Environmental features of population dynamics of hazard nongregarious locusts in northern Kazakhstan

Kurmet Serikovich Baybussenov[1], Amageldy Taskalievich Sarbaev[2], Valery Kenessovich Azhbenov[3], Vili Borisova Harizanova[4]

[1]Kazah National Agrarian University, Abaya avenue, 8, Almaty, 050010, Kazakhstan
[2]Kazah Scientific-Research Institute of Cultivation and Crop Production, Erlepesova str.,1, Almalybak village, 040909, Karasay district, Almaty region, Kazakhstan
[3]Kazakh Agro Technical University named after S.Seifullin, Pobeda avenue, 62, Astana, 010000, Kazakhstan
[4]Agricultural University – Plovdiv, Mendeleev blvd., 12, Plovdiv, 4000, Bulgaria

Abstract. Analysis results of long-standing population dynamics of nongregarious locusts in northern regions of Kazakhstan are presented in the article. Some regularity was revealed. Thus, the expected cyclicity of certain phases of the phytophagous organisms population dynamics is not always maintained. They are subject to change under the influence of environmental factors. They often vary depending on the weather conditions of the previous and the current year, as well as the completeness of the volume of chemical treatments. The data obtained can be offered by us as a criteria of forecasting trends of the the next phase of nongregarious locusts population dynamics in northern Kazakhstan.

[Baybussenov K.S., Sarbaev A.T., Azhbenov V.K., Harizanova V.B. **Environmental features of population dynamics of hazard nongregarious locusts in northern Kazakhstan.** *Life Sci J* 2014;11(10s):277-281] (ISSN:1097-8135). http://www.lifesciencesite.com. 49

Keywords: nongregarious locusts, colonization, spread, population dynamics, protective measures

Introduction

North Kazakhstan in terms of prevalence of nongregarious locusts belongs to the region with a high degree of colonization [1]. They damage crops, grain legumes, forage crops and pastures. Fauna of harmful locusts in this territory is presented mainly by Calliptamus italicus L. - one of the most harmful species. Nongregarious locusts: *Dociostaurus kraussi* Ingen, *Dociostaurus brevicollis Ev.*, *Aeropus sibiricus* L., *Arcyptera microptera* F.d.W., *Chorthippus albomarginatus Deg.* и *Stauroderus scalaris F.W.*, *Stenobothrus fischeri Ev.* [2,3]. The most frequent types are: *Stenobothrus fischeri Ev., Chorthippus albomarginatus Deg., Aeropus sibiricus L.*, *Dociostaurus brevicollis Ev*. They can be found in all of the above stages, fallow lands, pastures and hayfields. Other species are less prevalent [3, 4].

Due to variability of environmental factors, distinctive features of interaction of organisms with the environment acquire dynamic character at present time. The immediate result of these interactions is the change of the population type, in general, fauna and biocenosis take place in time and space. The change of the abundance of insects at different times is the outbreak of harmful species in certain years [5].

We conducted appropriate analysis in examined regions to identify the causes and characteristics of population dynamics of nongregarious locusts. At the same time we compared changes that took place in population according to years and indicators with the state of biotic, abiotic and anthropogenic factors of their habitat. This made it possible to understand the underlying causes of fluctuations in this species population in the region.

Nongregarious species of locusts were the subjects of the study. Methods and analysis of research– are common in entomology and plant protection [6,7,8]. Research data and results obtained by us – is the statistical information provided by the phytosanitary service in Kazakhstan and results obtained by us.

The Body

Regularities of long-term fluctuations of insects' population - phytophagous organisms, is one of the central problem in entomology [9]. Regular fluctuations in insects' population can be caused without exogenous factors for biocenosis, due to interaction of organisms belonging to different trophic levels [10]. We have made a systematic analysis of population dynamics of nongregarious locusts, over the past 16 years. In addition respective, main and absolute colonization by phytophagous organisms was defined according to years. These indicators are measures of the pest population level at the stages. Quantitative changes of population processes at different times can be displayed using population indices. To those we attributed indicators characterizing change of pest population in agricultural land, rate of reproduction and population dynamics and index of dispersal, population, net reproduction, progradation and the energy of dispersal, reproduction.

Analysis of population dynamics level of nongregarious locust complex in northern Kazakhstan during 1998-2013 years allowed to build and develop a system of numerical indicators (Tables 1, 2 and Figures 1, 2, 3).

Table 1. Population of farmland by nongregarious locusts in Northern Kazakhstan (Akmola, Kostanai, Pavlodar, North Kazakhstan oblast), 1998-2013 years

Years	Examined area, Thousand, ha	Populsted area, Thousand, ha	Population		
			respective, %	main, exemplar/ examined area	absolute, exemplar/ examined area
1	2	3	4	5	6
1998	2955,0	1222,3	41,3	7,2	2,9
1999	7650,5	6789,1	88,7	6,3	5,5
2000	13210,1	3717,2	28,1	1,0	0,2
2001	8312,2	3456,5	41,5	8,1	3,3
2002	1455,5	453,3	31,1	7,3	2,2
2003	2312,3	789,9	34,1	5,6	1,9
2004	1154,7	464,1	40,2	6,0	2,4
2005	822,03	636,1	77,4	4,9	3,7
2006	1596,3	1027,8	64,4	4,8	3,0
2007	1437,05	1045,9	72,8	5,4	3,9
2008	1256,7	917,4	73,0	6,0	4,3
2009	1467,9	1157,4	78,8	6,7	5,2
2010	832,9	701,6	84,2	5,7	4,7
2011	1185,5	925,2	78,0	5,6	4,3
2012	2480,7	2001,2	80,6	6,7	5,4
2013	1235,7	939,8	76,0	5,5	4,1

Table 2. Nongregarious locusts population indexes in Northern Kazakhstan (Akmola, Kostanai, Pavlodar, North Kazakhstan oblast), 1999-2013 years

Years	Dispersal index	Population index	Net reproduction	Energy of dispersal	Energy of reproduction	Progradation index
1	2	3	4	5	6	7
1999	2,1	0,8	1,6	-	-	-
2000	0,3	0,1	0,03	0,6	0,04	0,02
2001	1,4	8,1	11,2	0,4	0,8	0,3
2002	0,7	0,9	0,6	0,9	7,05	6,3
2003	1,0	0,7	0,7	0,7	0,4	0,2
2004	1,1	1,0	1,1	1,1	0,7	0,8
2005	1,9	0,8	1,5	2,09	1,6	3,3
2006	0,8	0,9	0,7	1,5	1,09	1,6
2007	1,1	1,1	1,2	0,8	0,8	0,6
2008	1,0	1,2	1,2	1,1	1,4	1,5
2009	1,0	1,1	1,1	1,0	1,3	1,3
2010	1,1	0,8	0,8	1,1	0,9	0,9
2011	0,9	0,9	0,8	0,9	0,7	0,6
2012	1,0	1,2	1,2	0,9	0,9	0,8
2013	0,9	0,8	0,7	0,9	0,8	0,7

Algorithms of main indicators of population level measures have been established: respective, main and absolute population of agricultural land. The population indexes of nongregarious locusts have been calculated: indexes of dispersal, population, reproduction, progradation, the energy of dispersal, the energy of reproduction.

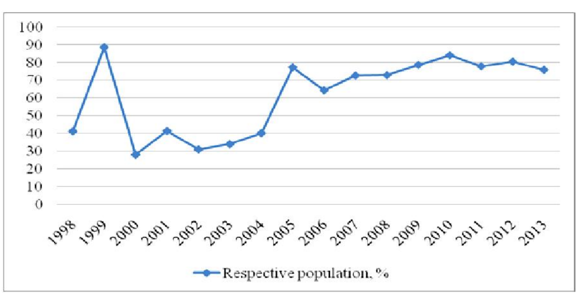

Figure 1. Dynamics of changes of the respective nongregarious locusts' population in Northern Kazakhstan, 1998-2013 years

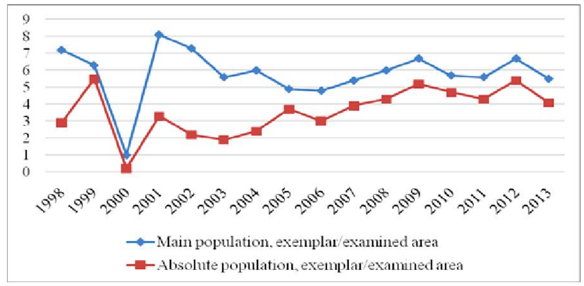

Figure 2. Main and absolute population dynamics of nongregarious locusts in Northern Kazakhstan, 1998-2013 years

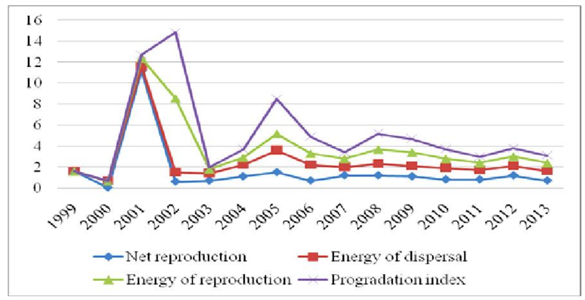

Figure 3. Nongregarious locusts population dynamics indices in northern Kazakhstan, 1999-2013 years

Variations of relative and absolute populations according to years, index of reproduction, the energy of dispersal and reproduction and progradation index had more prognostic value. The following diagnostic features of nongregarious locusts gradation phases by years have been established.

Table 4. Diagnostic features of nongregarious locusts gradation phases, 1998-2013 years

Dynamics phase	Diagnostic indicators	Years
1	2	3
Depression	Energy of dispersal – energy of reproduction < 2, Reproduction index< 1	2002, 2003
Population growth	Energy of dispersal - energy of reproduction<2, Reproduction index > 1	2001, 2004, 2007, 2008,
1	2	3
Population boom (Mass reproduction)	Respective population, Absolute population, Progradation index → max	1999, 2005, 2009, 2012
Population peak	Respective population, Absolute population, Progradation index ≥ max	2010, 2013
Population decline	Energy of dispersal - energy of reproduction<2, Reproduction index < 1	2000, 2006, 2011,

According to the diagnostic features of nongregarious locusts' gradation phases, population boom (mass reproduction) took place in 1999, 2005, 2009. Population peak was observed in 2010 and decline in 2000, 2006, 2011. Depression was in 2002 and 2003, while the population growth was marked in 2001, 2004, 2007, 2008, 2012. However, in the dynamics gradation phases the consistent sequence of certain dynamics phases is not always maintained. They may vary and occur inconsistently. So, after population decline in 2000, stepping over the phase of depression, population growth was marked in 2001.

And in 2002 - on the contrary, instead of growth a phase of depression came.

Mass reproduction of locusts in Kazakhstan was observed in 1909-1912, 1924-1927, 1931-1933, 1944-1947, 1953-1956, 1967-1970, 1977-1982, 1988 -1991 years, 1997-2000., i.e. about every 10-11 years. In general, long-term fluctuations in insects' population largely depend on human activities (anthropogenic factor) and climatic conditions (abiotic factor). Thus, major changes in agrophytocenosis occurred in cenoses in the above years and had a great influence on the locusts population dynamics. Under these conditions, population growth and population boom (mass reproduction) of phytophagous organisms lasted for 4-5 years and migration of insects from uncultivated land to crops became more regular. Also, a close correlation between solar activity (Wolf number) and locusts reproduction was revealed [11]. Meanwhile, the fluctuation of the population dynamics of nongregarious locusts largely depended on the abiotic and to a lesser extent on biotic factors. It was more convenient to characterize and express features of weather conditions change over years of research through hydrothermal index. Hydrothermal index was used on average across all the Northern Kazakhstan to find out the causes and relationship of the population dynamics variation with weather and climate conditions over the years. Normally, the average temperature in the northern part of Kazakhstan does not differ significantly by areas. Since hydrothermal index shows thermal conditions, as well as moisture conditions of the year.

Cross-spectrum analysis between the dynamics population of nongregarious locusts in absolute population and hydrothermal index of the vegetation period confirms this situation (Figs. 4 and 5).

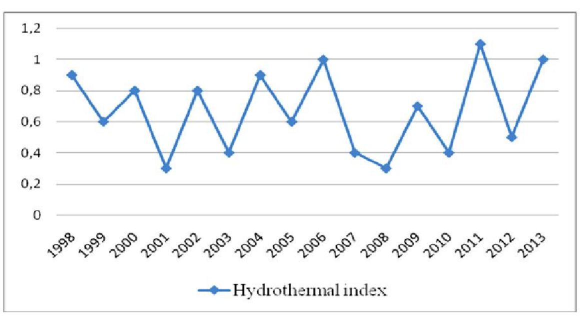

Figure 4. The change of hydrothermal index dynamics on average in Northern Kazakhstan over the years of analysis, 1998-2013 years

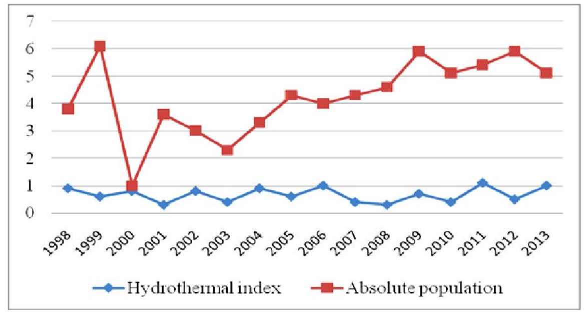

Figure 5. Relationship between the variation of absolute population and variation of hydrothermal index, 1998-2013 years

Dry and hot weather vegetation period is favorable condition for the development and reproduction of locusts. Whereas, wet and cool weather negatively affects their development and reproduction leading to a population decline. [11]. We have established a close relationship between population dynamics of nongregarious locusts species and change of hydrothermal index over certain years. This relationship can be seen from the above mentioned graphs. Thus, the population growth coincide with dry, hot or warm years (hydrothermal index > 0.9), while the decline mainly coincide with cool and rainy years, where hydrothermal index is ≤ 0,8. However, sometimes there can be exceptions. So, in 2003, despite dry and hot weather, with hydrothermal index = 0.3, the depression phase continued, which began in 2002 with hydrothermal index = 0.8. In 2009, despite cool and rainy vegetation period, a phase of population boom (mass reproduction) of nongregarious locusts came. Repeatability of dry vegetation periods for several years in a row (2005, 2007, 2008.) promoted a sharp increase in the number of outbreaks of phytophagous organisms. If we mention anthropogenic and technogenic factors a widespread reclamation of croplands and untimely or not fully carried out chemical treatments or their complete lack had the greatest impact on population dynamics. At the present stage budgetary funds are allocated on chemical treatments against nongregarious locusts, which allow to control phytosanitary situation more completely.

The volume of chemical treatments against nongregarious locusts in northern Kazakhstan are presented in Table 5 and Figure 6.

Table 5. Volumes of chemical treatments against nongregarious locusts in Northern Kazakhstan (SI "Republican Methodological Center for Phytosanitary diagnostics and Forecasts"), 1998-2013 years

Years	Examined area, Thousand, ha	Populsted area, Thousand, ha	Area populated above the economic threshold of harmfulness, Thousand, ha	Treated area, Thousand, ha
1	2	3	4	5
1998	2955,0	1222,3	203,3	121,5
1999	7650,5	6789,1	616,7	322,2
2000	13210,1	3717,2	211,2	33,6
2001	8312,2	3456,5	87,3	66,5
2002	1455,5	453,3	123,9	45,5
2003	2312,3	789,9	152,7	76,4
1	2	3	4	5
2004	1154,7	464,1	49,6	35,2
2005	822,03	636,1	35,07	25,7
2006	1596.3	1027,8	117,8	24,9
2007	1437,05	1045,9	95, 2	26,0
2008	1256,7	917,4	82,6	19,1
2009	1467,9	1157,4	356,3	161,6
2010	832,9	701,6	252,3	151,5
2011	1185,5	925,2	467,1	182,3
2012	2480,7	2001,2	697,4	312,7
2013	1235,7	939,8	533,2	328,0

The data shows that the volume of chemical treatments affects the change in the population dynamics of nongregarious locusts. Thus, the decline in the volume of chemical treatments concerning populated area above harmfulness threshold often leads to a growth of the last one for the next vegetation period.

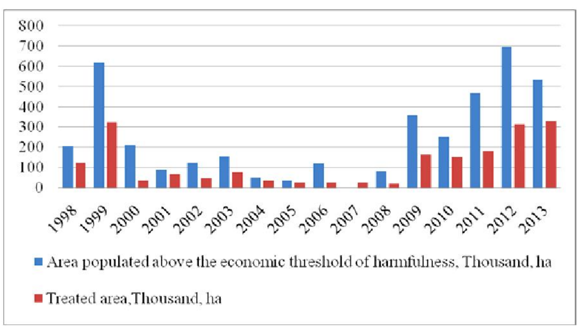

Figure 6. The relationship between the area populated with harmful nongregarious locusts above harmfulness threshold and treated area, 1998-2013 years

Meanwhile, the international experience shows lack of prospects of chemical agents' massive use during the peak of the outbreak of population boom (mass reproduction). [12]. Therefore, tracking core areas is a necessary condition for an effective system of preventive measures, especially during a period when there are not many pests [13].

Summary

To avoid losses, polytrophic pests, including nongregarious locusts should always be under the special phytosanitary control. Established change patterns of the phytophags population dynamics is a necessary part of pest forecasting. The obtained results can improve the accuracy of predicting the occurrence of certain phases of nongregarious locusts' population dynamics.

Conclusions

1. In the territory of North Kazakhstan periodic population boom (mass reproduction) of nongregarious locusts increases their importance as dangerous pests of agricultural land.
2. Population growth and population boom (mass reproduction) of phytophags in a greater degree coincide with dry and hot conditions of vegetation period. Wet and cool conditions of the vegetation often lead to pests' population decline.
3. The change of population dynamics of harmful nongregarious locusts largely depends on the abiotic factors. Depending on weather conditions of the previous and current year, as well as the completeness and timeliness of chemical treatments carried out in the previous year.
4. When there is sufficient volume of processing concerning populated area above harmfulness threshold, phytophags population decline noticeably following year, and vice versa, increases during its reduction.
5. The results of the analysis may be offered as appropriate indicators and criteria for improving the accuracy of forecasting next phases of nongregarious locusts population dynamics in the northern regions of Kazakhstan.

Corresponding Author:
Dr.Baybussenov Kurmet Serikovich
Kazah National Agrarian University, Abaya avenue, 8, Almaty, 050010, Kazakhstan

References

1. Baybussenov K.S., V.K. Azhbenov and A.T. Sarbaev, 2013. Nongregarious locusts spread in North Kazakhstan and the protection of agricultural land from pests. Data of the international scientific-practical conference "Protection of plants in modern technologies of crops cultivation." Novosibirsk.
2. Temreshev, I.I., 2001. Data on the fauna and phenology of harmful locusts (ACRIDIDAE) Akmola region in 2000. Materials of the International Round Table "Problems of locust control in Central Asia." - Almaty.
3. Baybussenov K.S., V.K. Azhbenov and A.T. Sarbaev, 2013. Bioenvironmental features and spread of harmful nongregarious locusts in northern Kazakhstan. Proceedings of the National Academy of Sciences of the Republic of Kazakhstan. Series of Agrarian Sciences.
4. Akmollaeva, A.S., 2005. Nongregarious locusts of Northern Kazakhstan (fauna, ecology, protective measures). Synopsis of a thesis. Almaty.

5. Bay Bienko, G.Y., 1980. General entomology. - Moscow: Higher School, pp: 372-276.
6. Polyakov I.Y. and G.E. Sergeev, 1975. Forecast of the development of agricultural plant pests. Leningrad: Kolos, pp: 186.
7. Polyakov I. Y., I.P. Persov and V.A. Smirnov, 1984. Forecast of development of pests and diseases of crops (with practicum). L: Kolos, pp:318.
8. Pravdin, F.N., 1978. Central Asia insects environmental geography. - Moscow: Nauka, pp: 271.
9. Leibhold A. and N. Kamata, 2000. Introduction. Are population cycles and spatial synchrony a universal characteristic of forest insect population? Population Ecology. 42: 205-209.
10. Royama T.A., 1996. Fundamental in key factor analysis. Ecology. 77 (1): 87-93.
11. Azhbenov, V.K., 2001. Analysis and Forecast of Kazakhstan farmland phytosanitary on locust pests. Materials of the International Round Table "Problems of management with locusts in Central Asia." - Almaty.
12. Azhbenov V.K. and N.V. Kostyuchenko, 2013. On the preventive approach of limits of Italian Locusts population in Kazakhstan. Phytosanitary optimization of agroecosystems. Collection of Third All-Russian Congress on Plant Protection. - St. Petersburg.
13. Lachininsky A.V., M.G. Sergeev and M.K. Childebaev, 2002. Locusts of Kazakhstan, Central Asia and cross-border regions. Laramie: The International Association of Applied Acridology and the University of Wyoming, pp: 122.

6/18/2014