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LONG-TERM ANALYSIS OF HARMFUL GRASSHOPPERS POPULATION DYNAMICS - SHAPING FACTOR OF FORECASTING THEIR ABUNDANCE

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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. Based on modeling of longterm population dynamics of this pest, the main predictors developed prediction of phase state on the basis of substantiated agricultural land to be treated at a different phase state studied herbivores. The findings may offer us as criteria for predicting trends in the next phase of the harmful grasshoppers population dynamics in Northern Kazakhstan.

Key words: harmful grasshoppers, distribution, population dynamics, forecasting, phase state, Northern Kazakhstan.

Introduction. Locusts and grasshoppers, as a kind of herbivores, give rise to many problems. One of the most important is related to the frequency of their mass reproduction in space and time. In such circumstances, sometimes it is very difficult to maintain the functioning of locust monitoring [1-4].

In Kazakhstan habitat home to over 270 species and sub-species of grasshoppers insects. Among them periodically heavy damage to farmland cause only 15-20 species [5,6]. Fauna of pest locusts and grasshoppers is presented mainly Calliptamus italicus L. - one of the most harmful species, Dociostaurus maroccanus Thunb., Locusta migratoria migratoria. Along with a gregarious species of locusts in the republic territory no small importance are nongregarious kinds of locusts or harmful grasshoppers. The most common types include: *Dociostaurus kraussi Ingen, Dociostaurus brevicollis Ev., Aeropus sibiricus L., Arcyptera microptera FdW, Chorthippus albomarginatus Deg.* and *Stauroderus scalaris FW, Steno-bothrus fischeri Ev.* [7,8]. Of these, the most frequently encountered species include *Stenobothrus fischeri Ev., Chorthippus albomarginatus Deg., Aeropus sibiricus L., Dociostaurus brevicollis Ev*. They are found on all of the above habitats, reservoirs, pastures and hayfields. Other species are less common [9].

Long-term analysis of the population dynamics makes it possible to identify the main environmental features, causes and patterns of population dynamics of harmful grasshoppers, and also allows building some forecast predictors based on the integral indexes of the population dynamics phases [10].

The Body. According to the methodology [11-13], to produce specific indexes or predictors of long-term forecasting of pests, it is necessary to conduct a long-term analysis of the population dynamics of these herbivores and based on the existing laws to build forecasting predictors of the phase population dynamics. To do this, we had collected and thoroughly investigated perennial materials of distribution and populations farmland of harmful grasshoppers in northern regions of Kazakhstan. To identify the causes and characteristics of the population dynamics of these pests, in the research areas we conducted appropriate tests. This compared changes in the abundance of years and with the state of biotic indices, abiotic and anthropogenic factors of their habitat. This made it possible to understand the underlying causes of fluctuations in numbers of this species in the regions.

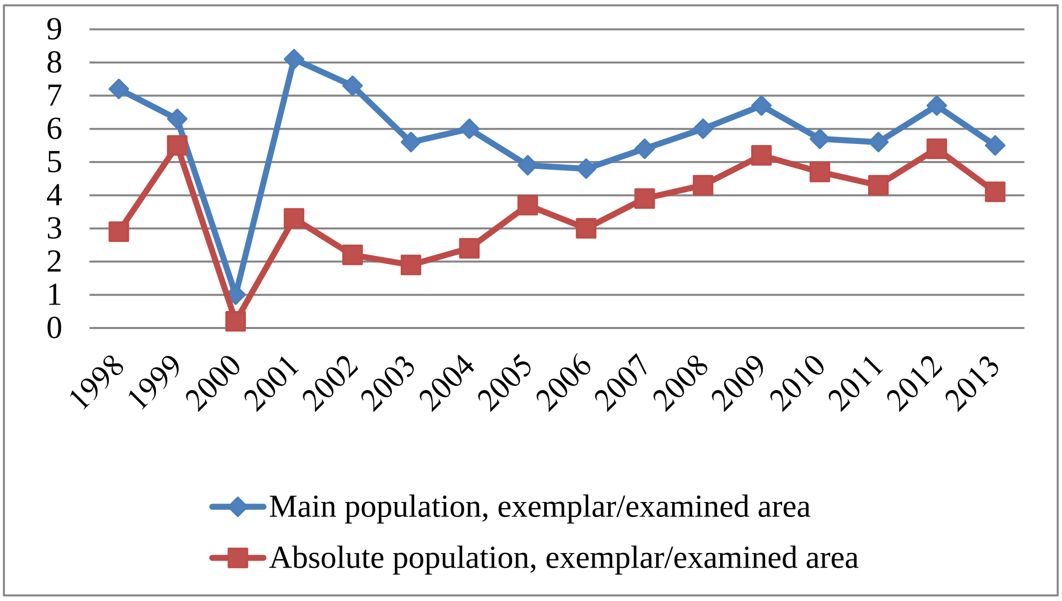
We have made a systematic analysis of the population dynamics of harmful grasshoppers the past 16 years. An analysis of the dynamics of harmful grasshoppers population complex in northern Kazakhstan for 1998-2013 years, will help to build and develop a system of numerical indicators (Tables 1, 2 and Figure).

Table 1 – Population of farmland by harmful grasshoppers 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
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 – Harmful grasshoppers 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
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



Main and absolute population dynamics of harmful grasshoppers in Northern Kazakhstan, 1998-2013 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 harmful grasshoppers gradation phases by years have been established.

Table 3 – Diagnostic features of harmful grasshoppers gradation phases, 1998-2013 years

Dynamics phase	Diagnostic indicators	Years
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
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 harmful grasshoppers 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.

In general, long-term fluctuations in the number of insects depend largely on human activity (anthropogenic factor) and climatic conditions (abiotic factor). Thus, large-scale changes in agrocenoses occurred in cenoses in the above years, had a marked effect on the population dynamics of locusts. Under these conditions, the rise of the abundance and the mass reproduction of herbivores lasted 4-5 years, and the migration of insects on crops uncultivated land becomes a regular. Also found a close correlation between solar activity (Wolf number) and locust breeding [11].

Meanwhile, the fluctuation of the population dynamics of harmful grasshoppers largely depends on the abiotic and to a lesser extent by biotic factors. Namely, depending on the weather conditions the previous and current year, as well as the completeness of the scope and timeliness of chemical control of locusts in the previous year [12].

In the process of population dynamics of pests observed regularities of phase change of qualitative state populations predetermining intrapopulation, intraspecific and interspecific relationships. Variation phases of population dynamics is primarily determined by food supply and the effects of weather on their formation and distribution.

Over the full cycle of the dynamics of reproduction of pests can be allocated to the five phases of population variability. Most often said ring population dynamics of pest species is incomplete. Thus, the phase of depression may occur immediately after the settlement, if sharply deteriorating living conditions. For drawing up long-term forecasts are extremely important statistical information system analyses of changes in population dynamics for several years.

We conducted a systematic analysis of the dynamics of population complex harmful grasshoppers in northern Kazakhstan for the period 1998-2013 years, will help to build and develop a system of numerical indicators that are important prognostic direction.

Based on the results of these analyzes have been built support schemes (Tables 4 and 5) diagnostic predictors of population status of harmful grasshoppers and their quantitative characteristics in different phases of their dynamics to produce long-range forecasts.

Table 4 – Diagnostic predictors of phase status of harmful grasshoppers populations at different dynamic phases (in Northern Kazakhstan)

#	Diagnostic indicators	Population dynamics phase				
		Depression	Increase in abundance	Mass reproduction	Abundance maximum	Abundance decay
1	Relative colonization, %/surveyed area	0-35	35-75	75-100	75-50	50-35
2	Absolute colonization, spec./surveyed area	0-2	2-4	4-6	6-4	4-2
3	Expansion energy	0.1-0.9	0.9-1.1	1.1-2.0	2.0-0.9	0.9-0.1
4	Reproduction energy	0.1-0.7	0.7-1.5	1.5-1.7	1.7-0.7	0.7-0.1
5	Net reproduction	0.1-0.7	0.7-1.2	1.2-1.6	1.6-0.7	0.7-0.1
6	Progradation rate	0.1-0.3	0.3-1.5	1.5-3.3	3.3-0.3	0.3-0.1

It should be noted, gradation data were built based on the analysis system during those 16 years. Thus, the phase state of populations of harmful grasshoppers depends on change of several numerical indicators (relative population, absolute population, etc.).

Based on the essential difference between them and other literature [12, 13] Forecasting pest have been made more quantitative characteristics (the density of adults, the density of egg capsules in the soil, etc.) to build a long-term forecasting of the expected number of herbivores (Table 5).

Table 5 – Predictive model of quantitative aspect of non-gregarious locusts populations at different dynamics phases (in Northern Kazakhstan)

#	Population dynamics phase	Summer survey		Autumn survey	
		Relative colonization, %	Imago density, spec./m^2	Density of egg-pots in the soil, spec./m^2	Infestation of egg-pots by parasites, %
1	Depression	0-35	3.0-5.0	0.01-3.5	>25
2	Increase in the abundance	35-75	5.0-15	3.5-5	25-15
3	Mass reproduction	75-100	15-30	5-15	15-10
4	Abundance peak	75-50	30-15	10-5	10-15
5	Decay in the abundance	50-35	15-3.0	5-3.5	<15

The basis for the construction of this projection, the recommendations have been taken of guidelines for other pests [11-14].

Results of analyzes of indicators measures the levels of pests listed in Table 2 were taken to rounding. Since, for the construction of the predictors tone required system parameters and sequence numbers. The table shows the predictive model -5 quantitative characteristics of populations harmful grasshoppers at different stages of their dynamics. Also, these figures need to reference in making early projections in determining the phase dynamics of pest populations.

Rational planning of the volume of protective treatments is an important element of preventive plant protection organization. We know two types of planning volumes protective measures: the current calculated for a year or a season, and a multi-year, justifying the need for plant protection products on the five-year period and more. Both types of planning based on the corresponding forecasts of distribution and development of pest - annual, seasonal and perennial.

To use the data planning summer adult locust survey and the autumn survey of egg capsules. According to the logical model of the quantitative characteristics of harmful grasshoppers populations at different phases of their dynamics can be represented in a table model on the areas treatments against harmful grasshoppers in northern Kazakhstan (Table 6).

Table 6 – Agricultural area to be treated against the locusts nongregarious complex harmful, depending on the phase of population dynamics (Northen Kazakhstan)

#	Population dynamics phase	Northen Kazakhstan		
		Relative colonization, %	The area required for treatment insecticides	
			Thousands of hectares	In % of the populated area
1	Depression	0-35	<10	<10
2	Increase in the abundance	35-75	60-90	40-45
3	Mass reproduction	75-100	200-250	60-70
4	Abundance peak	75-50	150-200	50-60
5	Decay in the abundance	50-35	40-60	<30

Irrational uses of pesticides in agriculture lead to their accumulation in the soil, food. However, there is no doubt that the rise of farming, improved pesticide application technology, limiting their use, strict dosage when applied to the soil can significantly reduce their negative impact. The treatment of crops with pesticides should be done in the recommended timeframe. Especially strictly necessary to comply with the terms of recent treatments before harvest, are listed in the "List of chemical and biological means of pest control, plant diseases and weeds".

Conclusion. On the territory of Northern Kazakhstan periodic mass reproduction of harmful grasshoppers increases their value as dangerous pests of agricultural lands. The above analysis of longterm population dynamics of harmful grasshoppers is a determining factor in the longterm forecast of the abundance these polyphagous pests. It was found that the change in the population dynamics of harmful grasshoppers depends largely on the state of the abiotic and anthropogenic factors. The established patterns of change in the population dynamics of herbivores allowed for support scheme diagnostic predictors of These pests population status and their quantitative characteristics in different phases of dynamics to produce long-range forecasts. It is a necessary part of pest forecasting.

ЗИЯНДЫ САЯҚ ШЕГІРТКЕЛЕРДІҢ ПОПУЛЯЦИЯ ДИНАМИКАСЫН КӨПЖЫЛДЫҚ ТАЛДАУЫ – ОЛАРДЫҢ САНДЫЛЫҒЫН ҰЗАҚ МЕРЗІМДІ БОЛЖАУДЫҢ АНЫҚТАУШЫ ФАКТОРЫ РЕТІНДЕ

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Аннотация. Мақала солтүстік Қазақстан аймағындағы негізгі зиянды саяқ шегірткелер кешенінің популяция динамикасының көпжылдық талдаулар нәтижелері мен соның негізінде анықталған олардың сандалылығын болжайтын предикторлар жайында ой қозғайды. Өткізілген талдау нәтижелері бұл зиянкестер сандылығын ұзақ мерзімді болжайтын анықтаушы факторы болып табылады. Мәліметтердің көрсетуі бойынша, зиянды саяқ шегірткелердің сандылық динамикасының өзгеруі көбінесе абиотикалық және антропогендік факторлардың жағдайына тәуелді болады. Фитофагтардың сандылық динамикасының анықталған бұндай заңдылықтары, зиянды саяқ шегірткелер популяциясы жағдайын көрсететін диагностикалық предикторлар сұлбасын құрастыруға, сондай-ақ, ұзақмерзімді болжамдарды және қорғау шараларын негіздеуде бұл зиянкестердің әр түрлі динамика фазаларындағы сан мөлшерінің көрсеткіштерін анықтауға септігін тигізді. Бұл фитосанитарлық болжамның қажетті құрамдас бөлігі болып есептеледі.

Тірек сөздер: зиянды саяқ шегірткелер, таралуы, сандылық динамикасы, болжамдау, фазалық жағдайы, солтүстік Қазақстан.

МНОГОЛЕТНИЙ АНАЛИЗ ПОПУЛЯЦИОННОЙ ДИНАМИКИ ВРЕДНЫХ НЕСТАДНЫХ САРАНЧОВЫХ КАК ОПРЕДЕЛЯЮЩИЙ ФАКТОР ДОЛГОСРОЧНОГО ПРОГНОЗА ИХ ЧИСЛЕННОСТИ

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Аннотация. Статья презентует результаты многолетнего анализа по пуляционной динамике основного комплекса вредных нестадных саранчовых северного Казахстана и предикторы прогнозирования их численности, обоснованные с помощью данного анализа. Проведенный многолетний анализ является определяющим фактором долгосрочного прогноза численности данных многоядных вредителей. Установлено, что изменение динамики численности вредных нестадных саранчовых во многом зависит от состояния абиотических и антропогенных факторов. Установленные закономерности изменения динамики численности фитофагов позволили составить опорные схемы диагностических предикторов состояния популяций вредных нестадных саранчовых, а также их количественных характеристик на разных фазах динамики для составления

долгосрочных прогнозов и обоснования защитных мероприятий. Это является необходимой составной частью фитосанитарного прогнозирования.

Ключевые слова: вредные нестадные саранчовые, распространение, динамика численности, прогнози-рование, фазовое состояние, северный Казахстан.

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