WHAT AFFECTS ALARM CALL STRUCTURE IN SPECKLED GROUND SQUIRRELS: MULTIFACTOR ANALYSIS

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INTRODUCTION

Processes, responsible for vocal variation in mammals are poorly understood so far. This 10-years study focuses on factors affecting evolution of alarm communication in speckled ground squirrels *Spermophilus suslicus*. We investigated effects on the alarm call structure of
1) caller identity,
2) sex,
3) age,
4) time-span between recordings,
5) population membership and
6) genetics.

ANIMALS AND METHODS

We recorded alarm calls on summer 2005-2014 in six natural colonies of the ground squirrels. Individually marked animals called toward a human from wire-mesh live-traps. Spectrographic analysis of calls was made with Avisoft SASLab Pro 4.3.

In total, we examined
171 individuals,
**10 calls per animal,**
8 acoustic variables.
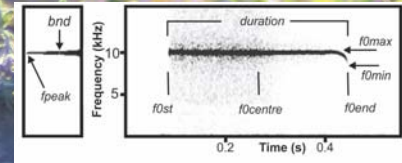
f0max - the maximum fundamental frequency; *f0min* - the minimum fundamental frequency; *f0st* - the fundamental frequency at the beginning; *f0centre* - the fundamental frequency in the middle; *f0end* - the fundamental frequency at the end; *fpeak* - the maximum amplitude frequency; *bnd* - the bandwidth of maximum amplitude frequency.

1. Caller identity and 2. Sex (*N=96 ind*)

We examined 96 individuals to determine whether their alarm calls encode information about callers identity, sex and age. Caller identity had strong effects on all acoustic variables.
No sex effect on call variables was found.
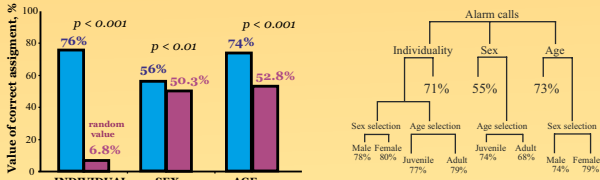
Matrosova V.A., Blumstein D.T., Volodin I.A., Volodina E.V. The potential to encode sex, age, and individual identity in the alarm calls of three species of Marmotinae // *Naturwissenschaften*, **2011**, v. 98, p. 181–192.
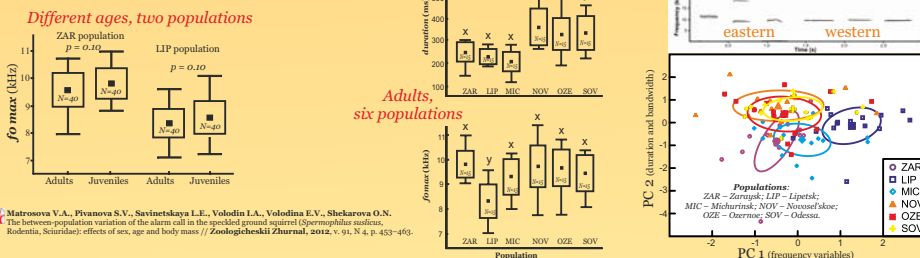
3. Age (*N=68 ind, 47 ad vs 21 juv*)

Age-class differences in the maximum and dominant fundamental frequencies of alarm calls lacked despite prominent age differences in body weight (222±50g *vs* 88±34g).
Age effects were significant only on call duration and bandwidth. Duration increased with age.

The same frequency in both

Matrosova V.A., Volodin I.A., Volodina E.V., Babitsky A.F. Pups crying bass: vocal adaptation for avoidance of age-dependent predation risk in ground squirrels? // *Behav. Ecol. Sociobiol.*, **2007**, v. 62, N 2, p. 181-191.
Volodina E.V., Matrosova V.A., Volodin I.A. An unusual effect of maturation on the alarm call fundamental frequency in two species of ground squirrels // *Bioacoustics*, **2010**, v. 20, N 1, p. 87–98.

4. Time-span between recordings (*N=20 ind*)

Twenty individuals were recorded 4 times with time-spans of 1 day, 2 weeks, and 1 year. Calls from individual callers were highly similar within recordings, but vocal individuality decreased with increase of time span between recordings. Nevertheless, calls remained individualistic, allowing distinguishing individual callers higher than was expected by chance. One third of callers kept stable alarm calls.
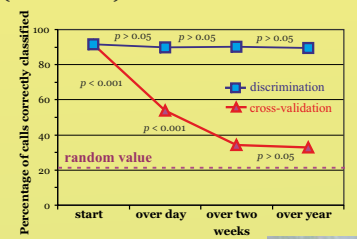
Matrosova V.A., Volodin I.A., Volodina E.V. The short-term and long-term individuality in speckled ground squirrel alarm calls // *Journal of Mammalogy*, **2009**, v. 90, N 1, p. 158-166.

5. Population membership (*N=160 ind, 80 per popul and N=90, 15 per popul*)

Effect of population membership was found on all frequency variables, but not call duration or bandwidth. Calls were significantly shorter in any populations located to the east of the Dnieper River compared to any populations located to the west th the Dnieper River (*p<0.01* for all comparisons, Tukey HSD test). Neither within eastern nor within western populations, alarms didn't differ by duration. The between population differences were similar by all frequency variables for the exception of LIP population, where it was substantualy lower compared to any other population (*p<0.01* for all comparisons, Tukey HSD test).

Different ages, two populations

Adults, six populations

Populations:
ZAR – Zaraysk; LIP – Lipetsk;
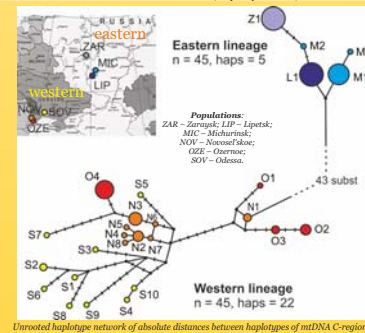*MIC – Michurinsk; NOV – Novosel'skoe;*
OZE – Ozernoe; SOV – Odessa.

Matrosova V.A., Pivanova S.V., Savinetskaya L.E., Volodin I.A., Volodina E.V., Shekarova O.N. The between-population variation of the alarm call in the speckled ground squirrel (*Spermophilus suslicus*, Rodentia, Sciuridae): effects of sex, age and body mass // *Zoologicheskii Zhurnal*, **2012**, v. 91, N 4, p. 453–463.

6. Genetics (*N=90 ind, 6 popul, 15 per popul*)

We compared the stucture of alarm calls and full-size mtDNA control region (998-1002 b.p.) polymorphism for 90 individuals from 6 populations. A comparison of acoustic, genetic and geographical distances among populations with Mantel test revealed a highly significant positive correlation between the genetic and geographical distances (r=0.97, *p=0.023±0.002*) and between the acoustic and geographical distances (r=0.74, *p=0.043±0.003*). A positive correlation between the acoustic and genetic distances didn't reach significance (r=0.66, *p=0.089±0.004*). These results support a hypothesis of effects of ecological selection on the call variables rather than the genetic drift hypothesis.
In addition, our data support the current taxonomic separation between subspecies of speckled ground squirrels, differing in diploid chromosome sets: 2n = 34 (*S. s. guttatus*) and 2n = 36 (*S. s. odessanus*).

Populations:
ZAR – Zaraysk; LIP – Lipetsk;
NOV – Novosel'skoe;
OZE – Ozernoe;
SOV – Odessa.

Eastern lineage
n = 45, haps = 5

Western lineage
n = 45, haps = 22

Unrooted haplotype network of absolute distances between haplotypes of mtDNA C-region. Each circle represents a unique haplotype, its size proportional to the haplotype frequency.

Matrosova V.A., Savinetskaya L.E., Shekarova O.N., Pivanova S.V., Rusin M.Yu., Volodin I.A., Volodina E.V., Tchabovsky A.V. Within- and between-population polymorphism of the mtDNA control region of the speckled ground squirrel (*Spermophilus suslicus*) // *Doklady Biological Sciences*, **2014**, v. 455, p. 143-148.

CONCLUSIONS: WHAT FACTORS AFFECT ALARM CALL STRUCTURE?

STRENGTH OT FACTORS

Caller identity: strong effects on all alarm call variables.
Time-span between recordings: affects especially frequency variables.
Population membership: affects all frequency variables.
Age: affects only duration and bandwidth.
Genetics: primarily affects duration.
Sex: no effects were found.