Orginal scietific paper **UDC: 599.322.2**

CYCLES OF ABUNDANCE DYNAMICS OF SQUIRREL (*SCIURUS VULGARIS*, L.) IN TRANSBAIKALIA, RUSSIA

Agafonov G. M. [1], *Yerdakov L. N.*[2]

Summary: The population′ rhythms as a basis of adaptable opportunities for living on specific area were studied. Permanently active physical factors (geomagnetic field, solar emission, geological rhythms of the Earth) have exact periodicity. Biotic influence is also exposed to specific rhythmicity (fructification of forage plants, predation pressure). By only having its own (endogenic) rhythm, a population can synchronize it with the relevant external rhythm. Thereupon we consider the population' rhythms as a basis for its environment adaptation. By studying this curve, it will be possible to identify the definite periodic components (population rhythms) that it contains.
The analysis is based on data on preparation of fells of squirrels in Transbaikal krai (Russia) over period from 1932 to 2003. The dynamics of *Pinus sibirica* seeds yield (one of the principal food types for squirrels) were identified by the markings of strobilus on fruiting boughs (3,164 specimens) of crowns (164 specimens). The time-series analysis was implemented for the detection of hidden periodical components. The strongest population rhythm in abundance dynamics of squirrels, approximately 9 years, could synchronize with the 8-11 year cycle atmospheric circulation known for the whole territory of Russia. The population waves on a periodic basis of 2-3 years in population are always stable, because there are weather cycles with similar periods in any habitat.
We studied the possibilities of squirrel abundance dynamics to "coordinate" its waves with the variation of yield of one of the principal food types for squirrel — *Pinus sibirica* seeds. The strongest population rhythm of squirrel (8.8 years) appears to be similar by value to basic, by strength, yield rhythms of local cedar forests (10.4 and 7.5 years rhythms). It could be prolonged by any of them. Even one of the low-frequency rhythms of squirrel (23.7 years) could synchronize well by 27.5 years yield rhythm.
It could be suggested that in the process of evolution of a population the abundance dynamics in the population develops a complex of cycles that insures population's development and survival. Among such cycles there are the low-frequency which ensure an adaptation to the secular variation, and many high-frequency cycles which ensure an adaptation to rapid fluctuations of the environment. Detection of low-frequency population cycles could become a basis for abundance forecast, and the occurrence of high-frequency could be useful for explaining a population's rapid reaction to the changing existence conditions by intrapopulation restructuring.

Key words: population, rhythms, spectral analysis, forecast.

Introduction

The main efforts of the researches in the studying of population abundance dynamics are directed to revealing its intrapopulation mechanisms (birth rate and mortality waves, genetic processes) and external influencing factors (dependence on nutritive base, predators and competitors). At the same time, less attention is given to the general process of the evolution of a population in a permanently balancing external environment in the widest sense. Why, for instance, on one territory the population cycle is 4 years, but 9 years on another?

We took the challenge to examine population rhythms per se and to try to present the cyclic characteristics of a population as the basis of its adaptive capabilities for living on in a specific area.

1 Gennady M. Agafonov, researcher, Institute of Natural Resources, Ecology and Kryology, Siberian Branch, Russian Academy of Science, Chita, Russia;
2 Lev N. Yerdakov, researcher, Novosibirsk State Theachers Training Institute, Novosibirsk, Russia;
Corresponding author: Gennady M. Agafonov, researcher, Institute of Natural Resources, Ecology and Kryology, SB, RAS, 672000 Chita, p/b 147

Permanently active physical factors (geomagnetic field, solar emission, geological rhythms of the Earth) have exact periodicity. Biotic influence is also exposed to specific rhythmicity (fructification of forage plants, predation pressure). In such a poly periodical environment a population must have its own rhythms; for instance, rhythms of abundance dynamics capable of fitting into characteristics dynamics in the external environment that are important for such a population. Only having its own (endogenic) rhythm, a population can synchronize it with the relevant external rhythm. Thereupon, the population rhythms is considered as a basis for its adaptation to the environment. The long-term dynamics abundance curve typically has a shaped form since such curve expresses several populations' rhythms. By studying this curve, it woul be possible to identify the definite hidden periodic components (population rhythms) it contains.

Material and Methods

The analysis is based on data on preparation of fells of squirrels in Krasnochikoysky District (Transbaikal krai, Russia) over the period from 1932 to 2003. The dynamics of *Pinus sibirica* seeds yield (one of the principal food types for squirrels) were identified by the markings of strobilus on fruiting boughs (3,164 specimens) of crowns (164 specimens); for the extension of records of the data of I.D. Kiris used (Kiris, 1969). It is not possible to identify the periodic components specific for this case study by using common chronogram. Also, it is not possible to identify the correlations of these components and their strength and continuity. Thereupon the time-series analysis was implemented for the detection of hidden periodical components (Sollberger,1968; Binkley,1973; Yerdakov,2011; Jenkins, Watts, 1971). Spectral analysis software owned by the Institute for taxonomy and zooecology of SB RAS (Novosibirsk) was used for the calculations.

Results and discussion

The strongest population rhythm in abundance dynamics of squirrels, approximately 9 years (Table 1), could synchronize with the 8-11 year cycle atmospheric circulation known for the whole territory of Russia (Drozdov, Grigoryeva, 1963).

Table 1. Magnitude and strength relation of periodical components of long-term dynamics abundance of squirrel and cedar forests yield

Period, year / Type	100-120	20-50	8-12	7-9	5-6	3.1-4	3-2.5	2-3
Squirrel	85.0 2.3	23.7 9.2	8.8 9.7		6.6 5.6	3.2 0.4		2.7 1.5
						3.8 4.8		2.1 0.7
Pinus sibirica	113.3 0.23	27.5 0.77	10.4 2.98	7.5 1.23	5.2 1.63	3.4 1.44	2.5 0.40	2.2 1.03
					4.4 0.26		3.0 1.09	

Note: figure above — period, year, figure below — strength (spectral density unit)

Furthermore, it could also be maintained by the intrasecular variability of climate with the periodicity of 7-11 years. This variability is connected to a 20-30 years Brikner cycle (Druzhinin, 1987; Krivenko, 1991). We have found such a cycle (Table 1), that has quite significant strength. It should be noted that the strongest rhythm of squirrel abundance could maintain its sustainability also by the geological rhythm of the Earth. There is a 7-12 years rhythm among such geological rhythms (Yakushev, 2002). This is why the most expressed population cycle through the environmental rhythms becomes the most stable cycle through the environmental rhythms.

The strong, approximately 7 year, population cycle could preserve its sustainability prolonging (by interaction with the nearest external rhythms) through the winter severity cyclicity. Such variability is characterized by several cycles; there is a 5-7 years cycle among them (Byalko, Gamburgcev, 2000).

The population waves on a periodic basis of 2-3 years in a population are always stable, because there are weather cycles with similar periods in any habitat. These are repeatedly described rhythms of atmosphere circulation that ensure meteorological conditions. Such nature cycles are also known in the whole territory of Russia (Drozdov, Grigoryeva, 1963; Druzhinin, 1987; Korotina, 2002).

We were also interested in the posiibility of squirrel abundance dynamics to "coordinate" its waves with the variation of the yield of one of the principal food types for squirrels — *Pinus sibirica* seeds. These waves could coincide when their rhythms have the nearest values. The comparison of the charachteristics of the harmonical components (Table 1) proves the existence of such possibilities for the squirrel population. Principally the majority of high-frequency harmonical components of the population are periodically close to the relevant yield rhythms. This alone provides the possibility for rapid "adjustment" to variation in the nutritive base.

Furthermore, the strongest population rhythm of squirrel (8.8 years) appears to be similar by value to the basicyield rhythms of local cedar forests by strength (10.4 and 7.5 years rhythms). It could be prolonged by any of them. Even one of the low-frequency rhythms of squirrel (23.7 years) could synchronize well by 27.5 years yield rhythm.

Conclusion

It could be suggested that in the process of evolution of a population the abundance dynamics in a population develops a complex of cycles that insures the population's development and survival. Among such cycles there are the low-frequency cycles which ensure the adaptation to the secular variation, and many high-frequency cycles which ensure the adaptation to the rapid fluctuations of the environment. Detection of low-frequency population cycles could become a basis for abundance forecast, and the occurrence of high-frequency cycles could be useful for explaining a population's rapid reaction to the changing existence conditions by intrapopulation restructuring.

Acknowledgement

The study was performed with the support of the integration project of SB RAS No. 146.

References

1. Kiris I.D.: Kormovye resursy belok, v Voprosy ekologii promyslovyh zhivotnyh (vypusk XXII). 1969, pod red. I.D.
2. Kirisa, M. izd-vo Lesnaya promyshlennost, s. 75-201 (Kiris I.D.: Squirrel nutritive resources, in Problems of Ecology of Game Animals (issue XXII): 1969 Eds. Kiris I.D., Moscow, Publishing house Lesnaya Promyshlennost, p. 75-201)
3. Sollberger A., Stuttgart, 1968, Natur. Wiss. Rund., 7: p. 277-289
4. Binkley S., 1973, J. Comp. Physiol., 85, N 2: p. 141-146
5. Yerdakov Lev: Biologicheskiye rytmy:osob, populatsiya, soobshestvo. Ciklichnost v zhivych systemah. 2011, Lap Lambert Academic Pub. GmbH &Co.KG. 152 s. (Yerdakov Lev: Biological rhythms: biont, population, association. Cyclisity in living systems. 2011, Lap Lambert Academic Pub. GmbH &Co.KG. 152 p)

6. Jenkins G., Watts D.: Spektralniy analiz i ego prilozheniya. 1971, Mir, Moskow , 317 s. (Wilym G., Jenkins M.: Spectral Analysis and its Applications. 1969, University of Lancaster, U.K. and Donald G. Watts University of Wisconsin, U.S.A. Holden-Day San Francisco, Cambridge, London, Amsterdam.)

7. Drozdov O.V., Grigoryeva A.S.: Vlagooborot v atmosphere. 1963, Gidrometeoizdat, Leningrad, 316 s (Drozdov O.V., Grigoryeva A.S.: Hydrological cycle in the atmosphere. 1963, Gidrometeoizdat, Leningrad, p. 316)

8. Druzhinin I.P.: Dolgosrochnyi prognoz i informaciya. 1987, Nauka, Sibirskoye otdeleniye, Novosibirsk, 246 s (Druzhinin I.P.: Long-time forecast and information. 1987, Nauka, Siberian Branch, Novosibirsk p. 246)

9. Krivenko V.G.: Vodoplavayushiye pticy i ih zashita. 1991, Argopromizdat, M, 271 s (Krivenko V.G. Swimming birds and its protection. 1991, Argopromizdat, Moscow, p. 271)

10. Yakushev D.I.: Algorytmy matematicheskogo modelirovaniya. 2002, MGP Polikom, SPb, 100 s. (Yakushev D.I.: Algorythms of mathematical modelling. 2002, MGP Polikom, St. Petersburg p.100)

11. Byalko A.V., Gamburgcev A.G.: Stastistika pogody. 2000, Priroda 12: 24-32 (Byalko A.V., Gamburgcev A.G.: Weather statistics. 2000, Priroda 12: 24-32)

12. Korotina E.F.: Mnogoletniye kolebaniya temperaturnogo rezhima Uzhnogo Urala, avtoreferat kand. diss. 2002 Chelyabinsk. (Korotina E.F.: Long-term fluctuations of temperature conditions of South Urals, Thesis, 2002, Chelyabinsk, p. 26)