11th Conference on Dynamical Systems Applied
to Biology and Natural Sciences DSABNS 2020
Trento, Italy, February 4-7, 2020

INFLUENCE OF HARVEST ON DYNAMICS OF "PREDATOR-PREY" COMMUNITY

Neverova G.P.*[1,2] and
Frisman E.Ya.[2]

[1]Institute for Automation and Control
Processes of the Russian Academy of Sciences,
Far Eastern branch 5, Radio st., Vladivostok, 690041, Russia

[2]Institute for complex analysis of regional
problems of the Russian Academy of Sciences,
Far Eastern branch 4 Sholom-Aleikhem St. Birobidzhan 679016 Russia

galina.nev@gmail.com (*corresponding author),
frisman@mail.ru

We propose a time-discrete model of "predator prey" community to describe dynamics of a community like arctic fox mouse rodents. [1] The community is under anthropogenic impact, which is realized as a harvest of some part of predator or prey population. The model takes into account seasonality of the life cycles of predator and prey populations. In addition, each of the species under consideration has an age structure represented by two stages of development. Prey population growth is limited by density-dependent regulation of birth rate. Limiting the survival of juveniles is observed in predator population. Harvesting is assumed to be discretely timed with intervals equal to the reproduction period, with a yield proportional to population size.

The bifurcations, dynamic modes and a possibility of its shifting are studied for the model proposed. It has been shown the stability loss of a non-trivial fixed point is realized according to both the Neimark-Saker scenario and the Feigenbaum one.

The study of anthropogenic impact influence on community dynamics shows harvest of some share of the prey's population from the community leads to an expansion of stability area of non-trivial stationary state. Consequently, harvest of prey population results in sustainable coexistence of community species (Figure). The harvest of part of prey population has little effect on the dynamics of the predator population. The changes are mainly associated with areas of multistability, in which the community dynamics depends on the initial population sizes. With high values of reproductive potentials of both populations, the community dynamics can adapt to the dynamics of both prey and predator, depending on their initial population sizes. Increasing harvest rate leads to multistability domain contraction, and as a result, expansion of parametric space area, in which fluctuations of prey population size are initiated by the predator (Figure).

In the case of the predator population harvest, stability domain of the nontrivial fixed point expands along the parameter characterizing the birth rate of predator (Figure). Accordingly, a situation, where a predator determines the prey population dynamics, is possible only at high values of predator reproductive

 ISBN: 978-989-98750-7-4

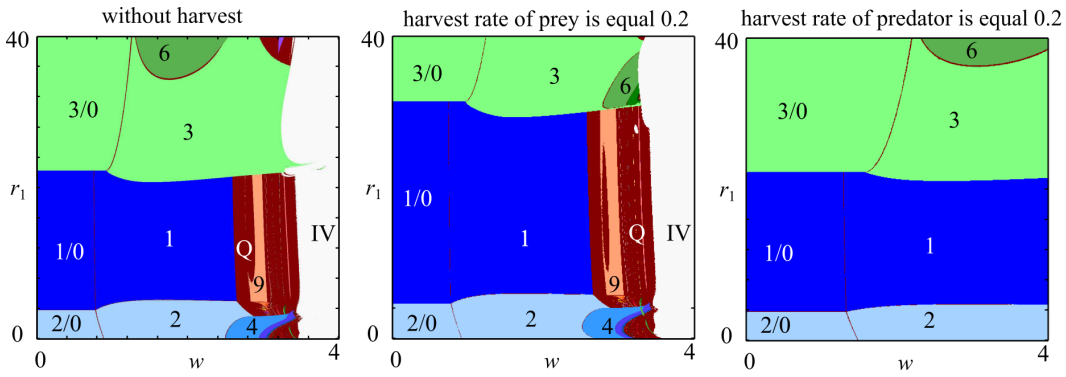

Figure 1: Dynamic mode maps of predator-prey model with harvest. The figures correspond to the period of observed cycle. Q is a quasi-periodic dynamics, C is chaotic dynamics. 1/0, 2/0, 3/0 are stable semi-trivial solutions: 1, 2, 3 are periods of cycles observed in prey population, 0 corresponds to extinction of predator population. IV is infeasible parameter value area where the model loses its meaning. r_1 and w are birth rates of prey and predator populations, respectively.

potential. With an increase in harvest rate an expansion of parametric areas is observed, where variation in the current population sizes leads to a change in the species determining the dynamics of the community. In particular, when the values of demographic parameters and interaction coefficients are fixed, for some current population sizes of community the predator suits to the periodic dynamics of the prey, while for others the predator initiates quasiperiodic fluctuations in the prey population.

Acknowledgements
This work was performed in the framework of the State targets of the Insititute for Automation and Control Processes FEB RAS and the Institute of Complex Analysis of Regional Problem FEB RAS and partially supported jointly by the Russian Foundation for Basic Research (no. 18-51-45004 IND_a).

References

[1] Neverova G. P., Zhdanova O.L., Bapan Ghosh, Frisman E.Ya. (2019). *Dynamics of a discrete-time stage-structured predatorprey system with Holling type II response function*. Nonlinear dynamics, 98 (1), 427446. https://doi.org/10.1007/s11071-019-05202-3

 ISBN: 978-989-98750-7-4