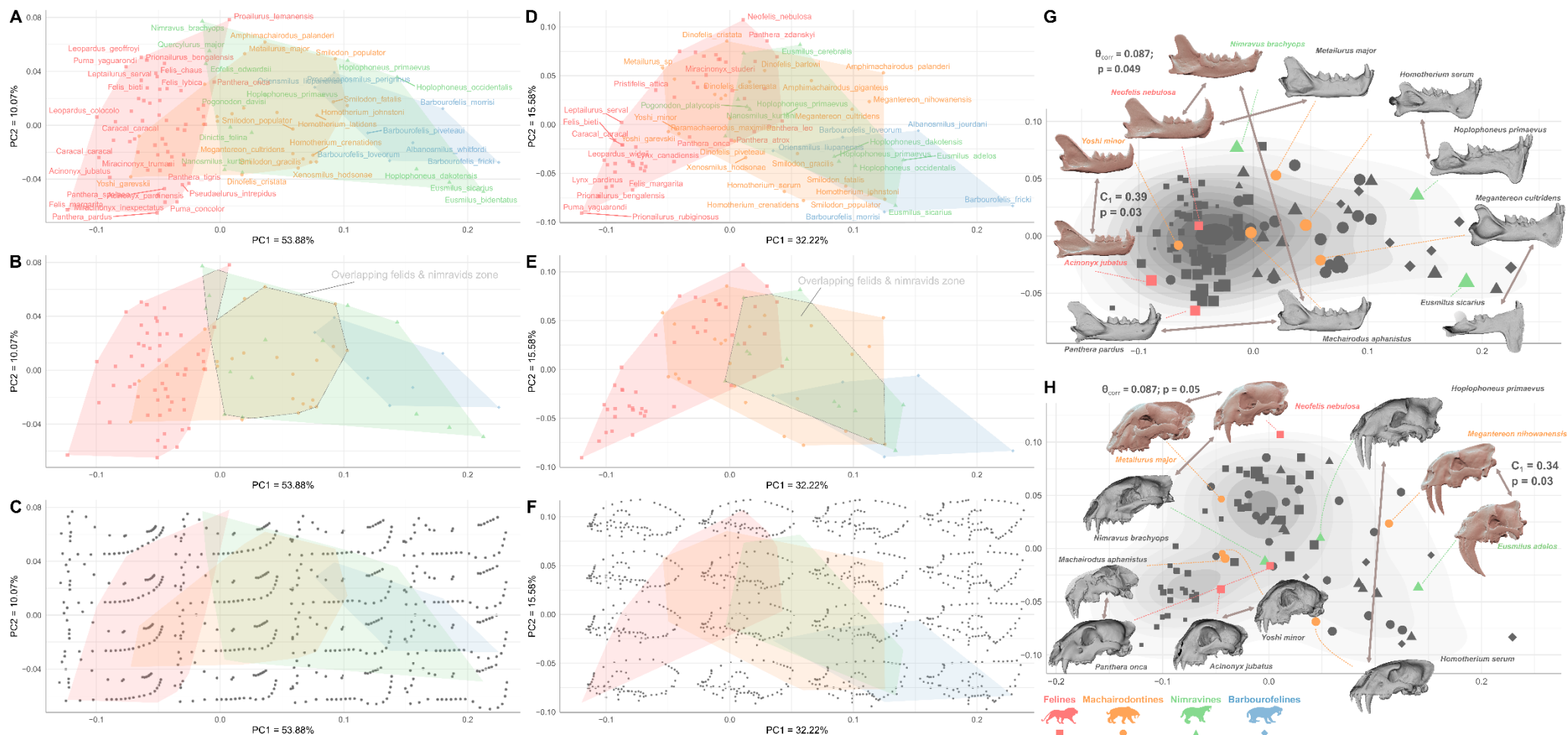
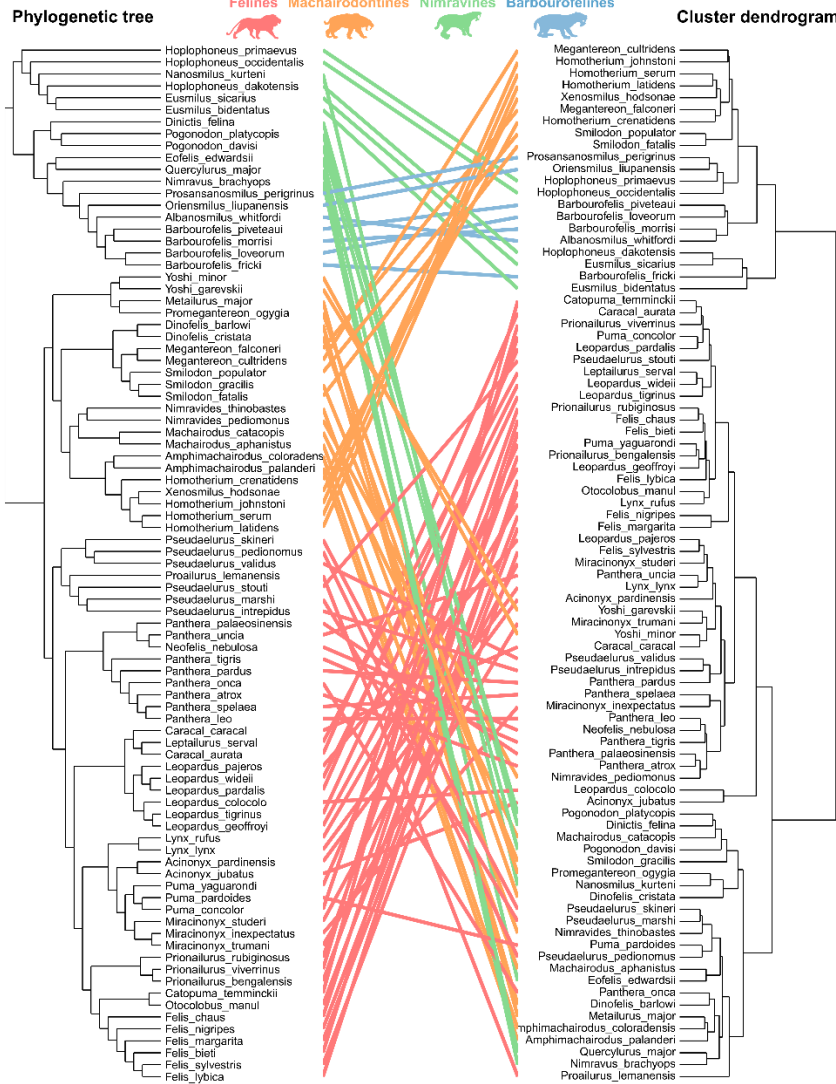


**Figure S1:** Landmark configuration used on the 99 mandibles from Tabel S1 with *Panthera tigris* (A, C) and *Barbourofelis fricki* (B, D) as examples. A-B: left lateral view; C-D: left anterolateral view; E-F: left posteromedial view. Landmark configuration used on the 90 crania from Tabel S2 with *Panthera tigris* (E, G, I) and *Barbourofelis loveorum* (F, H, J) as examples. E-F: dorsal view; G-H: ventral view; I-J: left lateral. Related to STAR Methods.

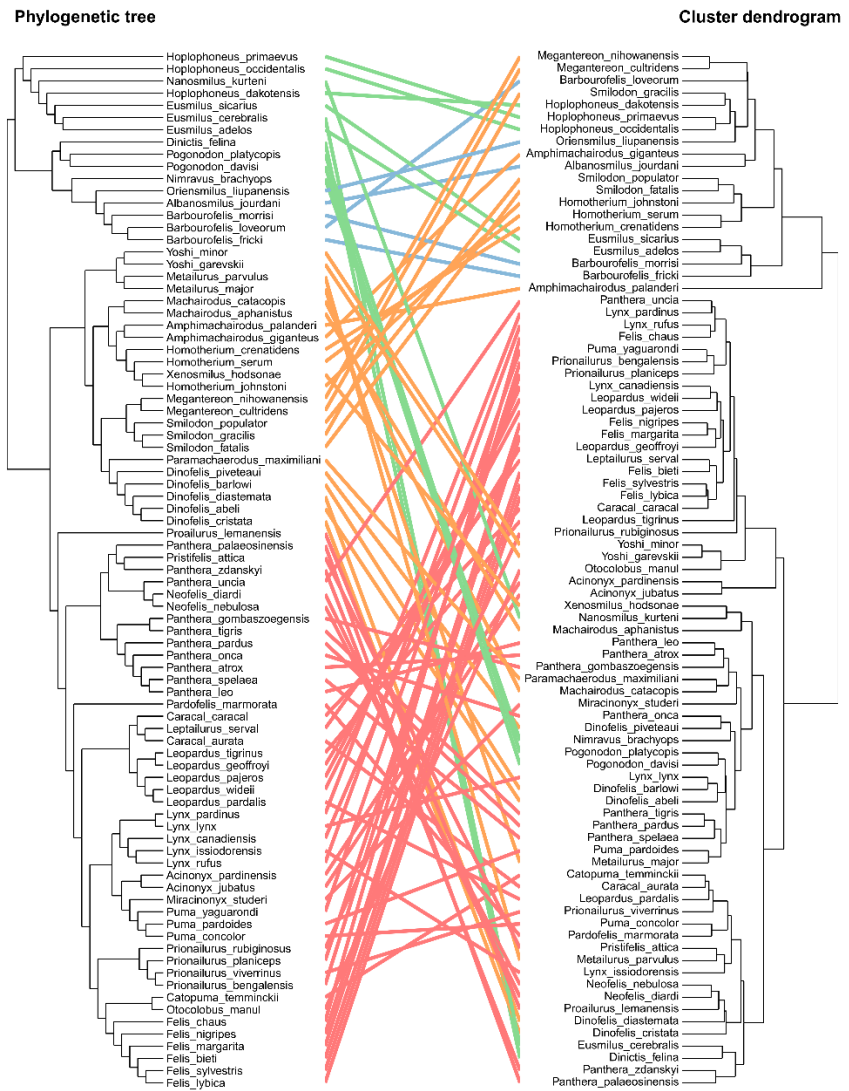


**Figure S2:** PCA on the mandible dataset showing **A** label of the species, **B** overlapping zone between felids and nimravids and **C** backtransform shapes in a grid pattern showing more intuitively how shape varies across morphospace. PCA on the cranium dataset showing **D** label of the species, **E** overlapping zone between felids and nimravids and **F** backtransform shapes in a grid pattern showing more intuitively how shape varies across morphospace. Figure illustrating pairs that were found convergent following 1 of the two metrics used for **G** the mandible and **H** the cranium. Related to Figure 1, Table 1, Table S3 and STAR Methods.

### A Mandible

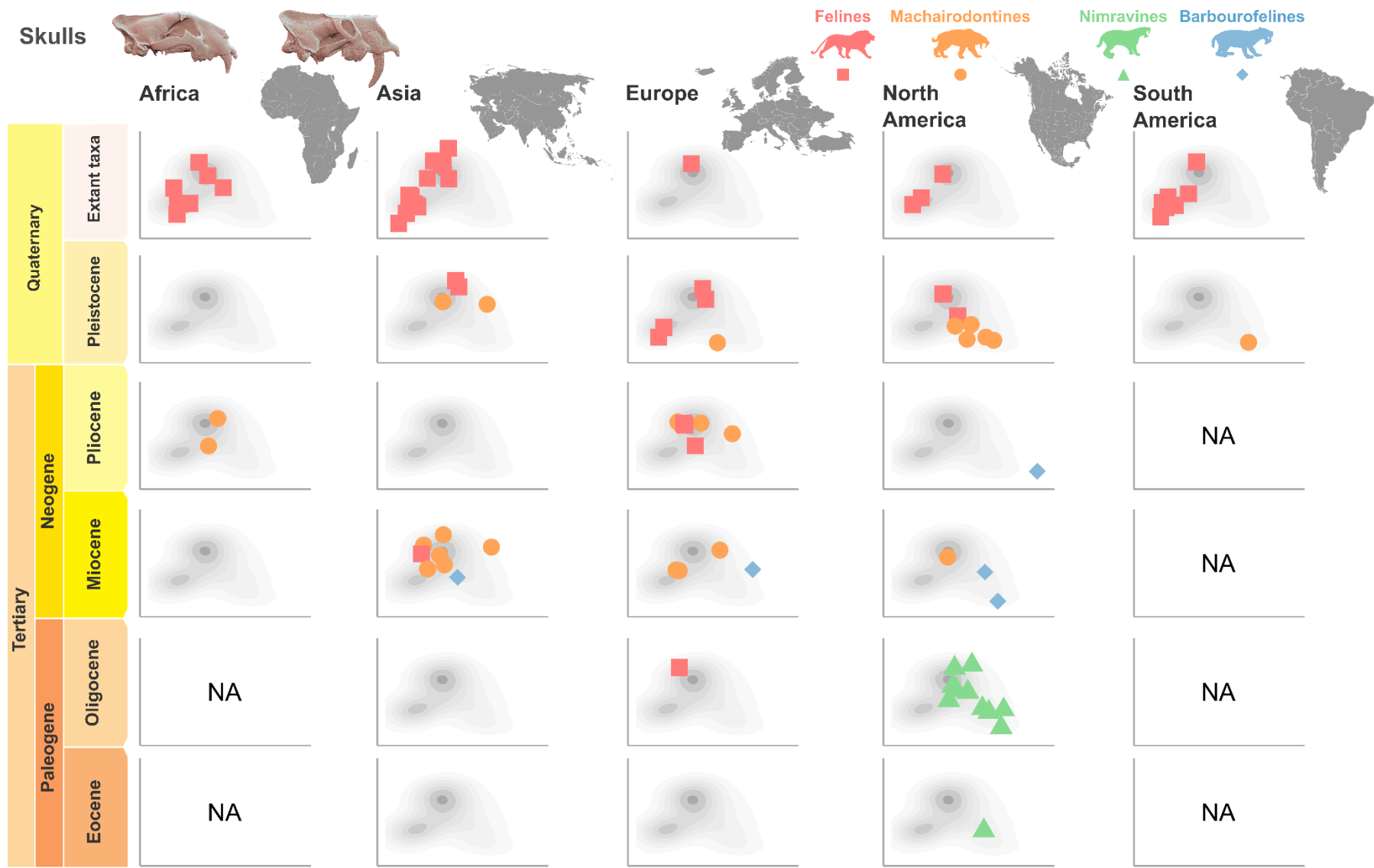


### B Skull

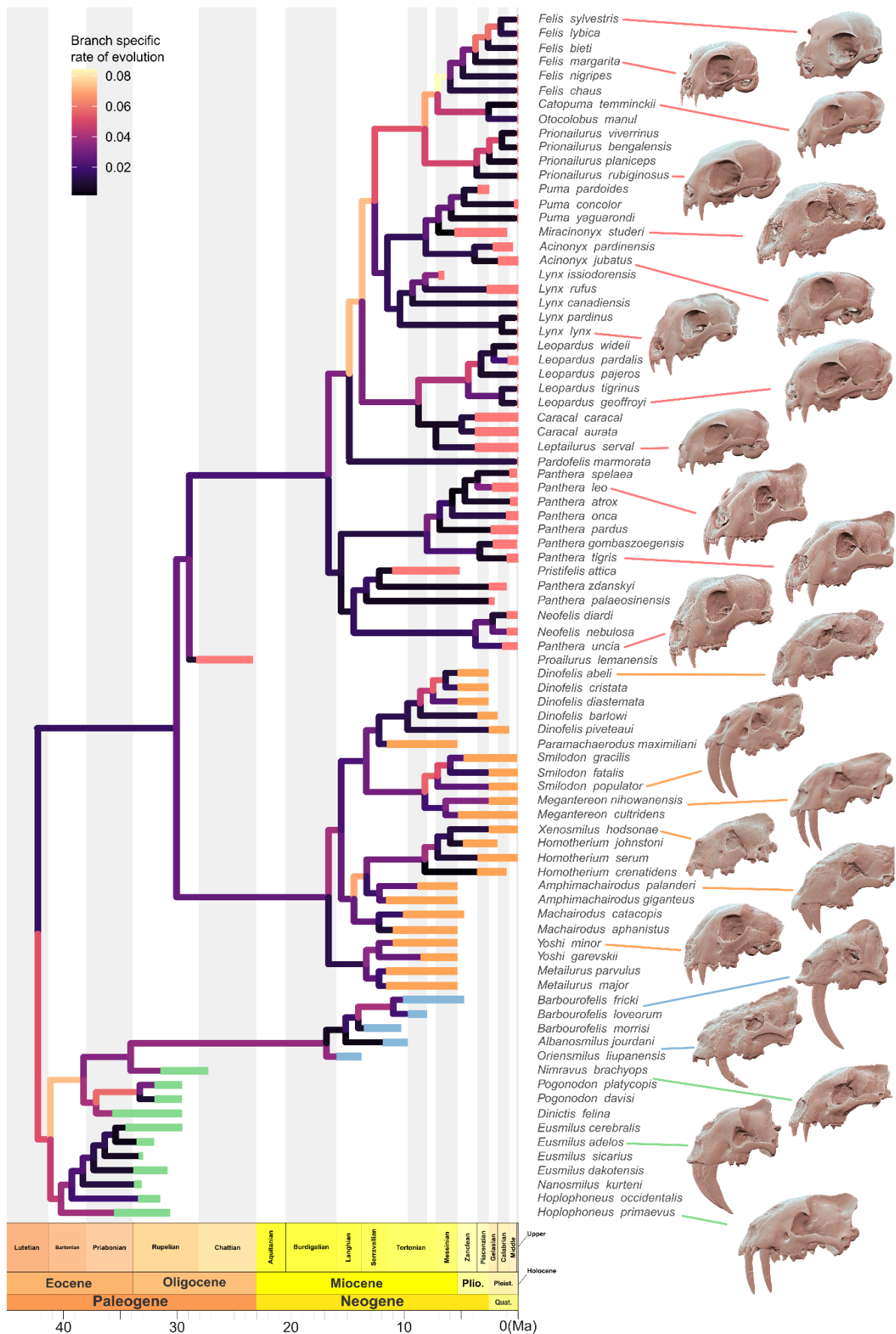


**Figure S3:** Tanglegram showing the correspondences between the phylogenetic supertree (left) and the hierarchical cluster build from the distance matrix based on the Procrustes coordinates (right) for the mandible dataset for **A** the mandible and **B** the cranium. Related to STAR Methods.





**Figure S5:** Occupation of the morphospace trough time and space for the skull data. Related to Figure 3.



**Figure S6:** Branch specific rate of morphological evolution for the cranium obtained from the RRPhylo function. Plio = Pliocene, Pleist = Pleistocene and Quat = Quaternary. Related to Figure 5.

Family	Clade	Species	Specimen number	Age	Continent	Scanned by
<b>MANDIBLES</b>						
Felidae	Felinae	<i>Acinonyx jubatus</i>	75-9-M-10	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Acinonyx pardinensis</i>	MHNL-2016822-3	Pliocene	Europe	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Albanosmilus whitfordi</i>	AMNH-F-AM-61858	Miocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Amphimachairodus coloradensis</i>	FHSMVP-6811	Pliocene	North America	Aly Baumgartner
Felidae	Machairodontinae	<i>Amphimachairodus palanderi</i>	PMU-21831	Miocene	Asia	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Barbourofelis fricki</i>	UCMP-124942	Pliocene	North America	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Barbourofelis loveorum</i>	UF-VP-36855	Miocene	North America	Jeanette Pirlo
Nimravidae	Barbourofelinae	<i>Barbourofelis morrissi</i>	AMNH-F-AM-80000	Miocene	North America	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Barbourofelis piveteaui</i>	MNHN.F.TRQ1017	Miocene	Euope	Narimane Chatar
Felidae	Felinae	<i>Caracal aurata</i>	A585866	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Caracal caracal</i>	A585401	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Caracal caracal</i>	AMNH-M-113794	Extant	Africa	MORPHOSOURCE
Felidae	Felinae	<i>Catopuma temminckii</i>	A581703	Extant	Asia	Narimane Chatar
Nimravidae	Nimravinae	<i>Dinictis felina</i>	LACM-162986	Oligocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Dinictis felina</i>	CIT-98	Oligocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Dinofelis barlowi</i>	DNMNH-BF-55-23	Pliocene	Africa	Justin Adams
Felidae	Machairodontinae	<i>Dinofelis cristata</i>	PMU 21777/2	Miocene	Asia	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Eofelis edwardsii</i>	MNHN.QU.9539	Eocene	Europe	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Eusmilus bidentatus</i>	Ulg-PA-17331	Miocene	France	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Eusmilus sicarius</i>	YPM-VPPU-012953	Oligocene	North America	Narimane Chatar
Felidae	Felinae	<i>Felis bieti</i>	1893-151	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Felis chaus</i>	A583184	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Felis lybica</i>	A583545	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Felis lybica</i>	NHMUK-PV-OR-47696	Pleistocene	Europe	Narimane Chatar
Felidae	Felinae	<i>Felis margarita</i>	IMNH-938	Extant	Africa	MORPHOSOURCE
Felidae	Felinae	<i>Felis nigripes</i>	MCZ.33976	Extant	Africa	Davide Tamagnini
Felidae	Felinae	<i>Felis sp-indet</i>	PMU-M14366	Miocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Felis sylvestris</i>	Ulg-PA-10542	Pleistocene	Europe	Narimane Chatar

Felidae	Machairodontinae	<i>Homotherium crenatidens</i>	MNHN.F.PET2000b	Pleistocene	Europe	Christine Argot, Florent Goussard
Felidae	Machairodontinae	<i>Homotherium johnstoni</i>	UCMP-34764	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Homotherium latidens</i>	IN-I-826	Pleistocene	Europe	Joan Madurell-Malapeira
Felidae	Machairodontinae	<i>Homotherium serum</i>	LACM-124107	Pleistocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus dakotensis</i>	YPM-VPPU-011079	Oligocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus occidentalis</i>	AMNH-102394	Oligocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus primaevus</i>	LACM-42890	Eocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus primaevus</i>	PIMUZ-AV-2593	Oligocene	North America	Sina Dupuis
Felidae	Felinae	<i>Leopardus colocolo</i>	A595502	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus geoffroyi</i>	A592001	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus pajeros</i>	A3457	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus pardalis</i>	A607369	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus tigrinus</i>	2006-542	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus wideii</i>	1941-80	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leptailurus serval</i>	A595801	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Lynx lynx</i>	NRM20025024	Extant	Europe	Narimane Chatar
Felidae	Felinae	<i>Lynx rufus</i>	CIT-3173	Pleistocene	South America	Narimane Chatar
Felidae	Felinae	<i>Lynx rufus</i>	OUVC-9576	Extant	North America	MORPHOSOURCE
Felidae	Felinae	<i>Lynx rufus</i>	UF-VP-258901	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Machairodus aphanistus</i>	BAT-3'13 1916b	Miocene	Europe	Narimane Chatar
Felidae	Machairodontinae	<i>Machairodus catacopis</i>	LACM-123831	Pliocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Megantereon cultridens</i>	NHMK-PV-OR-28882	Pliocene	Europea	Narimane Chatar
Felidae	Machairodontinae	<i>Megantereon falconeri</i>	NHMK-PV-OR-16557	Pliocene	Asia	Narimane Chatar
Felidae	Machairodontinae	<i>Metailurus major</i>	PMU 21771-1	Miocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Miracinonyx inexpectatus</i>	UF-VP-21604	Pleistocene	North America	Narimane Chatar
Felidae	Felinae	<i>Miracinonyx studeri</i>	UCMP-34770	Pliocene	North America	Narimane Chatar
Felidae	Felinae	<i>Miracinonyx trumani</i>	AMNH-FM-1444417	Pleistocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Nanosmilus kurteni</i>	AMNH-140559-001	Oligocene	North America	Narimane Chatar
Felidae	Felinae	<i>Neofelis nebulosa</i>	A585711	Extant	Asia	Narimane Chatar
Felidae	Machairodontinae	<i>Nimravides pediomonus</i>	UCMP-29186	Miocene	North America	Narimane Chatar

Felidae	Machairodontinae	<i>Nimravides thinobastes</i>	USNM-4819	Miocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Nimravus brachyops</i>	AMNH-6930	Oligocene	North America	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Oriensmilus liupanensis</i>	AMNH-F-AM-14575	Miocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Otocolobus manul</i>	MNHN-ZO-AC-2010-646	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Panthera atrox</i>	UF-VP-9076	Pleistocene	North America	Jeanette Pirlo
Felidae	Felinae	<i>Panthera leo</i>	RG30674	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Panthera onca</i>	2006-641	Extant	South America	Margot Michaud
Felidae	Felinae	<i>Panthera palaeosinensis</i>	PMU-21777-2	Pleistocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Panthera pardus</i>	RG29292	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Panthera spelaea</i>	IMNH	Pleistocene	Europe	Narimane Chatar
Felidae	Felinae	<i>Panthera tigris</i>	MNHN-ZO-1931-60	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Panthera uncia</i>	MNHN-ZO-2006-429	Extant	Asia	Margot Michaud
Nimravidae	Nimravinae	<i>Pogonodon davisi</i>	AMNH-62026	Miocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Pogonodon platycopis</i>	UCMP-102521	Oligocene	North America	Narimane Chatar
Felidae	Felinae	<i>Prionailurus bengalensis</i>	A595067	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Prionailurus rubiginosus</i>	2012-54	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Prionailurus viverrinus</i>	MNHN-ZO-AC-A12519	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Proailurus lemanensis</i>	USNM-PAL-635370	Oligocene	Europe	Narimane Chatar
Felidae	Machairodontinae	<i>Promegantereon ogygia</i>	BAT-3'10-1773	Miocene	Europe	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Prosansanosmilus perigrinus</i>	SMNS-41428	Miocene	Europe	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus intrepidus</i>	USNM-124	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus marshi</i>	AMNH-F-AM-61808	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus pedionomus</i>	AMNH-FM-25206	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus skineri</i>	AMNH-F-AM-61812	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus sp indet</i>	UCMP-44949	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus sp indet</i>	UCMP-67917	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus stouti</i>	UCMP-70141	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Pseudaelurus validus</i>	AMNH-F-AM-61829	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Puma concolor</i>	ISM-ZOO-693928	Extant	North America	MORPHOSOURCE
Felidae	Felinae	<i>Puma concolor</i>	LACM-8990	Pleistocene	South America	Narimane Chatar

Felidae	Felinae	<i>Puma concolor</i>	UCMP-21572	Pleistocene	North America	Narimane Chatar
Felidae	Felinae	<i>Puma pardoides</i>	MHNLY-20161854 R	Pliocene	Europe	Narimane Chatar
Felidae	Felinae	<i>Puma yaguarondi</i>	A585414	Extant	South America	Narimane Chatar
Nimravidae	Nimravinae	<i>Quercylurus major</i>	MNHN.F.QU.9533	Miocene	France	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon fatalis</i>	LACM-HC-2002-2	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon gracilis</i>	USNM-633574	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon populator</i>	MNHN.F.1907-6	Pleistocene	South America	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon populator</i>	NHMUK-PV-M9374	Pleistocene	South America	Narimane Chatar
Felidae	Machairodontinae	<i>Xenosmilus hodsonae</i>	UF-VP-60000	Pleistocene	North America	Jeanette Pirlo
Felidae	Machairodontinae	<i>Yoshi garevskii</i>	MNHN-Sk-69	Miocene	Europe	Denis Geraads
Felidae	Machairodontinae	<i>Yoshi minor</i>	PMU 21767/2	Miocene	Asia	Narimane Chatar
<b>SKULLS</b>						
Felidae	Felinae	<i>Acinonyx jubatus</i>	75-9-M-10	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Acinonyx pardinensis</i>	NMBS.St.V.975	Pliocene	Europe	Davide Tamagnini
Nimravidae	Barbourofelinae	<i>Albanosmilus jourdani</i>	IPS-49575	Miocene	Europe	David Alba
Felidae	Machairodontinae	<i>Amphimachairodus giganteus</i>	HD9196	Miocene	Europe	Denis Geraads
Felidae	Machairodontinae	<i>Amphimachairodus palanderi</i>	PMU-21831	Miocene	Asia	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Barbourofelis fricki</i>	USNM-531533	Pliocene	North America	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Barbourofelis loveorum</i>	UF-VP-27447	Miocene	North America	Jeanette Pirlo
Nimravidae	Barbourofelinae	<i>Barbourofelis morrissi</i>	AMNH-F-AM-79999	Miocene	North America	Narimane Chatar
Felidae	Felinae	<i>Caracal aurata</i>	A585866	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Caracal caracal</i>	A585401	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Catopuma temminckii</i>	A581703	Extant	Asia	Narimane Chatar
Nimravidae	Nimravinae	<i>Dinictis felina</i>	RAM280	Oligocene	North America	MORPHOSOURCE
Felidae	Machairodontinae	<i>Dinofelis abeli</i>	AMNH-F-AM-50445	Pleistocene	Asia	Narimane Chatar
Felidae	Machairodontinae	<i>Dinofelis barlowi</i>	DNMNH BF 55-22	Pliocene	Africa	Justin Adams
Felidae	Machairodontinae	<i>Dinofelis cristata</i>	PMU 21777/1	Miocene	Asia	Narimane Chatar
Felidae	Machairodontinae	<i>Dinofelis diastemata</i>	NMBS.Rss83	Pliocene	Europe	Davide Tamagnini
Felidae	Machairodontinae	<i>Dinofelis piveteaui</i>	DNMNH KA 61 M6069-5534	Pliocene	Africa	Justin Adams
Nimravidae	Nimravinae	<i>Eusmilus adelos</i>	USNM-12820	Oligocene	North America	Narimane Chatar

Nimravidae	Nimravinae	<i>Eusmilus cerebralis</i>	AMNH-6941	Oligocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Eusmilus sicarius</i>	YPM-VPPU-012953	Oligocene	North America	Narimane Chatar
Felidae	Felinae	<i>Felis bieti</i>	MNHN-ZO-AC-1893-151	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Felis chaus</i>	A583184	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Felis lybica</i>	A583545	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Felis margarita</i>	IMNH-938	Extant	Africa	MORPHOSOURCE
Felidae	Felinae	<i>Felis nigripes</i>	MCZ.33976	Extant	Africa	Davide Tamagnini
Felidae	Felinae	<i>Felis sylvestris</i>	Ulg-PA-11192	Pleistocene	Europe	Narimane Chatar
Felidae	Machairodontinae	<i>Homotherium crenatidens</i>	MNHN.F.PET2000a	Pleistocene	Europe	Christine Argot, Florent Goussard
Felidae	Machairodontinae	<i>Homotherium johnstoni</i>	UCMP-34764	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Homotherium serum</i>	LACM-124108	Pleistocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus dakotensis</i>	U CB-15	Oligocene	North America	Davide Tamagnini
Nimravidae	Nimravinae	<i>Hoplophoneus occidentalis</i>	AMNH-102394	Oligocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus primaevus</i>	LACM-42890	Eocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Hoplophoneus primaevus</i>	PIMUZ-AV-2593	Oligocene	North America	Sina Dupuis
Felidae	Felinae	<i>Leopardus geoffroyi</i>	A592001	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus pajeros</i>	A3457	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus pardalis</i>	A607369	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus tigrinus</i>	2006-542	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leopardus wideii</i>	1941-80	Extant	South America	Narimane Chatar
Felidae	Felinae	<i>Leptailurus serval</i>	A595801	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Lynx canadiensis</i>	IMNH 213	Extant	North America	MORPHOSOURCE
Felidae	Felinae	<i>Lynx issiodorensis</i>	MNCN-63887	Pliocene	Europe	Davide Tamagnini
Felidae	Felinae	<i>Lynx lynx</i>	NRM20025024	Extant	Europe	Narimane Chatar
Felidae	Felinae	<i>Lynx pardinus</i>	MNCN-16784	Pleistocene	Europe	Davide Tamagnini
Felidae	Felinae	<i>Lynx rufus</i>	OUV-9576	Extant	North America	MORPHOSOURCE
Felidae	Machairodontinae	<i>Machairodus aphanistus</i>	BAT-105-E6-92	Miocene	Europe	Davide Tamagnini
Felidae	Machairodontinae	<i>Machairodus catacopis</i>	AMNH-F-AM-104044	Miocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Megantereon cultridens</i>	MNHN.F.PET2001a	Pliocene	Europe	Davide Tamagnini
Felidae	Machairodontinae	<i>Megantereon nihowanensis</i>	CB-20	Pleistocene	Asia	Davide Tamagnini
Felidae	Machairodontinae	<i>Metailurus major</i>	PMU 21771-1	Miocene	Asia	Narimane Chatar

Felidae	Machairodontinae	<i>Metailurus parvulus</i>	NHMUK-PV-OR-28862	Pliocene	Europe	Narimane Chatar
Felidae	Machairodontinae	<i>Metailurus sp</i>	AMNH-131854	Miocene	Asia	Narimane Chatar
Felidae	Machairodontinae	<i>Miracinonyx studeri</i>	UCMP-34770	Pleistocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Nanosmilus kurteni</i>	AMNH-140559-001	Oligocene	North America	Narimane Chatar
Felidae	Felinae	<i>Neofelis diardi</i>	MNHN.CG1879-2133	Extant	Asia	Davide Tamagnini
Felidae	Felinae	<i>Neofelis nebulosa</i>	A585711	Extant	Asia	Narimane Chatar
Nimravidae	Nimravinae	<i>Nimravus brachyops</i>	UCMP-1681	Oligocene	North America	Narimane Chatar
Nimravidae	Barbourofelinae	<i>Oriensmilus liupanensis</i>	IVPP-V25220	Miocene	Asia	Xiaoming Wang
Felidae	Felinae	<i>Otocolobus manul</i>	MNHN-ZO-AC-2010-646	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Panthera atrox</i>	UF-VP-9076	Pleistocene	North America	Jeanette Pirlo
Felidae	Felinae	<i>Panthera gombaszoegensis</i>	ULg-PA-BR-II-81-146	Pleistocene	Europe	Narimane Chatar
Felidae	Felinae	<i>Panthera leo</i>	RG30674	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Panthera onca</i>	MNHN-ZO-AC-2006-641	Extant	South America	Margot Michaud
Felidae	Felinae	<i>Panthera palaeosinensis</i>	PMU-21777-1	Pleistocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Panthera pardus</i>	RG29292	Extant	Africa	Narimane Chatar
Felidae	Felinae	<i>Panthera spelaea</i>	IMNH	Pleistocene	Europe	Davide Tamagnini
Felidae	Felinae	<i>Panthera tigris</i>	MNHN-ZO-1931-60	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Panthera uncia</i>	MNHN-ZO-2006-429	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Panthera zdanskyi</i>	BC-294	Pleistocene	Asia	Davide Tamagnini
Felidae	Machairodontinae	<i>Paramachaerodus maximiliani</i>	PMU 21773	Miocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Pardofelis marmorata</i>	MNHN-ZO-AC 1886-25	Extant	Asia	Margot Michaud
Nimravidae	Nimravinae	<i>Pogonodon davisii</i>	UCMP-789	Oligocene	North America	Narimane Chatar
Nimravidae	Nimravinae	<i>Pogonodon platycopis</i>	UCMP-102521	Oligocene	North America	Narimane Chatar
Felidae	Felinae	<i>Prionailurus bengalensis</i>	A595067	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Prionailurus planiceps</i>	MNHN-ZO-AC-1873-228	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Prionailurus rubiginosus</i>	MNHN-ZO-AC-2012-54	Extant	Asia	Narimane Chatar
Felidae	Felinae	<i>Prionailurus viverrinus</i>	MNHN-ZO-AC-A12519	Extant	Asia	Margot Michaud
Felidae	Felinae	<i>Pristifelis attica</i>	AMNH-22331	Miocene	Asia	Narimane Chatar
Felidae	Felinae	<i>Proailurus lemanensis</i>	AMNH-101931	Oligocene	Europe	Narimane Chatar
Felidae	Felinae	<i>Puma concolor</i>	ISM-ZOO-693928	Extant	North America	MORPHOSOURCE
Felidae	Felinae	<i>Puma pardoides</i>	MHNL-20161852	Pliocene	Europe	Narimane Chatar

Felidae	Felinae	<i>Puma yaguarondi</i>	A585414	Extant	South America	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon fatalis</i>	LACM-HC-2002-2	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon gracilis</i>	AMNH-22572	Pleistocene	North America	Narimane Chatar
Felidae	Machairodontinae	<i>Smilodon populator</i>	NHMUK-PV-M9374	Pleistocene	South America	Narimane Chatar
Felidae	Machairodontinae	<i>Xenosmilus hodsonae</i>	UF-VP-60000	Pleistocene	North America	Jeanette Pirlo
Felidae	Machairodontinae	<i>Yoshi garevskii</i>	MNHN-Sk-69	Miocene	Europe	Denis Geraads
Felidae	Machairodontinae	<i>Yoshi minor</i>	PMU 21767/2	Miocene	Asia	Narimane Chatar

**Table S1:** List of mandibles and skulls included in the dataset with their metadata. Blue indicates extant taxa, orange indicates fragmentary specimens. Related to STAR methods and Figure 1.

<b>Landmark #</b>	<b>Description</b>
<b>1</b>	Posterior base of the coronoid process, serving as the first anchorage point for the curve characterizing the shape of the coronoid process.
<b>2</b>	Posterior extent of the tooth row, second anchorage point for the curve characterizing the shape of the coronoid process.
<b>3</b>	Anterior extent and shape of the lower carnassial (labial).
<b>4</b>	Anterior extent and shape of the lower carnassial (lingual).
<b>5</b>	Anterior extent of the tooth row, first anchorage point for the curve characterizing the shape and size of the diastema
<b>6</b>	Posterior extent of the lower canine, second anchorage point for the curve characterizing the shape and size of the diastema
<b>7</b>	Anterior extent of the lower canine and the symphysis, first anchorage point for the curve characterizing the symphyseal region and the ventral border of the mandibular corpus
<b>8</b>	Posterior extent of the angular process, second anchorage point for the curve characterizing the symphyseal region and the ventral border of the mandibular corpus.
<b>9</b>	Labial extent of the mandibular condyle
<b>10</b>	Ventral extent of the mandibular condyle
<b>11</b>	Dorsal extent of the mandibular condyle

**Table S2:** Description of the fixed landmarks placed on the 99 mandibles. Related to STAR methods and Figure S1A.

Landmark #	Description
1	Most ventral point of the narial aperture, first anchorage point for the curve characterizing the dorsal profile of the skull (anterior) and first anchorage point for the curve characterizing the narial aperture.
2	Most dorsal point of the narial aperture at the junction of both nasal bones, , first anchorage point for the curve characterizing the narial aperture.
3	Most anterior point of the sagittal crest, second anchorage point for the curve characterizing the dorsal profile of the skull (anterior) and first anchorage point for the curve characterizing the dorsal profile of the skull (posterior)
4	Junction between the sagittal and nuchal crest, second anchorage point for the curve characterizing the dorsal profile of the skull (posterior) and first anchorage point for the curve characterizing the nuchal crest and zygomatic arc.
5	Most dorsal point of the post orbital process of the zygomatic, second anchorage point for the curve characterizing the nuchal crest and zygomatic arc and first anchorage point for the curve characterizing the orbit.
6	Most ventral point of the post orbital process of the frontal, second anchorage point for the curve characterizing the orbit.
7	Most anterior point of the junction between both premaxilla, first anchorage point for the curve characterizing the palate.
8	Most posterior point of the junction between both palatine, second anchorage point for the curve characterizing the palate.
9	Most posterior point of the intercondyloid notch
10	Most posterior point of the tooth row
11	Anterior extent of the upper carnassial
12	Most anterior extension of the tooth row.
13	Posterior extent of the upper canine.
14	Anterior extent of the upper canine.
15	Anterior extent of the palatine fissure.
16	Posterior extent of the palatine fissure.
17	Oval foramen
18	Most posterior extant of the suture between the palatine and the zygomatic.
19	Most ventral extant of the suture between both premaxillae.
20	Most dorsal extant of the infraorbital foramen.
21	Most ventral extant of the infraorbital foramen.
22	Most dorsal point of the foramen magnum.

**Table S3:** Description of the fixed landmarks placed on the 90 crania. Related to STAR methods and Figure S1B.

Pairs	Bone	Stayton 2015					
		C2	p-value C2	C3	p-value C3	C4	p-value C4
<i>Yoshi minor</i> – <i>Acinonyx jubatus</i>	<b>Cranium</b>	0.00185	<b>0.510</b>	<b>0.0042</b>	0.538	0.000001	0.510
	<b>Mandible</b>	<b>0.04805</b>	<b>0.037</b>	<b>0.1668</b>	<b>0.031</b>	<b>0.00003</b>	<b>0.035</b>
<i>Hoplophoneus primaevus</i> – <i>Homotherium serum</i>	<b>Cranium</b>	0	1	0	1	0	1
	<b>Mandible</b>	0.00468	0.471	0.013749	0.505	0.000003	0.484
<i>Machairodus aphanistus</i> – <i>Panthera pardus</i>	<b>Cranium</b>	0	1	0	1	0	1
	<b>Mandible</b>	0.00373	0.472	0.0150	0.474	0.000004	0.466
<i>Machairodus aphanistus</i> – <i>Nimravus brachyops</i>	<b>Cranium</b>	0	1	0	1	0	1
	<b>Mandible</b>	0	1	0	1	0	1
<i>Megantereon</i> <i>nihowanensis</i> – <i>Eusmilus</i> <i>adelos</i>	<b>Cranium</b>	0.24717	0.017	0.08849	0.052	0.0000235	0.019
	<b>Mandible</b>	0.03162	0.092	0.06839	0.214	0.0000185	0.106
<i>Neofelis nebulosa</i> – <i>Metailurus major</i>	<b>Cranium</b>	0.005529	0.400	0.014008	0.444	0.0000046	0.417
	<b>Mandible</b>	0.014467	0.239	0.056397	0.233	0.000017	0.225
<i>Neofelis nebulosa</i> – <i>Nimravus brachyops</i>	<b>Cranium</b>	0.000123	0.612	0.000285	0.612	0	0.612
	<b>Mandible</b>	0.004514	0.547	0.013430	0.563	0.000003	0.556

**Table S4:** Results of Stayton convergence tests (C2, C3 and C4, see main document for C1 and comparison with Castiglione 2019). Related to Table 1, STAR methods and Figure S2 G-H.

Group tested	Structure	Phylogenetic signal (K)	p-value
<b>Whole dataset</b>	Cranium	0.2943	0.001
	Mandible	0.4943	0.001
<b>Felidae</b>	Cranium	0.3788	0.001
	Mandible	0.4656	0.001
<b>Nimravidae</b>	Cranium	0.5347	0.1129
	Mandible	0.7921	0.001
<b>Felinae</b>	Cranium	0.3552	0.043
	Mandible	0.4466	0.001
<b>Machairodontinae</b>	Cranium	0.565	0.001
	Mandible	0.4402	0.001
<b>Nimravinae</b>	Cranium	0.4888	0.2358
	Mandible	0.8095	0.002
<b>Barbourofelinae</b>	Cranium	0.6729	0.7033
	Mandible	0.7625	0.1149

**Table S5:** Phylogenetic signal on Procrustes coordinates for the cranium and mandible, for different clades. Non-significant p-values are highlighted in grey. Related to STAR methods.