On the specific status of holarctic long-tailed squirrels; a bioacoustical study

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Summary. An analysis of alarm calls of long-tailed squirrels demonstrates that the calls of the conspecific *Citellus parryi* populations of Alaska and North Siberia differ more from one another than those of *C. parryi* of Alaska and *C. undulatus* of Central Asia and South Siberia. The hypothesis is suggested that a pleistocene relic population of *C. undulatus* exists in North-West Alaska.

The temporary land connection existing in what is now the Bering Sea was often an exchange location for elements of Eurasian and North America fauna. Two squirrel species present in North and Central Asia are, in a classificatory sense, closer to American squirrels than their other Eurasian relatives. In the literature they are usually termed 'long-tailed squirrels', in contrast to the group of 'short-tailed squirrels' also to be found in Eurasia, and consist of the Asiatic long-tailed ground-squirrel *(Citellus undulatus)* and the Arctic ground-squirrel *(C. parryi)* which is indigenous to both Asia and North America[1]. The distribution of both species is illustrated in figure 1. The conspecificity of both populations of *C. parryi* has been confirmed in a number of studies[2,3].

In a recent publication[4] it was shown that the alarm call in response to ground predators (and to man) is pronouncedly species-specific for all Eurasian species. Furthermore, these are notable differences between the calls of long-tailed and short-tailed squirrels and likewise between *C. parryi* and *C. undulatus.* The alarm calls of long-tailed squirrels consist of short series of broad frequency noisy calls. In contrast to that of *C. undulatus,* the first call of a *C. parryi* series contains a harmonic component (fig. 2, A and B). These differences were confirmed in more than 100 individuals of each species spread over the entire distribution region.

In a paper by Melchior[5] published in 1971, alarm calls of the long-tailed squirrels of Alaska are described[6]. This paper is of interest for 2 reasons; first the squirrels exhibit different responses to ground and aerial predators (in the case of ground predators, a series of broad frequency calls are produced (fig. 2, C) whereas the response to aerial predators (birds of prey) consists of single whistles with harmonic frequencies (fig. 3, A)); second, in the first call of ground predator responses, the harmonic components characteristic of *C. parryi* are reported to be absent, i.e. the call is much more similar to that of *C. undulatus.*

In fact, the similarity of the acoustic signals of the population described by Melchior to those of *C. undulatus* is even more pronounced than Melchior's study alone might suggest. In the Khangai region of Mongolia the present authors were able to tape-record alarm calls of *C. undulatus* responding to an aerial predator *(Buteo hemilasius).* The sonagraphic representation exhibits a marked similarity to the calls described by Melchior (fig. 3, B). In both cases, not only do the calls consist of high-frequency whistles with harmonic structure, their frequency modulation is also identical.

This comparison of alarm calls leads one to the conclusion that the Nort-West American squirrels are closer, systematically speaking, to those of Central Asia than to their immediate neighbours on the other side of the Bering Strait, which contradicts generally held views. On the other

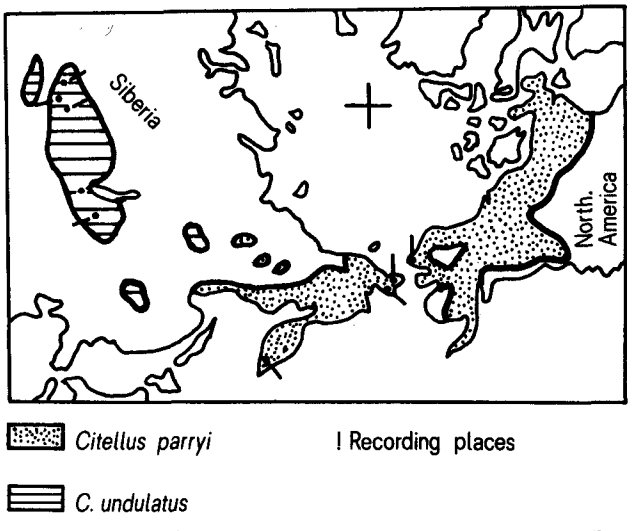

Figure 1. Distributions of the holarctic long-tailed squirrels *Citellus parryi* and *Citellus undulatus* in North America, Siberia and Central Asia (according to Robinson and Hoffmann[2]).

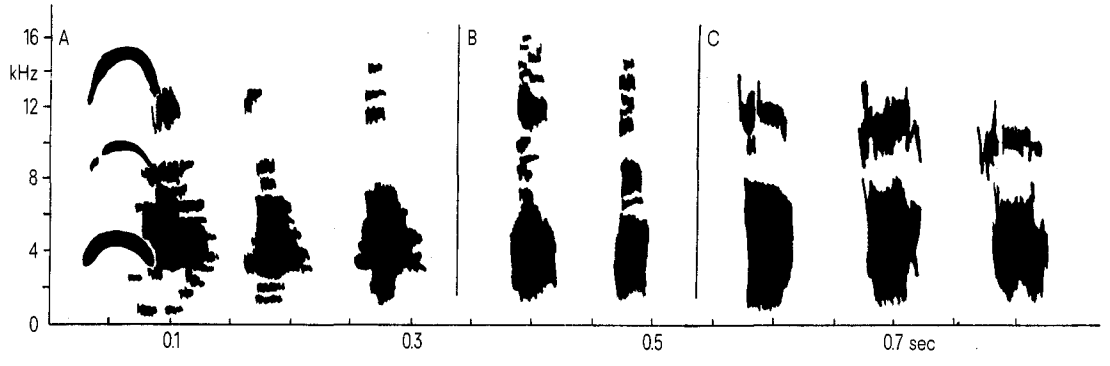

Figure 2. Broad frequency ground predator alarm calls (narrow band sonagrams were analyzed on a Kay Sonagraph 6061-B) *A Citellus parryi,* Chukotka Peninsula; *B Citellus undulatus,* Central Asia (vicinity of Ulan-Ude); *C Citellus 'parryi',* North-west of Alaska (according to Melchior[5]).

hand this notion is perhaps not so unexpected if one takes into account the fact that Melchior carried out his investigations at the Kukpuk River in the extreme north-west of Alaska. This region is separated from the rest of the *C. parryi* region by the Yukon, and since Alaska was mostly free of ice during the glacial period[7] it cannot be ruled out that in the region north of the Yukon there is a pleistocene relic population of *C. undulatus*.

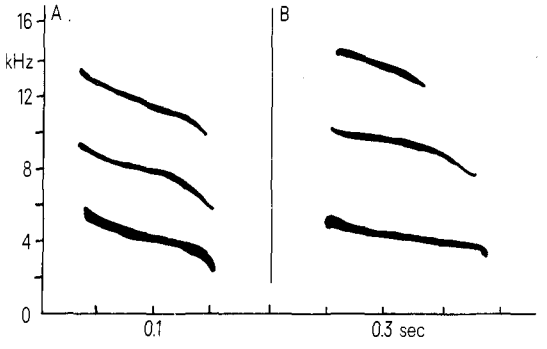

Figure 3. Whistling aerial predator alarm calls (narrow band sonagrams). *A Citellus 'parryi'*, North-west of Alaska (according to Melchior[5]); *B Citellus undulatus*, Mongolia (Khangai).

It is known that both species considered here spread into Asia from America during the pleistocene age, and that *C. undulatus* was the first to migrate, this species' location in East Siberia being in turn occupied by *C. parryi* in the late pleistocene[3]. It is therefore quite possible that *C. undulatus* survived not only in South Siberia and Central Asia but also in its native North America. The calls described here support this hypothesis; however, a final judgment must await results from further investigations. Research on the calls of squirrels living in the region south of the Yukon would be of great interest and could well decide the issue.

1 In the American literature the genus is often termed Spermophilus.
2 J.W. Robinson and R.S. Hoffmann, Syst. Zool. *24*, 79 (1975).
3 E.A. Liapunova and N.N. Vorontsov, Experientia *26*, 1033 (1970).
4 A.A. Nikolski, Zool. Zhurnal *58*, 1183 (1979).
5 H.R. Melchior, Oecologia *7*, 184 (1971).
6 Melchior uses the outdated terminology *'Citellus undulatus'* for *C. parryi* as may be inferred from the English name used for the species.
7 P. Woldstedt, Das Eiszeitalter, vol. 3. Enke, Stuttgart 1965.

Mating behavior and cytogenetical aspects of sex-inversion in the fish *Coris julis* L. (Labridae, Teleostii)

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Summary. It was observed that in the fish *Coris julis* L., in its natural environment, both primary and secondary males take part in reproduction. Chromosome studies showed 23 homologous chromosome pairs, which are identical in males and females, and a variable 24th pair. The heteromorphism of this pair is identical in secondary males and in the majority of females; these are presumably the females that can undergo sex inversion. Primary males show a different heteromorphism of the same pair.

In the order Perciformes sex inversion (from female to male) is a common phenomenon. In the species *Coris julis* L. (Labridae, Teleostii) 2 morphologically different types occur which were originally considered to be different species:

1. *Coris giofredi* Risso (with a greenish brown back and a pale yellow belly, displaying regional differences) representing the females and primary males. Of the giofredi type about 70% of the animals were found to be females and 30% primary males.
2. *Coris julis* L. (characterized by the lateral occurrence of an orange zigzag band and a blue spot), representing the secondary males.

During September and October some females turn into secondary males. This change is not only reflected in their outer appearance, but also in the morphological characteristics of the gonads as well as in the animals' behavior[2]. Environmental factors, i.e. physical and social interactions between individuals, as well as genetical factors are regarded as influencing this sex reversal[2-12]. This paper presents behavioral and cytogenetical aspects of the sex change in *Coris julis*.

Material and methods. In field observations on the coast of Elba (summer 1979 and 1980) and at Banyuls-sur-Mer (March 1980), we investigated the territorial and mating behavior of *Coris julis*. For complementary chromosomal, histological and electron-microscopical studies 70 live animals were transported to Basel in thick plastic bags filled with just enough water to cover the fish, topped up with pure oxygen before sealing.

In order to study the chromosomal aspects of sex change, fibroblastic cells were cultured according to a method described by Ahne[13]. The sex of the animals (primary males and females) was determined by studying the gonads. From cell cultures of 12 females, 5 secondary males and 3 primary males, karyotypes were made. Difficulties were

Number of animals studied with different last chromosome pair

Sex of animals	Morphological characteristics		
	2 large acrocentric chromosomes	1 large and 1 small acrocentric chromosome	1 large acrocentric and 1 metacentric chromosome
Females I	2	–	–
Females II	–	10	–
Secondary males	–	5	–
Primary males	–	–	3