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## Comparison of vocal anatomy and call structure in Asiatic wild dog and red fox for revealing potential sources of canid biphonation

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Biphonation, i.e. two independent fundamental frequencies ( $f_0$  and  $g_0$ ) in a call spectrum, is characteristic of all dog-like canids, but is lacking in all fox-like canids. Morphological, physiological and ecological prerequisites of this discrepancy between canid subtaxa were unknown so far. In dog-like canids, including Asiatic wild dogs or dhole (*Cuon alpinus*) and domestic dogs (*Canis lupus*, f. *familiaris*), the biphonic calls comprise two frequency components - the high-frequency squeak and the low-frequency yap, whereas fox-like canids, including red fox (*Vulpes vulpes*) produce only a low-frequency component – the whine. We studied vocalisation of 15 Asiatic wild dogs, of 9 domestic dogs of different breeds and of 75 individual red foxes. All studied dholes and eight of the nine domestic dogs produced both high-frequency and biphonic calls, whereas all red foxes neither produced high-frequency nor biphonic calls. We investigated the potential morphological basis for these acoustic differences in four Asiatic wild dog and two red fox specimens. Surprisingly, no basic differences of the vocal apparatus were found between these two species. Vocal membranes as a potential source of high frequencies were lacking in all specimens. Short ventricular folds, about half the length of the vocal folds and, thus, suitable as an alternative high frequency source, occurred in all specimens. Narrowings in the flexible nostril portion of the nasal vocal tract, which might produce high frequencies by a whistle-like mechanism, were found in both dholes and red foxes. Apparently, foxes have all anatomical prerequisites for biphonation, but, for some reason, do not use them. Potential physiological restriction of high-frequency vocalisation in red foxes may result from the shift of their auditory capacity towards lower frequencies, to locate the low-frequency rustling sounds of their prey. Literature data confirm the limited capacity of high frequency hearing in red foxes compared to dogs. In domestic dogs, the peak hearing sensitivity is 8 kHz and coincides with the upper (squeak) component of their biphonic calls, whereas the peak hearing sensitivity of red foxes is 2 kHz and, thus, in the range of their low frequency whine. Furthermore, there is a relation between producing biphonation and sociality. All dog-like canids using biphonation live in packs whereas foxes do not. In pack-living canids, biphonation may facilitate individual recognition and the coordinated movement of pack members during hunting. This is irrelevant for the mostly solitary red foxes. Financial support: The Russian Scientific Foundation, grant No 14-14-00237.