# Evolutionary Line Of The Smilodon And Its Habitat Changes

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The Smilodon, or well known in English, the Saber toothed tiger is an extinct Genus of the family of large cats called Machairodontine saber-toothed cats. Smilodon lived approximately 2.5 million to 10000 years ago in the late pliocene to late Pleistocene era. The first discovered Smilodon was in 1841 by a Danish naturalist and paleontologist Peter Weilhelm Lund . He found several fossils of species Smilodon populator in caves of Lagoa Santa, Brazil. Three species of the genus Smilodon have been found:

- Smilodon gracilis: this was the smallest and earliest species of the Smilodon genus. They weighed about 55-100kg and lived about 2.5 million to 500,000 years ago. This species was said to be the ancestor of another genus belonging to the Machairodontine family, Megentereon.
- Smilodon fatalis: this species replaced S. gracilis and populated North America and Western South America. Its body mass was around 160-225 kg. S. fatalis had two subspecies S. californicus and S. floridus.
- Smilodon populator. This was the largest species of the Machairodontine family. It populated the Eastern regions of South America about 1 million to 10,000 years ago. Its body mass was between 200-300 kg, but the largest specimen was 400 kg.

All three species had the same characteristic feature, the elongated upper canines, which reached a length of 28 cm and protruded 18 cm out of the mouth. Like most cats the claws of the Smilodon were retractable. Its stature resembled a bear more then a present day lion or tiger. Its body was robust, powerful and muscular, with well developed extensors, flexors and adductors in the hindlimb.
The most pronounced evolutionary progression can be seen in the development of the skull and mandible when comparing the two major felidae subgroups, the saber toothed and the feline cats.
The two subgroups followed two very different evolutionary paths according to their cranio-mandibular ratio and bite angle. The path of development of the skull may explain the reason for extinction of the saber toothed cats and why the evolution of the feline cats continued. The feline subgroup and the modern cat's skull is governed for uniform powerful biting irrespective of their body size with high precision biting. Where as in saber toothed cats hypertrophied canines and a large bite angle were emphasized. The efficiency and power of the bite where secondary and progressively weaker throughout evolutionary development. The large canines where only used after a large prey was brought down by the powerful Smilodon. They were most likely used as a dagger to sever nerves and vessels of the neck region to quickly kill or immediately bring down an animal. The modern day cats use their powerful bite force to completely block of the tracheal airway and prevent air flow, and in this way, leading to suffocation of the prey. To examine the differences few methods have been used.

The first method is the analyses of the shape of the skull and the observation of processes, fossas, condyles, grooves and relative surface area of the mastoid and perioccipatal regions using a Warp Analysis Program. The table below (Table 1) shows the observable differences on the skull of the saber toothed cats and the modern day cats (ex. lion and tiger).On the picture of the skull of a feline landmarks are marked with numbers 1 to 17(Figure 1). These specific landmarks are used in the Warp Analyzer program which will produce a scatter plot of open and closed squares with corresponding numbers (Figure 2).

Table 1

| Saber-toothed cats | Feline |
|---|---|
| -dorsoventrally tall skull<br>-anteroposteriorly very compact<br>-ventrally deflected glenoid fossa<br>- very curved, tall and compressed zygomatic arch<br>-elevated facial portion of skull<br>-abbreviation of mid-section of skull<br>-posterior retraction of infraorbital foramen<br>-enlarged external nares<br>-smaller and dorsally deflected occipital condyles<br>-deflection ventrally of posterior orbital rim<br>-elongated upper canines | -Elongated snout region(nasal)<br>-anteroposteriorly compressed mid-part skull<br>-straight, elongated posterior part of skull<br>-dorsoventrally elongated orbital aperature<br>-larger, pronounce zygomatic arch<br>-lowered glenoid fossa<br>- reduced, smaller upper canines |

Figure 1

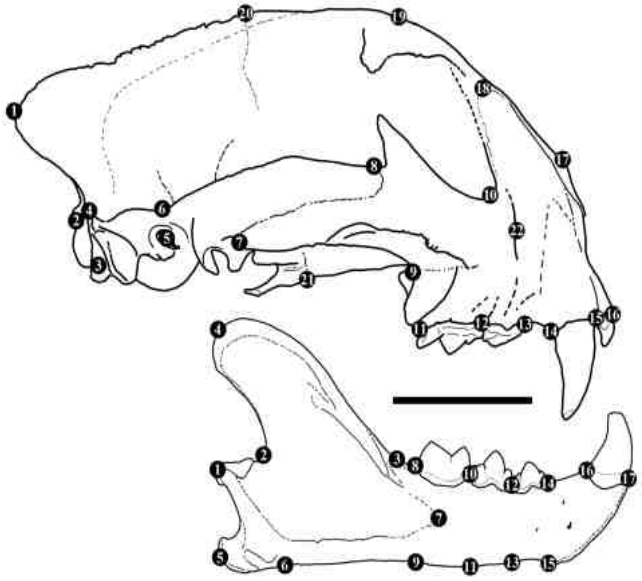
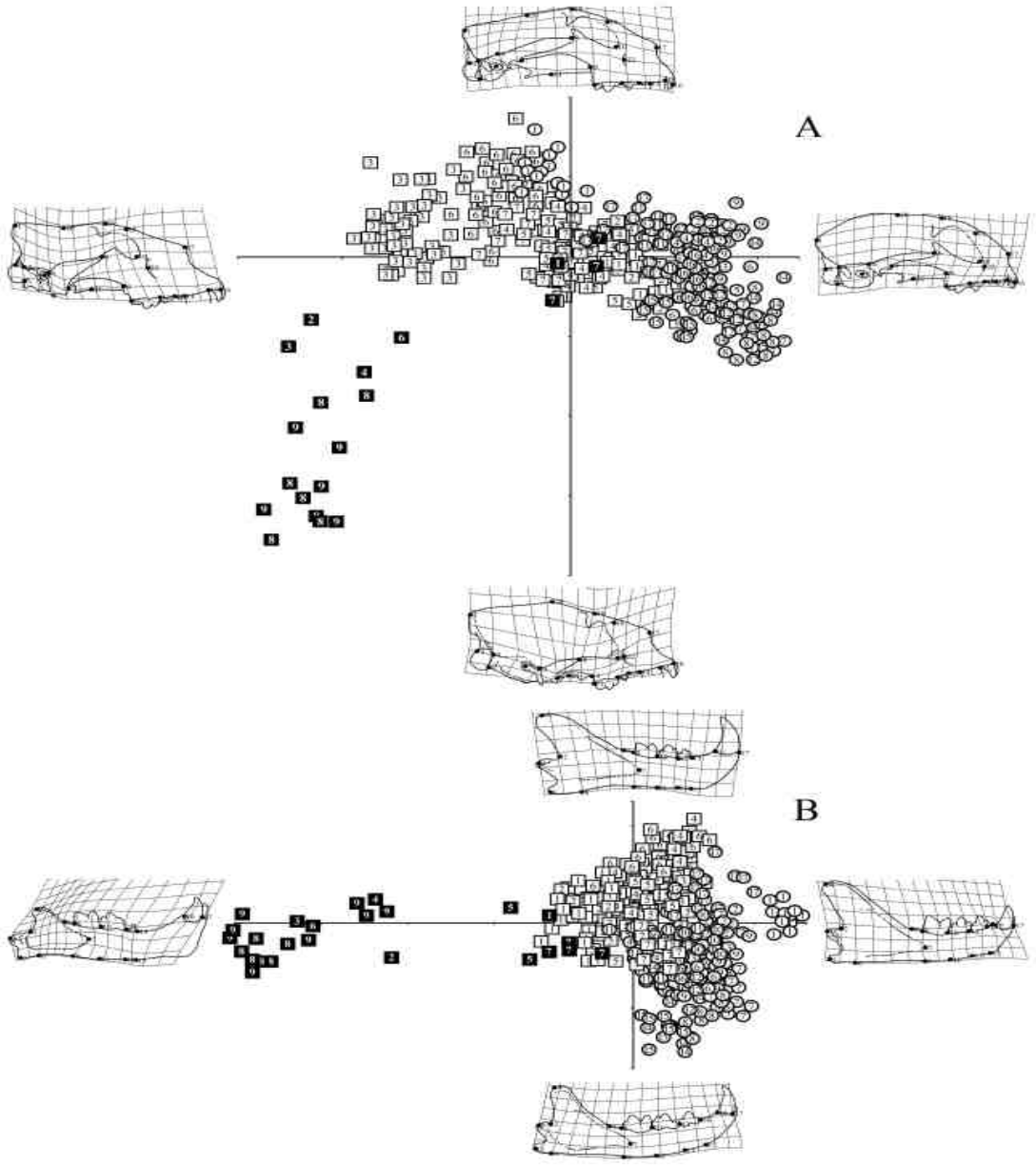
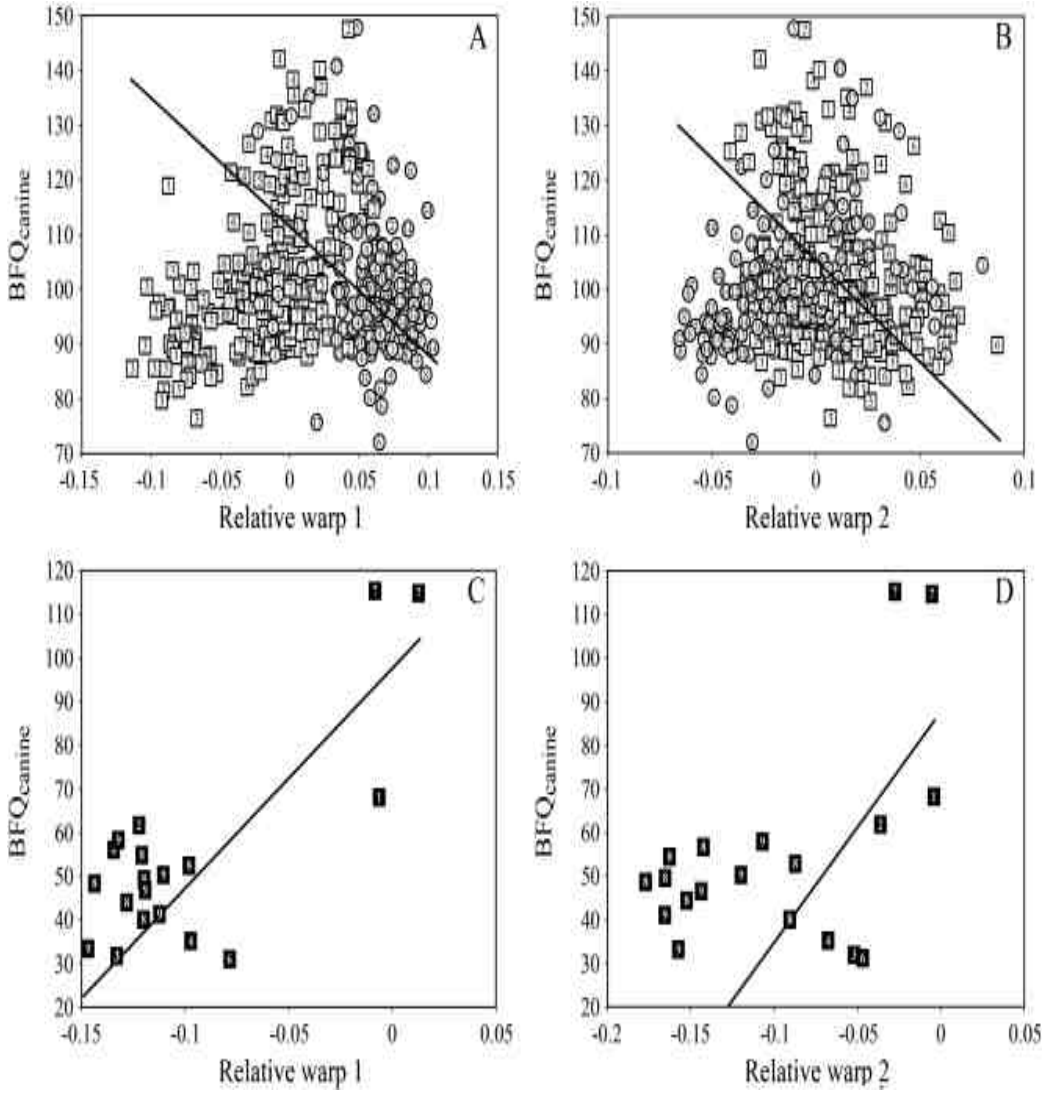


Figure 2




The second method is looking at the Bite force related to the size and shape of the skull. The bite force coefficient is used (BFQcanine). By looking a the Warp scatter plot a linear line is drawn.( Figure 3). The warp scatter plot that shows open squares ( modern day felines A, B), a negative linear line can be seen. This shows that in modern day cats there is no correlation with the bite force and the size or shape of the skull. Previously it was mentioned that the modern cat is modernized for uniform bite force irrespectively to the size or shape of the skull. The warp diagram with closed squares in turn, shows the saber toothed cats correlation (C, D). This line is positively linear therefore showing how the shape of the skull positively related to the force of the bite. The weakness in the bite force is also do to the angle of the bite. The Smilodon can open its jaws 120 degrees unlike the modern day cat which can only open it 60 degrees. The reason for this is the large upper canines which could only be used efficiently if there was a much larger range of motion. This can be explained because the larger the bite angle, the muscle inforce levers decrease , and so do bite forces.

Figure 3

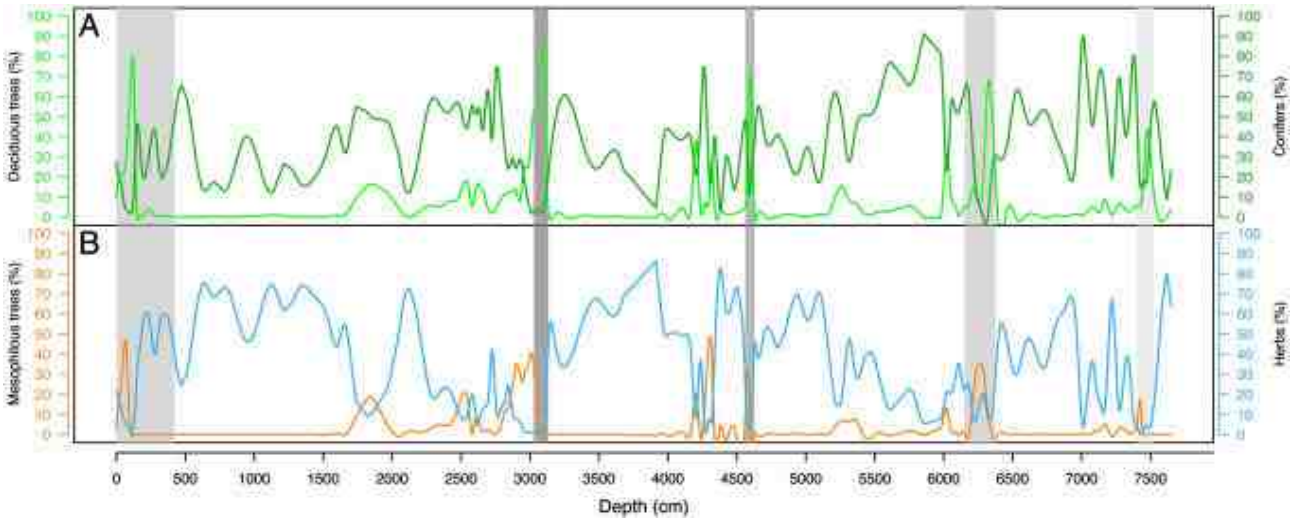



The extinction of the Smilodon and its species can be explained by the fact that due to its unique skull structure , most likely it was unable to adapt to the climate and geographical changes occurring during the late pliocene and pleistocene era.

Predominantly the pleistocene era(600,000-10,000BP) was characterized by continues glacial-interglacial cycles. These cycles that took place were a result of change in the earths orbit. Astronomical findings of these climate changes are described as changes in isolation of the earth and increase in CO2 concentration, which adds to increase in ice volume. The dramatic climate and geographical changes were mostly seen in North America, South America and North-West Europe. Longer glacial periods, or ice ages, where regularly interrupted by interglacial periods of rapid temperature increase and drastic changes in the environment. In the last 740ka the Earth has gone through 8 climate cycles. We are currently in an interglacial period. The last glacial period ended 10000 years ago.

To be able to observe the changes in fauna researches collected vegetation samples from the Valey region of French Massif Central. This region is a basaltic plateau with trachytic explosion craters and was able to provide few sample of distinct interglacial period fauna. From the collected data the Valey record was constructed(Figure 3), which shows the last four interglacial climate changes that took place and the changing of vegetation.

Figure 4




By looking at figure4, we can see the interglacial periods in gray and the glacial periods in white. During the glacial periods the characteristic vegetation was herbs(Asteraceae asteroideae, Asteraceae cichorioideae, Gramineae, Myriophyllum, Umbelliferae) and conifers(Picea abies, Pinus, Pinus sylvestris). These types of plants are able to grow in colder temperatures and able to survive below 0. This period was was characterized by large open planes and generally covered with ice and snow, with scarce vegetation. The annual precipitation during glacial periods was low. Nowadays the best method to learn more about the glacial periods is by referring to each period by their marine isotopic stage number. Marine records preserve all past glacial period evidence, along with taking ice core samples to find out the CO2 atmospheric concentration (Figure 5).

Right after the glacial period a dramatic change in the environment and temperature took place. Open plains where replaced by dense forests consisting of deciduous trees (Alnus, Alnus glutinosa, Corylus avellana, Quercus, Q. robur, Populus, Tilia) and Mesophilious trees (Acer campestre, Carpinus betulus, Fagu

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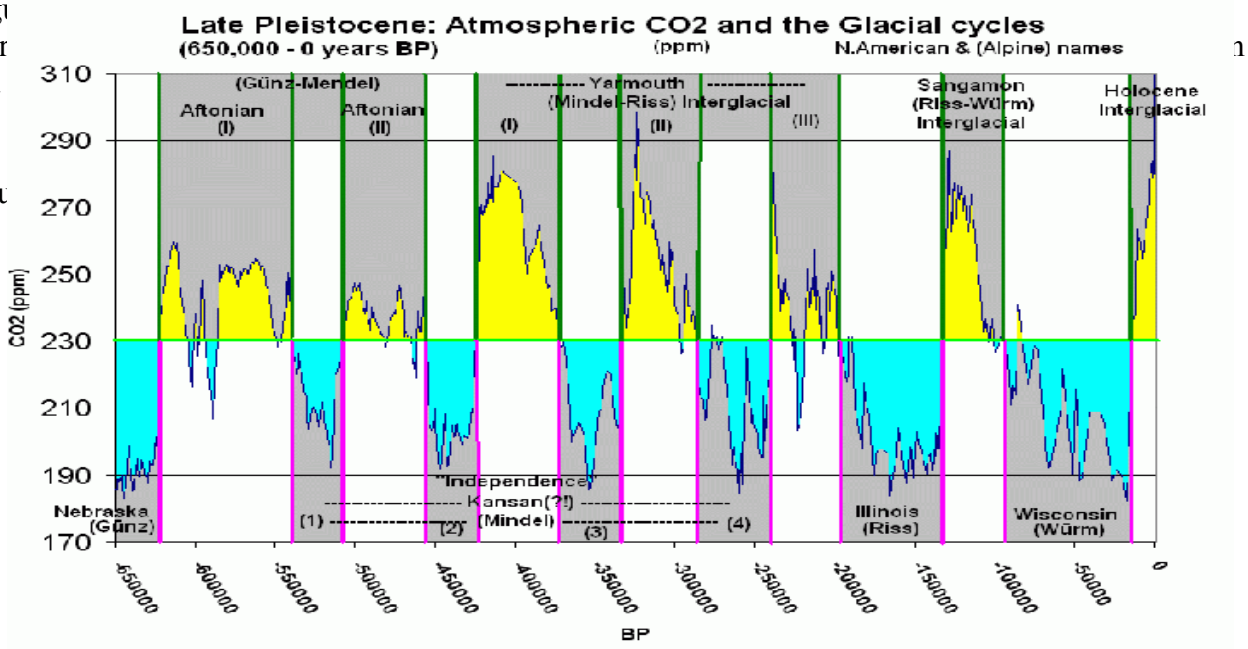

If we concentrate on the last glacial and interglacial period taking place manly in North America, the extinction of the Smilodon. fatalis can be explained. The Smilodon was precisely adapted to the ice age period. It lived as a social animal in prides, the same way as the current lion. Its body type was robust and strong and was created for bringing down large prey.

Smilodon fed mainly on large herbaceous land mammals including bison, deer, ground sloth, American camels, horses and where even thought to have brought down young mastodons (mammoths). The open plains where ideal for their hunting grounds. Modern day cats hunt by stalking and using their powerful bite to strangulate their prey. Smilodon, due to its hypertrophied upper canines and weak bite force had a different method to kill its prey. Its muscular limbs where used to tackle large prey, double or triple its size. After bringing it down, it only then used its canines to severe the nerves,vessels primarily the jugular vein of the neck, and not to strangulate but to immediately kill. Smilodons teeth were easily broken or severed if used in the wrong place or time or if used in a prolonged struggle. This technique made the Smilodon a unique hunter, but at the same time it made them extremely dependent on the supply of large animals. This hunting technique is used to explain the main reason for the extinction of these cats. Its size and build along with its large upper canines was not suitable for killing smaller animals which dominated in the interglacial period. The large herbaceous mammals that the Smildon preyed on during the glacial period all preferred open plains. Where grazing and safety in large herds was provided. During the change in fauna that was seen shortly after the glacial period, many of these animals became extinct or ones that where capable migrated. This lead to the drastic decrease of the Smilodon's source of food which in turn lead to starvation. These large cats where unable to maneuver between trees of the interglacial period and most likely where unable to catch the agile forest animals. At the same time an increase in the temperature and increase in precipitation also effected their ability to adapt to climate change. Heavy, warm fur that covered their body and protected them from the cold, may have lead to hyperthermia in the heat.

One of the most interesting causes of their mass extinction during the end of the last glacial period was the inhabitation of the Neanderthals. The Neanderthals after entering manly North America and Europe hunted the rest of the remaining prey that was left for the Smilodon. They were unable to compete against the more developed and smarter human inhabitants.

The cats we see today including the tiger, jaguar, leopard, ocelot and many more, have all been well adapted to living and hunting in areas which have an abundance of trees and forests. The characteristics of the skull shape and the decrease in upper canine size in survival was favorable next to the unique features of the Smilodon. The two species, lion and cheetah, vary from the previously mentioned large cats because they are able to survive in open plains or the African Serengeti. Modification in body shape and structure and the rearranging of the power of certain muscle groups aloud them to use speed, endurance and power at the same time. Although, in all of them , the skull shape, size and bite force remains the same.

The main question is, that because we are currently in an interglacial period, will the oncoming

of a new glacial period bring the mass extinction of these modern day cats? By gathered data the glacial period would cause freezing over almost world wide. Decreasing forests and increasing open plains, that are ideal for large herds of animals would be seen. Would the unique hypertrophied upper canines of the prehistoric Smilodon genus be once again favored in the evolutionary line? The modern day cat and the once living Smilodon both immerged from a common ancestral line, therefore it is safe to presume that this unique gene that brings out this character is still hidden in the feline genome and may once again be expressed during the on come of the next glacial period.

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