Supplementary File A: Testing for Locomotor Signal in postcranial indices

Linear Discriminant Function Analysis

To investigate whether the functional ratios contain sufficient information to distinguish among carnivorans with distinct locomotor modes and patterns of substrate use, I performed a linear discriminant function analysis using the `lda` function from the `MASS` library. To perform this analysis, we will need the script containing utility functions, as well as csv files containing the trait data and locomotor information:

```
library(MASS)
source("functions_postcranial.R")

## read in the data ##
mean.rat <- read.csv("postcranial_ratios/mean.ratios.csv", row.names=1)
habit <- read.csv("locomotor_mode.csv", stringsAsFactors = F, row.names = 1, header=F)
loc <- setNames(habit[,1], rownames(habit))

## perform dfa ##
dfa<-lda(loc ~.,as.data.frame(mean.rat))
```

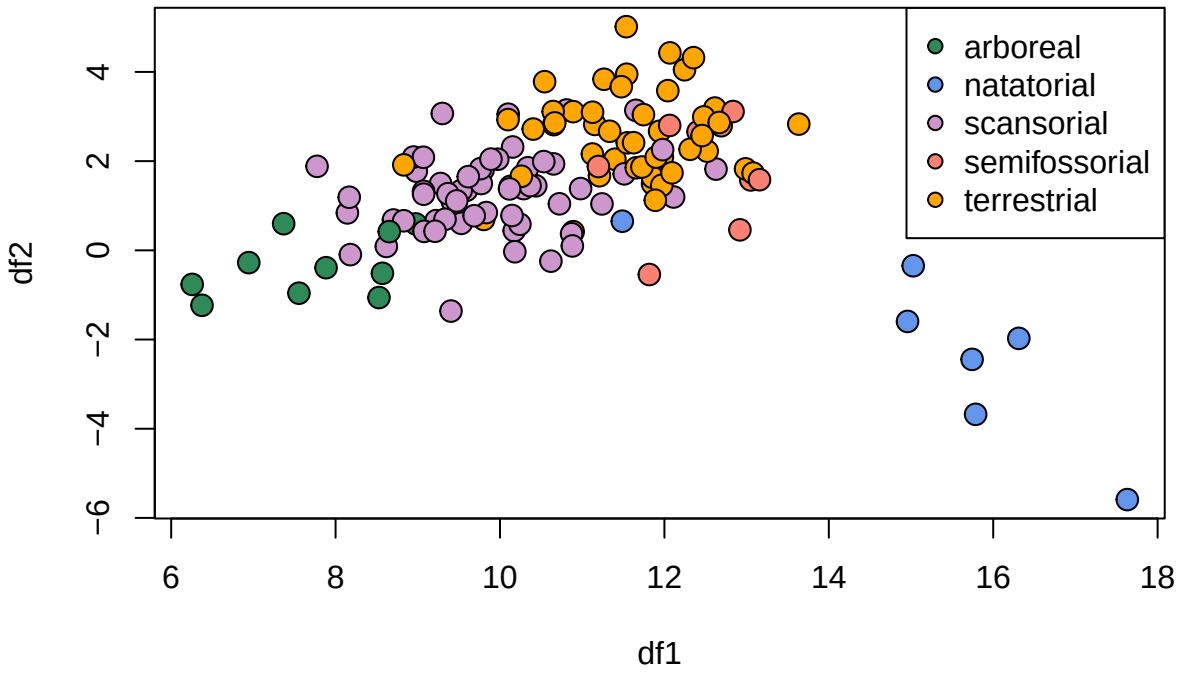
We can examine the relative amount of variance explained by each DF axis by calling

```
(dfa$svd^2)/sum(dfa$svd^2)
```

```
## [1] 0.54683244 0.29996473 0.08149963 0.07170320
```

which shows that the first DF axis accounts for around 55 % of the variance while the second is around 30%. To obtain species scores along each function we must multiply each species' trait values by the corresponding scaling factors (Table A1) and then sum them:

```
df1<-apply(mean.rat, 1, function(x) sum(x*dfa$scaling[,1]))
df2<-apply(mean.rat, 1, function(x) sum(x*dfa$scaling[,2]))
plot(df1, df2, pch=21, bg=c("seagreen", "cornflowerblue", "plum3", "salmon", "orange")
     [as.factor(loc)], cex=1.5)
legend("topright", legend=levels(as.factor(loc)), pch=21,
       pt.bg=c("seagreen", "cornflowerblue", "plum3", "salmon", "orange"))
```



We can now predict group membership for each taxon based on its traits using the discriminant functions. We can also repeat the linear discriminant analysis but with the option CV=TRUE to perform a leave–one–out cross–validation. The aim here is to determine, for each species, whether its combination of trait values yields a reasonable prediction of its group membership given the traits present in other taxa.

```
pred <-MASS:::predict.lda(dfa, as.data.frame(mean.rat))$class
dfa2<-MASS:::lda(loc ~.,as.data.frame(mean.rat), CV=TRUE)
head(cbind(loc, as.character(pred), round(dfa2$posterior,2)))
```

```
##                   loc                        arboreal natatorial scansorial
## Acinonyx_jubatus  "scansorial" "terrestrial" "0"      "0"        "0.24"
## Puma_concolor     "scansorial" "scansorial"  "0.03"   "0"        "0.97"
## Puma_yagouaroundi "scansorial" "scansorial"  "0"      "0"        "0.97"
## Lynx_canadensis   "scansorial" "scansorial"  "0"      "0"        "1"
## Lynx_rufus        "scansorial" "scansorial"  "0"      "0"        "0.98"
## Felis_silvestris  "scansorial" "scansorial"  "0"      "0"        "0.89"
##                   semifossorial terrestrial
## Acinonyx_jubatus  "0"           "0.76"
## Puma_concolor     "0"           "0"
## Puma_yagouaroundi "0"           "0.02"
## Lynx_canadensis   "0"           "0"
## Lynx_rufus        "0"           "0.02"
## Felis_silvestris  "0"           "0.11"
```

In the first 6 rows (which are all felids) we see that the posterior probability that theses species belong to the scansorial category is generally high, though the cheetah is perhaps more similar to terrestrial taxa. The full set of cross–validated assignments are provided in Table A2.

Table A1: Scaling matrix for the first two linear discriminant functions. The magnitude of the scaling factors indicates the importance of each variable on that function while the sign indicates the direction of the effect

	LD1	LD2
scapula.index	-7.73	-3.77
glenoid.shape	-7.93	-0.63
brachial.index	0.38	8.55
humeral.epicondylar.breadth	4.10	2.78
capitulum.shape	3.18	3.09
fossoriality.index	-5.90	14.26
crural.index	2.72	-9.62
femoral.shaft.shape	0.76	0.21
femoral.epicondylar.width	48.91	-26.45
patella.grove.index	-10.27	6.18
femoral.epicondylar.index	13.13	208.71
gluteal.index	17.47	1.37
intermembranal.index	5.54	-4.80
ischial.breadth	-0.75	6.73
iliac.breadth	-0.54	-1.24
pubic.symphysis.length	6.95	2.89

Table A2: Leave–one–out cross–validation of carnivoran locomotor classification. loc gives the assigned locomotor mode, predicted gives the best estimate as to group membership and subsequent columns give the posterior probability that the row taxon belongs to that group.

	locomotor	predicted	arboreal	natatorial	scansorial	semifossorial	terrestrial
Acinonyx jubatus	scansorial	terrestrial	0	0	0.24	0	0.76
Puma concolor	scansorial	scansorial	0.03	0	0.97	0	0
Puma yagouaroundi	scansorial	scansorial	0	0	0.97	0	0.02
Lynx canadensis	scansorial	scansorial	0	0	1	0	0
Lynx rufus	scansorial	scansorial	0	0	0.98	0	0.02
Felis silvestris	scansorial	scansorial	0	0	0.89	0	0.11
Felis margarita	scansorial	scansorial	0	0	0.79	0	0.21
Felis chaus	scansorial	scansorial	0	0	0.97	0	0.03
Otocolobus manul	scansorial	scansorial	0	0	0.68	0	0.31
Prionailurus bengalensis	scansorial	scansorial	0	0	0.93	0	0.07
Prionailurus viverrinus	scansorial	scansorial	0	0	0.98	0	0.01
Prionailurus planiceps	scansorial	scansorial	0.01	0	0.97	0	0.02
Caracal aurata	scansorial	scansorial	0.02	0	0.97	0	0
Caracal serval	scansorial	scansorial	0	0	0.99	0	0.01
Leopardus colocolo	scansorial	scansorial	0	0	0.97	0	0.03
Leopardus tigrinus	scansorial	scansorial	0	0	0.95	0	0.05
Leopardus pardalis	scansorial	scansorial	0	0	0.98	0	0.01
Leopardus wiedii	scansorial	scansorial	0	0	0.98	0	0.02
Pardofelis temminckii	scansorial	scansorial	0	0	0.86	0	0.14
Pardofelis marmorata	scansorial	scansorial	0.17	0	0.83	0	0
Neofelis nebulosa	scansorial	scansorial	0	0	0.99	0	0
Panthera leo	terrestrial	scansorial	0	0	0.7	0.14	0.15
Panthera onca	scansorial	scansorial	0	0	0.88	0.07	0.04
Panthera pardus	scansorial	scansorial	0	0	0.98	0	0.02
Panthera uncia	scansorial	scansorial	0	0	0.85	0	0.15
Panthera tigris	terrestrial	scansorial	0	0	1	0	0
Prionodon linsang	scansorial	scansorial	0	0	0.85	0	0.15
Arctictis binturong	arboreal	arboreal	0.95	0	0.05	0	0
Paguma larvata	scansorial	scansorial	0.09	0	0.9	0	0.01
Paradoxurus hermaphroditus	arboreal	scansorial	0.29	0	0.7	0	0.01
Paradoxurus zeylonensis	arboreal	arboreal	0.93	0	0.07	0	0
Arctogalidia trivirgata	arboreal	arboreal	0.95	0	0.05	0	0

Hemigalus derbyanus	scansorial	scansorial	0.04	0	0.96	0	0
Cynogale bennettii	scansorial	scansorial	0	0	0.92	0.01	0.07
Civettictis civetta	scansorial	terrestrial	0	0	0.02	0	0.98
Viverra zibetha	scansorial	scansorial	0	0	0.81	0	0.19
Viverra tangalunga	scansorial	scansorial	0	0	0.84	0	0.16
Viverricula indica	scansorial	scansorial	0	0	0.74	0	0.26
Genetta angolensis	scansorial	scansorial	0.01	0	0.76	0	0.24
Genetta maculata	scansorial	scansorial	0	0	0.9	0	0.1
Genetta tigrina	scansorial	scansorial	0	0	0.84	0	0.15
Genetta genetta	scansorial	scansorial	0	0	0.73	0	0.27
Genetta servalina	scansorial	scansorial	0	0	0.96	0	0.04
Genetta thierryi	scansorial	scansorial	0	0	0.92	0	0.08
Atilax paludinosus	natatorial	scansorial	0	0	0.68	0.01	0.31
Herpestes javanicus	terrestrial	terrestrial	0	0	0.01	0.46	0.53
Bdeogale nigripes	terrestrial	terrestrial	0	0	0.16	0.51	0.33
Cynictis penicillata	terrestrial	terrestrial	0	0	0	0	1
Ichneumia albicauda	terrestrial	terrestrial	0	0	0.56	0	0.44
Galerella sanguinea	scansorial	terrestrial	0	0	0.04	0	0.96
Herpestes ichneumon	terrestrial	terrestrial	0	0	0.1	0.56	0.35
Crossarchus alexandri	scansorial	terrestrial	0	0	0.13	0.15	0.73
Crossarchus obscurus	scansorial	terrestrial	0	0	0.13	0.01	0.86
Mungos mungo	terrestrial	terrestrial	0	0	0.13	0.03	0.84
Suricata suricatta	terrestrial	terrestrial	0	0	0	0	1
Cryptoprocta ferox	scansorial	scansorial	0.14	0	0.86	0	0
Galidia elegans	terrestrial	terrestrial	0	0	0.28	0	0.71
Galidictis fasciata	terrestrial	scansorial	0	0	0.88	0	0.12
Mungotictis decemlineata	terrestrial	terrestrial	0	0	0.38	0	0.61
Eupleres goudotii	terrestrial	terrestrial	0	0	0.01	0.04	0.95
Fossa fossana	terrestrial	terrestrial	0	0	0.43	0	0.57
Crocuta crocuta	terrestrial	terrestrial	0	0	0.04	0.02	0.94
Hyaena hyaena	terrestrial	terrestrial	0	0	0	0.01	0.98
Parahyaena brunnea	terrestrial	terrestrial	0	0	0.01	0.01	0.98
Proteles cristatus	terrestrial	terrestrial	0	0	0.1	0	0.9
Nandinia binotata	scansorial	scansorial	0.06	0	0.94	0	0
Ailuropoda melanoleuca	scansorial	arboreal	1	0	0	0	0
Tremarctos ornatus	scansorial	scansorial	0	0	0.92	0.07	0.01
Ursus malayanus	scansorial	scansorial	0.3	0	0.54	0.11	0.05
Ursus arctos	scansorial	scansorial	0	0	0.99	0	0
Ursus maritimus	terrestrial	scansorial	0.01	0	0.99	0	0
Ursus ursinus	scansorial	scansorial	0	0	0.81	0	0.18
Ailurus fulgens	arboreal	arboreal	0.36	0	0.63	0	0.01
Aonyx cinerea	natatorial	natatorial	0	0.93	0	0.03	0.04
Lutra lutra	natatorial	natatorial	0	1	0	0	0
Lontra canadensis	natatorial	natatorial	0	1	0	0	0
Lontra felina	natatorial	natatorial	0	1	0	0	0
Lontra longicaudis	natatorial	natatorial	0	1	0	0	0
Pteronura brasiliensis	natatorial	natatorial	0	1	0	0	0
Galictis cuja	semifossorial	semifossorial	0	0	0.14	0.07	0.78
Galictis vittata	semifossorial	semifossorial	0	0	0.01	0.93	0.06
Ictonyx striatus	scansorial	terrestrial	0	0	0.01	0.39	0.61
Poecilogale albinucha	terrestrial	terrestrial	0	0	0.02	0.18	0.81
Mustela frenata	terrestrial	terrestrial	0	0	0.38	0.01	0.62
Mustela vison	terrestrial	scansorial	0	0	0.98	0	0.02
Mustela putorius	terrestrial	terrestrial	0	0	0.54	0.03	0.43
Mustela nigripes	terrestrial	terrestrial	0	0	0.06	0.31	0.64
Mustela erminea	terrestrial	terrestrial	0	0	0.1	0	0.89
Melogale moschata	semifossorial	semifossorial	0	0	0.56	0.15	0.29
Melogale personata	semifossorial	semifossorial	0	0	0.01	0.89	0.1
Eira barbara	scansorial	scansorial	0	0	0.97	0.02	0.02
Martes pennanti	scansorial	scansorial	0	0	0.95	0.02	0.04
Gulo gulo	semifossorial	scansorial	0	0	0.88	0.01	0.1
Martes americana	scansorial	scansorial	0	0	0.95	0	0.04
Martes foina	scansorial	scansorial	0	0	0.97	0.01	0.02
Martes flavigula	scansorial	scansorial	0.12	0	0.87	0	0

Mellivora capensis	semifossorial	semifossorial	0	0	0.05	0.72	0.24
Arctonyx collaris	semifossorial	semifossorial	0	0	0.01	0.66	0.33
Meles meles	semifossorial	semifossorial	0	0	0.04	0.23	0.72
Taxidea taxus	semifossorial	semifossorial	0	0	0	0.79	0.21
Bassaricyon alleni	arboreal	arboreal	0.99	0	0.01	0	0
Bassaricyon gabbii	arboreal	arboreal	1	0	0	0	0
Bassaricyon medius	arboreal	arboreal	1	0	0	0	0
Bassaricyon neblina	arboreal	arboreal	0.87	0	0.13	0	0
Nasua narica	scansorial	scansorial	0.05	0	0.93	0	0.02
Nasuella olivacea	scansorial	scansorial	0.46	0	0.47	0	0.07
Nasua nasua	scansorial	scansorial	0	0	0.81	0.01	0.18
Bassariscus astutus	scansorial	scansorial	0.46	0	0.52	0	0.02
Procyon cancrivorus	scansorial	scansorial	0.01	0	0.87	0	0.12
Procyon lotor	scansorial	scansorial	0.03	0	0.88	0	0.09
Potos flavus	arboreal	arboreal	0.96	0	0.04	0	0
Conepatus mesoleucus	terrestrial	terrestrial	0	0	0.12	0.07	0.81
Mephitis mephitis	terrestrial	terrestrial	0	0	0.05	0.19	0.76
Spilogale gracilis	terrestrial	terrestrial	0	0	0.39	0.02	0.59
Mydaus javanensis	terrestrial	terrestrial	0	0	0.51	0.26	0.22
Atelocynus microtis	terrestrial	terrestrial	0	0	0.16	0.09	0.75
Cerdocyon thous	terrestrial	terrestrial	0	0	0.2	0	0.79
Lycalopex griseus	terrestrial	terrestrial	0	0	0.04	0	0.96
Chrysocyon brachyurus	terrestrial	terrestrial	0	0	0.56	0	0.44
Speothos venaticus	terrestrial	semifossorial	0	0	0	0.85	0.15
Canis adustus	terrestrial	terrestrial	0	0	0	0	0.99
Canis mesomelas	terrestrial	terrestrial	0	0	0.03	0	0.97
Canis aureus	terrestrial	terrestrial	0	0	0.01	0	0.99
Canis latrans	terrestrial	terrestrial	0	0	0.07	0	0.93
Canis lupus	terrestrial	terrestrial	0	0	0.03	0.04	0.93
Cuon alpinus	terrestrial	terrestrial	0	0	0.33	0.02	0.65
Lycaon pictus	terrestrial	terrestrial	0	0	0.02	0	0.98
Nyctereutes procyonoides	terrestrial	terrestrial	0	0	0.56	0.01	0.43
Urocyon cinereoargenteus	scansorial	terrestrial	0	0	0.07	0.01	0.92
Vulpes zerda	terrestrial	terrestrial	0	0	0.01	0	0.99
Vulpes rueppellii	terrestrial	terrestrial	0	0	0	0	1
Vulpes vulpes	terrestrial	terrestrial	0	0	0.13	0	0.87
Vulpes lagopus	terrestrial	terrestrial	0	0	0	0	1
Otocyon megalotis	terrestrial	terrestrial	0	0	0.01	0	0.99