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Simone Sommer, Petra Kretzschmar, Steven Seet, Heribert Hofer

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Leibniz Institute for Zoo and Wildlife Research (IZW)
Alfred-Kowalke-StraBe 17
10315 Berlin
Germany

www.izw-berlin.de

European Association for Zoos and Aquaria (EAZA)
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1000 HD Amsterdam
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www.eaza.net

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The vocal development of the goitred gazelle *(Gazella subgutturosa),* a species with permanently descended larynx

EFREMOVA KSENIYA[1], FREY ROLAND[2], VOLODIN ILYA[1,3], VOLODINA ELENA[3], MAKAROV ILYA[4], SOLDATOVA NATALIA[5]

[1]Department of Biology, Moscow State University, Vorobiovi Gori, 119991, RUSSIA; lavender@nm.ru
[2]Leibniz Institute for Zoo and Wildlife Research, Alfred-Kowalke-Str. 17, 10315 Berlin, GERMANY
[3]Scientific Research Department, Moscow Zoo, B. Gruzinskaya, 1, 123242, RUSSIA
[4]Institute for Information Transmission Problems, B. Karetny 19, Moscow 101447, RUSSIA
[5]Ecocenter "Djeiran", Bukhara, REPUBLIC OF UZBEKISTAN

Descended larynx and sexual dimorphism in vocal anatomy are not unique to humans, occurring also in a few ungulates: red deer *(Cervus elaphus),* fallow deer *(Dama dama),* Mongolian gazelles *(Procapra gutturosa)* and goitred gazelles *(Gazella subgutturosa).* The lowered and enlarged larynges result in the lower and deeper voices of harem holding stags that convey information on the quality of a male to conspecifics. These findings contradict to a hypothesis that descendent larynx is specifically related to human speech and instead support a hypothesis of sexual selection. Comparisons of vocal development of humans and nonhuman animals with similarly enlarged and descendent larynges may give much insight on the evolutionary development of pre-adaptations to speech.

This report provides data of longitudinal acoustic research, undertaken with 10 male and 13 female goitred gazelles from their birth to 6 months of age. Acoustic recordings of nasal calls (occurring daily) and measurements of body mass and neck region (occurring each two weeks) were made in May - August and in October 2008 in Ecocenter "Djeiran". The study animals were captured on a fenced territory of 5126 hectares of the Ecocenter and then human-raised. We also dissected neck and head regions of two male specimen of 3 - 4 weeks old. The fundamental frequency of 94 Hz in males and of 118 Hz in females at the age of 2 weeks was very low relative to juveniles of other ungulates, but very close to those of adult male humans. The vocal fold length (15 mm) and the vocal tract length (149 mm at rest and 189 mm with maximally retracted larynx) were also comparable to those of adult people. Differences between sexes in fundamental frequency were significant already at the age of 2 weeks; the differences in body mass and neck dimensions from the age of 10 weeks; and those in the size of larynx - at the age of 24 weeks. This is distinctive to humans, where sex differences in fundamental frequencies, body weight and dimensions of vocal tract appear only at puberty.

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