Specialized Larynges.

Morphological Studies of the Chinese Muntjac (*Muntiacus reevesi* OGILBY, 1839), the Muskox (*Ovibos moschatus* ZIMMERMANN, 1780), the Takin (*Budorcas taxicolor* HODGSON, 1850), and the Mongolian Gazelle (*Procapra gutturosa* PALLAS, 1777).

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Abstract

The larynges and vocal tracts of four species of Artiodactyla were investigated in combination with acoustical analyses of their respective calls. Different evolutionary specializations of laryngeal characters may lead to similar effects on sound production. Both the elongation of the vocal folds and the increase of the oscillating masses lower the fundamental frequency. The influence of an enlarged volume of the laryngeal vestibulum on sound production remains unclear.

1. Introduction

How is vocalization affected by laryngeal morphology? As the morphology of sound producing structures is a key to the interpretation of acoustical data, one species with less specialized and three species with more specialized larynges were investigated. The comparative anatomical results may be also helpful to specify and adjust assumptions about fixed and variable parameters of biomechanical models of sound production.

2. Material and Methods

Frozen heads and necks of the small cervid *Muntiacus reevesi* and of three bovid species *Ovibos moschatus*, *Budorcas taxicolor*, and *Procapra gutturosa* were macroscopically dissected while the specimen were submerged in water. In addition, heads of *M. reevesi*, of *O. moschatus* and of *P. gutturosa* were scanned by means of computer tomography.

3. Results and Discussion

3.1. The Chinese Muntjac (*Muntiacus reevesi*)

The vocal repertoire of *M. reevesi* comprises miscellaneous types of calls from whimpers to barks with a broad overall frequency range. The larynx of this Asian deer with a body mass below 15 kg may be taken as morphologically unspecialized. It lacks any conspicuous enlargement of the laryngeal cartilages and any further specializations as ventricles or air sacs. Significant differences between the larynges of both sexes of *M. reevesi* were not found. The membraneous vocal folds extend between the thyroid cartilage and the vocal process of the arytenoid cartilage. Thyroid and cricoid cartilages surround the laryngeal cavity.

3.2. The Muskox (*Ovibos moschatus*)

The body mass of the arctic *O. moschatus* is about 350 kg for adult males and one third less for females. The monotonous calls are characterized by their pulsed structure. The pulse rate averages 20 Hz. Both sexes achieve low frequencies of around 120 Hz. The male of *O. moschatus* has a small unpaired ventrorostral ventricle which extends into the extralaryngeal space. This specialization may contribute to producing the male's low-frequency calls, which are important for its mating success within a polygynous mating system.

3.3. The Takin (*Budorcas taxicolor*)

Its natural habitat are mountain forests. *B.* taxicolor has a body mass of about 300 kg. Similar to *O. moschatus*, its vocalization is also pulsed. Lowest prominent frequencies are around 210 Hz. Caudoventrally, the thyroid cartilage of both sexes of *B. taxicolor* forms a voluminous hollow structure. This thyroid bulla is partially filled by extensions of the conspicuously enlarged vocal folds. As a consequence, the frequencies of vocalization decrease because of the mass increase of the vocal folds. This may be understood as an adaptation to communicate with conspecifics in a habitat covered with dense vegetation which attenuates higher frequencies.

The Mongolian Gazelle (*Procapra gutturosa*)

The body mass of *P. gutturosa* is approximately 30 kg in the male and 25 kg in the female. In this species, sexual selection has led to a remarkable dimorphism of the larynx that is greater than expected by the differences of body masses. All cartilages of the male's larynx are enlarged. The thyroid bulges the ventral neck region (Fig. 1). The arytenoid cartilages, together with the epiglottis, form an exceptionally large entrance to the larynx. Paired lateral ventricles are located between the arytenoid cartilage and the thyroarytenoid muscle. The vocal folds of the male *P. gutturosa* are supported by broad fibroelastic pads. Compared to the call of the female with a fundamental frequency of about 600 Hz, the specialized larynx of the male reduces the fundamental frequency by about 100 Hz.

4. Conclusions

In the above mentioned examples, the laryngeal characters vary in the following parameters: 1) the lengths of the vocal folds, 2) the masses of the vocal folds, and, 3) the volume of the laryngeal air spaces, i.e. of the vestibulum and additional laryngeal ventricles. Evolutionary elongation and mass increase of the vocal folds led to a lowering of the fundamental frequency. The low frequency calls of the investigated species evolved as a consequence of sexual or natural selection. Although laryngeal ventricles were evolved independently in several taxonomic groups, their function is still unclear.

5. References

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Figure 1: *Computer tomographic image of the head of a male* Procapra gutturosa*, virtual mediosagittal section.*

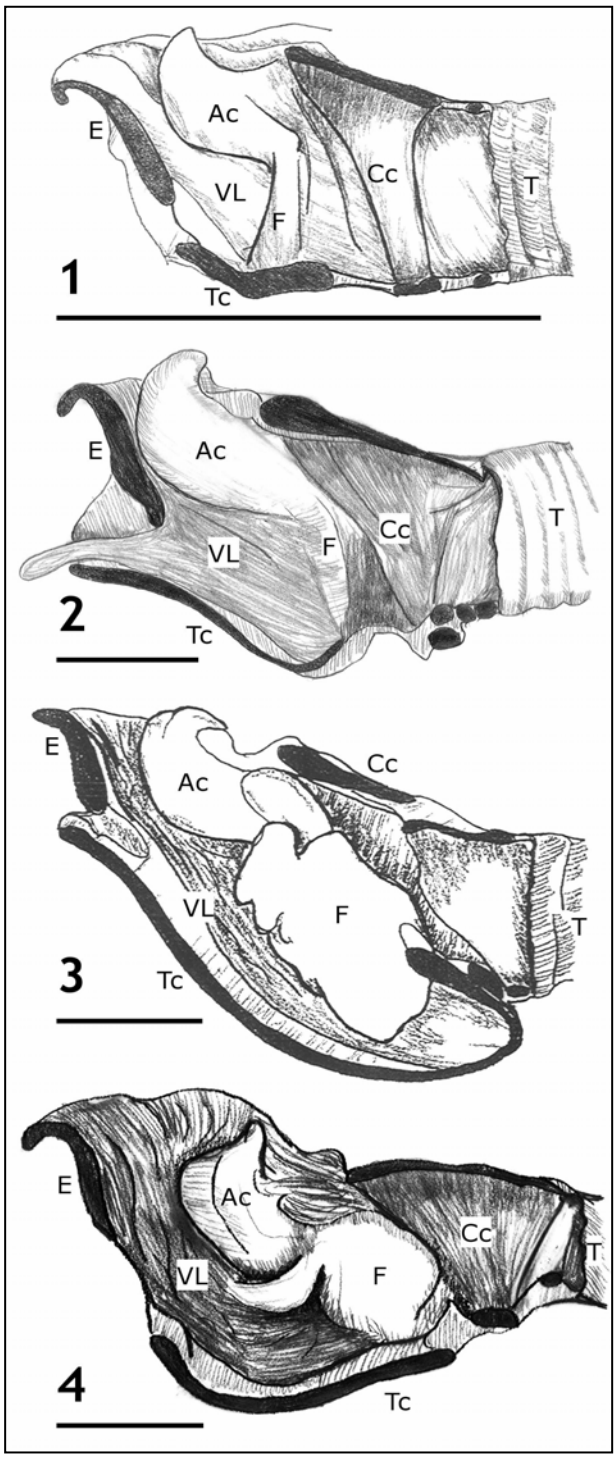

Figure 2: *Mediosagittal sections of larynges: 1)* Muntiacus reevesi*, 2)* Ovibos moschatus*, 3)* Budorcas taxicolor*, 4)* Procapra gutturosa*. Ac arytenoid cartilage, Cc cricoid cartilage, E epiglottis, F right vocal fold, T trachea, Tc thyroid cartilage, VL laryngeal vestibulum. Bold lines below numbers are equivalent to 5 cm.*