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Does purring "ronron" in the family? A longitudinal and intra-family study of purring in a female cheetah as a cub and as an adult and purring in her father as an adult and brother as a cub

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Abstract

In 2009 the author initiated his "zoonetics" activities by recording purring in the male cheetah Caine as well as in the domestic cat Misha and presented the results at the Fonetik Meeting in 2010 at Lund University. Subsequent studies of cheetah purring then followed, including a study of purring in Caine's daughter Jade and son Parker in 2013, Jade at the time 7 months old. In May 2019 the author recorded Jade again (now 7 years old) and was then able to study whether any changes in her purring had occurred and, specifically, whether Jade as an adult had kept her cub characteristics or was now more similar to her father, who was 7 years old when he was recorded. To the best of my knowledge this study presents the first longitudinal study of purring in a cheetah.

Introduction

In 2010 Eklund, Peters and Duthie (2010) compared purring in the cheetah and the domestic cat, based on recordings made of the male cheetah Caine in South Africa and the domestic cat Misha (recorded in Sweden).

In 2013 Caine's daughter Jade (pronounced [ˈʤɛjdɪ]), then 7 months old, was recorded alongside her brother Parker (11 months old) and a few other cheetahs and the analyses were presented in Eklund and Peters (2013).

In May 2019 the author had the opportunity to record Jade, now 7 years old, again which made it possible to study longitudinal development in Jade's purring and also see whether she, now being the same age as her father Caine was in the 2010 study, more resembled her father or whether she has retained the characteristics of her purring as a cub.

To the best of this author's knowledge the present study provides the first longitudinal study of purring in a cheetah.

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).

A widespread misconception is 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.

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 G. *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 12 May 2019. Jade, at the time around 7 years old, was recorded in her enclosure by the author and Estelle Kemp. Jade, who was not at all an approachable "people cheetah" – normally only Estelle Kemp was able to approach Jade – was exceptionally friendly and even (to everyone's great surprise) approached the author in a friendly manner and allowed herself to be petted by the authors, which also made it possible to obtain high-quality data.

Film captures of the data collection are shown in Plates 1 and 2.

Equipment

The equipment used was a handheld Canon HG-10 HD camcorder. A wide-angle lens was also used to enable filming closer to the cheetah while still capturing the entire scene.

Sound was recorded with an external professional high-fidelity Audiotechnica AT813 cardoid-pattern, condenser mono microphone (the same used to record Caine in 2009). The position of the microphone varied, partly due to Jade moving (albeit slightly), but was mostly directed towards the muzzle of the cheetahs, where the sound emanates (see e.g., Eklund, Peters & Duthie, 2010).

Data post-processing

Audio tracks were excerpted from the films with TMPGEnc 4.0 Xpress. Working audio format was 44.1 kHz, 16 bit, mono.

Analysis tools

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

Analyses

Identification of egressive and ingressive phases

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 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 and purring.

Egressive and ingressive phases were identified by the first author by a combination of visual inspection of the waveform and sound characteristics, based on the very distinctive sound quality and amplitude differences between egressive and ingressive purring.

It proved very easy to identity both ingressive and egressive phases from both a waveform and sound quality perspective; a sample is shown on Plate 3. Note the "two-stroke" characteristics of both egressive and ingressive phases.

Plates 1 and 2. Video captures from the recording session. Estelle Kemp (left) and Robert Eklund (right) taking turns in holding the microphone and the camera, respectively. Note the author's hand on Jade's back to make sure the identfications of egressive/ingressive phases were correct. The recording session took place in Jade's enclosure.

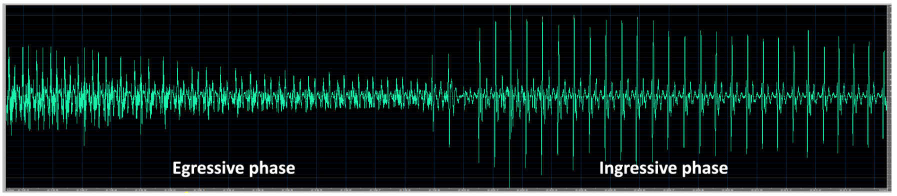

Plate 3. **Waveform example** showing egressive and ingressive phases (Cool Edit 2000 screenshot). Note the "two-stroke" characteristics of both phases which is much clearer in the ingressive phases, thus making identification much more straightforward for ingressive phases than for egressive phases.

Table 1. **Summary results**. For all four cheetahs results are given for duration, cycles per phase and fundamental frequency. Egressive and ingressive phases are given both separately and combined. Caine and Parker also 2013 data.

	Caine (M)		Parker (M)		Jade (F) 2013		Jade (F) 2019	
Age	7 years		11 months		7 months		7 years	
Weight (kilos)	> 70		25		18–20		~42	
Phonation type	Ingr	Egr	Ingr	Egr	Ingr	Egr	Ingr	Egr
No. phases analysed	38	38	21	21	24	25	25	22
Mean duration (ms)	2174	2438	1003	970	685	590	1816	1428
Mean duration egr+ingr (ms)	2306		986		637		1634	
Standard deviation	385.5	534.5	413.6	406.6	376.1	243.3	130.5	298.5
Maximal duration	3300	3640	1700	1710	2100	2100	1972	1790
Minimal duration	1280	1200	100	280	300	160	1816	1428
Δ *t* test (paired-samples, two-tailed)	$p = 0.014$		$p = 0.074$		$p = 0.168$		$p < 0.001$	
Δ Wilcoxon (two related samples)	$p = 0.018$		$p = 0.068$		$p = 0.094$		$p < 0.001$	
Mean no. cycles/phase	49.3	49.1	20.3	21.5	19.3	18.4	35.0	30.1
Mean no. cycles/phase egr+ingr	49.2		20.9		18.9		32.8	
Standard deviation	10.5	12.1	6.7	9.1	11.8	7.4	2.6	5.7
Maximal no. phases/cycle	69	77	35	38	67	34	38	43
Minimal no. cycles/phase	24	23	7	3	10	8	29	18
Δ *t* test (paired-samples, two-tailed)	$p = 0.921$		$p = 0.562$		$p = 0.576$		$p = 0.004$	
Δ Wilcoxon (two related samples)	$p = 0.959$		$p = 0.456$		$p = 0.471$		$p = 0.009$	
Mean fundamental frequency (Hz)	22.6	20.1	19.6	22.7	28.3	30.8	19.3	21.0
Mean frequency egr+ingr (Hz)	21.3		21.1		29.6		20.1	
Standard deviation	2.25	2.25	2.38	1.58	4.45	7.26	0.36	1.85
Highest fundamental frequency	25.7	21.9	23.4	25.7	37.5	49.0	20.1	24.8
Lowest fundamental frequency	18.7	11.2	16.4	20.0	22.5	24.1	18.4	17.8
Δ *t* test (paired-samples, two-tailed)	$p < 0.001$		$p < 0.001$		$p = 0.072$		$p < 0.001$	
Δ Wilcoxon (two related samples)	$p < 0.001$		$p < 0.001$		$p = 0.113$		$p = 0.001$	

Table 2. **Duration values** for egressive and ingressive phases combined (i.e. entire purring phases); *t* test for independent samples, two-tailed, equal variances assumed. Jade 2013/Jade 2019 are considered independent.

	Jade 2013	Jade 2019	Caine	Parker
Jade 2013		$p < 0.001$	$p < 0.001$	$p < 0.001$
Jade 2019	$p < 0.001$		$p < 0.001$	$p < 0.001$
Caine	$p < 0.001$	$p < 0.001$		$p < 0.001$
Parker	$p < 0.001$	$p < 0.001$	$p < 0.001$	

Table 3. **Cycles per phase** for egressive and ingressive phases combined (i.e. entire purring phases); *t* test for independent samples, two-tailed, equal variances assumed. Jade 2013/Jade 2019 are considered independent.

	Jade 2013	Jade 2019	Caine	Parker
Jade 2013		$p < 0.001$	$p < 0.001$	$p < 0.001$
Jade 2019	$p < 0.001$		$p < 0.001$	$p < 0.001$
Caine	$p < 0.001$	$p < 0.001$		$p < 0.001$
Parker	$p < 0.001$	$p < 0.001$	$p < 0.001$	

Table 4. **Hz values** for egressive and ingressive phases combined (i.e. entire purring phases); *t* test for independent samples, two-tailed, equal variances assumed. Jade 2013/Jade 2019 are considered independent.

	Jade 2013	Jade 2019	Caine	Parker
Jade 2013		$p < 0.001$	$p < 0.001$	$p < 0.001$
Jade 2019	$p < 0.001$		$p = 0.099$	$p = 0.060$
Caine	$p < 0.001$	$p = 0.099$		$p = 0.002$
Parker	$p < 0.001$	$p = 0.060$	$p = 0.002$	

Results

Summary results are shown in Table 1.

Amplitude

Previous studies, of both cheetahs (e.g. Eklund & Peters, 2013; Eklund, Peters & Duthie; 2010) and domestic cats (e.g. Eklund, Peters & Duthie; 2010; Peters, 1981; Moelk, 1944) have reported both egressive and ingressive phases being louder which suggest a substantial individual variation at play. In the present study, however, ingressive phases were clearly and consistently louder than egressive phases.

Although no absolute amplitude figures can be given here since no sound level meter was used during the recording, a marked relative amplitude difference was observed in that ingressive phases on average were 6–8 dB louder than egressive phases. This difference is clearly seen in Plate 3.

Phase durations

Comparing phase durations produced when Jade was 7 months old and when she was 7 years old the first obvious difference observed is that the duration for both egressive and ingressive phases had increased with a factor of around 2.5. However, phase durations were still not as long as they were in Caine, who was a considerably larger and heavier cheetah.

Cycles per phase

The number of cycles per phase in Jade's purring had increased with around 1.7 since Jade was 7 months old but, as was the case for durations, the number of cycles per phase was still much lower than for Caine number of cycles per phase was still much lower than for Caine.

Fundamental frequency

Comparing 2013 data and 2019 data Jade's fundamental frequency had decreased from 29.6 Hz to 20.1 Hz, the latter being even lower her than Caine's 21.3 Hz. The observed difference between the 2013 and 2019 recordings amount to 6 semitones (i.e. noticeable to a human ear) what is of interest here is perhaps not primarily human perception but rather the physiological changes have taken place in a cheetah growing into adulthood, and that may affect purring production.

Intra-family comparisons

In addition to individual characteristics shown in Tables 2–4, a number of one-way ANOVAs were also performed on the data sets.

For **duration** values ANOVAs were all significant at $p < 0.001$.

As for **cycles per phase** all ANOVAs were also significant $p < 0.001$ with the sole exception of Jade 2013 vs Parker where a Tukey post hoc test returned $p = 0.760$.

ANOVAS for **frequency** were significant at $p < 0.001$ for all pairs except for Tukey post hoc tests for Jade 2019 and Caine ($p = 0.994$), Jade 2019 and Parker ($p = 0.588$) and Caine/Parker ($p = 0.462$).

In short, the ANOVAs mainly confirm the general impression of the pair-wise *t* tests shown in Tables 2–4.

Conclusions

An immediate to be drawn is that almost all comparisons made are highly significant. Given the data set of only three individuals (whereof one at two ages) and three test parameters this is clearly not enough data to allow far-reaching conclusion but given that all the cheetahs are closely related and that so much difference are observed within the same family this strongly suggests that purring is a varied phenomenon, both physiologically and acoustically.

The only non-significant results all show up in the frequency domain, which perhaps is not surprising given the consistently low frequency, even across species (see Eklund, Peters & Duthie, 2010), at which purring occurs.

From the main perspective of the present paper, whether or not Jade's purring had changed between 7 months and 7 years old, the most interesting changes occurred in the frequency domain in that Jade had, in fact, become more like her father, and indeed in 2019 even purred at a lower frequency than her (very big) father. But again, it must be remembered that her brother Parker also purred at a very low frequency when he was a cub, and that even comparatively very small domestic cats, too, exhibit purring at very low frequencies (Schötz & Eklund, 2011). This, of course, means that purring frequency per se it not a reliable indicator of size and/or weight.

Summing up, purring seems to changes with age.

Notes

This paper was originally planned for the 2020 Fonetik meeting, for the tenth anniversary of the domestic can/cheetah purring paper. Covid (and other reasons) made this not happen until now and thus the paper now appears a few years late – although it's still intended as an "anniversary" publication.

A YouTube clip of the Jade 2019 recording is found here: https://www.youtube.com/watch?v=ACxi8vbwYKw&ab_channel=DrJubatus

A YouTube clip of the Caine 2009 recording is found here: https://www.youtube.com/watch?v=ZFvULxbN3NM&ab_channel=DrJubatus

Finally, "ronronner" is French for purring (of course!).

Acknowledgements

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The author would like to thank **myself** for making all old data files available.

A personal thanks is extended to **Jade** (she has sadly passed; the life expectancy of cheetahs is around ten years), who was *not* an approachable cat and the author was even a little wary of entering the enclosure and would not have done it without Estelle Kemp being there, the only person Jade accepted. To everyone's big surprise Jade suddenly stood up from her position on Estelle's lap and went straight for the author and started to rub herself against the author, friendly purring (which can be seen and heard on the YouTube clip). Needless to say, the author regards this is one of the pinnacle and most moving events in his career or even life! *Thanks, Jade!*

References

Eklund, R. & Peters, G. (2013). A comparative acoustic analysis of purring in juvenile, subadult and adult cheetahs. In: Robert Eklund (ed.), *Proceedings of Fonetik 2013, the XXVIth Swedish Phonetics Conference, Studies in Language and Culture, no. 21*, 12–13 June 2013, Linköping University, Linköping, Sweden. ISBN 978-91-7519-582-7, eISBN 978-91-7519-579-7, ISSN 1403-2570, 25–28.

Eklund, R., Peters, G. & Duthie, E. D. (2010). An acoustic analysis of purring in the cheetah (*Acinonyx jubatus*) and in the domestic cat (*Felis catus*). In: *Proceedings of Fonetik 2010*, Lund University, 17–22.

Frazer Sissom, D. E., Rice, D. A. & Peters, G. (1991). How cats purr. *Journal of Zoology* 223:67–78.

Hunter, L. & Hamman, C. (2003). *Cheetah*. Cape Town, South Africa: Struik Publishers.

Moelk, Mildred. 1944. Vocalizing In The House-Cat; A Phonetic And Functional Study. *The American Journal of Psychology*, 57(2):184–205.

O'Brien, S. J. & Johnson, W. E. (2007). The Evolution of Cats. *Scientific American*, July 2007, 68–75.

Peters, G. (2002). Purring and similar vocalizations in mammals. *Mammal Review* 32(4):245–271.

Peters, Gustav. 1981. Das Schnurren der Katzen (Felidae). *Säugetierkundliche Mitteilungen*, 29:30–37.

Schötz, S. & Eklund, R. (2011). A comparative acoustic analysis of purring in four cats. In: *Quarterly Progress and Status Report TMH-QPSR, Volume 51, 2011. Proceedings from Fonetik 2011*, 9–12.

Sunquist, M. & Sunquist, F. (2002). *Wild Cats of the World*. Chicago: University of Chicago Press.