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Chronicle of insect pests massive reproduction

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Insect populations are complex open biological systems with the chaotic illinear dynamics in space and time. The forecasting of their development in the future is not a simple task. Suffice it to recollect the “unexpected”, “sudden”, and “unpredictable” massive breeding of a number of insect pests. The purpose of the work is an attempt to identify the regularities of the mass reproductions of insects by analyzing the historical data about them, since in recent years the problem of catastrophic events, or the so-called in synergetics the aggravated regimes in illinear systems has become quite urgent, when one or more quantities that characterize the system, eventually have grown up to the infinity. A vivid example of this fact is the “unpredictable” massive reproductions of insects. By means of conducting the theoretical synthesis of the information about the regularities of the population dynamics of the most common insect pests, which is based on the past and the present, the analysis of the contemporary ideas about the dynamics of insect populations and the theories that explain the seasonal and annual changes in the number of the insects has been carried out. The emergence of the parasitic, climatic, trophic and other theories has become a logical historical stage of the environmental researches; they respectively reflected the methodology of that or this period of the populations’ ecology development. The existence of the theories explaining the dynamics of the populations on the basis of their interaction with one or two factors of the environment can only be temporary, because the facts that do not keep within the bounds of these theories are continuously accumulating. In the ecology of insects there is the necessity of the theoretical synthesis, which foresees the emergence of a new theory, in which the limitations of the former theories are dialectically removed. Each scientific theory must perform the descriptive, explanatory, synthesizing, and, most important, prognostic functions, but the mentioned theories of the populations’ dynamics do not correspond to this requirement. To create a theory that explains the reccurence and cyclic character of the insects’ mass reproduction, the synergetic synthesis is required. Such synthesis should take into account the system legitimacy of the insects’ development and their interaction with the systems of higher level of organization, the illinear population dynamics and chaos, the aggravated regimes and the limited prognoses. The chronicles and the regions where the most significant outbreaks of the harmful insects’ massive reproductions are noted, provide an opportunity to analyze the polycyclic character, synchronousness and illinearity of the populations’ dynamics.
Keywords: Mass reproduction; population dynamics; polycyclicity; synchronism; nonlinearity; insects; pests

Introduction

According tn the synergetics, the insects’ populations are complex open biological systems with the chaotic illinear dynamics in space and time. In this connection the prediction of their future development is not an easy task. Suffice it to recollect the “unexpected”, “sudden”, and “unpredictable” massive breeding of *Acridoidea, Agrotis segetum, Pyrausta sticticalis, Zabrus tenebrioides, Eurygaster integriceps, Asproparthenis punctiventris (L)* and a number of insect pests of forest and fruit and berry plantations (Biletskyi & Stankevych, 2018).
Practically an immence number of works on the problem of the dynamics of the insects’ populations has been published recently, but still there is no answer to the urgent questions, namely what are the mechanisms of the population dynamics, is it possible to predict the future mass reproductions of the insects and what are the limits of the predictability (Biletskyi, 2011; Biletskyi et al., 2017; Biletskyi & Stankevych, 2018)? In the last two decades the fundamental works on the problem of chaos and predictability of the complex systems behavior in the future have been published. At the same time the impossibility of the long-term prediction of even relatively “simple” mechanical systems, not mentioning the complex biological, environmental, economic, social, climatic, meteorological and other natural systems has been proved (Kravtsov, 1997; Malinetskyi, 1997; Moisieiev, 2001; Nikolas & Prigozhyn, 2003; Glushkov et al., 2009; Sergieiev, 2016).
The problem of the population dynamics is one of the central problems in ecology. It has arisen together with the beginning of life on the Earth and the agricultural activity of a man and is determined by the time dimensions of the past, present and

future. Therefore, the forecasting is the history oriented from the past to the future. Such a comparison has a certain meaning, because between the forecasting and the past there is some symmetry, the axis of which is the present; and the prediction of the insects' mass reproduction is a reflection of the history or chronological sequence of the dynamics of their populations in time. And what is more, the chronicle of the mass insects' reproduction has already contained the information on the results of the populations' interaction with almost all factors of the environment (Moisieiev, 2001; Biletskyi & Stankevych, 2018).

The insects, as one of the most ancient and numerous groups of animals that appeared on the Earth about 400 million years ago, have "genetic memory" in the past and, accordingly, transmit the genetic information from the generation to generation using the genetic code according to the evolutionary triad of heredity, variability and natural selection (Moisieiev, 2001). The latter is especially enhanced during the mass reproductions, which occur in the cyclic character, that is, at different intervals between the beginnings of the regular or the so-called population cycles (Biletskyi, 2011). However, as we know now, the population cycles are not an exact recurrence of the past in the future. They contain the information from the past, but at the same time the genetic and ecological structures (organizations) of the populations are naturally changing (Shvarts, 1980).

According to the scientific cosmological theories, the possibility of producing the new information in any evolutionary process is related to the action of the cosmic principle of the hypothesis about the Universe of the thermodynamic equilibrium at zero temperature suggested by the Harvard scientist David Leizer An interesting consequence of this hypothesis is the assertion that the Universe can never contain enough information about the future development; at any moment there may be something new, and the system can move to a new level of development, called in an unequilibrium and illinear dynamics (synergetics) as a bifurcation (Prigozhyn & Stengers, 1986; Malinetskyi & Potapov, 2000; Glushkov et al., 2009). Therefore "…we never know in advance when the next bifurcation will take place. The randomness occurs again and again as Phoenix from the ashes …" (Prigozhyn & Stengers, 1986).

The knowledge of the chronicles and regions where the most significant outbreaks of the harmful insects' mass reproductions have been noted, give an opportunity to analyze the polycyclic character, synchronousness and illinearity of the populations' dynamics.

Materials and methods

The purpose of the work is an attempt to identify the regularities of the mass reproduction of insects by analyzing the historical data about them, since in recent years the problem of the catastrophic events, or the so-called in synergetics the aggravated regimes in illinear systems, has become quite urgent when one or more quantities that characterize the system eventually have grown up to the infinity. In the ecology of the populations it is the "unexpected" disastrous massive reproductions of insects. By means of conducting the theoretical synthesis of the information about the regularities of the population dynamics of the most widespread insect pests of the agricultural crops, forests and fruit and berries plantations, which is based on the past and the present, the analysis of the contemporary ideas about the dynamics of the insect populations and the theories that explain the seasonal and annual changes in the number of insects has been carried out. When conducting this study in order to reveal the primary centres of the mass reproductions we have analysed various sources of scientific literature as for the massive breeding of the main pests of the agricultural crops and forest plantations. Based on the obtained data, the chronicles of the mass reproduction were made. By analysing these chronicles, it is possible to note certain regularities in the cyclic character and synchronousness of the mass reproductions of the most important pests of the agricultural crops and forest plantations with the aim to improve the prediction as for the beginning of the next mass reproductions and to find out the regions in which their occurrence is possible.

Results

The dynamics of the populations number as an elementary factor of microevolution: S.S. Chetverikov (1880-1959) was the first who pointed out the general nature of the fluctuations in the number of the individuals in the natural populations and the possible evolutionary significance of this phenomenon at the example of the insects' "waves of life" (Chetverikov, 1905).

Later the geneticists and evolutionists have shown that the population waves are an elementary factor in microevolution. They lead to the weakening of the natural selection with an increase in the number of the individuals in the natural populations and intensify the selection when the number of the individuals is decreasing.

In two decades S.S. Chetverikov in his work "About Some Moments of the Evolutionary Process from the Point of View of Modern Genetics" performed the theoretical synthesis of Darwinism and genetics and laid the foundations of the population genetics and the genetic theory of the species formation (Chetverikov, 1926).

Thanks to the above mentioned works, the fundamental importance of the populations which constitute the population of any species has been established in Biology. It became clear that all the evolutionary changes, called in 1938-1939 by N. V. Timofieiev-Ressovskyi (1900-1981) as microevolution, took place exactly at the population level (Timofieiev-Ressovskyi, 1958).

The detailed researches on the population genetics at the example of the insects were carried out in the 30s of the twentieth century by N. P. Dubynin (1906-1998) and D. D. Romashova (1899-1963). They substantiated the theory of genetic and automatic processes that explain the regularities of the mass insect appearance. The analyses that were carried out by the authors showed that the genetic and automatic processes (GAP) were taking place throughout the whole life of the populations (Dubinin, 1932). They occur in the populations with a constant number, but they are especially intensive in the period of declining the numbers, when the genetic structure of the populations is restructured. With the increase in the

number during the genetic and automatic processes the continuous differentiation of the genetic composition of the populations is extremely slow, but nonetheless it takes place.
The genetic and automatic processes can have a significant effect on the dynamics of the population changing the fertility and viability of the individuals in the populations, especially at that time when any mutation that has arisen, finds itself under the pressure of the natural selection. The changes in the number of the populations are the expression of various ecological dependencies between the environment and the organism. With the help of these dependencies the external environment realises a part of its influence for the genetic structure of the species and its evolutionary process. Thus, the theory of the genetic and automatic processes revealed some reasons for the fluctuations of the number of insects, which are based on the dynamics of the genetic composition of the populations.
The question of the populations's dynamics of harmful insects and rodents as limited panmixies were widely presented in the works of the famous biologist-evolutionist I.I. Shmalgauzen (1884-1963). The conclusions of I.I. Shmalgauzen (Shmalgauzen, 1946) about the four phases of changes in the number and their derivative effects are important for the theory of the populations' dynamics in the methodological aspect.
The first phase is an increase in number under the favorable conditions with the weakening of the natural selection action. It is associated with the accumulation and combination of the mutations (an increase in the individual variability).
The second phase is a relative stabilization accompanied by the increased competition, as well as a direct struggle for the existence. It is associated with the effective selection of the most favourable combinations and the reduction of the variability.
The third phase is a more or less sharp reduction in the number under the pressure of the powerful eliminating factors. It is associated with the subsequent reduction of the variability and, partially, with the occasional experiences of some more favourable combinations.
The fourth phase is a new reproduction; it is associated with the rapid proliferations of the surviving combinations and the subsequent accumulation of new mutations.
I.I. Shmalgauzen believed that the cyclic changes in the number of the populations made only a partial limitation of panmixia during the periods of depression, but their evolutionary importance is beyond doubt.
To know the laws of the insect populations' dynamics, the following conclusions are important:
- the populations are capable to maintain their number in a state of dynamic equilibrium despite the constant changes in the environmental factors; this is achieved by the adaptive homeostatic reactions of the separate individuals, the dynamics of the ecological structure of the population and the changes in its genetic composition;
- the fluctuations in the quality of the population; it is as much characteristic of its attribute as the number of the fluctuations.
As the author believed, an indispensable condition for maintaining the viability of the populations in the changing environmental conditions is the high degree of its genetic heterogeneity which is ensured by such ecological mechanisms as different way of life of various intrapopulation groups of animals, strict laws of the couples formation, different rates of sexual maturation of males and females, different ratios of sexes in different age groups and others.
According to S. S. Schwartz (1919-1976) (Schwartz, 1980) the ecological mechanisms of the evolutionary process are manifested in the three most important forms based on changing the age structure of the population (age selection), the change in the number (the non-selective elimination) and the change in the spatial structure of the population.
The sharp changes in the number are the most important factor for the transformation of the population and, contrary to the generally accepted notions, this factor (the non-selective elimination) affects the ecological structure of the populations and, as a rule, it has a strictly selective action, transforming it in certain directions which correspond to the changes in the environment. The sharp fluctuations in the number of the population, like the age selection, contribute to the rapid mobilization of the population reserves and, as a rule, they are one of the factors of its adaptive evolution (Schwartz, 1980).
At present there are many facts which show that the enrichment of the genetic fund of the populations is of the fundamental importance. Therefore it is naturally that the special mechanisms for maintaining the heterogeneity of the populations must exist. One of these mechanisms is the increased viability of heterozygotes. Heterozygosity in the populations is achieved by mixing the individuals, especially during the migration periods, when the probability of coupling the individuals from the populations of different genetic structures increases. The migrations and intermixing are one of the main mechanisms for the insects that maintain the genetic heterogeneity of the populations and prevent the depletion of the general genetic fund.
The genetic heterogeneity of the populations is one of the prerequisites for the microevolutionary transformations. However, as S.S. Schwartz rightly said "Natural selection can not work on credit. This means that the genetic heterogeneity of the populations is not only a prerequisite for their transformation, but it also increases the survival of the populations at the current moment in its history" (Schwartz, 1980).
Thanks to the researches of S.S. Schwartz (Schwartz, 1980) and other ecologists-evolutionists, there was a convergence of the evolutionary and ecological ideas. The beginning of a new stage of the ecological mechanisms of the microevolutionary process study during the development of the modern synthetic theory of evolution has been set. To know the ecological peculiarities of the populations, the relationship between the level and type of the number dynamics, the fertility, life duration, etc., the ecological and genetic structure of the populations was characteristic for that stage of the researches. The change in the ecological structure of the population, including the change in its number, leads not only to the genetic drift, that is, to the random change in the frequency of different genotypes birth, but also to the directed transformation of the genetic composition of the populations (the ecological mechanisms of the evolutionary process). The comprehensive study of these laws creates the preconditions for the development of a theory of management of the qualitative composition of the populations.

The synthesis of the evolutionary and environmental ideas, the creation of a single evolutionary and ecological approach to the study of the vital problems contributed to the exceeding of the biological knowledge the bounds of the empirical specificity and marked a new stage in the theory of Biology (Biletskyi & Stankevych, 2018).

The chronicle of massive reproductions of the insect pests

The desert locust (*Schistocerca gregaria Forskal* Lat., 1775): is widespread in the tropical and subtropical regions of Africa and Southwest Asia. As a result of the analysis, the historical data on the mass reproductions of *Schistocerca gregaria* in the natural habitat is summarized and supplemented. This natural habitat is relatively divided into four regions: the eastern, western, central, and southern ones. The eastern region includes Afghanistan, Iraq, Iran, Pakistan, India, Saudi Arabia, Yemen, Oman, Eritrea, Ethiopia, Somalia and Egypt; the west region includes Mauritania, Senegal, Mali, Niger, Guinea, Guinea-Bissau, Burkina Faso and Western Sahara; the central region includes Angola, Zambia, Zaire, Sudan and Chad; and the southern region includes Botswana, Namibia and South Africa.

In the eastern region the massive reproductions of *Schistocerca gregaria* took place in 1843-1845, 1862-1873, 1875-1881, 1889-1908, 1912-1919, 1926-1936, 1939-1946, 1950-1954, 1966-1968, 1972-1975, 1981-1983, 1986-1990, 1992- 1995, and in 2003-2004; in the western region it took place in 1863-1867, 1890-1894, 1900-1903, 1905-1911, 1913-1919, 1926-1936, 1940-1947, 1950-1952, 1966-1968, 1972-1975, 1979-1983, 1986-1989 , 1992-1995, and in 2003-2004; in the central region its massive reproductions occurred in 1863-1866, 1869-1870, 1877-1880, 1889-1896, 1903-1909, 1913-1917, 1926-1932, 1936- 1939, 1940-1952, 1965-1970, 1973-1980, 1986-1990, 1992-1995, and in 2003-2004; in the southern region it took place in 1900-1909, 1912-1917, 1926-1932, 1940-1947, 1959-1962, 1968-1970, 1978-1981, 1986-1990, 1992-1995, and in 2003-2004. In the natural habitat the reproductions of *Schistocerca gregaria* took place in 1800-1803, 1810-1813, 1821-1826, 1833-1834, 1843-1845, 1860-1866, 1878-1881, 1890-1896, 1900-1909, 1913-1917, 1926 -1932, 1939-1946, 1950-1960, 1965-1970, 1973-1980, 1986-1990, 1992-1995, and in 2003-2004.

***Locusta migratoria migratorioides* (Fairmaire & Reiche, 1849):** is widespread in all African countries, and during the period of 1889-2003 its mass reproductions occured in 1889-1892, 1903-1907, 1913-1914, 1927- 1929, 1936-1938, 1946-1951, 1953-1956, 1961-1968 , 1977-1978, 1986-1989, 1992-1994, and in 2003-2004. In 1889 D. Caruters observed the transmigration of this locust over the Red Sea. Its flock included about 40 billion specimens, and their mass exceeded the mass of copper, lead and zinc extracted for the entire nineteenth century. In 1954 10 billion of individuals of this type of pests turned about 500 km² of flowering land in Kenya into a languid desert. In 1998, the flocks of *Locusta migratoris capito* (Lat.) (Saussure, 1884) touched down the island of Madagascar and destroyed 2 million hectares of rice. And in 2004 the flock of *Locusta migratoris capito* of 10 km long flew from Egypt to Israel.

***Nomadacris septemfascuata* (Audinet-Serville, 1838):** From 1847 to 2004 there were 13 mass reproductions of this type in Namibia, Botswana and Zambia in 1847-1857, 1891-1892, 1906-1907, 1913-1920, 1927-1930, 1935-1938, 1940-1944, 1956-1958, 1961-1968, 1977 -1978, 1986 1989, 1993-1994, and in 2004-2005.

***Chortoicetes terminifera* (Walker, 1870):** In the eastern and north-western regions of Australia the massive reproductions of this species were marked in 1934, 1937-1939, 1946-1947, 1950-1951, 1953-1955, 1973-1974, 1977-1979, 1984-1987, 1990, 1999-2001, and in 2006.

Calliptamus italicus (Linnaeus, 1758). According to the chronicles the massive reproductions of this pest in Kyivska Rus took place in 1008, 1024, 1083-1086, 1092, 1094-1095, 1103, 1195-1196, 1408, 1501, 1534, 1536, 1541-1542, 1579, 1583, 1601 1603, 1615, 1646-1648, 1652, and in 1685; in Ukraine it took place in 1688-1690, 1710-1713, 1719-1720, 1743-1744, 1748- 1749, 1756-1757, 1780-1783, 1793-1794, 1796-1799, 1803-1810, 1820-1823, 1825-1829 , 1834-1839, 1841-1843, 1850-1852, 1859-1860, 1862-1864, 1866- 1869, 1884-1888, 1890-1893, 1901-1903, 1910-1913, 1923-1925, 1930-1932, 1937-1939, 1945-1947, 1951-1953, 1995-1997, and in 2003.

***Dociostaurus maroccanus* (Thunberg, 1815):** The natural habitat of *Dociostaurus maroccanus* is the steppes of the southwestern part of Ukraine, the Southern Crimea and the foothills of Ciscaucasus, Transcaucasus, Central Asia and Kazakhstan. As a pest of sugar beets *Dociostaurus maroccanus* was noted in Hungary, Bulgaria, Greece, and Yugoslavia (Camprag, 1973). The mass proliferations of this pest were: in 1901-1902, 1905, 1909, 1929-1932, and in 1939 in Bulgaria; in 1919 - 1925, 1937-1940, and in 1948-1949 in Hungary; in 1930-1933 and in 1946-1948 in Yugoslavia; in 1949 and in 1974 in Syria; in 1953 in Somalia; in 1955 in Morocco; in 1960 in Iraq; in 1993, 2000 and in 2006-2008 in Kazakhstan; in 2002 in Afghanistan; and in 2000-2001 in Chechnia.

***Locusta migratoria* (Linnaeus, 1758) in Ukraine:** *Migratoria rossica L.* (Uvarov et Zolotarevskyi, 1929). In Ukraine the mass proliferations of this pest took place in 1708-1712, 1719- 1720, 1726-1732, 1745-1748, 1756-1757, 1780-1785, 1793-1794, 1797-1799, 1804-1806, 1822-1825, 1834-1836, 1844-1848, 1850-1858, 1853, 1855-1860, 1862-1864, 1866-1868, 1875-1876, 1880-1882, 1890-1894, 1896-1897, 1899, 1912, 1920-1923, 1933, 1938, 1946, and in 1995-1996.

The solitary locusts are *Podisma pedestris* (Linnaeus, 1758), *Gomphocerus sibiricus* (Linnaeus, 1767), *Pararcyptera microptera* (Fischer von Waldheim, 1833) and *Stauroderus scalaris* (Fischer von Waldheim, 1849). In Krasnoiarskyi Krai their mass proliferations were noted in 1726, 1755-1756, 1840, 1902-1903, 1911-1913, 1942-1943, 1946-1948, 1951-1955, 1962- 1967 1986-1988, and in 1999-2002.

The mass reproduction of *Melolontha sp*. (Fabricius, 1775) took place in 1856-1861, 1863-1864, 1867-1868, 1879-1880, 1892-1893, 1895-1896, 1899-1900, 1905-1906, 1929-1932, 1936-1938, 1946-1947, 1949 -1952, 1957- 1958 1962-1963, 1965-1966, 1985-1986, and in 2009-2010.

The mass reproduction of *Letrus apterus* (Laxmann, 1770) were in 1846-1847 1852, 1867, 1873, 1879-1880, 1898-1902, 1933-1935, 1972, 1975, and in 2000-2001.

The mass reproduction of Elateridae (Leach, 1815) and Tenebrionidae (Latreille, 1802) occurred in 1873, 1879, 1881 1885-1890, 1900, 1916-1920, 1931-1940, 1972-1975, and in 1989-1990.
Opatrum sabulosum (Linnaeus, 1761) and *Pedinus femoralis* (Linnaeus, 1767) (beetles) massively reproducted in 1879-1881, 1925-1926, 1930, 1936, 1938, 1945-1948, 1953-1954, and in 1983-1985.
Scotia (Agrotis) segetum (Denis & Schiffermüller, 1775). The first mass reproduction of this pest in Europe was recorded in 1572, in Ukraine it was noted in 1638, in the Volga region - in 1764. In 1790 the caterpillars of this pest destroyed the spiked cereals in Latvia, and in 1795 - in the St. Petersburg province. At the beginning of the nineteenth century *Scotia (Agrotis) segetum* caused a great damage in the nonblack-soil belt of Russia and in the countries of Baltia. During the historical period of 1813-1999 there were 22 mass reproductions of *Scotia (Agrotis) segetum* in 1813-1819, 1823-1825, 1836-1842, 1846-1852, 1855-1856, 1867-1868, 1880-1881, 1892-1896, 1899-1900, 1907-1909, 1915-1919, 1923-1925, 1934-1941, 1946-1950, 1955-1957, 1964-1968, 1971-1973, 1981-1984, 1997-1998 and in 2007-2008.
Scotia (Agrotis) exclamationis (Linnaeus, 1758). The mass reproductions of this pest in Ukraine were in 1836-1840, 1843-1844, 1850-1852, 1855-1856, 1860, 1869-1870, 1879-1880, 1893-1895, 1907-1909, 1923-1924, 1936-1940, 1967-1968, 1972-1973, 1976, 1982-1984, 1987, and in 1999-2003.
***Autographa gamma* (Linnaeus, 1758):** In Ukraine the mass proliferations of *Autographa gamma* were registered in 1829, 1833, 1839-1840, 1854 1859-1860, 1864-1865, 1870-1871, 1879-1880, 1888-1889, 1899-1900, 1910, 1912-1913, 1922, 1928-1930, 1946, 1953, 1960 1961 1988, and in 1995-1996.
***Heliotis viriplaca* (Hufnagel, 1766):** In Ukraine during one century (1875-1976) the mass reproductions of this pest was noted in 1875, 1879, 1881-1882, 1886-1888, 1892-1894, 1897-1898, 1904-1905, 1928, 1934, 1945, 1948-1949, 1953, and in 1976-1977.
***Mametstra brassicae* (Linnaeus, 1758):** In Ukraine the outbreaks of this pest mass reproduction took place in 1871, 1878-1879, 1896, 1904-1905, 1908-1909, 1912-1914, 1922-1923, 1927-1928, 1932-1933, 1937-1938, 1956-1957, 1964 -1965, 1969-1970, 1973-1975, 1985-1986, 1990-1991, 1994, 1997-1998, and in 2000-2002.
***Mythimna unipuncta* (Haworth, 1809):** In the Far East its mass reproduction took place in 1926, 1939, 1943, 1950, 1953, 1955, 1966-1967, 1969-1970, 1972-1973, 1975, 1978, 1983, and in 1985.
***Ostrinia nubilalis* (Hubner, 1796):** From 1852 to 2006 in Ukraine there were 11 outbreaks of mass reproduction of this pest. They took place in 1852 1869-1870, 1879-1880, 1886-1887, 1892-1901, 1911-1918, 1929-1934, 1961-1962, 1977-1978, 1986-1996, and in 2006-2008.
***Margaritia sticticalis* (Linnaeus, 1761):** Known from the chronicles the first mass reproduction of this pest in Ukraine was dated 1686 (The Chronicle of the Eye-Witness, 1878, p. 164), the second one occured in 1769. According to the more accurate data its mass reproductions in Ukraine were in 1855, 1869, 1880, 1901, 1912-1913, 1920-1921, 1929-1932, 1935-1936, 1956, 1975 and in 2011-2013.
***Eurygaster integriceps* (Puton, 1881):** In Europe the massive proliferations of *Eurygaster integriceps* are known from the XIXth century, in Asia - from the end of the 1st century A. D. In Iraq during the reign of Harun-ar-Rashid (766-809), a caliph from the Abbasids dynasty, the Arabs went hungry for several years because of the destruction of wheat and barley crops caused by the mites. In Iran, according to the legend information, during the massive proliferations of *Eurygaster integriceps* in 1736 Nadir Shah Afshar (1688-1747) ordered his warriors to burn out the wild growing cereals in the mountain centres of the hibernation of *Eurygaster integriceps* and thus, as the legend said, he saved Iran from the disaster of this pest. If the legend information is true, then in 200 years, namely, in 1936-1937, the massive reproductions of *Eurygaster integriceps* were recured again in the countries of the Middle and Far East, Kazakhstan, the republics of Central Asia, the Caucasus, the Volga region and in Ukraine.
The formation of *Eurygaster integriceps* as a dangerous pest of wheat and barley has been accomplished during several subsequent historical stages. The first stage is the formation of the mites' primary harmfulness centres and, accordingly, the formation of the prerequisites for a focal increase in their number. The second stage is the settling of the mites and the separation of their geographical populations as a result of the agriculture development in the Western and Middle Asia and Transcaucasus, with their subsequent settling in the Southeast Europe, steppe and forest-steppe areas of Asia and Europe.
In Stavropolskyi Krai, according to the data clarified by us, the massive reproductions of *Eurygaster integriceps* took place in 1854-1856, 1865-1867, 1880-1884, 1892-1896, 1901-1905, 1909-1912, 1926, 1937-1941, 1950-1952, 1967-1968, 1984-1986, 1992-1994, 1997, 2003, and in 2007. In 2009 the next outbreak began.
In Rostov region the massive reproductions of *Eurygaster integriceps* took place in 1892-1893, 1901-1905, 1909-1912, 1916, 1923- 1924, 1937-1941, 1948-1949, 1955-1958, 1967-1968, 1984-1986, 1992-1994, and in 1996-2000. In 2009 the next outbreak began.
In republics of Adygea, Dagestan, Ingushetia, Kabardino-Balkaria, Karachaievo-Cherkessia, North Ossetia (Alania), Kalmykia, and in Volgograd region another massive reproduction of *Eurygaster integriceps* began in 2008, in Chechnyia it began in 2007.
In the steppe zone of the Volga region the mass reproductions occurred in 1890-1892, 1900-1905, 1909-1912, 1931, 1937-1941, 1952-1956, 1967-1968, 1972-1973, 1986-1988, and in 1996-2000; in 2008 the next outbreak began.
In the Central Chernozem region of Russia the masses of *Eurygaster integriceps* were in 1890-1894, 1901-1904, 1909-1912, 1937-1941, 1954-1956, 1967-1968, 1984-1986, and in 1996-2000; in 2009 the next mass reproduction began.
The massive reproductions of nine local populations of *Eurygaster integriceps* (Dnipropetrovsk, Donetsk, Zaporozhzhia, Kirovograd, Luhansk, Mykolaiv, Odessa, Kharkiv and Kherson) in Ukraine were in 1890-1896. In 1901-1902, 1909-1912, and in 1925-1926 they took place in Luhansk, Odessa and Kharkiv; in 1937-1941, 1950-1956, 1967-1968, and in 1972-1973 the mass reproductions were noted in Kharkiv and Kherson; in 1980-1984 and in 1992-1995 - in other regions, and in 2008 the next mass reproduction began.

The mass reproductions of the Crimea population of *Eurygaster integriceps* took place in 1870-1871, 1880-1881, 1890-1892, 1916, 1931, 1938-1941, 1955-1958, and in 1997-1998. In 2010 another massive reproduction of *Eurygaster integriceps* began in all administrative districts of the Crimea Autonomous Republic.

According to the information specified by us, the mass reproductions of *Eurygaster integriceps* in the countries of the Middle and Far East were: in Iraq - in 1909-1912, 1920-1921, 1924-1928, 1937-1938, 1943-1949, 1953-1958, 1978-1981, 1986-1991, and in 1997-1998; in Iran - in 1735-1736, 1909-1911, 1920-1921, 1924-1932, 1937-1938, 1943-1949, 1953-1958, 1978-1981, 1986-1991, and in 1997-1998; in Jordan - in 1924-1928, 1935-1938, 1943-1949, 1953-1958, 1989-1992, and in 1997- 1998; in Lebanon - in 1924-1928, 1935-1938, 1956-1958, 1961-1966, 1989-1992, and in 1997-1998; in Palestine - in 1920-1921, 1924-1928, 1937-1938, 1953-1958, 1989-1992, and in 1997-1998; in Syria - in 1909-1914, 1924-1928, 1937-1938, 1953-1958, 1961-1966, 1989-1992, and in 1997-1998; in Egypt - in 1931-1933, 1939-1941, 1956-1958, 1967-1972, 1979-1990, and in 1997-1998; in Turkey - in 1886-1889, 1909-1911, 1927-1930, 1932-1933, 1939-1941, 1956-1958, 1978-1981, 1986-1991, and in 1997-1998.; in Pakistan - in 1940-1946, 1956-1958, 1978-1981, 1986-1991, and in 1997-1998; in Morocco (*Eurygaster austriaca, Eurygaster maura* and *Eurygaster integriceps)* - in 1932-1934, 1940-1947, 1953-1955, 1967-1990, and in 1997-1998.

In Kazakhstan the massive proliferations of *Eurygaster integriceps* occured in 1901-1905, 1907, 1913, 1915, 1918, 1920-1922, 1924-1928, 1940-1943, 1961-1966 1986-1988, and in 1997-1998; in Kyrgyzstan - in 1901 -1905, 1907, 1913, 1915, 1918, 1920-1922, 1924-1928, 1939-1943, 1961-1966, 1986-1988, and in 1997-1998; in Uzbekistan - in 1901-1905, 1909-1913, 1915, 1918, 1920-1922, 1924-1928, 1939-1943, 1961-1966, 1986-1988, and in 1997-1998; in Tajikistan - in 1901-1905, 1907, 1909-1912, 1915, 1918, 1920-1922, 1924-1928, 1939-1943, 1961-1966, 1986-1988, and in 1997-1998; in Turkmenistan - in 1900-1905, 1907, 1909-1913, 1915, 1918, 1920 1921 1924-1928, 1939-1943, 1961-1966, 1986-1988, and in 1997-1998.

In the Palearctic realm the mass reproductions of this pest took place in 1854-1856, 1865-1867, 1880-1886, 1890-1896, 1900-1905, 1909-1914, 1920-1922, 1924-1928, 1931-1933, 1937-1943, 1948-1957, 1964-1970, 1972-1981, 1984-1991, 1996-2003, and in 2008-2010.

The mass reproductions of *Eurygaster austriaca, Eurygaster maura* and *Eurygaster integriceps* in Bulgaria, Hungary, Germany, Italy, Poland, Portugal, Romania, Czechoslovakia and Yugoslavia were in 1929-1933, 1950-1956, 1964-1970, 1977-1981, 1984-1986, 1996-1998, and in 2008-2010.

***Zabrus tenebrioides* (Geoze, 1777):** During the period from 1860 to 2001 in the Steppe and Forest-Steppe zone of Ukraine there were 13 mass reproductions of this pest in 1860-1864, 1880-1881, 1903-1905, 1923-1925, 1937-1941, 1947-1948, 1951-1953, 1957-1959, 1961-1963, 1966-1967, 1979-1982, 1991-1993, and in 2003-2007.

***Mayetiola destructor* (Say, 1817):** From 1847 to 2000 the massive reproductions of *Mayetiola destructor* in Ukraine were in 1847-1848, 1852 1855-1856, 1874-1876, 1879-1881, 1896-1898, 1900-1903, 1906-1911, 1923-1925, 1930-1932, 1936-1938, 1947-1948, 1952-1955, 1961-1963, 1968-1969, 1972-1973, 1979-1980, 1986-1987, 1991-1992, and in 2000-2003.

***Oscinella frit* (Linnaeus, 1758):** *Oscinella frit* severely damaged the grain crops in the western part of Latvia from 1825 to 1837, in Germany and Poland - from 1867 to 1870. In Ukraine its mass reproductions took place in 1880-1882, 1890-1892, 1902-1903, 1907-1909, 1911-1912, 1923-1925, 1930-1932, 1949-1953, 1961-1962, 1972-1975, 1985-1986, 1991-1992, and in 2000-2003.

***Anisoplia austriaca* (Herbst, 1783):** In Ukraine for the period from 1841 to 1996 there were registered 17 mass reproductions in 1841-1842, 1845-1846, 1856-1857, 1860-1861, 1868-1869, 1879-1880, 1886-1887, 1896-1903, 1906 1910 1915-1917, 1924-1925 1936-1939, 1956-1957, 1962-1964, 1966-1969, 1980-1984, and in 1996-2007.

***Apamea sordens* (Hufnagel, 1766):** In the Forest-Steppe zone of Ukraine the massive reproductions of this pest were in 1871, 1881, 1885-1887, 1896, 1911-1913, 1923-1924, 1933, 1939-1940, 1946-1947, 1950-1951, 1960, and in 1963-1965.

***Apamea anceps* (Denis & Schiffermüller, 1775):** The mass proliferations of *Apamea anceps* were noted in Northern Kazakhstan in 1887-1888, 1901-1903, 1911-1912, 1924-1926, 1937-1939, 1949-1951, 1957-1959, 1965-1966, 1969-1970, 1974-1975, 1980-1981, 1992, and in 2003-2004.

***Amphiposa fucosa* (Freyer, 1830):** The mass reproductions in Ukraine were in 1877-1879, 1886-1887, 1889-1892, 1913-1914, 1929-1932, 1960, and in 1986-1989; in Tatarstan - in 1877-1881, 1885, 1960, and in 1986-1987; in the south of Moscow region they took place in 1913-1914.

***Oria musculosa* (Hubner, 1808):** In the Steppe zone of Ukraine the mass reproductions occurred in 1882, 1884, 1886-1889, 1891-1896, 1898-1902, 1910-1913, and in 1931-1933.

***Cerapteryx graminis* (Linnaeus, 1758):** The caterpillars of this pest damage rye, oats, and barley and meadow grasses. In Ukraine (Forest-steppe and Polissia) they caused the damages in 1842, 1847-1849, 1854-1855, 1866-1867, 1878, 1880, 1882, 1886-1889, 1896, 1912, 1919, 1923, and in 1926-1928. In the northern districts of Karelia and in the Leningrad province these caterpillars caused the damages in 1924-1927; in 1907 they were noted in Finland. Earlier this pest was noted in 1866-1867, 1880-1881, 1882-1883, 1885-1886, 1891-1893, 1896-1897, 1914-1916, 1920-1921 and in 1925-1926. In 1890-1891, 1911-1916 and in 1921 it was noted in Sweden, in 1899, 1911 and in 1917 - in Norway, in 1917 and in 1919 - in England, in 1923 - in Denmark, in 1917 - in Scotland, in 1923-1924 and in 1928 - in Germany, in 1915 - in Austria-Hungary. In the Baltic State of Kurliandiia *Cerapteryx graminis* caused the damages in 1854; in the environs of Lītava it was noted in 1829. In Riga and Revel *Cerapteryx graminis* together with *Agrotis segetum* destroyed the crops of peas. The damages of flax and peas were known in 1787.

***Oulema melanopus* (Linnaeus, 1758):** Over the past 118 years the mass reproductions of *Oulema melanopus* in Ukraine took place in 1878-1880, 1882, 1894-1895, 1907-1910, 1912-1914, 1934-1935, 1938-1939, 1952, 1955-1956, 1962-1963, 1971- 1972, 1983-1988, and in 1995-1996.

Cephus pygmaeus **(Linnaeus, 1767):** The mass reproductions of this pest in Ukraine took place in 1850, 1870, 1875 1878 1880-1883, 1887-1888, 1893-1895, 1902-1903, 1907-1910, and in 1912-1914. In the last century this pest was in the depression, and its number did not exceed the economic threshold of harmfulness.

Chlorops pumilionis **(Bjerkander, 1778):** In Ukraine (mainly in Polissia) the massive reproductions were in 1879-1881, 1887-1888, 1923-1924, 1952-1954, 1956-1957 and in 1962-1963.

Opomysa florum **(Fabricius, 1794):** In 1829, 1968-1969, 1980-1984, 1986-1987, and in 1990-1991 the mass proliferations of *Opomysa florum* took place in Polissia.

Acyrthosiphon pisum **(Harris, 1776):** The mass reproductions of this pest in Ukraine were noted in 1903-1905, 1911, 1913-1914, 1923, 1926, 1929, 1931-1932, 1937, 1963-1964, 1973 and in 1986.

Chaetocnema sp**: (Stephens, 1831):** The mass reproductions of this pest in Ukraine were noted in 1841-1842 1852, 1858, 1878-1880, 1922, 1933, 1946-1947, 1953-1954, 1958-1959, 1968-1969, and in 1990.

Cassida nebulosa **(Linnaeus, 1758):** The mass reproductions of this pest in Ukraine were noted in 1834, 1841, 1859, 1871, 1878, 1897, and 1903, 1911-1912 and in 1915.

Cassida viridis **(Linnaeus, 1758):** Its mass reproductions in Ukraine occurred in 1840-1841, 1859-1860, 1871, 1878, 1897, 1903, and in 1911-1912.

Asproparthenis punctiventris **(Germar, 1824)**: The mass proliferations of *Asproparthenis punctiventris* in Ukraine were in 1851-1855, 1868-1869, 1875-1877, 1880-1881, 1891-1893, 1896-1897, 1904-1906, 1911-1912, 1920-1922, 1928-1930, 1936 - 1940, 1947- 1949 1952-1957, 1963-1964, 1973-1976, 1986-1988, 1998-200, and in 2010-2012.

Plutella maculipennis **(Linnaeus, 1758):** The mass reproductions of this pest in Ukraine were noted in 1908, 1914-1916, 1923, 1928, 1938, 1946, 1952, 1958, 1964, 1970-1972, 1976-1978, 1987-1988, and in 1995-2000.

Pieris brassicae **(Linnaeus, 1758):** In Ukraine the mass reproductions of this widespread pest took place in 1846-1847, 1851-1852, 1854-1855, 1862, 1866, 1868, 1910, 1913, 1927, 1931-1932, 1936-1937, 1947-1948, 1981-1982, 1991-1992, and in 2001-2002.

Athalia rosae **(Linnaeus, 1758):** The mass reproductions of this pest in Ukraine were noted in 1756, 1760, 1782, 1806, 1818, 1833, 1835-1836, 1838, 1866, 1878-1879, 1889, 1895-1896, 1922-1924, 1925-1928, 1956, and in 1978-1979.

Rhynchites auratus **(Scopoli, 1763):** The mass reproductions of this pest took place in 1903, 1913-1914, 1916-1917, 1924-1925, 1937-1941, and in 1947-1949.

Aporia crataegi **(Linnaeus, 1758):** The mass reproductions of this pest occurred in 1838-1839, 1849-1853, 1859-1860, 1867-1869, 1896-1897, 1906-1907, 1910-1911, 1916-1917, 1923-1925, 1933-1934, 1946-1948, 1954-1956, 1966- 1967 1980-1983, 1993-1994, and in 2003-2004.

Yponomeuta malinellus **(Zeller, 1838):** The mass reproductions of this pest were noted in 1843-1845, 1857-1858, 1874-1875, 1884-1885, 1894-1896, 1903-1905, 1916-1919, 1924-1925, 1934-1936, 1946-1948, 1957-1959, 1965-1967, 1973- 1975, 1985-1987, and in 1994-1996.

Malacosoma neustria **(Linnaeus, 1758):** Its mass reproductions took place in 1826-1829, 1838-1839, 1843-1844, 1849-1850, 1856-1857, 1862-1866, 1882-1883, 1889-1890, 1903-1907, 1915-1916, 1923-1925, 1933-1936, 1947-1948 1956-1957, 1967-1968, 1977-1978, 1987-1988, and in 1998-1999.

Cydia pomonella **(Linnaeus, 1758):** The mass reproductions of this pest took place in 1855-1856, 1868-1869, 1879-1880, 1885, 1888-1890, 1894-1896, 1898-1899, 1936-1937, 1950-1952, 1955-1956, 1960-1961, 1986-1987, 1993-1996, and in 2007-2008.

Operophthera brumata **(Linnaeus, 1758):** The mass reproductions of this pest took place in 1844-1845, 1848-1850, 1856, 1868-1869, 1880-1881, 1892-1893 1903-1904, 1911-1912, 1948-1951, 1953-1954, 1960-1965, 1967, 1972-1977, 1979-1980, 1986, 1993-1994, and in 1999-2001.

Tortrix viridana **(Linnaeus, 1758):** The mass reproductions of this pest took place in 1853-1854, 1864, 1875, 1886, 1906-1910, 1923-1925, 1929, 1947-1949, 1952-1954, 1961-1964, 1966, 1968, 1972-1975, 1983-1984, 1986-1988, 1992, 1996-1998, and in 2000.

Euproctis chrysorrhoea **(Linnaeus, 1758):** The mass reproductions of this pest took place in 1841-1842, 1847-1848, 1855-1856, 1859-1860, 1862-1863, 1867-1868, 1880-1881, 1885-1888, 1896-1897, 1907-1909, 1912-1913, 1920-1921, 1924-1925, 1929-1930, 1933-1934, 1937-1941, 1948-1951, 1958-1959, 1965-1967, 1971-1973, 1983-1984, and in 1997-2000.

Ocneria dispar **(Linnaeus, 1758):** The mass reproductions of this pest took place in 1837-1839, 1841-1842, 1850-1852, 1859-1863, 1868-1871, 1879-1880, 1886-1887, 1895-1898, 1907-1910, 1912-1914, 1920-1923, 1931-1936, 1942- 1944, 1948-1952, 1956-1957, 1964-1968, 1972-1973, 1982-1983, and in 1995-1997.

Ocneria monacha **(Linnaeus, 1758):** The mass reproductions of *Ocneria monacha* took place in 1846-1849, 1851-1852, 1855-1860, 1863-1867, 1889-1892, 1905-1907, 1925-1927, 1937-1942, 1946-1950, 1952-1960, 1978-1980, 1987-1988, and in 1999-2000.

Dendrolimus pini **(Linnaeus, 1758):** The mass reproductions of this pest occurred in 1839-1842, 1850-1854, 1863-1870, 1875-1877, 1883-1884, 1890-1891, 1896-1899, 1902-1904, 1913-1915, 1923-1925, 1937-1941, 1947-1948, 1961-1962, 1971-1973, 1977-1978, 1983-1988, and in 1995-1998.

Dasychira pudibunda **(Linnaeus, 1758):** The mass reproductions of this pest occurred in 1853-1855, 1867-1868, 1883-1884, 1901-1902, 1917-1918, 1926-1928, 1932-1933, 1940-1941, 1953-1955, 1964-1965, 1968-1970, 1980-1981, 1986-1989, and in 1997-1999.

Phalera bucephala **(Linnaeus, 1758):** The mass reproductions of this pest occurred in 1875, 1893-1894, 1941-1942, 1945-1946, 1953-1954, 1958-1959, 1962, 1966, 1968, and in 1972.

***Panolis flammea* (Denis & Schiffermüller, 1775):** The mass proliferations of *Panolis flammea* were noted in 1825-1827, 1888, 1892, 1912, 1922-1925, 1930-1931, 1938-1940, 1946-1947, 1957-1959, 1962-1964, 1973-1975, 1983-1985, and in 1997-2000.

***Bupalus piniarius* (Linnaeus, 1758):** The mass proliferations of *Bupalus piniarius* were noted in 1869-1872, 1875-1880, 1890-1896, 1914-1915, 1918-1919, 1923-1925, 1937-1941, 1947-1948, 1956-1957, 1961-1966, 1971-1972, 1975-1980, 1988-1992, and in 1995-1999.

***Diprion pini* (Linnaeus, 1758):** The mass proliferations of *Diprion pini* were noted in 1838-1839, 1842-1844, 1848-1849, 1854-1855, 1875-1876, 1883-1884, 1887-1891, 1899-1900, 1903-1904, 1910-1911, 1926-1930, 1932-1933, 1936-1938 1941-1943. 1947-1950, 1956-1957, 1966-1968, 1978-1972-1973, 1975-1976, 1978-1980, 1983-1984, 1991-1994, 1997-2000, and in 2002-2005.

***Neodiprion sertifer* (Geoffroy, 1785):** The mass reproductions of this pest took plce in 1880-1881, 1886-1887, 1893-1894, 1907-1908, 1917-1918, 1922-1924, 1934-1937, 1945-1948, 1950-1955, 1958-1960, 1964-1966, 1972-1973, 1975- 1976, 1978-1980, 1983-1984, 1991-1994, 1995-2000, and in 2009-2010.

As it can be seen from the above-mentioned chronology of mass reproduction of the certain types of harmful insects, the outbeaks in number are often of a random character, and their frequency is from 2-3 to 1000 years. Such data can not explain the theories based on the dependence of the number of insects on the hydrothermal coefficient or the availability of the fodder plants (Poliakov, 1964). In the twentieth century the theoretical concepts, called by H.A. Viktorov (Viktorov, 1967) as a stochasticism and regulatsionism were popular among the ecologists; and he considered the current stage of the researches in the population dynamics as a searching for the mechanisms of the number regulation. In the twenty-first century the necessity for the theoretical synthesis in the insects' ecology has arisen. This synthesis should predict the appearance of a new theory, in which the limitations of the old theories are dialectically removed (Biletskyi, 2011, Biletskyi & Stankevych, 2018). This article is one of the first steps in creating the theory that will explain the recurrance and cyclic character of the mass reproductions of insects. To do this task the synergistic synthesis which takes into account the systemic regularities of the insects' development and interaction with the systems of the organizations of higher level is necessary. It also should take in account the illinearity of the population dynamics and chaos, as well as the aggravated regimes and the limited prognoses.

Discussion

The theories that explain the regularities of the population cycles: For many decades the problem of the insects' mass reproduction has taken one of the central places in the environmental researches all around the world**.** However, up to the present time the frequency of the mass reproductions outbreaks of certain types of harmful insects remains the subject of reflection, and the laws of the insects' reproductions are almost not studied (Biletskyi, 2011, Biletskyi et al., 2017, Biletskyi & Stankevych, 2018).

The recurrence of many years insects and other animals mass reproductions was observed long ago, but the natural character of this phenomenon was first shown by F.P. Keppen (1833-1908) (Keppen, 1870) at the example of the analysis of the massive appearance and migration of harmful locusts in Russia and the European countries in the period from 592 to 1866.

In the mid-twenties and in the early thirties of the twentieth century, based on the analysis of the historical data, the ecologists put forward the theoretical ideas about the frequency of the mass reproductions (rodents and insects), their relationship and interaction with the cycles of the solar activity, climate and natural enemies (zoophagous and entomophagous). Several different theories were proposed to explain the causes of the cyclic oscillations. They are the meteorological theory, the theory of random oscillations, the theory of the interaction between the populations (a predator - a victim and a parasite - a host) and the theory of the trophic levels (Odum, 1986).

However, all the attempts to link the cyclic fluctuations of numbers with the climatic factors are still remain unsuccessful (Odum, 1986).

The issue of the connection of the population cycles of insects and other animals with a long-term dynamics of the solar activity has long been discussed in the environmental literature.

This question, which has grown into the theoretical problem about the possibility of using the indicators of the latter as a criterion for predicting the appearance of the agricultural crops pests, has always affected the basis of the population dynamics theory (Biletskyi, 2011).

The first attempt to establish a connection between the massive reproductions of the insects belonged to F.P. Keppen (Keppen, 1870). After analyzing the mass reproductions and migrations of the harmful locusts in Russia and in the European countries for almost 1300 years historical period, he compared them with the long-term dynamics of the sun-spots and came to the conclusion that the periods with the particularly significant reproductions and subsequent migrations of the locust species in most cases had begun during the epochs of the minimum solar activity, in a year after the minimum or one year before it.

According to his data, the immense outbreaks of the locust populations took place in 1333-1339, 1689-1693, 1800-1806, 1822-1829, and in 1855-1862. These periods lasted for several years and ended on the sixth or seventh year after the minimum of the sun-spots (Keppen, 1870).

Half a century later M.M Kulagin (1860-1940) (Kulagin, 1921) turned to this problem again. Having systematized the historical materials as for the mass reproductions of the locust in Russia and some countries of Europe in the XVIIIth and XIXth centuries and compared them with the dynamics of the sun-spots, he came to the conclusion that the frequency in the dynamics of the number of the locusts is absent. This is due to the complexity of those factors that determine the dynamics of their populations. The mass breedings of the locust are more often observed in warm years and not in cold ones, although there are some exceptions (Kulagin, 1921).

In 1930, summarizing the chronicles of *Pyrausta sticticalis* mass reproductions in the central chernozem areas for the period of 1854-1929, M.M. Konakov also established the fact of their coincidence with the dynamics of the solar activity. For 61 years, from 1854 to 1915, the outbreaks in the number of this pest occurred five times (1855, 1867, 1889, 1901 and 1912), with the strict adherence to the minimum of the sun-spots or in the year preceding it. Only in 1878 (the year of the minimum), there was no *Pyrausta sticticalis*, but *Acridoidea, Anisoplia austriaca, Autographa gamma, Ocneria dispar* and *Dendrolimus pini* appeared in a great number. Beginning from 1916 to 1922, the outbreaks in number of *Pyrausta sticticalis* and *Locusta migratoria* were observed annually, and only in 1922 the mass reproductions of *Autographa gamma* and *Yponomenta malinellus* were noted (Konakov, 1930).

Since the middle of the fifties of the twentieth century the problem of the solar-induced outbreaks of the insect numbers concerning *Schistocerca gregaria* was especially intensively developed by M.S. Shcherbynovskyi (1891-1964). As M.S. Shcherbynovskyi pointed out, the cyclic character is one of the characteristic aspects in the life and reproduction of *Schistocerca gregaria*. According to his data, the outbreaks of this pest reproductions occurred 13 times over 150 years and repeated with the average intervals between the maximum outbreaks in 11,5 years. In addition, the synchronousness in the bases, process and extinction of the outbreaks in the number of *Schistocerca gregaria* on the vast territory of two continents, from India to Morocco was observed. These facts indicate that the proliferations of *Schistocerca gregaria* depend not only on the ecological conditions of its habitats, but also on some processes that cover the whole continents and cause more or less similar changes in the ecological environment in the permanent reservations of the pest, remoted from one another to tens of thousands of kilometres. According to M.S. Shcherbynovskyi (Shcherbynovskyi, 1952) the main reason for the cyclic nature of *Schistocerca gregaria* mass reproduction is the change in the solar activity that affects the dynamics and the circulation regime of the atmosphere and, accordingly, the weather in the zone of the primary centres of this pest reproduction. *Schistocerca gregaria* reacts upon these very changes with the cyclic recurrence of the reproductions and migrations of the flocks, flying thousands of kilometers from their primary centres. The author believed that under the conditions of savanna, desert and semi-desert, the form of *Schistocerca gregaria* existence and migration of its flock evolved during each year as well as during the cycles of its mass reproduction that could be evaluated as a reaction of the species to the geological course of the rhythms of weather conditions in the desert zones of their main natural habitat.

M.S. Shcherbynovskyi (Shcherbynovskyi, 1952) wrote that during the monsoon period in the arid districts of the tropical zone the rapid growth of the vegetation begins, which in turn leads to a sharp increase in the number of the locusts, to the formation of the last flock form that carries out the long-distant migrations. He proved that the migration has the same cycles as the solar activity. Along with it he denied emphatically all the anti-scientific explanations of the reasons for the temporary mass reproductions and extinction of the insects as the self-regulation of the species life of the organisms or the “dynamic equilibrium” between the “hosts” and their parasites. With the help of the dialectical methods Shcherbynovskyi tried to disclose the material causes of the observed natural phenomena. He proposed to lift up from the earth surface to the air where the energy that goes to us from a single energy source of our planetary system, the Sun, is transformed” (Shcherbynovskyi, 1952).

Later, in the 60's of the twentieth century M.S Shcherbynovskyi developed the idea that the outbreaks in the number of all harmful insects depend on the Sun activity, and in order to improve the methods of their mass reproductions forecasting he recommended to consider the trinominal dependence and conditionality. They are as follows:

- the rhythm of the solar activity variability;
- the regime of the atmospheric circulation, which is subordinated not only to the rotation of the Earth around the axis, but also to the pulses of wave and corpuscular radiation of the Sun;
- the ecological changes in the biocoenoses caused by the unsteady spatial and temporal seasonal changes in the weather regime under the influence of the solar and human activities.

The main works of M.S. Shcherbynovskyi made a significant contribution to the substantiation of the problem “The Sun - Biosphere”. At one time they were appreciated by O.L. Chyzhevskyi (1874-1977) (Chizhevskyi, 1995).

However, at that time these works did not obtain the recognition among the entomologists, mainly because the natural history didn’t possess the convincing evidencies of the real links between the Earth and the outer space. This problem was very complicated and not very familiar to the ecologists (Benkevych, 1948).

The detailed investigations of the changing regularities in the number of *Ocneria dispar* were made by V.I. Benkevych (Benkevych, 1984). He analysed the chronicles of this pest mass reproductions in the European part of the USSR for the period of 100 years and showed their connection with the solar activity, circulation regime of the atmosphere, weather and climate. As it was established by the author, most of the outbreaks in the number of *Ocneria dispar* took place at the stage of decline and during the minimum of the 11-year cycles of the solar activity, or in 2, 3, and 4 years after the maximum index of the reccurent processes and the maximum of the meridial processes of the atmospheric circulation development, namely in May, June or in November - March. The solar activity creates a cyclic background of *Ocneria dispar* massive reproductions, and it is not an ordinary modifying factor. The regulatory role of the Sun activity is manifested in regulating the influence power of other modifying factors and giving them a peculiar cyclic recurrence (Benkevych, 1984).

Acridologist A.N. Dobretsov (Dobretsov, 1967) also believed that there was a close connection between the population cycles of the locust and the solar cycles. Thus, analyzing the cyclic recurrence of outbreaks in the number of the solitary locusts’ species in the Krasnoiarskyi Krai, he came to the conclusion that they had the relationship with the droughts, which in this region mainly happened in the ninth or tenth years of the eleven-year solar cycle.

Many foreign ecologists associated the outbreaks of the harmful insects' massive reproductions with the cyclic recurrence of the solar activity (Biletskyi, 2011).
However, the hypothesis of the solar-terrestrial relationship between the harmful insects' mass reproductions and the solar activity was not recognised by the well-known Japanese ecologist K. Miiashita. He denied the frequency of the harmful insects' mass reproduction and their conditionality by the Sun. He showed the demonstrative results of his researches with a detailed analysis of the long-term (over 60-70 years) changes in the number of 12 species of pests of the agricultural and forest plants in different regions of Japan (Miiashita, 1963). The main conclusion of the author is that the outbreaks of the mass reproductions for most kinds of pests are irregular, and their duration varies. The exception is only the gregarious locusts, which dynamics number coincides with the changes in the solar activity of many years. The mass proliferations of the forest pests and the dynamics of the Sun activity in different regions of Germany are asynchronous; such a conclusion is made by the German ecologist D. Klimetzek (Klimetzek, 1976).
As we think, the main reason for the scepsis lies in the outdated methodological approach to assessing the cyclic character of the population dynamics, which consists of an unambiguous explanation of this complex environmental process, an attempt to bring the changes in number to one or more environmental factors, and to distinguish the main one among them; but such factor can not exist according to the systemic approach.
The linear approach to explain the characteristics of the solar activity and its terrestrial manifestations is also an important reason of the contradictions presented in the ecological literature. One more popular reason is misunderstanding of the fact that in the self-organised systems of populations, biogeocoenoses and biosphere there are direct and indirect connections that provide the hierarchy, interaction, synchronization and homeostasis of these systems. According to modern imaginations the solar activity is a complex open system with strange attractors and chaos; it has a sensitivity to the initial conditions, and its index W (Wolf number) is measured quite roughly; so one can expect only the forecasting of several long-term vibrations of the solar activity (Malinetskyi, 1997).
That is why the opponents' indications as for the lack of analysis and the confirmation of the connection between the Sun and environment are true (Viktorov, 1983).
In this regard H.A. Viktorov (1925-1974) (Viktorov, 1983) wrote that "the establishment of a connection between the fluctuations in the number and the rhythm of the solar activity requires more substantiated evidences based on the clarification of causal relationships, but not on a simple statement of the cyclic character with a certain average period of the fluctuations".
Naturally, this circumstance caused some scepticism in a part of domestic and foreign ecologists, even in those cases where the solar-ecological synchronization was established on the basis of a qualitative model.
In one time Yu.I. Vitynskyi (1926-2003) successfully described the situation in heliobiology. He pointed out that there were more sceptics than the adherents of that theory, who thought about the reality of the solar activity influence on the biosphere; especially it concerned the biologists and physicians.
We think that to some extent this is explained by the fact that the researchers of the connections between the Sun and the Earth often identify the terms of periodicity, rhythm and cyclic character (Vozovik, 1970). In order to clearly differentiate these notions and the necessity for a theoretical substantiation of the insects' mass reproductions regularities we consider it necessary to use such terms and notions in our general conclusions and studies.
A cycle is a complete or incomplete (interrupted) process which elements (phases, stages, steps, etc.), following one after another or in their turn, form a single row or a single whole.
A cycle character is the presence or existence of a cycle or cycles in the development (or structure) of something.
A rhythm is a regular (uniform) alternation, passing (correlation) and (or) recurrence of any elements characteristic to the development and proceeding of any system in space and time.
A rhythmical pace is the presence of a rhythm in the development (or structure) of something. The rhythm and rhythmical pace are manifested not only in their combination, alternation and recurrence of the cycles, but also in the cycles themselves and within them. It is not quite correct to bring the meaning of the term "rtythm" only to the uniform recurrence and periodicity. Despite its widespreading the periodicity is only a special case of the rhythmical pace. So, the rhythm is the most common property of inanimate and living matter organization; and the manifestation of its regularities is unlimited.
A period is the interval of time (or another dimension) during which something is happening (beginnig, developing and ending). Thus, the cycle period is a period of time during which it is proceeding (from its beginning to the end).
A periodicity is a regular (including uniform) recurrence of any (completed) phenomena, processes (cycles) in time and (or) in space through certain but necessarily equal units of any measurement system. The authors briefly formulated the difference between the notions of the cycle, rhythm and period as follows: the cycle is a process and a phenomenon; the rhythm is its characteristic, internal organization, and structure; the period is the measure (in any units of measurement) of the process and the phenomenon from the beginning to the end.
In many respects such a description of the processes and phenomena, occurring in the inorganic and organic world, is in a harmony with the dialectical concept of the development, according to which the recurrence (cyclic character) is a necessary sign of any law, the presence of the internal legitimity in the processes and phenomena and it has the objective character.
According to the scientists, the biological processes and phenomena are of a cyclic character. On the one hand their cyclic nature is explained by the constant influence of the external cosmic factors, and on the other - by autofluctuations inherent in any material system (Ivanytskyi, 1997; Chizhevskyi, 1995).
The theories explaining the seasonal and annual changes in the number of insects: The historical registers about the regularities of the insects' number dynamics are not numerous and they are fragmentary. The earliest studies of the ecology

of insects were made by the French naturalist R. Reaumur (1683-1757). In his paper, published in 1735, the naturalist describes the original observations about the influence of some environmental factors on the development of the insects. In the same year for the first time Reaumur described the mass appearance of *Autographa gamma* in France, and during the next few years he performed a number of observations on the development of the insects at different temperature regimes. Reaumur is the author of the classical studies of parasitism among the insects and he is rightfully considered the founder of the parasitic and meteorological concepts of the insecsts' population dynamics.
With the invention of the thermometer the temperature has become the most obvious factor in the environment; and it is naturally that the first studies in the field of the insects' ecology primarily were devoted to this factor.
The earliest observations of the influence of the upper temperature limits on the ontogenesis and survival of insects were performed by O. Byutchli (1848-1920) in 1874 and by F. Graber (1844-1892) in 1887 (Biletskyi, 2011, Biletskyi & Stankevych, 2018).
At the beginning of the XIXth century revealing the reaction of insects to various changes in temperature, precipitation, relative humidity of air and various combinations of the latter became the basis for the formation of the climatic concept for the insects' number regulation.
In the middle of the nineteenth century two theoretical concepts of the population dynamics were formulated simultaneously. They are "the moving equilibrium" concept (Spencer, 1858) and the trophoclimatic one, formulated by K.F. Rouille (1814-1858). Their essence and conceptual foundations are described in the review of I.Ya Poliakov (1912-1992), who showed the formation of the basic theoretical ideas about the dynamics of the populations in the historical aspect.
The theory of the evolution by Charles Darwin (1809-1882) (Darwin, 1937) became the real scientific one. According to Charles Darwin the number of animal and plant organisms fluctuates in the natural environment more or less regularly, depending on the environmental and population changes; and like other biological systems, the basis of these fluctuations is the self-regulation of the populations. Despite the fact that Charles Darwin shared the views of T. Malthus (1766-1834) on the volatility of the populations' number, he emphasized the logical nature of this process and laid the foundations for the development of modern population ecology and biology in general. "Later this theory was modified and interpreted on the basis of Genetics regulations; and now it is the very core around which all modern Biology is built" (Mayr, 1982).
The main regulations of Darwin's evolutionary theory, especially which concern the populations' dynamics, have become a powerful incentive for further studies of the population ecology, the development and improvement of the theoretical ideas about the dynamics of the animals' number. The problem of the populations' dynamics soon became one of the most important in the ecological researches.
In the late 30s and in the early 40s of the twentieth century the domestic and foreign scientists simultaneously formulated the factorial dynamics of the populations, namely the parasitic, biocoenotic and the climatic ones. The main theses an the critical analysis of the above-mentioned theories are given in the monograph by Ye.M. Biletskyi (Biletskyi, 2011).
A characteristic feature of these theories was a clandestine attempt to fully explain the causes of the fluctuations in the number of any organisms by their reaction to any abiotic factors. A.M. Giliarov (1943-2013) (Giliarov, 1981) qualified such an approach to ecology as "outecological reductionism". As the author points out, the latter was a progressive methodology and prevailed in ecology until about the sixties.
In the 50s of the twentieth century at the example of the mouse-like rodents I.Ya. Poliakov formulated a theoretical conception of changing the viability of the populations in the process of their number gradation. Its essence lies in the fact that the viability of the population in the given period (its structure, physiological condition of separate age groups, the pace of development, reproduction intensity, survival, and resistance to various adverse factors) is determined by those conditions in which the age groups that constitute it, developed in the past. The author of this concept believes that the populations are differed not only in age composition, the ratio of sexes, and body proportions, but also in the nature of the reactions to the same environmental factors. This variability is formed under the direct influence of the nutritional conditions and climatic factors in which the individuals undergo the separate stages of ontogenesis or under the influence of the corresponding age fractions of the populations. Poliakov believed that the pests of the agricultural crops belonged to such groups of animals for which the physical factors and the forage reserve of the environment had a decisive importance in the dynamics of the populations. The morphophysiological properties of the populations, their reactions to the energy resources and climatic factors, the nature of the intrapopulation and intraspecies relationships and the importance of the latter for the trends in the population changes are formed under the influence of these factors. The basic and fundamentally new provision of this theory is that it allows us to judge in advance the dynamics of the number and the probable factors that can affect it, to appreciate the state of the forage reserve, the physical environment and the morphophysiological properties of the population; and this makes this theory acceptable for solving the problems of the forecasting (Poliakov, 1976).
In the last years of the twentieth century the theoretical concepts called by H.A. Viktorov (1925-1974) (Viktorov, 1983) as stohastizm and reguliacionizm were popular among the domestic and foreign ecologists; and the current stage of the researches in the populations dynamics was called by him as the search for the mechanisms for the number regulation.
The adherents of the first direction considered the effects of environmental factors on the population to be of a random nature. The combinations of different factors determine the changes in the number of the insects (ups and downs); and a favourable combination of the conditions that determine the rise in the number is observed in nature very seldom unlike the unfavourable one.
The representatives of the second direction consider the fluctuations in the number as a regulated process. They believe that the number random changes, caused by the direct or indirect effects of abiotic (mainly physical) factors, are indemnified for the activity of the regulatory mechanisms that are controled by the changes in the population density based on the principle of the negative feedback. As the adherents of the reguliacionizm think, the biotic factors of the environment, responding to

the changes in the number of other organisms, can play this role.

According to the ideas of most modern ecologists, the change in the number of insects is considered as the interaction of various mechanisms. H.A. Viktorov divided them into modifying and regulating ones. He related the climatic and other geographical factors of the environment to the modifying mechanisms; the natural enemies (parasites, predators and pathogens), the intraspecies relations (competition) as well as the trophic factors (quantity, quality and availability of food) he reckoned to the regulating mechanisms.

More than seven decades ago the trophic theory of the populations' dynamics was formulated on the basis of example of the forest insects. The founder of this theory D.F. Rudniev (1902-1987) considered the number and quality of food as the main factor in the dynamics of the number of the stem- and needle-feeding insects. According to this author the weather and other environmental factors have an indirect effect on the number of populations through the condition of the forage crops. He wrote that "...they can only accelerate or slow down the growth rate of the population, which main direction is determined by the physiological condition of the plants themselves".

In the late 60s and in the early 70s of the twentieth century P. M. Rafes (1903-1991) substantiated the biogeocoenotic theory of the dynamics of the forest insects' population. Its conceptual basis is the dependence of the formation and size as well as the changes in the population on the biogeocoenosis as a supersystem, and the interdependence between the previous (a plant) and the following (a phytophagus) links in the nutrition chains. In accordance with this theory the population together with the factors regulating its number is a dependent system, namely it is a separate element in the biogeocoenoses. In this case the state of the population and the changes it undergoes are determined by the flow of the matter passing through it along the nutrition chains and carries out the circulation of matter in the given biogeocoenosis (Rafes, 1978). At the example of *Ocneria dispar* P.M. Rafes concluded that the mass reproduction of any herbivorous insects is a sign of the fact that the rate of its nutritional resource delivery has increased since the quality of the fodder became better and the possibility of its consumption also has increased (for example, due to the weather). So, the autrhor thinks that the circulation of matter and the flow of energy in the biogeocoenosis determine the productivity (number) of each population, and thus the ratio of the number of partners in relation to the trophic links.

Evaluating the biogeocoenosis theory of P.M. Rafes as an attempt to the systemic approach to the population dynamics analysis, one should admit that it was one of the variants of the trophic theory (Biletskyi, 2011; Biletskyi & Stankevych, 2018).

Conclusions

The insects' populations are a complex open biological system with the chaotic illinear dynamics in space and time. In this regard the prediction of the insects' future development is not an easy task. The emergence of the parasitic, climatic, trophic and other theories has become a legitimate historical stage of the ecological researches; these researches respectively reflected the methodology of a certain period of the populations' ecology development. The existence of the theories explaining the dynamics of the populations on the basis of their interaction with one or two factors of the environment can only be temporary, because the facts that exceed the limits of these theories are continuously accumulating. The necessity for the theoretical synthesis that will be able to predict the emergence of a new theory has been riped in the ecology of the insects. The limitations of the former theories should be dialectically removed in the new ones (Bestuzhev-Lada, 2000). Any really scientific theory must perform the descriptive, explanatory, synthesizing, and most important, the prognostic functions. The above-mentioned theories of the populations' dynamics do not correspond to this requirement. To create a theory that will explain the recurrence and the cyclic character of the insects' mass reproductions the synergistic synthesis is required. This syhthesis should take into account the systemic regularities of their development and interaction with the systems of higher level of organization, the illinearity of the population dynamics and chaos, the aggravated regimes and the limited prognoses (Prigozhyn & Stengers, 1986; Malinetskyi, 1997; Kurdiumov & Malinetskyi, 2001; Moisieiev, 2001; Glushkov et al., 2009). The problem of the catastrophic events, or the so-called in synergetics the aggravated regimes in the illinear systems, when one or more quantities characterising the system grow to the infinity in the ultimate time, now is more acute than ever before. A striking example of this fact is the "unpredictable" massive reproductions of insects. The chronicles and the regions where the most significant outbreaks of the massive reproduction of harmful insects are noted, provide an opportunity to analyse the polycyclic character, synchronousness and illinearity of the dynamics of the populations. This assumption can become the basis for predicting the mass reproductions of the agricultural crops and forest plantations pests through the synergistic synthesis and taking into account the systemic regularities of their development and interaction with the systems of the higher level organizations, the illinearity of the populations' dynamics and chaos, the aggravated regimes and the limited prognoses.

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