Unique hip and stifle extensor muscle patterns in the Eurasian lynx, *Lynx lynx* (Carnivora: Felidae)

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**Abstract**

The Eurasian lynx (*Lynx lynx*) is a medium-sized felid, with a tendency to hunt for prey larger than itself. We studied the lynx hindlimb musculoskeletal anatomy in order to determine possible anatomical adaptations to hunting large prey. In our previous work, we had found characters of both large and small felids in the lynx forelimb. The crouched limbs, typical of all felids, increase the energy demands for the antigravity muscles during locomotion. As a powerful pounce is required for the smaller felid to bring down large prey, strong hindquarters may be needed. We hypothesized that the muscle attachments are more mechanically advantageous and muscles heavier in the lynx as compared to other felids to compensate for the energy requirements. In support of this, we found unique patterns in the hindlimb musculature of the lynx. Insertion of the m. gluteus medius was large with a short moment arm around the hip joint, providing mechanical disadvantage, but rapid movement. The musculus vastus medialis was relatively heavier than in other felids emphasizing the role of the *m. quadriceps* femoris as a powerful stifle extensor. The extensor muscles support the crouched hind limbs, which is crucial when tackling large prey, and they are also responsible for the swift powerful pounce brought by extending the hindlimbs. However, we cannot rule out the possibility the characters are shared with other *Lynx* spp. or they are adaptations to other aspects of the locomotor strategy in the Eurasian lynx.

**KEYWORDS**

Felidae, locomotion, morphology, musculoskeletal, scaling

**1 | INTRODUCTION**

The felids are obligatory meat eaters, with a limited potential to scavenge. Thus, they rely primarily on hunting in their food acquisition. The body mass of a felid determines its hunting habit and prey size: the small-bodied forms hunt prey smaller than themselves, whereas larger forms enhance the increased need in the energy gain by hunting prey larger than themselves (Meachen-Samuels & Van Valkenburgh, 2009). The size limit between the large and small felids is approximately 15 kg. Interestingly, the adult Eurasian lynx (*Lynx lynx*) has a body mass of around 15 kg. The fact that the Eurasian lynx is fully capable of hunting large prey (Sunquist & Sunquist, 2002) raises questions about the anatomical adaptations needed for this type of demanding food acquisition.

In addition to the skeletal changes, musculature may be modified to meet the increased demands for power and support. If muscles are modeled as beams between the elements (Stern Jr, 1974), the force generated depends on the size/mass of the muscle. We apply this simplified model here. The power can also be increased by increasing the mechanical advantage of the muscle attachment around the joint (Smith & Savage, 1956).
1.1 | The Pleistocene lynx adapted to the role of a small prey hunter

The Eurasian lynx is the largest wild felid in Europe today, and one of the few larger predators on the continent. The Eurasian lynx weighs only 12–25 kg (Sunquist & Sunquist, 2002). The ancestral lynx was probably a large game hunter Lynx issiodorensis in the Pliocene (Kurtén, 1978; Werdelin, 1981). The radiation of the modern lynx species took place as a part of the evolution of a diverse carnivore community in the fluctuating climate of the Pleistocene (Croitor & Brugal, 2010; Reumer et al., 2003; Stuart, 1991). Likely as a response to competition with the large sabertooth and pantherine cats, as well as to the probable pressure from scavengers, surviving forms of lynx became small prey specialists with a relatively small body size (Krofel et al., 2012).

Today, two lynx species remain in Eurasia. The Iberian lynx (Lynx pardinus) is restricted to two isolated populations in Southern Spain, and the Eurasian lynx ranges throughout the Europe and Asia, consisting of several possible subspecies. Genetic structuring has revealed three clades for the Eurasian lynx reflecting mainly the glacial refuges and the following migration events (Rueness et al., 2014). The Pleistocene distribution of the Iberian lynx is known to have included areas from Iberia to Italy (Rodriguez-Varela et al., 2015).

Based on fossil evidence on the teeth and skull, Werdelin (1981) has suggested that the modern Eurasian lynx maybe reverting to the ancestral condition of the lynx, which is to hunt prey larger than themselves. Ecological studies suggest that the modern Eurasian lynx is a predator capable of using wide prey spectrum, ranging from almost 100% of hares and other small game to more than 80% ungulates (Jędrzejewski et al., 1993) and demonstrating a preference for smaller ungulates especially European and Siberian roe deer (Capreolus capreolus, ~20 kg) whose combined distribution overlap around 50 percent of lynx distribution range (Hunter, 2015). Regionally, other important ungulate species include chamois (Rupicapra rupicapra) in Central Europe, white-tailed deer (Odocoileus virginianus) in Finland and semi-domestic reindeer (Rangifer tarandus) in reindeer husbandry area in Scandinavia (Kojola & Holmala, 2009; Molinari-Jobin et al., 2007; Odden et al., 2006; Okarma et al., 1997; Pulliainen et al., 1995). Larger lynx males may occasionally hunt on larger ungulates such as the red deer (Cervus elaphus; ~220 kg; Okarma et al., 1997), although Eurasian lynx rely on smaller species where ungulates are absent or less abundant (Breitenmoser et al., 2015; Jędrzejewski et al., 1993; Kojola & Holmala, 2009; Matyushkin & Vaisfeld, 2003; Pulliainen et al., 1995). Recently, however, the hunting habitat and prey size of the lynx has been largely limited by the presence of humans (Filla et al., 2017).

When hunting prey larger than themselves, lynx ambush, stalk and finally take few long jumps which end in a powerful grasp of the prey (Krofel et al., 2009). The ability to perform powerful pounces may have become more important for the Eurasian lynx if the prey size indeed has increased from the size of the rabbit to the size of a deer. Also subduing large prey requires strong stable hindquarters.

Day and Jayne (2007) have suggested that felids are conservative in the anatomy by maintaining the crouched limbs even in the larger species. The Canadian lynx was included in their study. Felids maintain the angulation between the limb segments throughout the stepping cycle, whereas many other taxa fully extend their limbs at the foot fall and midstance. Also, even the large felids stand on crouched limbs. The flexed joints are advantageous in generating vertical forces needed for, for example, pouncing and climbing, but they are not biomechanically advantageous as they are costly during locomotion and require muscle to work even when standing still. On the contrary, in most mammals, angulations between the limb segments decrease with increasing body mass in response to increasing energy requirements (Bertram & Biewener, 1990). The more erect angulations between the segments reduce the moment arm for the ground forces relative to the moment arms for the muscles responsible of supporting the posture and moving the joints (Biewener, 2005).

1.2 | How do the large felids maintain a crouched position?

Cuff et al. (2016) hypothesized that the larger felids may compensate the biomechanical disadvantage of the crouched position by shortening the muscle fascicles (negative allometry) and increasing the tendon lengths (positive allometry). However, when comparing across the taxa, the authors failed to find any significant change in the muscle anatomy, and concluded that the musculature of large felids reflect decreased running speed. Cuff et al. (2016) also hypothesized that muscle mass should similarly show positive allometry to the increased body size, but they found strong positive allometry only in one major extensor of the hip joint, the m. gluteus medius. Cuff et al. (2016) concluded that larger felids simply have weaker hindquarters.

1.3 | Four segments of the hind limb and their musculature

The hindlimb of a felid consists of four segments. The limb is attached to the trunk via the pelvic girdle, which forms the hip joint with the stylopodium (femur). The femoral region articulates with the ischium (crus) at the knee (stifle) joint. The gluteal muscles work as extensors of the hip joint, working against gravity, and some of them also participate in the abduction of the joint (Dyce et al., 2002). While most movements in the hindlimb occur in the sagittal plane, the abductors are important in stabilizing the hip joint. The largest of the gluteal group, the m. gluteus medius acts as a powerful extensor of the hip. This muscle was found to correlate with positive allometry in felids by Cuff et al. (2016). The musculus tensor fasciae latae is also part of the gluteal group. It stabilizes the joint and may participate in flexion of the hip. The caudal muscles of the thigh (the hamstrings) also attach to the pelvic girdle and participate in the extension of the hip. The antagonists or the flexors of the hip include the m. iliopsoas (consisting of the musculi iliacus and psoas major) and...
one of the cranial muscles of the thigh, the m. rectus femoris. In addition, one of the muscles of the medial group of the thigh, the m. sartorius, participates in flexion and adduction of the hip. The other adductors, the mm. adductorii, gracilis, and pectineus, are also located on the medial side of the thigh. They participate in joint stabilization by resisting and reversing abduction. During sagittal movements and stand still (stalking), they adduct the thigh. The stifle joint, which is also maintained in a crouched position in felids, is extended by the m. quadriceps femoris and flexed by the hamstrings. The musculus quadriceps femoris consisting of four heads (the mm. vastus lateralis, vastus intermedius, vastus medialis, and rectus femoris) is the strongest antigravity muscle for the stifle.

The aim of this study was to gain an understanding of the anatomical changes that may have taken place in the lynx hindlimb to adapt to the crouched position, powerful pounces and other demands to the capture of the large prey. Our previous results (Viranta et al., 2016) showed that although many skeletal traits are similar to those of the feline, the upper arm musculature share features with the pantherine felids.

2 | MATERIAL AND METHODS

2.1 | Material

The material consisted of five Eurasian lynx (Lynx lynx Linnaeus, 1758) that were legally hunted during the 2013/2014, 2014/2015 and 2016/2017 hunting seasons (December to February) in Western and Inland Finland. Hunters sent the frozen carcasses to the Taivalkoski Research Station of the Natural Resources Institute Finland (Luke), where the lynxes were measured, weighed and, in some cases, skinned. Some lynx had already been skinned by hunters or taxidermists prior to the anatomical examination. Tissue samples of major internal organs were also collected for ongoing monitoring of the lynx population by the Luke. The carcasses were then shipped frozen to the Faculty of Veterinary Medicine of the University of Helsinki. The bones of the dissected hind limbs were deposited to the teaching collection of the Faculty of Veterinary Medicine, and catalogs using the numbers assigned by Luke. Two euthanized domestic cats donated by their owners to the Faculty of Veterinary Medicine for research and teaching purposes, were included in the study for comparison. We were also able to dissect the mm. glutei of a male snow leopard (Panthera uncia) euthanized (for welfare) in the Korkeasaari zoo, Helsinki. No animals were killed for the purposes of this study.

2.2 | Dissection and muscle mapping

We dissected the hindlimb musculature, and mapped the muscle origins and insertions on the bone and fascia. The key findings were photographed. We recorded muscle weights immediately upon removal from the bone with an OHAUS® LS200 portable balance (accurate to 0.1 g). Because the freezing procedure we could not measure the muscle fiber lengths, nor study the architecture of the muscle. As a result, we had to rely on modeling the muscles as force generators acting between two segments (Stern Jr, 1974; Zajac, 1992). The strength and speed of a muscle correlates with the attachment sites and the weight. This is a simplified model, as only few muscles have parallel muscle fiber arrangements, but tend to be pennate or multipennate, which increases the force (Woittiez et al., 1983).

The allometric scaling of the muscles to body mass within the Felidae were taken from Cuff et al. (2016). We compared our muscle mass data to the results gained using their equations. We were able to compare only three of our five specimens, because one (13695) lacked the body weight and the other (10913) was a juvenile. We also compared the muscle attachments to those of previously published carnivoran muscle maps (Carlson & Hubbard, 2012; Cuff et al., 2016; Davis, 1964; Ercoli et al., 2013; Fisher et al., 2008; Hermanson et al., 2020; Hudson et al., 2011; Spoor & Badoux, 1988; Taylor, 1976). We also confirmed some morphology of the domestic cat by our own dissections, but also relied on Field and Taylor (1969) for the domestic cat.

Anatomical terminology in this study follow the recommendation of the Committee on Veterinary Gross Anatomical Nomenclature (Nomina Anatomica Veterinaria 2017).

3 | RESULTS

The muscle weights are provided in the Table 1. Some muscle masses are missing either because the muscles were damaged by bullets or during the skinning, or they were impossible to cut apart.

3.1 | Extension and stabilization of the hip joint

The most superficial hip muscle, the m. gluteus superficialis, was less massive than the more dorsal and deeper m. gluteus medius. The musculus gluteus superficialis attached on the gluteofemoral fascia over the m. gluteus medius and on the lateral margin of the ilium and the sacrum. The musculi gluteus medius and profundus originated on the ala ossis ili. The musculus gluteus medius had a wide origin extending close to the hip joint (articulation coxae; Figure 1). All the gluteal muscles inserted on the trochanter major of the femur, with the m. gluteus superficialis also sending a wide attachment on the fascia of the m. gluteofemoralis and fascia lata.

We could separate three origins for the m. gluteofemoralis on the caudal vertebra in one of the individuals (11653) from the transverse process of the second to forth caudal vertebra, while the rest showed the more typical two origins only on the second and third caudal vertebra. The musculus gluteofemoralis inserted on the fascia cruris on the cranial margin of the m. biceps femoris on all five specimens.

The musculus piriformis originated on the dorsal surface of the sacrum and inserted to the trochanter major. The musculus piriformis was a part of the m. gluteus medius in one of the specimens (13116).
female). The more superficial abductor, the m. tensor fascia latae continued as the tractus iliotibialis which inserted on the lateral aspect of the patella. The musculus quadratus femoris inserted widely to the intertrochanteric crest. The two mm. gemelli were fused in all the lynx. The musculi gemelli and m. obturator internus were small muscles parallel to the m. quadratus femoris. They originated from the dorsal part of the ischium and inserted to the crista and fossa intertrochanterica (Figures 1 and 2). If the m. articularis was present, it was not visible as a separate muscle but as muscle fibers attached to the joint capsule.

### Table 1

| ID number | 10756 | 11653 | 10913 | 13116 | 13695 |
|-----------|-------|-------|-------|-------|-------|
| Sex       | Male  | Male  | Male (juvenile) | Female | Female |
| BM        | 17.9 kg | 19.0 kg | 10.2 kg | 14.4 kg | ? |

### Muscles

**Gluteal group:**
- M. gluteus superficialis: 23.5 g, 9.1 g, 16.1 g
- M. gluteus medius: 30.9 g, 58.5 g, 26.0 g, 47.2 g, 36.8 g
- M. gluteus profundus: 8.8 g, 3.5 g, 8.5 g

**Adductor group:**
- Mm. adductori: >200 g, 211 g, 90.7 g, 95.6 g, 166 g
- M. gracilis: 54 g, 71.8 g, 22.8 g, 48 g
- M. pectineus: 10.5 g, 4.2 g, 11.8 g
- M. sartorius: 53.8 g, 79.5 g, 26.4 g, 51.7 g, 48 g

**Hamstrings:**
- M. biceps femoris: >200 g, 222 g, 183.0 g, 184.6 g, 174.4 g
- M. semitendinosus: 68.6 g, 79.8 g, 28.7 g, 66.5 g, 63.1 g
- M. semimembranosus: >200 g, 230 g, 97.4 g, 110 g, 175 g

**Quadriceps femoris:**
- Vastus medialis: 96.6 g, 138.4 g, 26.8 g, 22.5 g, 39.9 g
- Rectus femoris: 74.9 g, 100 g, 40 g, 31.5 g, 66.1 g
- Vastus intermedius: 24.6 g, 16.9 g, 17.5 g, 29 g
- Vastus lateralis: 82 g, 62.3 g, 25.4 g, 78.3 g

**FIGURE 1** Lynx lynx, muscle map on the os coxae (lateral side). Most of the muscle attachment of the muscles are color on the bones. Many muscles have additional or solo attachments on the fascia or muscles. These are not depicted here.

### 3.2 Extension of the stifle (knee)

The vasti of quadriceps muscle had proportionally wider attachment on the femur than we observed on the domestic cat. The musculus rectus femoris was similar to that of the house cat. It had an origin on or near the hip joint/on the dorsal brim of the acetabulum and it inserted together with the vasti via the tendo patellaris on the tuberositas tibiae. The musculus rectus femoris also attached to the m. vastus lateralis fascia on the distal aspect. The musculi vastus medialis, intermedius and lateralis originated directly on the femur.
While the origin of the two latter were similar to that of the house cat, the m. vastus medialis had a proportionally wider origin spanning over two thirds of the proximal femur (Figure 2).

### 3.3 Flexion of the hip and stifle

The musculus psoas major with the m. psoas minor originated in the caudal thoracic and lumbar vertebra (transverse processes) and the corresponding disci intervertebrales, and inserted to points on the pubis (m. psoas minor) and trochanter minor of the femur (m. psoas major). The musculus iliacus had its origin on the medial aspect of the ilium and shared a common tendon for insertion with the m. psoas major (Figure 1).

The musculus sartorius had its origin on the ilium (tuber coxae) and it inserted via a divided belly on the epicondylus medialis tibialis and the ligamentum patellar inserting on the tuberositas tibiae. The musculus semitendinosus originated from the ischial tuberosity and consisted of two heads; it was located deep to the m. semimembranosus. Both of these muscles inserted directly and via tendon on the tibia: the m. semimembranosus with two insertions to the epicondylus medialis and the m. semitendinosus to the tibial shaft (Figure 3). The musculus biceps femoris originated from the ligamentum sacrotuberale and ischium and had an insertion on the lateral border of the tuberositas tibiae and with the fascia cruris via the tendo calcanealis to the tuber calcanei.

### 3.4 Adduction of the hip

The musculus gracilis originated via a thin aponeurosis near pubic symphysis and inserted via broad direct attachment on the
condylus mediales, fascia cruris, and m. sartorius. In the mm. adductori, the two heads, the mm. adductor magnus and brevis were visible. They had their origin on the os pubis and also attached to the contralateral adductors. They inserted on the medial aspect of the linea aspera.

3.5 | Scaling of the muscle masses

We compared our data to the results of Cuff et al. (2016) by adding our measured muscle masses to the regression analysis of Cuff et al. (2016); Figure 4) and calculating percentage errors for each muscle. As Cuff et al. (2016) analyses are based on nine species represented by one individual each, our results can only be taken suggestive. The only muscle mass in Cuff et al. (2016) showing positive allometry to the body mass was the m. gluteus medius. All our weighed m. gluteus medius confirmed this result and were close to the slope of Cuff et al. (2016) (percent prediction error (%PE) 1-17).

The musculus gluteus profundus showed also strong positive allometry in the lynx. The musculi semimembranosus and gracilis displayed the biggest differences being very close, but not above the upper predicted slope (%PE 18-32) of felids. Only one muscle, the m. vastus medialis was heavier and above the upper predicted slope (%PE 26).

4 | DISCUSSION

4.1 | Comparison of the Eurasian lynx hind limb muscle masses to those of other felids

The muscle masses measured for this study indicate increased size of some hip and stifle extensors for the Eurasian lynx as compared to other felids. In general, in addition to acting as hip extensors the gluteal muscles stabilize the hip while standing (Dyce et al., 2002). However, Rasmussen et al. (1978) have demonstrated that the m. gluteus profundus, showing positive allometry in our study, is active only during locomotion in the domestic cat. The two other extensors of the hip, found to be somewhat heavier than predicted by the slope of Cuff et al. (2016), the m. semimembranosus and m. gracilis, are also active only during the locomotion (Rasmussen et al., 1978). As hip extensors provide propulsion for the hind limb, their heavier muscle mass indicates more powerful lift-off in the lynx.

4.2 | Comparison of the muscle maps within carnivores

When comparing the muscle maps of felids from previous studies (Carlon & Hubbard, 2012; Cuff et al., 2016; Hudson et al., 2011) as well
as those of the other previously studied carnivores (Davis, 1964; Fisher et al., 2008; Spoor & Badoux, 1988; Taylor, 1976), we found some differences in the muscles around the hip joint. The musculus gluteus superficialis originates on the sacrum in the carnivores (Hermanson et al., 2020). In the lynx, it had an additional small bony origin on the crista iliaca as well. This attachment is not present in the domestic cat or clouded leopard, Neofelis nebulosa (Carlon & Hubbard, 2012) or the viverrids (Taylor, 1976) but it is indicated on the ilium just dorsal to the acetabulum in the cheetah, Acinonyx jubatus (Hudson et al., 2011) and lesser grison, Galictis cuja (Ercoli et al., 2013) and on the ischiium of the giant panda, Ailuropoda melanoleuca (Davis, 1964). The origins of the mm. gluteus medius and profundus in carnivores are on the ala ossis ili. In the lynx, the m. gluteus medius origin covered most of the lateral aspect of the ala. The origin of the m. gluteus profundus covered smaller and more truncated area and it started more caudally on the ala ossis ili than in the clouded leopard and domestic cat (Carlon & Hubbard, 2012). The pattern in the lynx was more similar to that of the fox, Vulpes vulpes, as provided by Carlon and Hubbard (2012), and also to the striped hyena, Hyaena hyaena, provided by Spoor and Badoux (1988). Interestingly striped hyena has a massive m. gluteus medius. The os ilium of the hyena is broad (Spoor & Badoux, 1988), while in felids it is craniocaudally long, but narrow. In a cursorial felid, the cheetah, the origin of the m. gluteus profundus is elongated spanning the whole length of the origin of the m. gluteus medius on the ala ossis ili (Hudson et al., 2011). A short-legged mustelid, lesser grison, has similarly narrow m. gluteus profundus origin (Ercoli et al., 2013). Also, our dissection of the snow leopard revealed longer tendon for the m. gluteus profundus and smaller origin for the m. gluteus medius than in the lynx (Figure 5).

The proximal part of the Estonia lynx and snow leopard lateral view of the left hind limbs showing dissected m. gluteus medius still attached to the trochanter major of the femur. The photo reveals the origin of the m. gluteus medius on the ilium (white oval) while the m. gluteus profundus is still attached. The blue line indicates the approximate border of ilium. Not to scale: the snow leopard ilium is brought to the size of the ilium of the lynx in order to visualize the distances in the muscle origins.

The origins of the vasti of the quadriceps muscles on the femur were more extensive in the lynx than those observed in the other felids, and the origins were closer to the stifle in the lynx. Similarly, they may facilitate swift extension of the stifle. Surface anatomy of mm. vastus lateralis and medialis is shown in Figure 6. The origins closer to the joint have probably evolved to shorten the moment arm and make the extension of the hind limb swifter.

The rest of the proximal hind limb muscles of the lynx were similar to those of clouded leopard and the domestic cat. The musculus tensor fascia latae had a similar origin on the ventral margin of the ala ossis ili in the lynx and the comparative specimens from the literature. The musculi biceps femoris, semimembranosus and semitendinosus originated at the caudal end of the ischiium and their origins are similar in all species compared. The medial side of the ilium was mostly
covered by the origin of m. iliacus in the lynx, and it was similar to the clouded leopard and the domestic cat. This muscle is not shown in Hudson et al. (2011), but most likely it is present also in the cheetah.

4.3 Is the unique anatomy of the Eurasian lynx hind limbs adaptation to the hunting mode?

The main findings of this work were the indications of increased muscle mass of some of the hip and stifle extensors, but also the more mechanically disadvantageous attachment around the joints in the Eurasian lynx. In our previous study, we found mosaic patterns in the lynx forelimb (Viranta et al., 2016). The skeleton of the thoracic limb had functional characteristics of the small cats, while the musculature, especially that around the pectoral girdle and the proximal limb, resembled that of the larger felids. Differences in the hindlimb were less expected because the functions of the hindlimbs are less diverse. Martin-Serra et al. (2014) and Martin-Serra et al. (2015) have suggested that the shape of the hindlimb bones is mainly determined by phylogeny and size, less by locomotion of the animal. However, several indexes measuring the functional adaptation to the cursorial locomotion in the hindlimb bones have been found (e.g., Carlton, 2014; Van Valkenburgh, 1985) and Harris and Steudel (1997) found correlation between hunting mode and relative hind limb length in carnivores.

Doube et al. (2009) have shown that the felid forelimb bone shafts show stronger interspecific positive allometry with size increase than those of the hindlimb bones. This may indicate greater need for adaptations for the forelimb during demanding activities such as the prey capture, but we argue that these activities are also reflected in the hind limb anatomy. However, it is possible that the unique musculature of the lynx is adaptation to locomotory demands unrelated to hunting. The lack of muscle maps for felids with different hunting styles such as the serval that is known for its high jumps toward smallish prey, prevents comparisons at the moment.

Our way of modeling the muscles as force generators acting between two segments is the simplest way of estimating muscle force and the only one available for the fossil data (see e.g. Salesa et al., 2010; Turner, 1997). However, the ability of muscles to generate forces depends not only on the mass or distance and size of the attachment, but also on the muscle architecture and physiological properties of its fibers (Biewener & Roberts, 2000; Zajac, 1992). As the next step, our model of muscles as beams needs to be expanded to more comprehensive study of muscle architecture and force. Also, the composition of different muscle fibers in propulsive muscles of lynx should be studied to gain understanding of the possible microanatomical adaptations of the Eurasian lynx.

5 CONCLUSIONS

The Eurasian lynx anatomy shows unique biomechanical adaptations. The heavy hip and stifle extensors and wide attachment sites close to the joints for the gluteal and quadriceps muscles support the hypothesis that the smallish sized lynx is adapted for powerful swift pounces required for a felid to catch large prey, and subdue it.

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AUTHOR CONTRIBUTIONS

Suvi Viranta: Conceptualization; formal analysis; investigation; methodology; writing-original draft; writing-review and editing. Katja Holmala: Conceptualization; resources; writing-review and editing. Juha Laakkonen: Conceptualization; investigation; methodology; resources; writing-review and editing.

CONFLICT OF INTEREST

Authors declare they have no conflicts of interest relevant to the contents of this article.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of this article.

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