A comparative acoustic analysis of purring in juvenile, subadult and adult cheetahs

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Abstract

Previous studies of cheetah purring have described purring in adult cheetahs. This paper extends the cheetah purring research to include juvenile and subadult cheetahs and analyzes purring data from cheetahs in ages ranging from 7 months to 7 years, and with weights ranging from 18 kilos to over 70 kilos. Results show that while there is considerable variation across most parameters analysed (amplitude, phase duration, cycles per phase and fundamental frequency), mainly attributable to degree of relaxation/agitation, previously reported observations that ingressive phases tend to be lower in frequency are largely confirmed, with one notable exception.

Introduction

Despite the fact that the purring domestic cat (*Felis catus*, Linneaus 1758) has been a companion of humans for around 10,000 years (Driscoll et al., 2009), and the fact that the prominent purrer, the cheetah (*Acinonyx jubatus*, Schreber 1776), also has been kept as a pet animal for thousands of years, it is still not known exactly how purring is produced.

Eklund, Peters and Duthie (2010) compared purring in the cheetah and the domestic cat, while Eklund et al. (2012) compared purring in four adult cheetahs.

However, the papers mentioned above studied purring in adult cheetahs. The present paper extends the previous studies by including analyses of juvenile/subadult cheetahs, ranging in age from around 7 months to 7 years, with a weight range of 18 kilos to more than 70 kilos.

The cheetah

The cheetah (*Acinonyx jubatus*) is probably best known for being the fastest land animal in the world with an estimated top speed of circa 112 km/h (Sunquist & Sunquist, 2002:23). Contrary to a widespread misconception that the cheetah "is not a cat", it is a full-fledged felid, most closely related to the puma (*Puma concolor*) and the jaguarundi (*P. yaguarondi*) (O'Brien & Johnson, 2007:70).

The cheetah is of roughly the same size as the leopard (*Panthera pardus*) – with which it is often confused – but is of a lighter and more slender build, has a smaller head and smaller teeth. The cheetah is distinguished by dark tear-marks in the facial fur running down its eyes, towards the muzzle.

Sexual dimorphism is not very pronounced in the cheetah: a male cheetah weighs 29–65 kg, and is 172–224 cm nose-to-tail with a shoulder height of 74–94 cm; a female cheetah weighs 21–63 kg, and is 170–236 cm nose-to-tail with a height of 67–84 cm (Hunter & Hamman, 2003:141). Although the cheetah is a relatively large carnivore, there are no records of a wild cheetah ever killing a human being (Hunter & Hamman, 2003:17).

Purring

The term 'purring' has been used liberally in the mammal vocalization literature, and an exhaustive review is given in Peters (2002). Using a definition of purring that continuous sound production must alternate between pulmonic egressive and ingressive airstream (and usually go on for minutes), Peters (2002) reached the conclusion that only "purring cats" (Felidae) and two species of genets (Viverridae *sensu stricto*), *Genetta tigrina*, and likely also *Genetta genetta*, had been documented to purr. For further discussion see Eklund, Peters and Duthie (2010).

Data collection and processing

Data were collected at the Dell Cheetah Centre, in Parys, South Africa, on 30 December 2011. Recordings were made of the two males Finley (F) and Mufasa (M), and from the two sisters Tippi (T) and Jade (J) – daughters of the previously studied male cheetah Caine (see Eklund, Peters & Duthie, 2010).

All five cheetahs were recorded in their enclosures and purring was elicited by Pieter Kemp or the first author. While F and M were quietly resting, the two sisters were playful and agitated, which occasionally led to a number of passages with very short exhalation–inhalation sequences. Finally, film clips from December 2009 of the juvenile (male) cheetah Parker (P) were analysed. Parker, too, was also active during the recording, rather than resting calmly on the ground. Biographical information about all cheetahs are found in *Table 1*.

Equipment

The equipment used was a Canon HG-10 HD camcorder with a clip-on DM50 electret stereo condenser shotgun microphone with a frequency range of 150–15,000 Hz, and a sensitivity of –40 dB. The position of the microphone varied, partly due to the cheetahs moving, but was mostly directed towards the muzzle of the cheetahs, where the sound emanates (see e.g., Eklund, Peters & Duthie, 2010). Photos from the data collection are given in *Plate 1* and *Plate 2*.

Data post-processing

Audio tracks (44.1 kHz, 16 bit, mono) were excerpted with TMPGEnc 4.0 Xpress.

Analysis tools

The sound files were analyzed with Cool Edit 2000 and Cool Edit Pro 2.1. Cycles per phase were counted manually from the waveform. Statistics were calculated with SPSS 12.0.1.

Egressive–ingressive identification

For most of the data, egressive and ingressive phases were identified according to the method described in Eklund, Peters and Duthie (2010), i.e. with the first author keeping his hand on the side of the chest of the cheetah to monitor breathing, while uttering the words “in” and “out” in synchronization with the cheetah’s breathing/purring. When this method was not possible (during playful stretches), the phases were identified by the first author from a combination of visual inspection of the waveform and sound characteristics – based on the distinctive sound differences between egressive and ingressive purring. Finally, in difficult cases, the original video was consulted for visual confirmation where it could be seen whether or not the ribcage of the cheetah was expanding or collapsing.

Parts of the recordings where analysis was difficult or not possible for some reason, e.g. talkover, bird chirps or other background noise, were discarded.

Results

The results are presented in *Table 1*.

Amplitude

Previous studies have reported louder egressive phases in both cheetahs and domestic cats (Eklund, Peters & Duthie, 2010; Schötz & Eklund, 2011; Eklund et al., 2012). This general pattern was observed in this study, as shown in *Figure 1*, where a long stretch of purring (from M) shows egressive–ingressive phases with clearly stronger egressive phases.

However, while Eklund et al. (2012) reported louder egressive phases in all four cheetahs analysed, one cheetah (Aisha) did produce a number of louder ingressive phases, which they attributed to the fact that she was in an agitated state. This was confirmed in the present study, and a less consistent and varying pattern was observed in P, T and J, all of whom were moving about, playing or licking the author’s hand. Often there were no discernible amplitude differences between egressive and ingressive phases, and in some cases ingressive phases were clearly louder than egressive phases, as is shown in *Figure 2*.

Phase durations

Previous studies have not reported any consistent pattern in phase durations. Eklund, Peters and Duthie (2010) observed longer egressive phases while Schötz and Eklund (2011) reported longer ingressive phases. Eklund et al. (2012) reported longer egressive phases in two of the cheetahs studied, and longer ingressive phases in the two other cheetahs studied. This inconsistent pattern was also observed in the present study. Three of the cheetahs (P, T, J) exhibited no significant differences between egressive and ingressive phases, while M had significantly longer egressive phases and F significantly longer ingressive phases. It should be noted, however, that the F data set is very small ($N = 12$), and that far-reaching conclusions based on this data set should be subject to extreme caution. On average, shorter phase durations were observed in the three young cheetahs. This can likely partly be explained by the fact that they were in an agitated state and moving about rather than resting peacefully. However, all young cheetahs were capable of long purrs – although no phases longer than 3 s were observed.

Plate 1. Pieter Kemp and first author recording Mufasa. Photo by Miriam Oldenburg.

Plate 2. First author recording Jade and Tippi. Photo by Miriam Oldenburg.

Table 1. Summary Table. For all five cheetahs results are given for duration, cycles per phase and fundamental frequency. Results are presented independently for egressive and ingressive phases and for the two combined, and statistical tests are performed on differences between egressive and ingressive phonation.

	Mufasa (M)		Finley (M)		Parker (M)		Tippi (F)		Jade (F)	
Age	7 years		6 years		11 months		7 months		7 months	
Weight (kilos)	> 70		50		25		18–20		18–20	
Phonation type	Ingr	Egr	Ingr	Egr	Ingr	Egr	Ingr	Egr	Ingr	Egr
No. phases analysed	38	38	6	6	21	21	42	43	24	25
Mean duration (ms)	2174	2438	2763	1662	1003	970	1045	1063	685	590
Mean duration egr+ingr (ms)	2306		2212		986		1054		637	
Standard deviation	385.5	534.5	398.9	268.7	413.6	406.6	406.4	359.9	376.1	243.3
Maximal duration	3300	3640	3270	2100	1700	1710	2000	1790	2100	2100
Minimal duration	1280	1200	2360	1360	100	280	300	460	300	160
Δ t test (paired-samples, two-tailed)	$p = 0.014$		$p = 0.004$		$p = 0.074$		$p = 0.807$		$p = 0.168$	
Δ Wilcoxon (two related samples)	$p = 0.018$		$p = 0.028$		$p = 0.068$		$p = 0.726$		$p = 0.094$	
Mean no. cycles/phase	49.3	49.1	63.7	37.7	20.3	21.5	25.3	28.0	19.3	18.4
Mean no. cycles/phase egr+ingr	49.2		50.7		20.9		26.7		18.9	
Standard deviation	10.5	12.1	6.7	3.5	6.7	9.1	10.5	10.6	11.8	7.4
Maximal no. phases/cycle	69	77	75	43	35	38	50	50	67	34
Minimal no. cycles/phase	24	23	57	35	7	3	7	12	10	8
Δ t test (paired-samples, two-tailed)	$p = 0.921$		$p = 0.001$		$p = 0.562$		$p = 0.182$		$p = 0.576$	
Δ Wilcoxon (two related samples)	$p = 0.959$		$p = 0.028$		$p = 0.456$		$p = 0.268$		$p = 0.471$	
Mean fundamental frequency (Hz)	22.6	20.1	23.2	22.2	19.6	22.7	24.2	26.1	28.3	30.8
Mean frequency egr+ingr (Hz)	21.3		22.8		21.1		25.2		29.6	
Standard deviation	2.25	2.25	1.9	2.14	2.38	1.58	3.1	3.1	4.45	7.26
Highest fundamental frequency	25.7	21.9	24.9	26.5	23.4	25.7	32.9	35.0	37.5	49.0
Lowest fundamental frequency	18.7	11.2	20.5	19.7	16.4	20.0	20.0	21.5	22.5	24.1
Δ t test (paired-samples, two-tailed)	$p < 0.001$		$p = 0.048$		$p < 0.001$		$p = 0.002$		$p = 0.072$	
Δ Wilcoxon (two related samples)	$p < 0.001$		$p = 0.053$		$p < 0.001$		$p < 0.001$		$p = 0.113$	

Cycles per phase

Once again, this study repeats previous studies (ibid.) that have failed to observe any consistent differences as regards numbers of cycles per phase. This is perhaps not very surprising, given that cycles per phase can be expected to be closely linked to phase durations in general. While there is a strongly significant difference observed in F, this is likely attributable to the very limited data set, and no strong conclusions should be drawn based on this observation.

Fundamental frequency

Previous studies on the cheetah have in general reported lower fundamental frequency (F_0) patterns in ingressive phases (Eklund et al., 2012; Frazer Sissom, Rice & Peters, 1991). In the present study, two cheetahs (P, T) had significantly lower F_0 in ingressive phases, while M showed the opposite pattern. F and J exhibited no strong tendency in either direction. The observation that one cheetah (M) has significantly lower F_0 in egressive phases shows that this parameter, too, is subject to individual variation. While some “high” frequencies were observed in the playing cheetahs, P produced some very low F_0 values showing that body size seemingly does not play an important role, shown in studies on the domestic cat (ibid.).

Discussion and conclusions

The present study extends on previous studies on purring in the cheetah by including subadult cheetahs in the data studied. Young cheetahs seemingly exhibit the same characteristics as do adult cheetahs, with the possible exception of very long phase durations, and no phases with a duration of 3 seconds or more were observed.

While individual variation is observed in both the present study and previous reports, actual value ranges are basically the same, with very low F_0 produced by all animals, regardless of body size and/or age. However, there is still a tendency for ingressive phases to have lower F_0, even if this study has found an exception to this general trend.

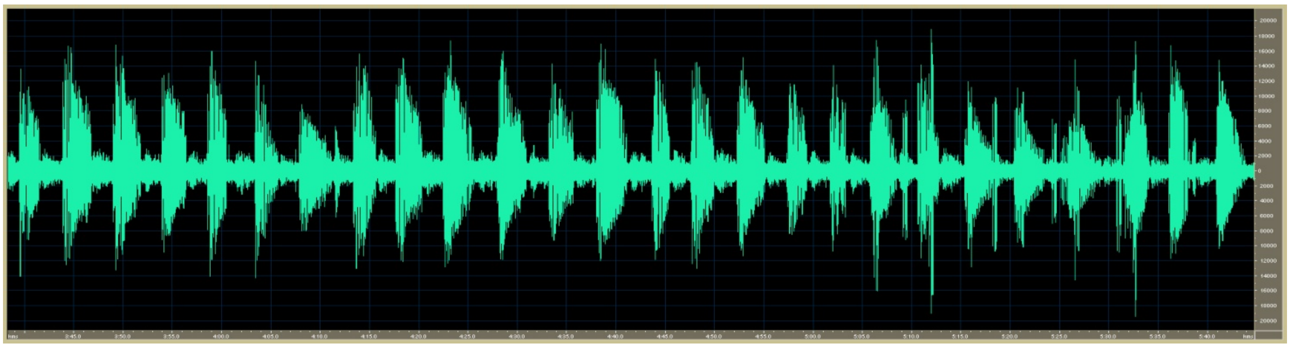

Figure 1. Mufasa purring amplitude pattern. Egressive phases clearly exhibit consistently higher amplitude. Window duration = 2 minutes 34 seconds.

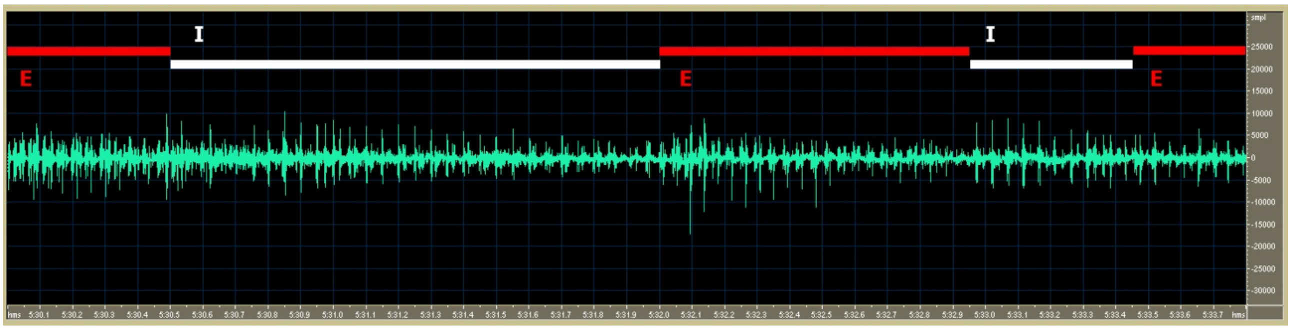

Figure 2. Tippi purring durations. Egressive phases (E) red/upper bar. Ingressive phases (I) white/lower bar. Durations: E: 480 ms – I: 1515 ms – E: 960 ms – I:480 ms – E: 340 ms.

Notes

Sound files/film clips found at http://purring.org

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