

Supplementary Material S1

Morphological differences between Asiatic and African Lions.

The sparser mane having a typical “mohawk” look and a prominent belly fold differentiate adult Asiatic male lions (S1a) from African (S1b), while adult Asiatic lionesses besides the typical belly fold, have more elongated and sleeker facial features (S1c) compared to the more rounded facial features with ‘bluntish’ muzzles in African lionesses (S1d).



a.



b.



c.



d.

Supplementary Material S2

Field guide for aging free ranging Asiatic lions

Several guides for aging free ranging African lions are available (Smuts et al. 1978; Whitman et al. 2004; Whitman and Packer 2006, Miller and Funston 2016) primarily for aiding in trophy hunting and lethal control. Herein, we combine this information with our field observations of known aged lions ($n > 35$) to develop a field aging technique for Asiatic lions. We could differentiate lions of both sexes into six age groups (stages: cubs < 12 months, juveniles 1-2 years, sub-adults > 2 -3 years, young-adults > 3 -5 years, prime-adults > 5 -10 years, old-adults > 10 years) based on field observations. Field ageing of carnivores has been done using body characteristics and measurements (Schaller 1972, Smuts et al. 1978, Whitman and Packer 2006, Banerjee & Jhala 2012), tooth eruption, wear and coloration (Smuts et al. 1978, Stander 1997, Banerjee & Jhala 2012, Sadhu et al. 2017), gum line recession (Laundre et al. 2000, Fabregas and Garces-Narro 2014). We used body size, body characteristics, teeth eruption, wear and coloration, nose pigmentation, gum-line recession and jaw scowl to age lions in the field (Fabregas and Garces-Narro 2014) (Figure S2-1).

Lions "yawn" when approached by people, probably showing their teeth in a non-confrontational manner, as a means to intimidate. This allows observation and photography of teeth and gum-line condition (**Figure S2-1**).

1. Cubs (< 12 months) Figure S2-2:

Prior to giving birth, a lioness usually leaves its pride and stays away with her new born cubs for several weeks to over a month and a half. Cubs were usually observed after they were about two months old. At 2-3 months they are the size of a large domestic cat. Before this time, they rarely accompany their mother and are restricted to their birth-site. Asiatic lion cubs have prominent spots on the limbs, the sides of their bellies, on the forehead and inside of the thighs. Cubs are born toothless and develop their milk dentition by one to one and half months' of age. They start to eat some meat by the age of 2-months, but primarily depend on their mother's milk, which changes to a more meat-diet by 4-5 months. Cubs are born with a slight black tip on the tail that grows into a tuft by the age of 5-6 months. By 5-6 months, cubs become as large as a jackal. At this stage, they accompany their mothers/pride members to nearby kills to feed, and are usually weaned. The scrotum of the male cub is visible from early on, and there is a distinct size difference between male and female cubs by the age of 5-8 months.

2. Juveniles (1 to 2 years) Figure S2-3:

Juvenile lions accompany their prides to larger kills, making it easy to make size comparisons with that of adults. Lions at this stage are roughly half the size of their mothers (about the size of a leopard, 45-70 Kg). Males show faster growth than females and appear to be substantially larger. Males sprout manes covering the sides of the face and a bit of the neck. Face proportions are cub like, with a shorter snout and smaller roundish face. Permanent dentition has replaced milk teeth by this age (which begins at the age of about 8-10 months and is completed by 12-14 months).

3. Sub-adults (> 2 to 3 years) Figure S2-4:

Males are substantially larger than the females. Sub-adult male lions start forming coalitions with their siblings/cohort males and roam together often further away from their natal pride. Mane growth in males is further enhanced, covering more of the neck and sides. In exceptional cases, sub-adult males can weigh between 110-150 Kg and females as much as 70-100 Kg by 30 months (YV Jhala, unpublished data). The body proportions begin appear like adults after 20-22 months. However, close inspection with binoculars by an

experienced observer can still distinguish facial features of sub-adults (roundish) from that of adults. The belly of sub-adults is flat as compared to the more rounding of the bellies in adults, belly fold starts to appear. Permanent dentition is fully formed, canines are milk-white often with a pinkish tinge, tips are pointed without any wear on them, and there are no signs of a receding gum line.

4. Young-adults (>3 to 5 years) Figure S2-5:

By three years, lions are close to full adult size, but continue to grow heavier up to 4-5 years of age. Manes in males start getting darker. Adult males range from 130 to 180 kg, while adult females range from 90 to 135 kg showing a pronounced sexual dimorphism in size. By this stage, the face is no longer cub like with full snout and adult skull proportions. Belly gets rounded, with the prominent appearance of a belly fold.

Teeth start to turn creamy to yellowish by three to four years and are no longer milk-white. By five years of age, the yellowish canines begin to get slight brownish stains. The canine ridge and groves are visible, with little or no wear seen on them and the tips. The jaw is taut with no slack on the lower lip.

For un-bred females and early days following first parturition, the teats are pink in color and become pigmented to dark grey and keratinized after cubs suckle intensely. Teats subsequently retain this dark coloration throughout an individual's life, allowing for the differentiation between bred and un-bred females.

5. Prime-adults (>5 to 10 years) Figure S2-6:

Manes in males attain full luxuriant length, covering the neck, nape and sides of the face. The mane is darker towards the neck and the nape (but mane coloration and profuseness often changes with social status). The belly fold is prominent and the belly rounded. Teeth are brownish-yellow and begin to show wear which is visible on canines (no sharp edges) and incisors when seen. The canine ridge is almost indiscernible, and the groove is highly worn out. Careful inspection shows a receding gum line, making the canines appear larger.

6. Old-adults (>10 years) Figure S2-7:

Belly-fold is sagging. Canines and incisors are worn down, often broken or missing and with dark brown stains. Jaw and lips droop, while the lips show a fold with a prominent jaw scowl. Close observation with binoculars/telephoto- photographs show receded gum-line on worn canines (if any).

We believe that by using the criteria described above, an experienced researcher can age an adult Asiatic lion to its stage accurately with an error margin of about a year, and younger lions (sub-adults and juvenile) to about 3-4 months. Cubs can be aged with the accuracy of about a month by field observations.

References:

- Banerjee K, Jhala Y.V. (2012) Demographic parameters of endangered Asiatic lions (*Panthera leo persica*) in Gir Forests, India. *J. Mammal.*, 93(6), 1420-1430
- Fàbregas M.C., Garcés-Narro C. (2014) Validation of gum-line recession as a reliable technique to age tigers. *Eur. J. Wildl. Res.* 60(6), 947-950
- Laundré J.W., Hernández L., Streubel D., Altendorf K., González C.L. (2000) Aging mountain lions using gum-line recession. *Wildl. Soc. Bull.*, 963-966
- Miller, J. R., Balme, G., Lindsey, P. A., Loveridge, A. J., et al. (2016). Aging traits and sustainable trophy hunting of African lions. *Biol. Conserv.*, 201, 160-168.
- Miller, Jennifer R.B. and Funston, P. (2016). Aging the African lion. Available at <http://agingtheafricanlion.org>.

Smuts G.L., Anderson J.L., Austin J.C. (1978) Age determination of the African lion (*Panthera leo*). *J. Zool.*, 185(1), 115-146

Stander P.E. (1997) Field age determination of leopards by tooth wear. *Afr. J. Ecol.*, 35(2), 156-161

Van Horn R.C., Mcelhinny T.L., Holekamp K.E. (2003) Age estimation and dispersal in the spotted hyena (*Crocuta crocuta*). *J Mammal*, 84(3):1019–1030

Whitman K, Starfield A.M., Quadling H.S., Packer C. (2004) Sustainable trophy hunting of African lions. *Nature*, 428(6979), 175-178

Whitman, K.L. and Packer, C. (2007). *A hunter's guide to aging lions in eastern and southern Africa*. Safari Press.

Figure S2-1. Tooth and jaw characteristics for aging Asiatic lions



Longitudinal Ridge a. Outer Groove Gum Line Recession b. Inner Groove Outer Groove c. d. Jaw Scowl

Figure S2-2. Cubs (<1 year of age). Small cubs (<3 months) have embryonic spots on their foreheads and have shoulder heights below the belly line of their mother (a,b). They lack a tail tuft (b & c, smaller cub), which start developing at the age of around 4-5 months and can be prominently visible after 5 months of age (c, larger cub). Females in a pride rear cub in a crèche and a pride often can have a cohort of cubs from multiple females that differ in their ages (d). Male cubs start growing faster than female cubs after they reach about 5-6 months of age, and a brother-sister dyad can appear to be of different ages at this stage (e). Permanent dentition start erupting around 5-7 months of age (f).



a.



b.



c.



d.



e.



f.

Figure S2-3. Juveniles (<2 year of age). Males start sprouting manes around the face and the neck (a,b). The spots on the sides of the bellies start fading out, while that on the limbs still remain. At this age, permanent milky white teeth with pointed canines characterize their dentition (d).



a.



b.



c.



d.

Figure S2-4. Sub-adults (2-3 years of age). Manes in males cover the sides of the face and the entire neck (a,d). Belly-fold is not visible at this age (a,b). Facial features still remain slightly roundish and cub like (b). Often sub-adult males start forming coalitions with their siblings (a,d). Faded spots on the limbs still remain visible (a,b). Dentition is characterised by milky white teeth with pointed canines having slight pinkish tinges close to the gum-lines (d).



a.



b.



c.



d.

Figure S2-5. Young adults (3-5 years of age). Manes in males become more prominent, with little to moderate blackening. Manes come up over the nape (a,d). The mohawk formation is distinct at this age.. White teeth with slight yellowing around the roots, canines are pointed and unworn (a,b). The belly-fold becomes prominent, individuals reach full adult size (c). Unbred adult lionesses have pinkish-white teats (e), that get keratinized and turn dark after first born cubs suckle intensely (f). Teats remain pigmented and grey subsequently throughout life.



a.



b.

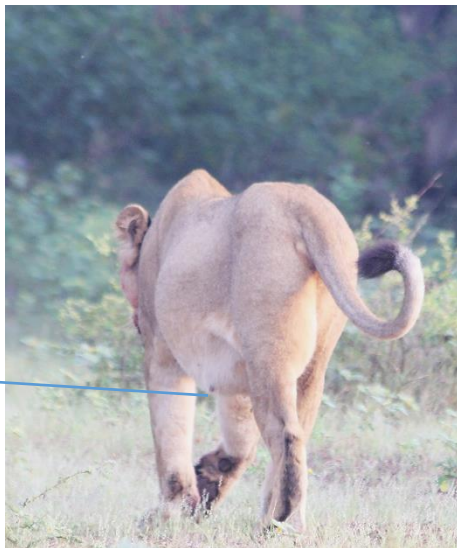


c.



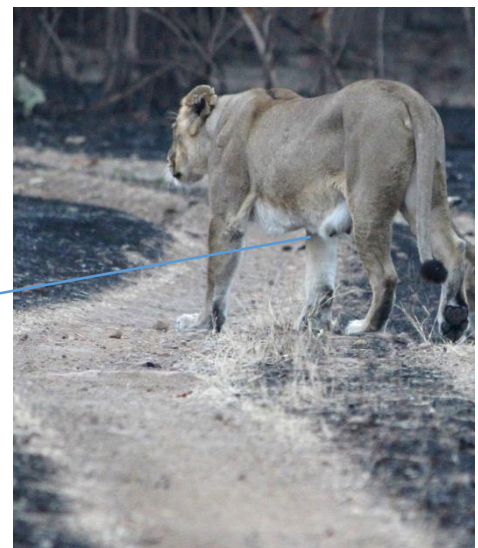
d.

Pinkish-white teat of an un-bred but pregnant lioness.



e.

Lactating female with suckling marks on teats, showing their dark-keratinized texture.



f.

Figure S2-6. Prime adults (6-10 years of age). Manes completely developed in males, covering the nape, neck and sides of the face (c). Manes are darker towards the neck and the nape (c). Yellow teeth with dark stains at the bottom, with slight to moderate recession of the gum line (a,b, d).



a.



b.

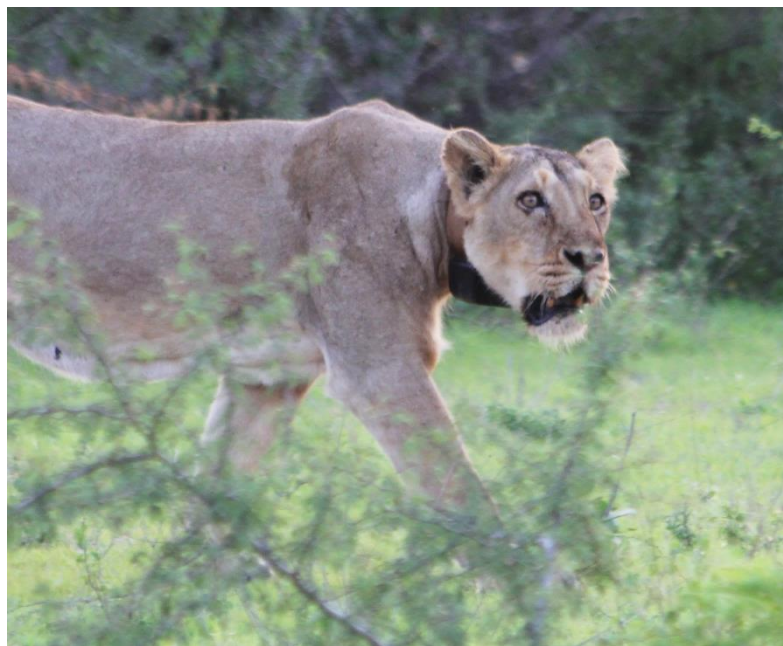


c.



d.

Figure S2-7. Old adults (>10 years of age). Dark yellow to brownish worn out teeth, with drooping jaws (prominent jaw-scowl) (a,b, c, e) and heavily black speckled nose-pads. Appearance of body skin look saggy (b).



a.



b.



c.



d.



e.

Supplementary Material 3:


Program LION: Monitoring of uniquely identified individuals is important for understanding their ecology and estimating their population. Lion software (Jhala et al. 2005) is built for the identification of individual lions based on vibrissae patterns and other permanent body marks enabling the user to maintain a long-term database of individual lion sightings. The software archives photographs, geolocations and other attribute data as a database while enabling search and comparisons to match and identify individual lions based on quantitative criteria. The database helps to understand specific fates of known individuals, generate encounter history for population estimation in a mark-recapture framework. This software is particularly useful for managing large dataset on lions collected over relatively long timespans. The software is freely available on website of the Wildlife Institute of India at http://wii.gov.in/lion_id.

Representation of protocol for collecting field data and its input in Program LION.

75


Lion Identification Data Sheets

11.6.2010 Dharsawa Galt, Paturan, Girnar GPS: 21°33'48.5" / 76°34'12.2"
8:00 hrs. Prime Adult ♀



LEFT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•



RIGHT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

NOTES

Left Row:

A = 3, 5, 6 1/2

B = 8 (large gap between spots 5 & 6, spots 7 & 8 closer)

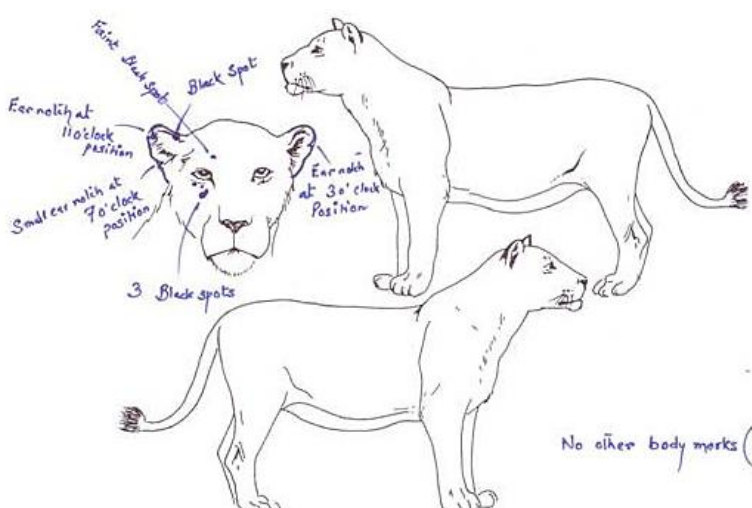
C = 5 1/2 (very faint spot)

Right Row:

A = 3 (faint spot)

B = 7

C = 4 1/2



No other body marks (permanent)

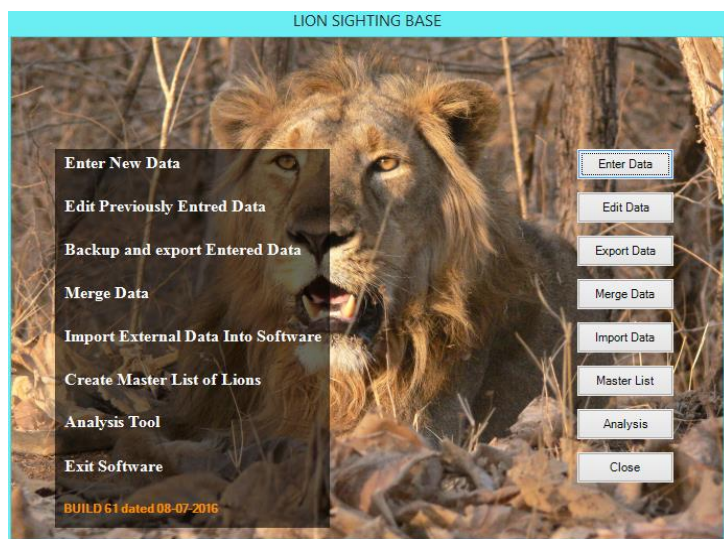
NOTES

Habitat: Teak mixed.

Associated Animals: Four (4) Small cubs (< 6 months), One (1) large cub (> 6 months)

Performa of the data sheet used in the field for individual lion identification. Vibrissae patterns are calibrated on a graph paper and position of additional body marks are recorded.

Schematic representation of the entry and upload of the above field data in Program LION (Jhala et al. 2005)



LION LOCATION

Observer name: Date: Start Time: End Time: Search Path (km):

Protected Area: ☒ Yes ☐ No

Division: Range: Block:

District: Taluk: Village:

Locality: Longitude: Latitude:

Do you have information for km Search: ☐ GPS Track log ☐ Excel ☒ No Data

Group Size: Group Description: Sample Size:

Broad Habitat: Micro Habitat: Terrain:

LION DESCRIPTION

Select Lion: Gender: Unique Lion ID: Longitude: Latitude:

LEFT SIDE VIEW

Age:

RIGHT EAR **LEFT EAR**

☒ Face Left Profile
☒ Face Right Profile
☐ Face Front
☐ Full Body Right
☐ Full Body Left
☐ Additional -1
☐ Additional -2
☐ Additional -3
☐ Additional -4
☐ Additional -5

Location: ScarType: ScarL_in_cm: ScarW_in_cm:

Comments if any:

RIGHT SIDE VIEW

Location: ScarType: ScarL_in_cm: ScarW_in_cm:

Location	ScarType	ScarL_in_cm	ScarW_in_cm
330.30	Black spot	4	4
340.30	Black spot	1	1

Reference:

Jhala, Y.V., Qureshi, Q., & Dey, P. (2005) “Lion” a software to identify individual lion and database management, Wildlife Institute of India, http://wii.gov.in/lion_id.

Supplementary Material 4:**Congenital deformities in wild lions collected opportunistically from across Gir Landscape.**

Date	Area	Symptom
March 2010	Raidi, Dedakadi Range, West Gir Protected Area	One juvenile male died due to deformities in the humerus.
February 2014	Girnar Wildlife Sanctuary	A litter of 3 cubs (2 F, 1 M) – all born blind
May 2014	Jabal Village, Sawarkundla Range, Gir East (outside Protected Area)	One cub (male) in a litter of 3 lacked a humerus bone (died), another cub (female) had a kink in the tail.
August 2015	Raidi, Dedakadi Range, West Gir Protected Area	Cub born blind
March 2016	Girnar Wildlife Sanctuary	Two cubs born without claws.

Supplementary Material 5:

Details of the compensation scheme (in Indian Rupees, 1 US\$ = 68.63 Indian Rupee) by Gujarat Forest Department (year 2016).

Compensation category	Compensation amount (Indian Rupee)
Ex-gratia paid for human death	400,000
For human injuries	4,300
Milch livestock	
Buffalo/cattle/camel	30,000
Sheep and goat	3,000
Non-milch livestock	
Bullock/camel/horse	25,000
Calves, juveniles and sub-adults of Buffalo and cattle	16,000

Reference:

1. Government of Gujarat Order Number 102015/CF 62/W/Secretariat, Gandhinagar dated 07-06-2016.