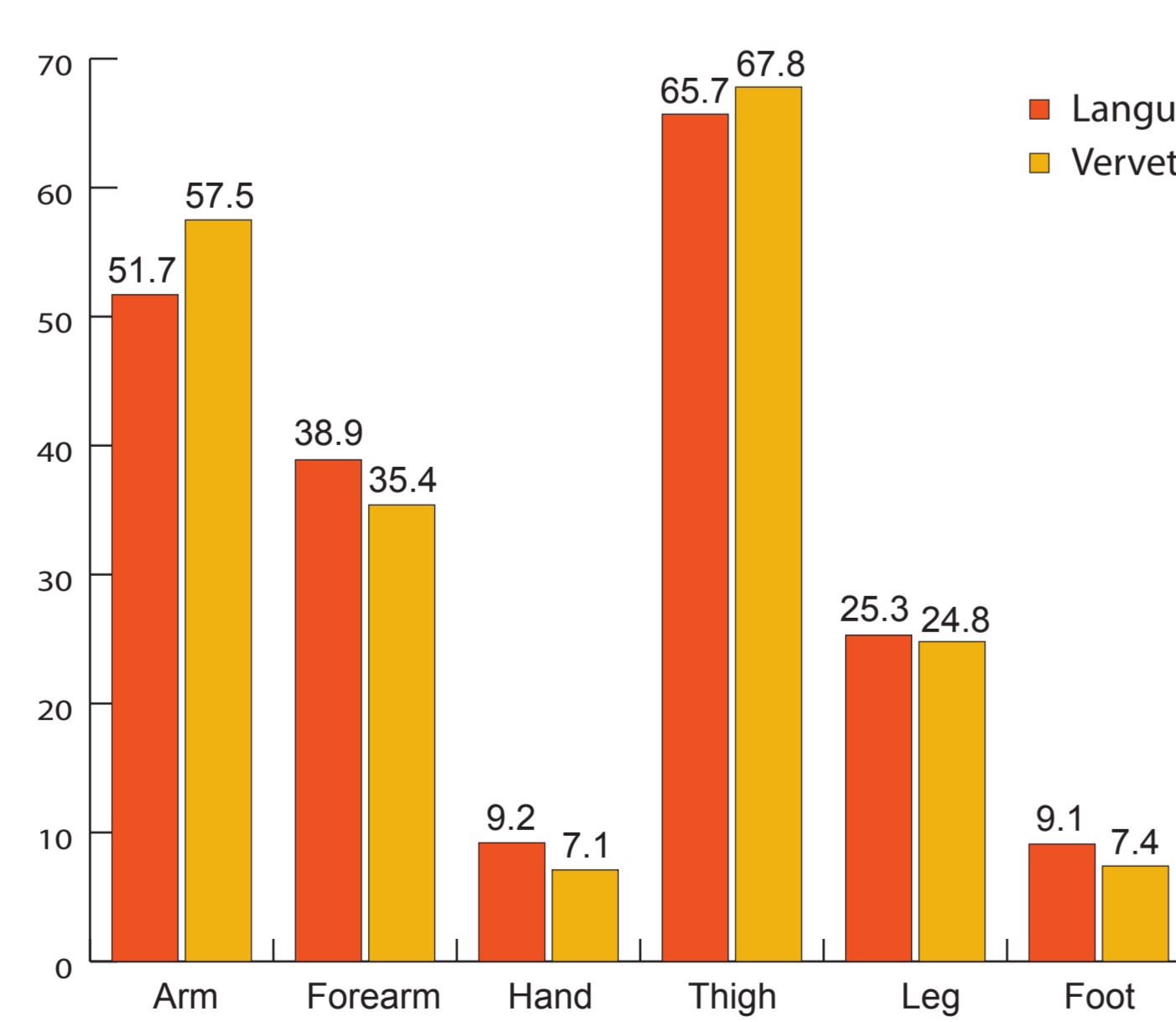


Figure 3. Percent Segment Lengths Relative to Total Lengths in Hand and Foot.

	Adult Male Langur	Adult Male Vervet
Hand		
Hand (Metacarpals)	46.5%	50.1%
Hand (Phalanx)	36.3%	31.4%
Hand (Tarsals)	17.2%	18.5%
Foot		
Foot (Metatarsals)	33.2%	35.0%
Foot (Phalanx)	33.4%	31.8%
Foot (Tarsals)	33.4%	33.2%

(langur hand and foot drawn to scale)

## VI. ACKNOWLEDGMENTS & BIBLIOGRAPHY

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Ayer AA. 1948. The Anatomy of *Semnopithecus entellus*. Madras: Indian Publishing House.

Dunbar D. 1994. The influence of segmental movements and design on whole-body rotations during the airborne phase of primate leaps. *Z Morph Anthropol.* 80 (1): 109-124.

Grand TI. 1976. Differences in terrestrial velocity in *Macaca* and *Presbytis*. *Am J Phys Anthropol.* 45: 101-108.

Grand TI. 1977. Body weight: Its relation to tissue composition, segment distribution, and motor function. *Am J Phys Anthropol.* 47: 211-240.

Isbell LA, JD Pruetz, M Lewis, TP Young. 1998. Locomotor activity differences between sympatric patas monkeys (*Erythrocebus patas*) and vervet monkeys (*Cercopithecus aethiops*): Implications for the evolution of long hindlimb length in *Homo*. *Am J Phys Anthropol.* 105: 199-207.

McGraw WS. 1998. Comparative locomotion and habitat use of six monkeys in the Taï Forest, Ivory Coast. *Am J Phys Anthropol.* 105: 493-510.

Napier J and Napier P. 1967. *A Handbook of Living Primates*. New York: Academic Press.

Ripley S. 1967. The leaping of langurs: A problem in the study of locomotor adaptation. *Am J Phys Anthropol.* 26: 149-170.

Schultz AH. 1970. The comparative uniformity of the Cercopithecoidea. In: JR Napier and PH Napier (Eds.) *Old World Monkeys: Evolution, Systematics and Behavior*. Pp 39-51, New York: Academic Press.

Zihlman AR, Mootnick AR, Underwood CE. 2011. Anatomical contributions to hylobatid taxonomy and adaptation. *Int J Primatol.* 32: 865-877.