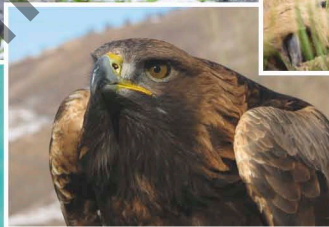
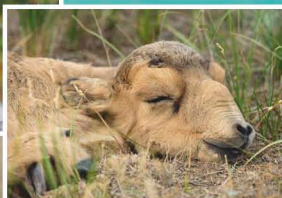


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ANIMAL ECOLOGY



Karaganda
2020

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN
NLC «KARAGANDY UNIVERSITY OF THE NAME OF ACADEMICIAN E.A. BUKETOV»

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ANIMAL ECOLOGY

Textbook

Karaganda
2020

UDC
LBC

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*Presented by the Academic Council
of Academician E.A. Buketov Karaganda State University*

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A **Animal ecology**: textbook / G.K. Turlybekova, G.O. Zhuzbaeva, A.Zh. Shaibek, G.Zh. Zhomartova, —

ISBN

The manual is made according to the curriculum. The manual "Animal Ecology" is intended for Bachelor and Master Students of the Faculty of Biology and Geography. It is designed for Bachelor and Master students majoring in biology, ecology, biology teachers and University teachers.

The manual is intended to form students' fundamental concepts of animal ecology as a science of the interactions between living organisms and the environment, meaningful perception of the diversity of the animal world and its significance for the existence of the biosphere as a global ecosystem.

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Preface

Ecology as a science with its purposes and objectives was formed relatively recently, although its origins go back to antiquity. It has a long history, but, despite this, there is still no consensus on its content. Many scientists argue that ecology is a science; others believe that it is not so much a science as a worldview. There is some truth to this - the worldview aspect in ecology is undoubtedly present.

Animal ecology considers animal organisms in their environment, in interaction with the physical elements of the environment, with other animals and plants. This is a science that studies the behaviour of species or their groups concerning a changing habitat, their adaptive reactions, expressed both in behaviour and structure, and environmental responses. It investigates the reactions of animal organisms to their environment, reactions that carry mostly, but not always, characteristic adaptations to habitat conditions.

Man, like all living organisms, is a natural component of the ecosystem. Land development, gathering, hunting, animal husbandry and agriculture have identified important stages in the development of human society and have necessitated the use of environmental knowledge by a person required to master the natural complexes, to change them, adapt to human needs. Primitive hunters already possessed certain environmental knowledge, applying them; the primitive man hunted animals more successfully, extracting the meat of animals and birds, as well as skins and feathers.

Over ten millennia, man has been engaged in agriculture. A significant part of the globe is involved in agricultural production. About 14% of the land is occupied only under arable land. Huge territories, mainly in arid zones, are used for grazing farm animals. In the agricultural landscapes, considerable areas are allotted for the construction of livestock yards, livestock farms and complexes, summer camps for keeping cattle and other animal species.

Man has a dual role. As a biological species, it is a component of the Ecosystem (biogeocenosis), and its agricultural activity is an environmental (biogeocenotic) factor that has a strong influence on nature, including the animal world.

The manual is intended for students and undergraduates majoring in biology, ecology, biology teacher and teacher of zoology. The manual deals with issues of animal ecology, the doctrine of the effects of environmental factors on animals, biocenosis, adaptation, and other environmental issues. The subject and method of animal ecology, its relation to related sciences are considered.

The manual is written in an accessible language, the material is accompanied by graphs, drawings, tables after each topic questions are given for practical and seminar classes, as well as test questions for self-control.

Theme 1

Introduction. The subject of ecology

1.1. A brief history of ecology

Ecology is one of the fundamental divisions of biology that studies the fundamental properties of life at the supraorganism level of an organization. Ecology studies the totality of living organisms that interact with each other and form a certain unity with the environment, i.e. the system within which the process of transformation of energy and organic matter is carried out (Figure 1.1).

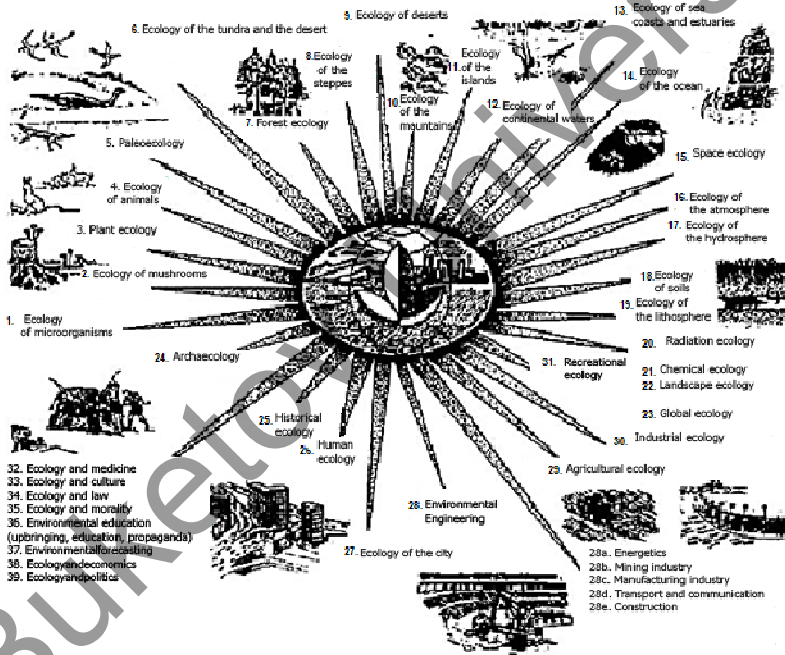


Figure 1.1 The structure of the general ecology.

In the modern sense, ecology is the science of the relationship of organisms or groups of organisms with their environment. This logically implies the main goal of ecology as a science - to obtain the

most complete and comprehensive understanding of the relationship between living organisms and their environment. Ecology has its specific research objects:

- on the one hand, firstly, it is the habitat in all its manifestations and all its parameters;

- on the other hand, living organisms are living matter, mainly at three levels of its organization: organismic (individuals, individuals and their groups), population-species (populations, taxa of ranks lower than species and species) and ecosystem (communities).

The first environmental knowledge by mankind was accumulated at the dawn of its development. Knowledge of the environment - animals, plants, other tribes, the power of nature, which often manifested themselves very hostilely was vital to primitive man because helped to survive. In the future, the most important milestone in the development of mankind was the development of fire and other natural phenomena, as well as the creation of tools that allowed a person to transform his environment, which was the beginning of the emergence of human civilization. With the development of human civilization, new factors began to appear that affect the state of the biosphere, which have a significant impact on environmental processes. Thus, the history of ecology is inextricably linked with the doctrine of the evolution of mankind [1-9]

I. Prehistory of Ecology

1. The antique period. This period is characterized by biology with inaccurate, but in many respects true, general ideas about the life and development of the organic world.

2. The Age of Renaissance. This is the period when biology begins to be divided into separate sciences (including ecology), ideas about the organic world and its diversity expand, new, accurate data and facts accumulating.

II. The emergence and development of ecology as an independent science

1. The before Darwinian period. During this period, ecology is formed as an independent science with two main sections: a) autecology, studying the ecology of species; b) synecology, or biocenology, studying the ecology of communities.

2. The Darwinian period (Figure 1.2.). Animal ecology is becoming an independent science with the main practical task of regulating the number of economically important animal species and changing natural communities (biocoenosis) in a direction beneficial to the economy.

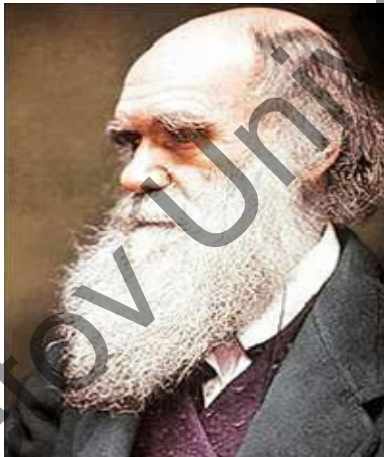


Figure 1.2 Charles Robert Darwin (1809-1882)

1. The modern period. Ecology begins to develop rapidly. The main problem arises in controlling the dynamics of populations and the productivity of communities. During this period, the ecology of animals is divided into three sections: the ecology of individuals, populations, and communities. Special organizations are opening, which begins to monitor and take into account the dynamics of the number of animals.

Science as a specific area of public consciousness began to take shape in the ancient world. The works of Hippocrates, Aristotle, and other thinkers of that time contain a wealth of environmental information.

In the Middle Ages, scientific activity in European countries was banned, the accumulation of scientific knowledge almost stopped, much was lost. At this time, natural sciences (and hence environmental studies) to one degree or another developed in the countries of the East.

Many works of the Renaissance naturalists were of a pronounced ecological character. An example is the research by Antonie van Leeuwenhoek (1632-1723) of the microorganism communities of grape juice at different stages of its fermentation at the beginning of the 17th century. In the Russian Empire in the eighteenth and nineteenth centuries, natural scientists actively worked to describe the nature of Eastern Europe and North Asia. A great contribution to the study of the animal world was made by P.S. Pallas (1741-1811), K.M. Baer (1792-1876), M.A. Menzbir (1855-1935), A.F. Middendorf (1815-1894). The founder of the ecological direction in natural science in Russia was a professor of Moscow University K.F. Rulier (1814–1858), (Figure 1.3) which encouraged the study of living organisms in their relationships with the environment, since: “No organic creature lives on its own; each is brought to life and lives insofar as it is in interaction with the world relatively external to him”.

In Russia, the first environmental scientific work is considered to be the master's thesis of N. A. Severtsov (1827-1885) "Periodic phenomena in the life of animals, birds and reptiles of Voronezh province." However, environmental studies up to the XIX century did not differentiate among other branches of the so-called natural-historical sciences.



Figure 1.3 Karl Frantsevich Rulier (1814–1858)

The term ecology was proposed by the prominent biologist Ernst Heinrich Haeckel (1834-1919) in 1866 (Figure 1.4.).

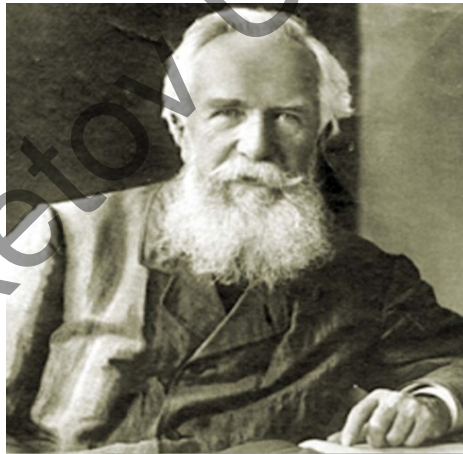


Figure 1.4 Ernst Heinrich Haeckel (1834-1919)

The term biocenosis was introduced in 1877 by the German hydrobiologist Mebius Karl-August (1825-1908).

Ecology as an independent discipline was formed at the beginning of the twentieth century, then the term ecology was still little used, it was finally established in the post-war years. The first Soviet environmental work was categorized in the direction of biocenology. The author of the first domestic textbook on animal ecology was a professor. D.N. Kashkarov (Figure 1.5).



Figure 1.5 Kashkarov Danil Nikolaevich (1978-1941)

Interest in various aspects of ecology, especially conservation, began to manifest itself in the consciousness of the population in the developed capitalist countries of Europe and North America in the late 60s of the twentieth century. Since that time, the broad masses of the population began to show concern over the problems of environmental pollution, nature conservation, and issues of consumption of raw materials and energy, population growth. During that period, environmental research was being funded, environmental research centres, departments of ecology at universities were being organized, and environmental specialists themselves were being trained. In the countries of the socialist camp, this process did not take on an avalanche-like character. New scientific institutions were organized gradually, and departments at universities were occasionally opened. Awareness of the environmental problems facing society by the

masses of the population did not occur until the end of the 1980s after the Chernobyl accident.

1.2. The content, subject and objectives of ecology.

A hierarchical approach provides a convenient basis for the subdivision and study of environmental situations. On this basis, we can define ecology as a science, its content, subject and tasks. Ecology is a science that explores the laws of life of organisms (in all its manifestations, at all levels of integration) in their natural environment, taking into account changes made to the environment by human activities.

The subject of consideration for ecology is the relationship between living organisms and their environment. The subject of environmental research is biological macro-systems (population, biocenoses) and their dynamics in time and space.

Animal ecology is one of the sections of ecology and studies the relationship of animal organisms or groups of organisms with their environment. The principles of animal ecology are identical to general ecological ones. Animal ecology is associated with other areas of ecology and zoology. Among the latter, the morphology and physiology of animals, ethology, and zoogeography should be highlighted.

The main content of modern ecology is the study of the relationship of organisms with each other and with the environment at the population-biocenotic level and the study of the life of biological macrosystems of higher rank: biogeocenoses (ecosystems), biosphere, their productivity and energy.

The main tasks of animal ecology can be reduced to studying the dynamics of populations, to the study of biocenoses and ecosystems. The structure of biocenoses, at the level of formation of which the development of the environment takes place, contributes to the most economical and full use of vital resources. From this point of view, the main theoretical and practical task of ecology is to uncover the laws of these processes and the ability to control them in the conditions of the inevitable industrialization and urbanization of our planet.

1.3. Method of ecological studies

After the publication of the works of A. Tensley (1935), G. G. Vinberg (1936), V. N. Sukachev (1942), R. Lindeman (1942), humanity realized that the ecosystem is a subject of ecology. A systematic approach is becoming a method of ecosystem research, reflected in the works of Ludwig von Bertalanffy (History and Status of the General Theory of Systems, 1973), W. Ashby (General Theory of Systems as a New Scientific Discipline, 1969), V. B. Sochava (Introduction to the Doctrine of geosystems, 1978), Yu. Oduma (Ecology, 1986), and others.

Along with the methods and concepts used in such sciences as biology, mathematics, physics, chemistry, several research methods are unique to ecology. For example, if studies of the ecology of individuals (autecology) are sometimes close to studies in the field of physiology or biogeography, then the study of populations and biocenoses is entirely ecology. When moving from one level to another - higher - new properties come to light in substances. We give two examples: one from physics, the other from ecology. Hydrogen and oxygen, combining in a certain ratio, form water - a liquid that is completely different in its properties from the source gases. Algae and intestinal animals, evolving together, form a coral reef system, and an effective mechanism of nutrient cycling arises, which allows such a combined system to maintain high productivity in waters with a very low content of these elements. The actual productivity and diversity of coral reefs are qualitatively new (emergent) properties that are characteristic only of the reef community.

The main methods of environmental research are field, experimental studies using the ecosystem approach, community studies (synecology), population approach (demecology), habitat analysis, evolutionary and historical approaches.

There are two approaches to the study of environmental objects. A static or phenomenological approach involves the implementation of environmental observations and descriptions (for example, determining the structure of biological diversity of animal organisms).

A dynamic approach or a causal approach is aimed at identifying cause-effect relationships (as a rule, an environmental experiment is

used). Like any other science, ecology uses both specific research methods and takes the methodology of other branches of knowledge. Among the methodological approaches and principles used by modern animal ecology, three should be highlighted:

1. The principle of consistency means that any ecological system is considered as a whole, having properties that are not reducible to the sum of the properties of its components. Each level of the ecosystem is characterized by the properties that are inherent only to it, has the sum of the properties of the component subsystems included in it. An example is the cumulative effect of poisons produced by animals; compensation for precipitated specimens in colonies of intestinal; synergistic antitoxic effect of mucus produced by fish in a limited volume of water.

2. Statistical methods allow the correct quantitative description of environmental processes, considering them as stochastic (the probabilistic nature of the processes in biological and ecological systems was considered in detail in the course of biometrics).

3. Modelling. A model is an abstract description of one or another phenomenon of the real world, allowing one to make predictions about this phenomenon. The simplest models have an informal basis - these are verbal (verbal) and graphic models. Models are detailed descriptions (diagnoses) of zoological species, cave paintings of hunting animals, schemes of biological cycles of parasites, etc.

1.4. The relationship of ecology with other biological sciences. Subdivisions of Ecology.

Ecology as a science is based on different branches of biology (physiology, biophysics, genetics, etc.) and is closely related to non-biological natural sciences (physics, chemistry, geology, geography, mathematics, etc.). From this base, when conducting environmental studies, they rely on terminology and technological capabilities.

Environmental knowledge is an integral part of the information base of modern medicine and veterinary medicine. Animal ecology is closely related to applied areas of science - zoo technology, hunting, forestry, plant protection, medical and veterinary zoology, nature

conservation. Based on the foregoing, it is possible to formulate various tasks of animal ecology:

1) the study of the laws of interaction of animal organisms with the environment, including in connection with anthropogenic impact on natural systems;

2) forecasting changes in nature under the influence of human activity;

3) ecological indication when determining certain components and elements of the living environment, including bioindication of environmental pollution using animal organisms;

4) management of processes occurring in the biosphere, including regulation of the number of animal populations;

5) conservation of the biological diversity of animal organisms and standards of undisturbed natural systems as their habitats;

6) creating the scientific basis for the rational exploitation of biological resources, incl. the transition from the fishing of animals to their cultivation;

7) restoration of disturbed natural systems (including restoration of pastures, the productivity of water bodies, etc.).

Unreasonable attempts to transform nature contrary to its laws gave rise to the acute problem of the ecological crisis. The main task of ecology as applied to practice is to create the necessary scientific base for its successful and cost-effective resolution [1-8].

Questions for self-control

1. Define the concept of "ecology"? What is the current understanding of ecology?

2. What is characteristic of the ecology of the Ancient period and the Renaissance?

3. What works of scientists contributed to the formation of ecology in an independent discipline?

4. What is the main practical task of animal ecology?

5. What are the content, subject and objectives of modern ecology?

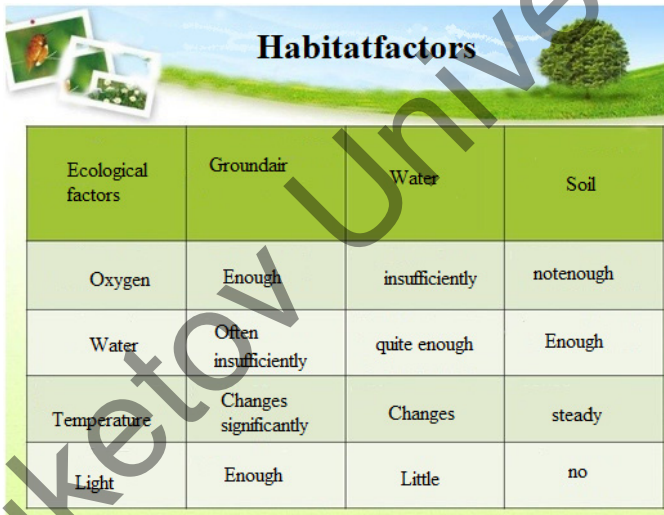
6. Why is animal ecology closely related to various sciences, and specially applied?

Theme 2

Environmental factors and general regularities of their effect on organisms

2.1. Environment and living conditions of organisms

For environmental science, the environment is bodies and phenomena (objects and processes) with which the body is in direct or indirect relations. Environmental factors, that is, environmental factors, means any element of the environment (Figure 2.1) that are capable of exerting a particular influence on living organisms.



Ecological factors	Groundair	Water	Soil
Oxygen	Enough	insufficiently	notenough
Water	Often insufficiently	quite enough	Enough
Temperature	Changes significantly	Changes	steady
Light	Enough	Little	no

Figure 2.1 Habitat factors

For example, the effect on animals of cosmic neutrino radiation penetrating the globe does not appear. Because of this, it can be excluded from the list of environmental elements related to the number of environmental factors operating on the planet under consideration at a given time. In turn, the body responds to the environmental factor with specific adaptive reactions. The ability to

adapt, adjustment is a fundamental property of organic life. This ability provides an opportunity for living organisms to survive in the specific conditions of their habitat.

There are a large number of different classifications of environmental factors. So, environmental factors can be divided into abiotic and biotic (Figure 2.2).

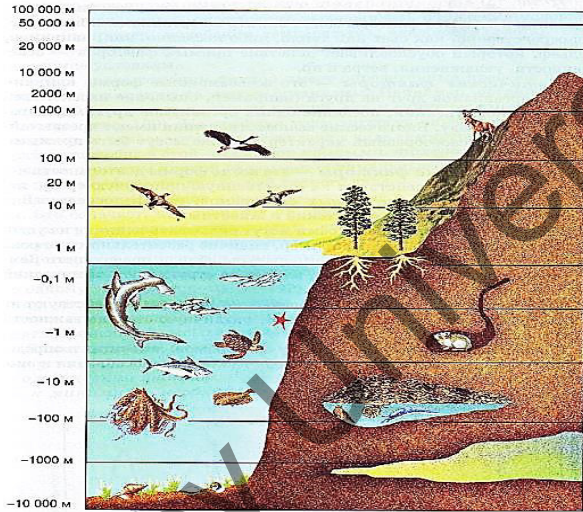


Figure 2.2 Habitats of living organisms

Abiotic factors are understood as the influence of matter (in the form of matter or fields) and its main characteristics (temperature, acceleration rate of gravity, etc.). Among others, the following groups of abiotic factors stand out:

- climatic (temperature, water/moisture, light, atmospheric pressure, wind, etc.);
- edaphic (mechanical composition, moisture capacity, breathability, soil density); orographic (topography, altitude, slope exposure);
- chemical - gas composition of the air and the presence of chemical pollution; water composition - the content of dissolved substances and suspensions;

- acidity, osmotic pressure and composition of soil solutions; chemical composition of the soil).

Climatic factors are one of the most important, determining the living conditions of animals on land. The data of ordinary meteorological observations give an idea of the macroclimate of a certain territory. The same indicators for an individual biotope allow us to judge its mesoclimat. Accordingly, the mesoclimates of the northern and southern slopes of the same hill will be different. The concept of microclimate refers to small sizes (up to tens of square decimeters in the area) to parts of the soil surface, vegetation cover, etc. For example, the midday temperature of the bark on the north and south sides of a tree trunk on a sunny day can vary by tens of degrees.

Biotic factors are all sorts of effects of living organisms, including individuals of their species (Figure 2.3).

Microbiogenic factors mean the activity of bacteria, viruses, rickettsias and other microscopic organisms; microgenic - fungi;

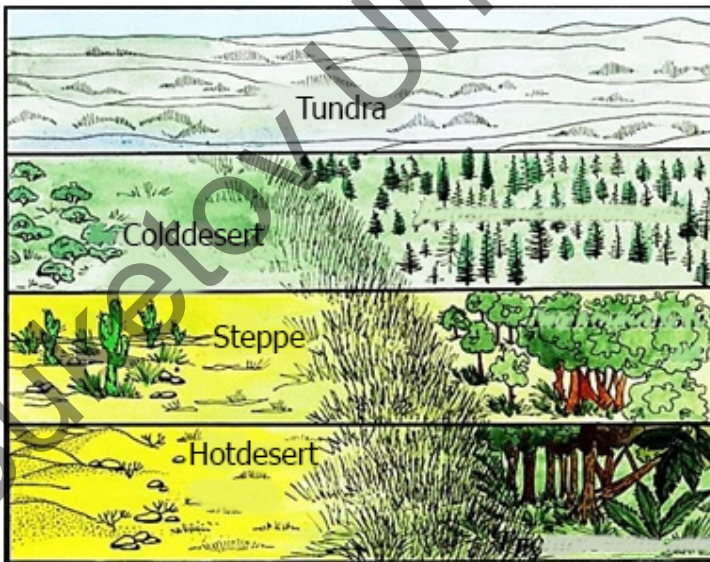


Figure 2.3 Biotic factors

phytogenic - plant organisms; zoogenic - the activity of animal organisms. The anthropogenic factor as a specific human activity is somewhat aloof. Other systems for classifying environmental factors are based on different criteria. For example, it is possible to divide factors into those that depend on the number (density) of organisms and are independent of that. Thus, the regional macroclimate is practically independent of the composition and density of the animal population in the region. At the same time, animals can significantly affect microclimatic conditions. For example, with total eating of conifers or foliage of trees by insects during outbreaks of mass reproduction in the forest, the wind regime, humidity, and temperature dynamics at the level of crowns and near the soil surface change. Due to the loss of individual plants, the forest stand can thin out, and groups can form glades. These changes will inevitably affect subsequent generations of the same insects, as well as their competitors and entomophagy. From a practical point of view, differentiation of environmental factors according to the frequency of their action is useful. It is this criterion that underlies the classification proposed by prof. A. S. Monchadsky, who proposed to distinguish the following groups:

- primary periodic - phenomena associated with the rotation of the Earth and the Moon (changing seasons, parameters of solar radiation, tidal phenomena determined by the position of the Moon relative to the Earth);

- secondary periodic, which are the consequences of the primary periodic (daily course of temperature, humidity, illumination, dynamics of feed resources, etc.);

- non-periodic - factors that do not have the correct cyclicality (natural phenomena, the mechanical and chemical composition of the soil, orographic factors as such, volley emissions of volcanic matter, as well as technogenic xenobiotics, etc.).

Adaptations to the action of periodic factors have evolved evolutionarily in living organisms (Figure 2.4). The adverse effect of non-periodic factors is often fatal because living organisms are not able to develop appropriate adaptations due to the unpredictability of their manifestations.

According to the spatiotemporal parameter, stable and labile environmental factors can be distinguished. The values of the former (for example, the level of gravity, the nitrogen content in the atmospheric air) are constant over very long periods. The action of the latter is subject to pronounced changes in time and space.

Changes in time may be:

- regular periodic (regular) - these are seasonal and diurnal rhythms, tidal phenomena;
- random (irregular) - changes in weather conditions (up to catastrophic natural phenomena, such as storms, typhoons, downpours, landslides, mudflows, etc.), earthquakes, salvo xenobiotics, meteorites, etc. ;
- vector (directed) - directed climate change, desertification, overgrowing of water bodies, increasing concentration of carbon dioxide in the atmosphere, increasing emissions of sulfur compounds and other xenobiotics into the environment.

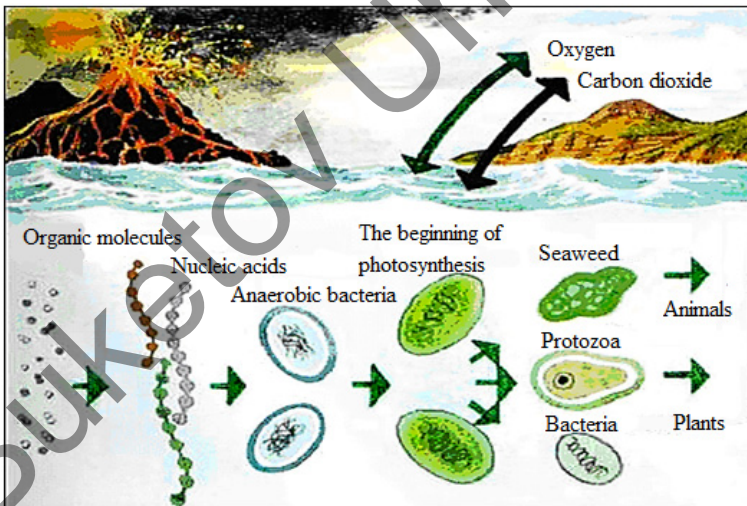


Figure 2.4 Adaptations of living organisms

The action of individual factors should be delimited from the action of complexes of factors. For example, the eastern exposure of

a hillside in itself (as the presence of a slope) does not differ from the northern or southwestern one. However, it determines the blowing of the territory by winds, the illumination of the slope by the rays of the rising sun and the warming up of the midday, as well as the earlier onset of evening twilight, expressed in a decrease in illumination, supplemented by a decrease in temperature and an increase in the relative humidity of the surface layer. Altitude and diving depth is associated with even more extensive sets of factors. Environmental factors can have a different effect on animals, acting as:

- a limiter, causing the possibility or impossibility of existence in these conditions (for example, low temperatures for thermophilic forms; lack of food for birds in winter);

- an irritant, leading to the manifestation of appropriate physiological and behavioural adaptive reactions (for example, at high temperatures, many mammals resort to hyperventilation of the lungs, which leads to body cooling due to evaporation);

- the modifier, initiating morphological and physiological-biochemical rearrangements (desert and semi-desert forms usually have intensely sclerotized and reflective properties body covers, while inhabitants of moist biotopes have weakly sclerotized integuments and colour, allowing the body to better accumulate heat of sunlight, - an example is migratory locusts living in semi-desert conditions or river floodplains);

- a signal informing about a change in the parameters of other environmental factors (for example, a shorter daylight hour informs the animals about upcoming seasonal temperature changes). In this case, the environmental factor can act as:

- conditions that animals are not consumed and cannot be exhausted; one organism cannot make conditions inaccessible or less accessible for another (for example, temperature or relative humidity, total salinity of water);

- a resource that is consumed by animal organisms (it can be feed resources, trace elements in a chemically accessible form, oxygen dissolved in water, etc.);

- a source of information, that is, a signal (for example, light as an indicator of open space initiates a reaction of seeking shelter or

concealment in hiding insects). The variety of environmental factors is very large, great specificity and manifestations, their effects on animal organisms. The establishment of general laws of action of environmental factors is also a subject of ecology. The law of ecological optimum can be formulated as follows: "Each variable factor has only certain limits of a positive effect on organisms. Both insufficient and excessive effects of the factor negatively affect the lives of individuals. " A consequence of this law is the rule of limiting action of factors, which states that environmental factors, the values of which are farthest from the optimum, primarily limit the possibility of the existence of the species in these conditions.

Limiting environmental factors determine the geographical range of species and other animal taxa. The range of the parasite cannot go beyond the range of its owner. The speckled ground squirrel does not spread from the few island habitats in the southern half of Belarus since it is not able to tolerate low temperatures in winter. Swallows and swifts arrive later than other birds, not because of their exceptional heat lovingness, but because of seasonal changes in the density of aeroplankton. Mallard ducks wintering in the cities of Belarus confirm that the main reason for the migration of these birds is the lack of sufficient food supply during the freezing period. Each organism has its range of tolerance (Shelford's law of tolerance), tolerance to the effects of various environmental factors. This is a zone between critical points, beyond which its existence is not possible. To assess the breadth of this range, the concept of environmental valency is used. Wide ecological valency, in particular, is characterized by many of the widespread, sometimes all-around, widespread animals. Species with a wide ecological valency are called eurybiontic, with a narrow one - stenobiontic. More often there is information about the degree of ecological valency of animals for individual environmental factors. Hence the corresponding terms:

- - stenotherms - animals that can exist in a narrow temperature range, eurytherms - in a wide range;
- euryphagous animal - consumers of a wide range of feed objects, stenophagy - a narrow circle of objects. Representatives of various systematic groups of animals differ significantly from each

other, both in terms of optimum and ecological valency. Sometimes an appropriate rule is formulated for the mismatch of the ranges (spectra) of ecological valencies of different species. Arctic foxes, inhabitants of the tundra, tolerate temperature fluctuations in the range from -55 to $+30$ ° C, and their tolerance range is 85 ° C. Animals of temperate latitudes are mostly eurythermic. On the contrary, the inhabitants of caves, warm springs, inhabitants of trophic forests and coral reefs, as a rule, are stenothermal. For example, the crustaceans of *Copilia mirabilis* have a tolerance range of about 6 ° C, and they can live in warm springs with a temperature in the range of $23-29$ ° C. Many fish species are euryhaline, that is, they can live in water bodies of different salinity levels - from fresh to salty. So, zander is common in the estuaries of the Azov and Black Seas; Caspian herring in the XIX century on an industrial scale was hunted in the Volga. On the contrary, coral polyps are stenohaline, and heavy rains locally desalinated with seawater can lead to the mass extinction of surface located polyps.

Among animals, there are like euryphagous animals for example cockroaches, nomad ants, possums, rats, pigs, baboons, as well as humans. There are also stenophagies, for example, silkworm, aardvark, koala, beetle bear.

The rule of the ambiguity of the effect of factors on various processes in the same organism can be illustrated by the example of mill fire butterflies - an increase in temperature leads to an intensification of metabolism in these insects and a decrease in their motor activity (thermal numbness). The rule of the variability of responses to the action of environmental factors in different individuals of the same species is manifested in the fact that the tolerance range, critical points, optimal and pessimal zones do not coincide for individual individuals. This variability is determined by individual hereditarily determined characteristics of individuals, gender, age and physiological differences.

The victims of predators, diseases, adverse weather conditions are, first of all, physiologically weakened (low temperatures, nourishment, etc.) individuals.

The minimum temperature for insects resting in stages of development is much lower than for active ones. The eggs of many

aphids, openly located on the needles and shoots of plants, remain viable during prolonged winter frosts down to -35°C , while the larvae die after several hours of exposure to slightly negative (-5°C) temperatures. As a rule, animals during the breeding season are most sensitive to extreme values of environmental factors. From the foregoing, we can conclude that the ecological valency of the species is always wider than the ecological valency of the individual. The following rule says that fitness for one environmental factor does not depend on fitness for other factors, or in a different sound - animals adapt to each environmental factor independently.

Euryhaline species can be either stenotherms or eurytherms, stenophagies or euryphages. The set of ranges of ecological valencies over the entire set of environmental factors makes up the ecological spectrum of the species.

Environmental factors may interact but are not completely interchangeable. Thus, low temperatures with strong winds are perceived as even lower, and heat is easier to tolerate with low relative humidity. Most animals are characterized by mobility and a high level of development of sensory-regulatory systems, which provides them with specific capabilities in registering various environmental parameters and the operational use of existing adaptive capabilities. It makes sense to consider the specific effects on animals of some of the main environmental factors.

Electromagnetic fields, light, sound waves of various fields can have a significant effect on animals. Electric fields are of great importance for water and small sizes of land animals. However, only a few aquatic animals can purposefully generate electric fields and accurately record changes in the strength of their lines of force. Electric stingrays, electric eels, marine world-like and some other fish have special electric organs, which use them for protection (the "shock" of an electric stingray exceeds the level of stun guns used by security services), as well as the paralysis of its victims. Weak intensity electric fields inevitably arise when nerve impulses are reduced and, especially, muscle contraction. It is them that are recorded by their specialized analyzer, a hammerhead shark, capable of accurately detecting completely buried in the groundfish and other animals that make only breathing movements or preserve the beating

of the heart muscles. In small terrestrial animals with integuments not moistened with electrically conductive secrets, a significant problem is the accumulation of charges of static electricity on their surface due to friction on the surface of various substrates. Electrostatic attraction to foreign objects can be dangerous. Besides, electrical discharges can disrupt the normal functioning of some receptors. It is assumed that immovable tweezers, and bristles and other chetoid formations in beetles and other insects perform the function of a kind of “lightning rods”. Magnetic fields are used by animals for orientation in space. Thus, the lines of force of the Earth's magnetic field serve as reference points for navigation in many migratory birds. Electromagnetic waves, depending on the frequency, are sound, infra- and ultrasonic waves, light, infrared, ultraviolet, x-ray and other types of radiation. As a rule, in the environment at the same time, the spectrum of oscillations of various frequencies is presented. Cosmic radiation is the only external source of energy on Earth. In the energy balance of the planet, 99.9% is the radiant energy of the Sun. 0.1% is accounted for by other sources of energy on Earth. On average, only 47% of direct and scattered radiation reaches the surface of the planet, 19% is absorbed by the atmosphere, the rest is reflected into space. Direct radiation contains waves 0.1–30 000 nm long, with 1–5% of ultraviolet radiation, 16–45% of radiation in the visible part of the spectrum, and the rest being infrared. Hard (i.e., shortwave) ultraviolet and x-ray radiation is delayed by the upper atmosphere, including due to the ozone layer. Scattered radiation is characterized by a maximum in the blue-violet part of the visible spectrum (400–480 nm), which determines the corresponding colour of the sky. The biological effect of radiation of different frequencies varies. Ultraviolet for terrestrial vertebrates is important in terms of the synthesis of group D vitamins from steroids. However, direct exposure to ultraviolet radiation can have a host of adverse effects, from direct photodamage to the initiation of carcinogenesis. The main photo protectors in animals and fungi are melanin pigments.

In many birds and mammals, provitamins are part of fat secretions designed to care for feather or wool. Then, photoactivated by ultraviolet radiation outside the living tissues of the body, vitamin

precursors enter the digestive tract when brushing feathers with a beak or licking wool and are used to synthesize group D vitamins. In the described case, ultraviolet radiation acts as a resource. However, most often, for animals, light is a medium of information. Radiation in the visible and infrared parts of the spectrum is perceived differently by different animals. Insects, as a rule, do not perceive infrared and red rays, but they see the rays of the near-ultraviolet part of the spectrum. Most other animals do not perceive with their organs of vision even the longest ultraviolet waves. Differences in spectral sensitivity make a direct comparison of light perception by different animals impossible. The pigments that are equally white in the eyes of man — lead and titanium white — have different reflection spectra in the long-wave ultraviolet range and are reliably distinguished by bees. The monotonously bright front and hind wings of male lemongrass butterflies look different for females, since the front wings have an extensive spot reflecting ultraviolet rays, and the rear ones do not. The dark red corollas of poppy flowers in the eyes of red-blind flies shine with reflected ultraviolet light. *Drosophila* flies can absorb the short-wave ultraviolet radiation emitted by yeast cells during division. This allows them to successfully search in the twilight of the tropical forest for yeast-infested fruits, which are a substrate for the development of larvae. Pit snakes possess vision in the infrared wavelength range.

Blood-sucking insects, female *Culicidae* mosquitoes perceive some thermal radiation, and other animals (mainly insects) can perceive the plane of polarization of light waves. Many nocturnal insects, some birds can orient, navigating along the plane of polarization of the radiance of the sunset, or predawn sector of the night sky.

Concerning the animals, to the lighting and light intensity, they are divided into photophiles and photophobes.

1. Photophilic songbirds, day-old club-moth butterflies.
2. Strictly nocturnal forms are photophobic - most owls, nocturnal lepidoptera, burrowing and soil animals (for example, moles), cave animals. Some animals are euriphotic - many waders, coons, mice-bugs, several lepidopteran insects (scoops-gamma, some hawks, moths, springflies) are active

both day and night. Colour vision, contrary to popular belief, is not so widespread in wild animals.

Night forms, as a rule, do not have colour vision, since the illumination at night is too low for high-quality colour perception.

Living in low light or complete darkness leads to loss of vision with the reduction of the corresponding organs, or their hypertrophic development, often with the acquisition of phosphors. Not all animals have a bulky vision. Binocular vision is voluminous if the observed sectors of vision overlap. The volume perceives the surrounding world and the faceted eyes of insects. Different animals have different ability to distinguish between stationary objects, to separate them from the background. Most amphibians and reptiles with motionless or slightly mobile eyeballs respond only to moving objects. Birds with almost no overlapping eye sectors (for example, chickens) alternately examine the object, shaking their heads.

The common mantis (*Mantis religiosa*) shakes only its head, the caterpillars raise the front end of the body and sway. Crustaceans usually have very perfect surround vision. The eyes of animals are adapted to function in a certain environment and are ineffective in other conditions. For example: in four-eyed fish, the eyes are divided in half, the upper halves are adapted to work in the air, and the lower halves are adapted to work in the aquatic environment.

For terrestrial animals, light is primarily a condition of their habitat. Animals must consider this factor in their colour, adapting it accordingly or moving to areas with suitable lighting conditions. In the latter case, animals are adaptively distributed in space. Ultimately, the light regime acts as one of the parameters determining the distribution of animals in their habitats. Mobile animals can move between areas of the environment with different lighting conditions. Besides, changes in the body posture and condition of the integument (moisturizing with the secrets of the glands, ruffling of the feather cover, etc.) make it possible to adapt to changing lighting conditions (primarily insolation) without changing the habitat.

A resource for animals can be a space with one or another level of illumination. So, anthophilous insects can fly under the forest canopy and visit the flowers of plants growing here only at a

sufficiently high level of illumination. Therefore, bees and day butterflies are found only in glades, clearings and forest roads, but before leafing in the trees, they can visit deciduous forests without restrictions in search of early flowering plants. Similarly, light conditions in bright broad-leaved forests allow many bees to forage under the crowns of trees. With highly effective neuro-positional vision, dipterans are free from such restrictions and can populate even dark coniferous taiga forests.

For heliophilic (i.e., sun-loving) animals (some flies, lizards and snakes), the resource is a surface heated by the sun's rays, for which they sometimes compete. Illuminated or unlit space can be a resource for animals living in the illuminated area of water bodies. For example, some predatory insects (larvae of dragonflies and some beetles) need the illuminated space to successfully hunt their victims, for whom an unlit space (as a refuge), in turn, becomes a resource. Of course, light and illuminated space will be a resource for animals (some nudibranch and bivalve molluscs, intestinal turbellaria, etc.), which have zoochlorella and zooxanthellae as symbionts.

Summing up, it should be concluded that the light to one degree or another performs the functions of:

- habitat conditions: animals must take it into account in colouring, orientation on the terrain, etc .;
- a resource (for example, for the synthesis of vitamin D);
- signalling factor: the ratio of the duration of daylight and night time (photophases and scotophases) informs the animals about the upcoming onset of seasonal changes in living conditions.

Sound waves play a significant role in the life of aquatic and terrestrial animals, acting primarily as a carrier of information. In the seas, infrasound waves are the harbingers of impending storms, their timely registration allows jellyfish to sail to a safe (meaning damage to the surf) distance, and siphonophores to bleed gas from a pneumatophore and fall under the water. Ultrasonic radiation is used to orientate in space and determine the location of prey by aquatic (dolphins) and air (bats, some swine-like) predators.

Many nocturnal moths can pick up ultrasonic signals from hunting bats, which allows them to change the flight path or make a controlled fall to the surface of the soil.

Usually, animals perceive a wide range of sound waves, and the vital task is to distinguish between relevant information (communication signals of individuals of their species and competitors, alarms, sounds made when predators move, etc.) from information noise, which is a living condition. Some animals cannot tolerate high noise levels and leave their habitats, for example, after settling near a weaver colony or starting regular operation of an airfield.

Thus, sound waves are important for animals as a condition for their habitation and a source of information.

2.2. Water-salt exchange of hydrobionts and land animals

Living things arose in the aquatic environment. Physico-chemical characteristics of the aquatic environment affect the metabolism of aquatic organisms. Animals and plants that live in water are called hydrobionts. They are fully adapted to exist in this environment and are usually contrasted with the so-called aerobionts - the inhabitants of the land, and pedobionts - the inhabitants of the soil.

The water exchange of the body with the environment includes two opposite processes: the flow of water into the body and its return to them in the external environment. Animals not only get moisture in the form of drinking water, but they can also receive water through integument or specialized tissue sites that are permeable to water (such as gills). Water can also be ingested with food, especially for terrestrial forms.

Between the animal's body and the environment, there is a constant exchange of water and substances dissolved in it, which is accompanied by a change in the content of both in the animal's body. Water in the body is the main environment in which biochemical processes of both aquatic and land animals occur. A decrease in water content below a known limit leads to the animal falling into a stupor, and then to death. Water loss is harder than

starvation. The water content in the body ranges from 46 to 92% in insects, from 80 to 92% in molluscs, in the body of *Chondrosia reniformis* sponges it is 84%, in crayfish - 77%, lancelet - 87%, in frog tadpoles reaches 93%, and the jellyfish *Rhizostoma cuvieri* - even 95%.

In water, there are all the elements necessary for building the body of animals and plants. The sources of water and salts are their penetration through the covers, adsorption of moisture from the air (in amphibians, insects, molluscs, worms, etc.), drinking water, water and minerals in food, and metabolic water formed during the oxidation of substances, especially fats in the body.

The return of water and salts by the body is accomplished by evaporation from the surface of the respiratory tract, skin, secretion by sweat and other glands and special excretory organs.

The need to obtain, return and retain water in the body, as well as the regulation of the amount and composition of dissolved minerals, is the same for land animals, soil inhabitants and aquatic organisms, although the nature and mechanisms of water-salt metabolism are different for these three groups of animals. At the same time, conditions of physiological dryness can also occur in water bodies, and excess moisture harmful to the animal can also be observed on land.

In natural water bodies, salts of nitric, phosphoric, hydrochloric, carbonic and other acids are mainly dissolved. The maintenance of the osmotic pressure and ionic state of solutions in the body of aquatic animals necessary for metabolism is provided by the regulation of their water-salt metabolism with the environment.

Water-salt exchange of different fish is peculiar.

In freshwater animals, the concentration of internal fluids is usually slightly lower than that of marine forms, but still higher than in surrounding water. Several freshwater animals have various integumentary formations that impede the penetration of water through the skin (shells, scales, etc.). For example, fresh-water bony fish remove excess water entering the body through enhanced work of the excretory system. Their kidneys contain a large number of Malpighian glomeruli (body). Marine bony fishes, which, due to the permeability of their integument, can be dehydrated in brackish-

water basins, live, in essence, in conditions of high physiological dryness. They struggle with the danger of tissue dehydration by drinking seawater, highlighting the excess of salts coming in this way by gill lobes. The kidneys of marine fish are distinguished by a small number of glomeruli; they excrete little urine and the latter is only slightly hypotonic for blood. The whole mechanism of isolation in them is aimed at retaining water in the body and eliminating excess salts.

The whole set of chemical factors in the reservoir serves as one of the most important conditions that determine the species composition of its population, the number of individual species, the degree of its stability and fluctuation.

The absorption of water by integument plays an important role in the life of amphibiotic and soil animals. Frogs, toads and earthworms have water-permeable covers and behave like poikilosmotic hydrobionts in water and moist soil, removing the excess of incoming water in the form of abundant hypotonic urine. The intake and release of water are subject to neuro-humoral regulation, in which the hormone of the posterior pituitary gland plays an important role. The absorption and release of water are especially significant among the inhabitants of dry places.

Amphibians living in wet habitats are more permeable to water than amphibians living in dry places.

For example, in individuals with intact skin and completely deprived of its grass frog, the permeability of the skin is so great that the loss in weight when dried is almost the same as in the toad, the difference in living in drier places is noticeable. Evaporation through the skin is dramatically different in amphibians and reptiles. So in amphibians, evaporation significantly reduces body temperature, and in reptiles, evaporation has little effect on the skin. The evaporation of water in birds is noticeably different. It occurs through the respiratory system (trachea, lungs), the oral cavity, etc. If we talk about mammals, then during evaporation, water is released through the sweat glands, the work of which is controlled by the thermal centre of the brain.

The inhabitants of less dry places - the white rat, the crested gerbil and the grey hamster, have pulmonary skin and water losses

two to three times more than the inhabitants of the arid biotopes. Both species of gerbils live in the desert zone. However, the crested gerbil is closely associated with a relatively humid habitat, feeds mainly on seeds and leads a strictly nocturnal lifestyle. Unlike her, a large gerbil, living in dry places, leads a daily life and eats juicy parts of a hodgepodge.

Of major importance for land animals and soil inhabitants is the regulation of the return of water and salts in connection with the humidity of the air and soil, the water content in food, the availability of drinking water and the necessary mineral substances.

2.3. Mineral nutrition of land animals

In modern times, our knowledge about the needs of animals for substances that are found in nature in very small quantities (trace elements) has greatly increased. Previously considered random impurities in the body, trace elements were necessary for many biochemical reactions. The lack of trace elements reduces or upsets many functions, and their absence causes developmental disorders (deformities), diseases, and premature death of animals. In the formation of such a biologically active substance as a vitamin: B 12, cobalt is involved; thyroxine hormone - iodine; the hormone insulin and the enzyme carbonic anhydrase - zinc; xanthine oxidase enzyme - molybdenum; trypsin - chrome; tyrosinases - copper; arginases - manganese; haemocyanin respiratory pigment - copper; vanadocytes - vanadium.

Naturally, the excess or deficiency of these elements in the external environment (soil, water bodies) affects the metabolism, vitality and shape of organisms and contributes to the development of compensating for the adverse effects of the chemistry of the environment devices.

2.4. Gas exchange and breathing

Primary animals use oxygen dissolved in water for breathing. The solubility of oxygen is small: at 15 ° C and a dry gas pressure above water, a surface of 1 atm. (101.3 kPa) in 1 litre of water dissolves about 34 ml of O₂. The oxygen content in the water is

influenced by environmental factors such as water mixing (rapid flow, rapids and waterfalls, storms, excitement). It increases the oxygen saturation of the water, while in calm weather or closed standing water bodies the opposite situation is observed. Green plants also increase the amount of oxygen in the water.

Vertebrates, which are characterized by a relatively high level of metabolism, have a simple contact of the respiratory surface with the aquatic environment (skin, passively hanging gills in water), which is characteristic of some invertebrates, can provide the necessary rate of oxygen into the body. In all fish, the gill apparatus is arranged so that water is actively pumped through the system of gill lobes, through which gas exchange occurs. In bony fishes, the movement of the oral and gill apparatus combines the injection and suction principles, which ensures the intensive movement of water through the gills. Respiratory features of some bony fish can extract up to 85% O₂ dissolved in gill-washing water. The degree of utilization of O₂ entering the bloodstream is also great in bony fish (2.5 times more than in mammals).

In cartilaginous fish, the efficiency of O₂ extraction from water is 70-77% (with a faster flow 40-50%), which is quite comparable with the efficiency of O₂ extraction in bony fish.

Oxygen is 20.95% of atmospheric air, but in fact, the partial pressure of O₂ is lower, since there is water vapour in the air but remains high enough for an effective gas exchange on the surface of the respiratory organs.

A factor limiting gas exchange in the air is dry air. The morphological principles of gas exchange in the air are based on the fact that the gas exchange surface is located inside the body and does not border directly on the surrounding air. Evolution aimed at increasing the intensity of external gas exchange, as in aquatic animals, is associated with an increase in the respiratory surface and the formation of the mechanism of active ventilation of the lungs. In animals of different species, skin and pulmonary respiration are not the same, as it is related to their ecology: the drier the habitat of one or another species, the greater the relative role in the gas exchange of the lungs.

The structure of the respiratory system in birds is very different from the respiratory system of other terrestrial vertebrates. The lungs of birds do not have an alveolar structure and are characterized by low extensibility, the tissue is represented by a system of air ducts that are open at both ends and therefore allow the possibility of unidirectional airflow and, accordingly, a continuous flow of gas exchange process. The birds have 5 pairs of air sacs, which are functionally combined into two groups: anterior (cervical, interclavicular, prothoracic) and posterior (hind thoracic, shaving). Airbags significantly increase the total respiratory volume and take an active part in the "air pump" system, which pumps air through the lungs. The air entering the lungs from the back sacs has the highest O₂ partial pressure. As it passes through the parabronchial system, the air gradually loses O₂ and receives CO₂ from the blood. At the same time, air meets blood along the entire path, having a lower partial pressure of O₂ and a higher content of CO₂. Due to this, the process of counter diffusion of gases does not stop and does not even slow down, which ensures maximum gas exchange efficiency.

2.5. The joint action of environmental factors

Environmental factors usually do not act alone but as a whole. The action of one factor depends on the level of others. The combination with different factors has a noticeable effect on the manifestation of the optimum in the properties of the organism and within the limits of their existence. The action of one factor is not replaced by the action of another. However, with the complex impact of the environment, one can often see the "substitution effect", which manifests itself in the similarity of the results of exposure to various factors. So, light cannot be replaced by excess heat or an abundance of carbon dioxide, but, acting on temperature changes, you can stop photosynthesis of plants or activity in animals and thereby create a diapause effect, as in a short day, and by lengthening the active period, create a long day effect. And at the same time, this is not a substitution of one factor for another, but a manifestation of quantitative indicators of environmental factors. This phenomenon is widely used in the practice of crop production and livestock.

The leading factor may not be the same for the same species living in different physical and geographical conditions. For example, the activity of mosquitoes, midges, biting midges in warm areas is determined by the complex of light conditions, while in the north - by changes in temperature.

The concept of leading factors cannot be confused with the concept of limiting factors. A factor whose level in qualitative or quantitative terms (deficiency or excess) is close to the endurance limits of a given organism is called limiting or limiting. The limiting effect of the factor will also be manifested in the case when other environmental factors are favourable or even optimal. Both leading and background environmental factors can act as a limiting factor.

The concept of limiting factors was introduced in 1840 by the chemist J. Liebig. The Liebig law of minimum applies to all abiotic and biotic factors affecting the body. This may be, for example, competition from another species, the presence of a predator and a parasite. The formulated law applies to both plants and animals.

The limiting factor can be not only a drawback, as Liebig pointed out, but also an excess of factors such as, for example, heat, light and water. As noted earlier, organisms are characterized by an ecological minimum and an ecological maximum. The ranges between these two values are usually called the limits of stability, endurance or tolerance.

The idea of the limiting effect of the maximum along with the minimum was introduced by W. Shelford (1913), who formulated the law of tolerance. After 1910, numerous studies were conducted on the "ecology of tolerance", thanks to which the limits of existence for many plants and animals became known.

The value of the concept of limiting factors is that it gives the ecologist a starting point in the study of complex situations. By studying a specific situation, an ecologist can identify weak links and focus on those environmental conditions that are most likely to be critical or limiting. If the body is characterized by a wide range of endurance (stability, tolerance) to a factor that is characterized by relative constancy and is present in the environment in moderate amounts, this factor is unlikely to be limiting. On the contrary, if it is known that an organism has a narrow range of tolerance to some

variable factor, then this factor deserves careful study since it can be limiting. Thus, the oxygen content in terrestrial habitats is so high and so accessible that it rarely serves as a limiting factor for terrestrial organisms, except for parasites, inhabitants of soils or high altitudes. While oxygen is relatively small in water, its content there often varies significantly, and as a result, for aquatic organisms, primarily animals, it often serves as an important limiting factor. Therefore, an environmental hydrobiologist always has a device in place to determine the amount of oxygen and measures the content of this gas during the study of any unfamiliar situation. An environmentalist who studies terrestrial ecosystems is less likely to measure oxygen content. In general, the meaning of the analysis of environmental conditions, for example, when assessing human impact on the natural environment, is as follows:

- by observation, analysis and experiment to detect "functionally important" factors;
- determine how these factors affect individuals, populations, communities, then it is possible to fairly accurately predict the result of environmental disturbances or its planned changes [1,4,13,14].

Questions for self-control

1. What do the leading and limiting factors mean?
2. Who introduced the concept of limiting factors? What does the law of minimum mean?
3. What is the concept of limiting factors and what is its value?
4. Who introduced the concept of the Law of Tolerance, what is its essence?
5. Using the data from graph 2.5, describe the effect of polluting open air substances on the human body.
6. What is the analysis of environmental conditions conducted for?

Theme 3

The most important abiotic factors and organisms adaptation to them

The abiotic or inanimate component of the environment is divided into climatic, soil (edaphic), topographic, and other physical factors, including the effects of waves, sea currents, fire, etc. The abiotic content of the medium is determined by climatic, soil, and water conditions. Therefore, following one of the popular classifications, abiotic environmental factors are classified into:

- physical (temperature, light, humidity, barometric pressure, radiation);
- chemical (composition of the atmosphere, organic and mineral substances of the soil, pH of the soil, water, salinity, etc.);
- mechanical factors (topography, soil and water movements, wind, landslides, etc.).

The significance of these factors lies in the fact that they essentially determine the distribution of species, that is, they determine the range of species, which means the geographical zone, which is the habitat (distribution) of organisms of one or another species.

For living organisms, a tolerance range for the action of abiotic factors is characteristic, and this is determined by their reaction rate. Some organisms can tolerate fluctuations in environmental factors over a very wide range. They received the name of euribiont organisms (from the Greek. Eurys - wide). Others withstand the influence of abiotic factors in a very narrow range. They are called stenobiontic organisms (from the Greek. Stenos - narrow). Eurybiont and stenobiont organisms are found both among plants and among animals.

3.1 Radiation: light

Light is one of the most important abiotic factors, especially for photosynthetic green plants. The sun radiates a huge amount of energy into outer space (Figure 3.1). At the boundary of the Earth's

atmosphere with space, radiation ranges from 1.98 to 2 cal/cm, or 136 MW / cm² (“solar constant”).

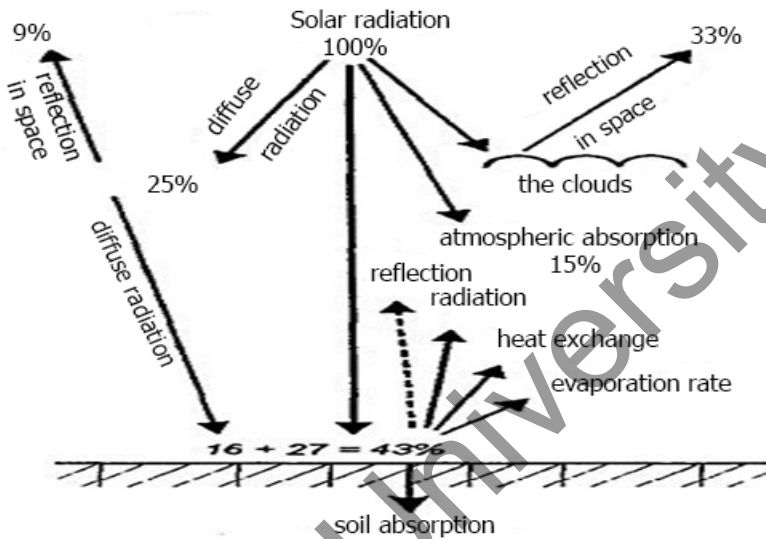


Fig. 3.1 The balance of solar radiation on the earth's surface in the daytime.

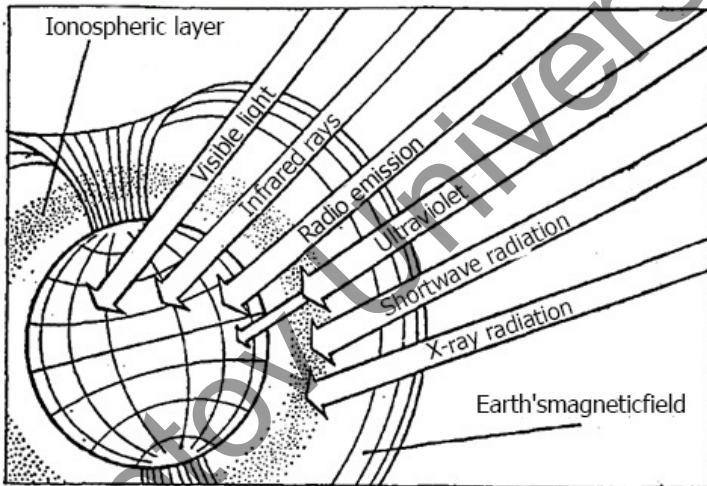
As can be seen in fig. 3.1, 42% of all incident radiation (33 + 9%) is reflected by the atmosphere into world space. 15% is absorbed by the atmosphere and goes to its heating and only 43% reaches the earth's surface. Such a fraction of radiation consists of direct radiation (27%) - almost parallel rays coming directly from the Sun and carrying the greatest energy load, as well as scattered (diffuse) radiation (16%) - rays coming to the Earth from all points of the sky scattered by gas molecules air droplets of water vapour, ice crystals, dust particles, as well as reflected down from the clouds. The total amount of direct and diffuse radiation is called the total radiation.

Light for organisms, on the one hand, serves as the primary source of energy, without which life is impossible, and on the other hand, the direct effect of light on protoplasm is deadly for the body. Thus, many morphological and behavioural characteristics are

associated with a solution to this problem. The evolution of the biosphere as a whole was mainly aimed at "taming" the incoming solar radiation, using its useful components and attenuating harmful ones, or protecting them.

Therefore, light is not only a vital factor but also limiting both at the minimum and maximum levels. From this point, not one of the factors is so interesting for ecology as light.

Among the solar energy penetrating the Earth's atmosphere, visible light accounts for about 50% of the energy, the remaining 50% is thermal infrared rays and about 1% are ultraviolet rays (Fig. 3.2).



Visible rays ("sunlight") are composed of rays of different colours and have different wavelengths.

Sunlight spectrum

Rays Wavelength in micrometres (μm)

UV 0.06-0.39

Violet 0.39-0.45

Blue 0.45-0.48

Light Blue 0.48-0.50

Green 0.50-0.56

Yellow 0.56-0.58
Orange 0.58-0.62
Red 0.62-0.78
Infrared 0.78 - up to 4 mm

In the life of organisms, not only visible rays are important, but also other types of radiant energy reaching the earth's surface:

- ultraviolet; infrared rays, electromagnetic (especially radio waves) and some other radiation. Thus, ultraviolet rays with a length of 0.25-0.30 microns contribute to the formation of vitamin D in animal organisms, with a wavelength of 0.326 microns, a protective pigment is formed in human skin, and rays with a wavelength of 0.38-0.40 microns have greater photosynthetic activity. These rays in moderate doses stimulate the growth and reproduction of cells, contribute to the synthesis of highly active biological compounds, increasing the content of vitamins, antibiotics in plants, and increase resistance to disease.

Infrared radiation is perceived by all organisms, for example, acting on the thermal centres of the nervous system of animal organisms, thereby regulating oxidative processes and motor reactions both in the direction of preferred temperatures and from them.

Of particular importance in the life of all organisms is visible light. The most important processes take place with the participation of light in plants and animals: photosynthesis, transpiration, photoperiodism, movement, vision in animals, and other processes.

Light is the most important abiotic factor, especially for photosynthetic plants (phototrophs). The level of photosynthesis depends on the intensity of solar radiation, the qualitative composition of light, and the distribution of light over time. However, for other organisms, its value in comparison with temperature is less, since many types of bacteria and fungi are known that can multiply for a long time in complete darkness. There are light-loving, heat-loving and heat-hardy plants. For many zooplankton animals, light is a signal for vertical migration, as a result of which during the day they remain at depths, while at night they rise into the warm, rich in food upper layers of water. For animals with vision, the most successful is the extraction of food in daylight.

In animals of many species, the duration of daylight affects their sexual function, stimulating it during the increase in daylight hours (photoperiod) and inhibiting it with a decrease in daylight hours (autumn or winter). In birds, the photoperiod affects the eggs. Shortening the daylight serves as a signal for migration.

Photoperiodism (from the Greek. Photos-light, periodos - circulation) change in the duration of daylight hours.

3.2 Temperature

Physical factors make up a significant portion of abiotic factors. Of particular importance is temperature, since it is the most important factor limiting life. There are thermal zones - tropical, subtropical, moderate and cold, to which the life of organisms is confined to various temperature conditions. The upper and lower levels of the temperature range are legal for organisms. The temperature, which is favourable for the life of organisms, is called optimal. Most organisms are capable of living in the range of 0 ° to 50 ° C.

Based on the ability of organisms to exist at different temperatures, they are classified into eurythermic organisms that can exist under conditions of significant temperature fluctuations, and stenothermic organisms that can exist only in a narrow temperature range. Eurythermic are organisms that live mainly in continental climates. An example of these are animals of many species that live in freshwater bodies and can withstand both freezings of water and its heating to 40-45 ° C. Eurythermic organisms withstand the most severe temperature conditions. For example, the larvae of many dipterans can live in water at a temperature of 50 ° C. In hot springs (geysers) at 85 ° C and more many species of bacteria, algae, and helminths live. On the other hand, arctic species of bacteria and algae live in very cold seawater. Many eurythermal organisms are characterized by the ability to fall into a state of stupor if the effect of the temperature factor is "toughened". In this condition, the level of metabolism decreases sharply. Examples of numbness are the numbness of insects or fish with a significant drop in temperature. In mammals (bears, badgers, etc.), numbness manifests itself in the form

of winter hibernation, when the metabolism decreases sharply, but the body temperature drops slightly.

Anabiosis should be distinguished from numbness (from the Greek. Ana- again, bios-life, anabiosis-revitalization), which is a phenomenon that in organisms under the influence of various reasons the level of metabolism can sharply decrease. For example, the encystation of ciliates allows them to remain alive for up to 6 years, and *Diaptomus sanguineus* eggs survive for over 300 years.

Stenothermic organisms are found both among animals and plants. For example, many marine animals can withstand a temperature increase of only 30 ° C. Some corals survive at a water temperature of not more than 21 ° C.

Many animal species are capable or incapable of thermoregulation of their own, that is, maintain a constant temperature. On this basis, they are divided into poikilothermic (from the Greek Poikiloi - different, variable and therme-heat) and homoiothermal (from the Greek. Homoios-equal and therme-heat). The former is characterized by a variable temperature, while the latter is a constant.

Homoiothermal mammals and some species of birds. They are capable of thermoregulation, which is provided by physical and chemical pathways. Physical thermoregulation is carried out due to the accumulation of the subcutaneous fat layer, leading to the conservation of heat, or due to rapid breathing. The chemical way of thermoregulation is sweating. Poikilothermic are all organisms except mammals and several species of birds. Their body temperature approaches the temperature of the environment. Only some species of these animals are capable of changing the temperature of their body, moreover, under certain conditions. For example, tuna have this ability. It is important for poikilothermic organisms that their body temperature rises when their activity, their metabolism increases.

During evolution, homoiothermal animals developed the ability to defend themselves from the cold (migration, hibernation, coat, etc.).

3.3 Humidity

Humidity is a complex factor and is represented by the amount of water vapour in the atmosphere and water in the soil. Humidity is measured by determining the relative humidity of the air as a percentage of the pressure of water vapour to the pressure of saturated steam at the same temperature. The importance of humidity for the life of organisms is determined by the fact that its loss by cells leads to their death.

Typically, plants absorb water from the soil. As for animals, they realize the necessity for water by drinking it, or by absorption through the integument of the body, or with food, or by oxidizing fats.

Depending on the humidity, the distribution of species occurs. For example, amphibians, earthworms and some molluscs can live only in very humid places. In contrast, many animals prefer dryness.

Soil moisture depends on the amount of precipitation, the depth of soil water and other conditions. It is important for the dissolution of minerals in the water.

Of great importance as an abiotic factor is the combined effect on organisms of temperature and humidity. A special role is played by radiation.

3.4 Chemical Factors

Chemical factors in their value are not inferior to physical factors.

For example, the gas composition of the atmosphere and the aquatic environment plays a large role. Most organisms need oxygen, and some organisms need nitrogen, methane, or sulfur.

The gas composition is extremely important for organisms that live in the aquatic environment. For example, in the water of the Black Sea, there is a lot of hydrogen sulfide, which makes this pool not very favourable for the life of many organisms in it. As for terrestrial organisms, they are insensitive to the gas composition of the atmosphere, since it is constant.

Salinity is also very important in the aquatic environment. For example, the largest number of species from among aquatic animals

live in the seas and oceans, the smaller in freshwater and the even smaller in brackish water. The ability to maintain the salt composition of the internal environment affects the distribution of aquatic animals.

The mechanical factors are the formation of life-free plots, which are then populated, but the content of new “settlers” will differ from the initial one until the formation of new communities of living beings.

The formation of areas free from life occurs as a result of natural disasters (fires, floods, etc.), various geological processes, human actions in nature, etc. An example of mechanical factors is the shallowing of the Aral Sea. Following this, new species of animals and plants appeared on the territories liberated from water.

A characteristic feature of the species in the context of their relationship to abiotic factors is that each species has a certain range of tolerance (resistance) to one or another factor, and tolerance is determined by the reaction rate, i.e., is determined genetically. If the action of the abiotic factor occurs outside the tolerance range, the body dies. The optimal conditions for the life of a species are the middle part of the range of its tolerance to one or another factor. In this part of the range, species organisms also multiply. The extreme limits of the tolerance range are unfavourable for the life of the species.

On the other hand, a characteristic feature of any abiotic factor is that it can limit not only life but to one degree or another the size of the species while acting as a regulatory factor. The regulatory influence of abiotic factors especially increases against the background of the interaction of organisms among themselves (fatal effects on populations of suspended animation, predation, parasitism), which in itself is regulatory.

The next characteristic feature of abiotic factors is their limiting ability, which consists in the fact that with the optimal action of all possible abiotic factors on organisms, the lack of one of the factors will nevertheless have a restrictive effect on the population. Abiotic factors are in constant interaction with each other, and the sensitivity of organisms to the dependence of one factor on another is also determined by the norm of the reaction, that is, it is genetically controlled. For example, the disastrous result of a rise in temperature

is most pronounced in the case of an increase in humidity. In other words, with the “toughening” of the action on organisms of one abiotic factor, the range of their resistance to another abiotic factor narrows.

In the course of historical development, organisms in response to a change of day and night, to a change of seasons, i.e., in response to the basic rhythms of the Earth due to its rotation around the Sun, developed the ability to rhythmic life activity in the process of adaptogenesis, which was called biorhythms. A characteristic feature of biorhythms is that they are carried out synchronously with processes occurring in the medium periodically. There are circadian rhythms (24-hour), and circadian rhythms, which occur during the period from 20 to 28 hours and which are called circadian (from lat. Circa- around, around, dies-day).

It is believed that these rhythms are genetically controlled since neurospores and *Drosophila* have the so-called “clock” genes that determine the circadian rhythms of these organisms. It was also established that the circadian rhythm is inherent in the synthesis of mRNA on “clock” genes and that there are “clock” proteins that can inhibit the expression of “clock” genes.

The science that studies biorhythms is called chronobiology (from the Greek. Chronos-time, logos-science). Knowledge of the laws of biorhythms is of great importance in agriculture and preventive medicine [1,2,7,16,17].

Questions for self-control

1. What physical factors are the abiotic components of the environment divided into?
2. How do not only visible rays affect the life of organisms, but also other types of radiant energy reaching the earth's surface?
3. How are organisms classified according to their ability to exist under different temperature conditions?
4. How do animals thermoregulate?
5. How did organisms adapt to different humidity conditions?
6. Why should abiotic factors be considered comprehensively?

Theme 4

The main environments of life

Four main habitats of animal organisms are traditionally distinguished: aquatic, soil, land-air, and living organisms as a habitat. Let's consider the main features of the living conditions of animals in these environments.

4.1. Aquatic life

The following features are characteristic of the aquatic habitat:

- high density;
- significant pressure drops;
- relatively low oxygen content;
- strong absorption of light waves;
- differences in salinity;
- the presence of horizontal, and sometimes vertical movements of water masses;
- the presence of suspensions that determine the turbidity.

Significant density allows you to rely on water. Depending on the method of movement of animals, they are divided into appropriate environmental groups. Neuston is made up of animals moving along the surface tension film (an example is the well-known water-bugs and bugs-twirls). The border of water and air is an arena of life for representatives of the Pleiston (siphonophores). Specialized inhabitants of the bottom of reservoirs are benthos (aquatic round and ringed, adult echinoderms, most molluscs and crustaceans, stingrays, flounders, gobies and much other fish). In the water column, animals belonging to the nekton actively move (dolphins, pelagic fish, fish, squid, swimming beetles - most of them have a streamlined body shape and effective swimming facilities). Plankton is composed of animals that passively plan (float) in the water column and are transported by water masses (many flagellates and rotifers, cladocerans and copepods, larvae of many aquatic invertebrates).

In addition to physical activity, special formations that increase the area of the supporting surface (antennas in cladoceran and

copepods, spines and outgrowths of the shell in rotifers and armoured flagellators, and an umbrella in jellyfish) help to keep the body afloat with plankton animals. The presence of gas vacuoles and chambers, fatty inclusions (pneumatophores of the siphonophore, fatty inclusions of the cytoplasm of the night-light, foamy cytoplasm of radiolarians, etc.), as well as reduction of the skeleton, can reduce the specific gravity of the body and increase buoyancy. When diving for every 10 m, the pressure rises by about one atmosphere. Many aquatic organisms are eurybathic. In the experiment, swimming beetles withstood pressures of up to 600 atmospheres, corresponding to an immersion depth of 6 km. Eurybate forms may have special devices to compensate for sudden changes in pressure during rapid immersion and ascent, such as a swim bladder in fish, a spermaceti “pillow” in the skull of a sperm whale, etc. Wall-walled animals do not have similar adaptive devices, which determines their habitat at certain depth ranges. For example, pogonophorans belong to the deep-sea stenobathic forms. Oxygen is a resource in the aquatic environment since its maximum content here is at least 21 times lower than in standard air. With increasing temperature and salinity, the concentration of dissolved oxygen decreases. Oxygen enters the water from the atmosphere (its dissolution is facilitated by agitation - stormy waves, the presence of rifts, waterfalls, etc.) or is produced by autotrophs (algae). Due to the limited transparency of water, photosynthetically active radiation penetrates the water to a depth of 50-200 m, where the border of the euphotic zone passes. In freshwater, it is much thinner. Outside, the oxygen content is usually 5–7 times lower. Thus, with increasing depth, the oxygen content in water is steadily decreasing, both due to a decrease in its supply and intensive consumption. Near the bottom of the oxygen is often so small that the living conditions of animals are close to anaerobic.

Aquatic animals differently solve the problem of limited oxygen resources. The main options may be as follows:

1. Animals effectively remove dissolved oxygen by exchanging gas over the entire surface of the body (the integument should be thin and the volume to area ratio not too large), or using gills, which can be cutaneous (echinoderms), intestinal (dragonfly larvae, Holothuria), tracheal (many aquatic insect larvae), limb (crustacean) and ctenidia

(molluscs). Water circulation allows for increasing the gas exchange efficiency. For this, many sedentary and sedentary animals create a watercourse around them (barnacle crayfish, polychaetes, etc.).

2. Animals consume atmospheric oxygen:

- entering through the air ducts (the larvae of the iris-bug beetles build the spiracles into the air-vessels, piercing the stems of amphibiotic plants; the larvae of the female fly flies, called rats, expose the end of a long and flexible breathing tube to the surface; water scorpions are placed with a rigid breathing tube);

- typed by them during ascent (aquatic mammals, labyrinth fish, pulmonary molluscs, etc.);

3. Animals use so-called physical gill. It is an air bubble attached to the body. Due to its low solubility, oxygen constantly enters the bubble from the surrounding water. Carbon dioxide, by contrast, is removed from it due to its good solubility. As a result, there is a natural regeneration of air in the bubble. The end of the abdomen in water bugs and bugs is equipped with air-retaining hydrophobic hairs, here the spiracles of the tracheal system open. The effectiveness of the physical gills is low, and many large insects are forced to regularly ascend to refresh the vesicle.

4. Animals store oxygen:

- air (underwater bells of a silver spider);

- in a bound form, as part of respiratory pigments.

So, in larvae of mosquito-bells (red bloodworm), haemoglobin reserves can be up to 45% of body weight, which allows you to continue active life at the bottom of water bodies frozen for winter.

5. Animals with a lack of oxygen go into an inactive state - the state of anoxybiosis (one of the variants of suspended animation).

6. Animals switch to anaerobic metabolic variants (protozoa, for example, optionally pathogenic flagellates trichomonads). Some animals have both air and water breathing (double breathing fish, some siphonophores, amphipods, pulmonary molluscs, etc.). Some inhabitants of reservoirs can withstand any significant fluctuations in the oxygen content in the water (tubule, lawn, golden and silver crucian carp, loaches, tench, horsefly larvae, etc.) without any negative consequences - these are the so-called euryoxybionts. On the contrary, stenooxybionts (many salmonids, minnow, midge larvae and

several mayflies, barley, barnacles, etc.) need a large amount of dissolved oxygen and are not able to tolerate its deficiency. Otherwise, kills occur. In addition to the lack of oxygen, the kills can be caused by a sharp rise in temperature (an example is the arrival of a warm current to the coast of Ecuador and Peru), ice freezing and an increased concentration of carbon dioxide generated during the breathing of living organisms. The low light conductivity of water makes it difficult not only photosynthesis but also the communication of animals. In Amu-Darya and Syr-Darya, Juanha, Ganges, water transparency at times approaches zero. Under such conditions, vision is an ineffective source of information. The dolphins of the *Platanista gangetica* that live in the muddy waters of the Ganges have lost their sight due to uselessness and are oriented in space using ultrasonic sonar.

Sound waves propagate in the aquatic environment with less attenuation than in the air. As a source of information, they are used by aquatic animals more often and more efficiently than light ones. As a rule, organs of chemical sensation are very well developed in aquatic animals. It is by the chemical composition of water that migratory salmon recognize the river in which they spawned from caviar. The inhabitants of the drying up reservoirs are forced to adapt to the short duration (ephemerality) of their existence. Specific living conditions led to the development of two main strategic directions of adaptation:

1) shortening the life cycle — in this case, the change of generations is quick, the life span of individuals is small (shields, gills, branchy crustaceans, rotifers);

2) the ability to tolerate drying:

- in a state of brumation (turbellaria, nematodes, leeches, gastropods, shellfish, bipedal fish);
- in the stage of cysts (protozoa, nematodes);
- at the stage of eggs (cladocerans, spawning cyprinids);
- at other experiencing stages (gemmules of fresh-water sponge, statoblasts of bryozoans).

4.2 Soil as a living environment

The soil is a loose thin surface layer of land that is in direct contact with the atmosphere. It is densely populated by living organisms and at the same time is the result of their vital functions. On this basis, Academician V.I. Vernadsky carried the soil to bioinert substances. In contrast to solid rocks, the soil is not a single-phase, but a three-phase polydisperse system, combining solid particles, liquid and gases in the cavities. Water, moisture is present in five states:

- 1) vapour - water vapour in the soil air;
- 2) gravitational - falling drops flowing through the wells of the soil of the stream;
- 3) capillary - water rising the shallow capillary wells;
- 4) film - water film on the surface of soil particles;
- 5) hygroscopic - water associated with soil colloids and other substances, the water content in the soil can vary within wide limits. If all cavities and wells are filled with gravitational water, the living conditions of the animals are close to those in the aquatic environment. In air-dry soil, only hygroscopic and possibly vaporous moisture remains, and the living conditions resemble a terrestrial-air environment. With depth, the concentration of oxygen in the soil air decreases, and carbon dioxide, as a rule, increases. The flow of oxygen is due to diffusion. In finely porous and finely dispersed soils (clay, loess soil) it is very difficult. Intensive decomposition of organics also leads to an increase in the concentration of H_2S , NH_3 , CH_4 and other gases, which worsen the living conditions. The temperature conditions here are very stable. Only the temperature regime of the soil surface is variable, with the depth it is levelled. At a depth of more than a meter, the temperature is close to the annual average and almost does not experience daily and seasonal fluctuations. The living conditions in the soil of animal organisms largely depend on their size. Representatives of the microfauna - protozoa, rotifers, small nematodes - actually remain aquatic animals and inhabit pores and cavities filled with gravitational and capillary water. For these animals, the soil may be a micro-reservoir system. Often, with equal success, they can inhabit ordinary water bodies (like

Colpoda ciliates), or are represented there by larger sizes (sometimes 5–10 times) with similar forms (like some amoebas).

For representatives of the mesofauna - soil mites, wingless prickle (foottail, two-tailed), large nematodes, millipedes - the soil is a system of caves. Independent laying of moves for them is not characteristic. Gravity and film moisture is dangerous for these animals, as they can drown or suffocate, being wrapped in a film of surface tension. Very often there are devices for overcoming adhesion: water-repellent integuments of the body, wax pollination, hopping or numerous limbs. An air of the well saturated with water vapour allows gas exchange over the entire surface of the covers. When the soil dries, the animals migrate inland, that is, against the gradient of oxygen concentration. They can experience flooding in air bubbles that perform the function of a physical gill. Representatives of the macrofauna have larger body sizes (2–20 mm) and are forced to resort to laying moves. Millipedes and pot worms squeeze into wells and push apart soil particles. Earthworms and larvae of centipedes mosquitoes work hydraulically - they redistribute coelomic fluid or hemolymph. Larvae of other insects are used to lay the jaw moves, the head capsule as such, or limbs. If an open passage remains behind the animals, moisture evaporates along with it, and the predator can easily overtake the owner. Therefore, most insect larvae fall asleep after themselves, constantly being in a chamber of approximately the same volume. Even larger animals - representatives of megafauna - usually build tunnel systems. These are moles of Eurasia, mole rats, mole rats, zokors, African gold moles and Australian marsupial moles, giant earthworms of this family. Megascolecidae and large insects (e.g., bear). To ensure the supply of oxygen, they leave a course open. So, mole rats track the integrity of the galleries by smell. In addition to the permanent inhabitants of the soil, that is, pedobionts, digging activity in the soil is carried out by representatives of the ecological group of burrows. They feed on the surface of the soil, but spend most of their time in burrows, where they rest, hibernate, breed, and escape from predators and adverse factors. These animals include crickets, burrows, many rodents (woodchucks, ground squirrels, gophers, gerbils, etc.), rabbits, and badgers. In many ways, the soil is

essentially a transitional habitat that combines the features of water and ground-air. Soil habitat is combined with the aquatic environment:

- stable temperature conditions;
- limited oxygen resources;
- the ability to move in three dimensions;
- variability of the chemical composition of soil solutions;
- the fact that water is more a condition than a resource. With the

ground-air soil habitat combine:

- sharp temperature fluctuations at the media boundary;
- limited water resources of the surface layer;
- the fact that in the upper horizons oxygen is more likely a condition, not a resource.

A huge contribution to the justification of the evolutionary role of soil in the development of land by animal organisms was made by the Soviet school of soil zoologists, headed by academician M.S. Gilyarov

4.3. The ground-air environment of life

This habitat of animal organisms is characterized by the greatest variety of environmental factors. Only a few were able to master it, namely molluscs, arthropods and chordates. Oxygen, due to the constantly high content in the atmosphere, is a condition here, not a resource. Only in the mountains, due to the low partial pressure of oxygen, can problems arise with the supply of the body to it. For vertebrates, the height of 4600 m above sea level is considered the upper limit of adaptive capacity. The low density of air leads to its low lifting force and low support.

Terrestrial animals must have a perfect musculoskeletal system based on either the external (most of the arthropods), or internal (chordate) mechanical skeleton, or abdominal (caterpillar and pseudo-caterpillar), or cell-intercellular (gastropod mollusc) skeleton. The same circumstance imposes restrictions on the maximum body sizes in vertebrates. In different geochronological eras, the speed of rotation of our planet around its axis, and hence the level of gravity, did not remain unchanged. From the point of view of biomechanics, the existence of many large dinosaurs at present would be impossible,

since their bone tissue is not able to support the modern weight of their body. Approximately $\frac{3}{4}$ of terrestrial animals have the ability to fly - these are insects, birds, mammals (bats), as well as individual reptiles and amphibians (masterfully planning tree dragons and some tree frogs). However, no animal spends all its life in the air. The presence of vertical (convection currents) and horizontal (wind) streams of air masses allows many animals to passively pass through the air without energy and muscular work.

Aeroplankton in temperate latitudes is present only in the warm season, in the tropics there is no such seasonality. Its small dipterans, hymenopterans, and aphids are recorded at altitudes of up to 4–5 km, sometimes more. The phenomenon of animal transport by air currents is called anemochory. Protozoa and nematodes cysts, small insects and arachnids are susceptible to this. Mass migrations on cobwebs are especially characteristic of spiders. The caterpillars of the pigeon butterflies have special hairs with air capsules - pneumatophores, which contribute to soaring in the air. In many species, caterpillars hatching from eggs rush to the tops of plant shoots, where they are more likely to be caught in air currents. Moreover, they do not start eating until they have completed a minimum duration flight.

The temperature conditions on land are contrasting - from constantly negative to extremely high positive (+70 C and more) on the surface of the sand, illuminated by the direct rays of the midday sun at low latitudes.

In humid biotopes, the temperature is quite stable; in dry biotopes, the daily temperature variation can be an order of magnitude higher. For example, in the Sahara desert, daytime heat does not prevent freezing at night.

The ground-air environment is characterized by a moisture deficit. In this case, moisture-loving animals are forced to switch to a nocturnal lifestyle or use short-term periods of high humidity (slugs).

Hard surfaces serve as ground support for animals, or as a substrate for attachment. The most important edaphic factor is the nature of the soil. Special devices are used for efficient movement on loose soil - various types of hoofs in ungulates, corns for camels, horn spikes for lizards, and "skis" made of bristles in sand wasps. In rocky soil, burrows have to be dug with difficulty, so they are usually

permanent here. Snow cover, on the one hand, mitigates frosts (partridges sleep under the snow, weasels and mouse-like rodents carry out all their life activity in winter), on the other hand, it makes food difficult to obtain.

4.4. Living organisms as a living environment

The use of living organisms as habitat is a widespread phenomenon in the animal kingdom (Figure 4.1).

There are probably no single species of multicellular organisms completely free of parasites. Intracellular parasites even have amoeba. The higher the level of organization and the greater the degree of morphological and histological differentiation, the more variable the potential habitats for the parasites, and the more diverse the endo- and exoparasite. More ancient groups of animals are more likely to “acquire” parasites than evolutionarily young, although there are exceptions (horseshoe crab, shields, existing for millions of years). Similarly, among them, as a rule, there are more parasitic forms.



Figure 4.1 Living organism and habitat

On the contrary, in the evolutionarily young type of chordate parasites are single. It is believed that the emergence of parasitic forms is a consequence of the pressure of the "press of life", that is, the effects of predators and competitors in conditions of limited

resources, including habitable space. Parasitic lifestyle has several advantages, namely:

- almost unlimited feed resources;
- protection from direct adverse effects of environmental factors (these factors have only an indirect effect, and its sign may even change to the opposite, - adverse conditions weaken the host's immune barriers, making it easier for the parasite to overcome them);
- the relative stability of the conditions of existence of parasites.

Based on this, the parasite as a whole is interested in saving the life of its owner. An exception is the so-called parasitoids, the development of which naturally leads to the death of the host. The absolute majority in this group of parasites are parasitic insects (Figure 4.2).



Figure 4.2 Parasite

The consequences of a parasitic lifestyle can be a simplification of the organization and vital processes of parasitic forms, including a reduction in information (sensory organs in endoparasites) and regulatory (nervous system in sacculins) systems. Many difficulties are also associated with the parasitic lifestyle. Among them:

- the need to overcome the host's immune barriers and to exist in extreme conditions (the cuticle of nematodes and trematodes provides them with protection against the action of the host's digestive

enzymes; parasitic hymenopterans often lay eggs in the ganglia, where they are inaccessible to the host's immune system.

- limited living space (if two individuals of tapeworms are settled in one host, he has a great chance of dying due to exhaustion and toxicity of the parasite metabolites);

- the difficulty of supplying oxygen; This problem is solved by:

- a) respiration of the entire surface of the body (abdominal, pulmonary and blood parasites);

- b) the consumption of oxygen-depleting host materials (for example, red blood cells);

- c) connection to the respiratory system of the host (for example, the integration of their spiracles into the tracheal system of an insect);

- d) transition to anaerobic metabolic variants - they are energetically less beneficial, but parasites are rarely limited by food resources (gregarines, adult stages of many flatworms and nematodes constantly live in anaerobic conditions);

- difficulties with the resettlement and infection of new hosts.

To overcome the last difficulty, the parasites have developed appropriate devices. One of them is the production of a huge number of descendants. In this case, the bet is on the so-called "law of large numbers." Indeed, the more invasive sources (eggs, cysts, spores, larvae, etc.) are produced, the higher the statistical probability of accidental infection of the host individuals. Thus, an adult female human roundworm produces 250,000 eggs daily. With an average reproductive period of 20 days, one female is capable of producing 50,000,000 eggs in her life. An adult hermaphrodite specimen of a bovine tapeworm separates up to 28 mature proglottid segments containing about 5 million eggs. With a life expectancy of more than 10 years, the total number of eggs produced by it reaches astronomical values.

To increase the number of offspring, parasitic animals can move on to other methods of reproduction. Polyembryony is characteristic of some parasitic hymenopteran insects. In this case, more than one embryo develops from one zygote or egg. So, in *Platygaster hiemalis*, a parasite of the Hessian fly, a pest of cereals that is secondary in Belarus, 2 embryos are formed in each fertilized egg. In the wasp - *Chalcidides lithomastix*, a parasite of large caterpillars, the egg is

initially crushed into 200-250 cells. After this, conglomerates of 25–30 cells are separated. In the formed secondary germinal embryos, cell division continues. When their number reaches 200–250, again there is a division into conglomerates. Then everything repeats, as a result, from one egg 2000 or more parasitoid larvae develop, which allows utilizing the host biomass without residue. Pedogenesis (reproduction of non-imaginal stages) is characteristic of parasitic larvae of gall midges in fruit bodies of fungi. Fruit bodies are difficult to detect (given the small size and imperfect flight of these insects) and ephemeral (short-lived) resource, which is desirable to use to the maximum extent. Hatching by older larvae of young larvae accelerates the change of generations and significantly increases the reproductive potential of the species. By the time of the destruction of the fruiting body, gall midges pass to the standard version of sexual reproduction. Another option is the transition to parthenogenesis, that is, the development of unfertilized eggs. This method of reproduction is characteristic of sporocysts and rare trematodes, many hymenopterans (riders, chalcids, walrus, wasp-like, bee) and homopterans (aphids, whiteflies, mealybugs and scale insects) of insects.

Many taxa of parasitic animals have developed complex biological cycles in which various methods of reproduction are involved, including:

- heterogony - the alternation of true sexual and parthenogenetic reproduction (sporozoans, aphids, walnuts);

- metagenesis - the alternation of sexual and asexual generations (parasitic intestinal); often there is a differentiation of functions between developmental stages and the appearance of specialized settlement or invasive stages. For example, adults parasitize in the puparium of the mukhtahin and cocoons of the braconids, and the riders carry out the functions of settlement and reproduction, and the larvae perform trophic functions.

In trematodes, larvae of sporocysts (miracidium) and marita (cercaria) perform the functions of resettlement and infection of intermediate hosts, adolescaria - the function of infection of the main hosts, adult trematodes (marita) - trophic and reproductive functions.

Another device that increases the efficiency of host invasion is the use of carriers (gall mites attach to the hairs on the body of flying

insects. The nodules of the nematodes of the genus *Dirofilaria*, family Filariidae of the suborder Filariata, which cause an invasive disease of carnivores - *Dirofilaria immitis* (the probability of ingesting a cyclops infected with plerocercoid by a fry is higher than the microscopic size of the eggs of a wide ribbon, invaded by the larvae of the Ligulidae of the morning fish they increase their speed of movement and remain at the water surface for a long time, which significantly increases the likelihood of their catch by birds, which are the main owners of these flatworms).

Parasites can exhibit a high level of synchronization of the biological cycle with the host cycle. For example, sexual reproduction of opalina occurs in the digestive tract of tadpoles, as they approach the time of their transformation into frogs, it is replaced by asexual. The female flea *Spilopsyllus cuniculi* proceed to oviposition, only the blood consumption of the pregnant rabbit. This allows us to coincide with the timing of hatching of the imago of a new generation to the time when rabbits left their mother hole. Permanent ectoparasites have adaptations for living on the border of two environments - the host organism and its habitat. They are aimed primarily at retaining ectoparasite on the surface of the host body. These are a variety of hooks, suction cups, hooks, claws and other attachment mechanisms. Temporary ectoparasites maintain contact with the host (s) occasionally and must have adaptations to exist in the appropriate habitat and effectively search for the host. The presence of a large number of specific adaptations makes the parasites dependent on a narrow circle of hosts and deprives these animals of the ability to quickly adapt to changing environmental conditions. This circumstance determines a high level of fluctuation in time of the population of many parasites [1,4,5,9,16,17].

Questions for self-control

1. What are the characteristics of the aquatic environment?
2. What are the adaptations of organisms to the aquatic environment? Give examples.
3. What adaptations do organisms living in the soil have?
4. Why is the land-air habitat of animals characterized by the greatest variety of environmental factors?

5. Explain the characteristics of organisms leading a parasitic lifestyle.
6. Why in the process of evolution of parasitic organisms often was no complication, but rather a simplification of structure and physiology?

Theme 5

Biotic factors

Biotic factors are forms of the influence of organisms on each other, both within a species and between different species.

Beklemishev V.N. divided biotic factors into 4 groups (types of interaction):

- topic - on changes in the environment (tearing of the soil)
- trophic - food relations (producers, consumers, reducers)
- fabric - for housing (parasitic worms use the body as a habitat)
- phoric - on transfer (hermit cancer transfers sea anemone)

5.1 Homotypic and heterotypic reactions

Clements and Shelford (1939) gave the name interactions between the various organisms that inhabit this environment. Coalitions were divided into two types.

Homotypic reactions, or interactions between individuals of the same species. Reactions of this type are very diverse. The main ones are group and mass effects, intraspecific competition.

Heterotypic reactions, i.e. relationships between individuals of different species. The influence that two species living together have on each other can be zero, favourable or unfavourable. Hence, the types of combinations may be as follows.

Neutralism - both types are independent and do not exert any influence on each other.

Competition - each of the species harms the other species. Species compete in search of food, shelter, egg-laying sites, etc. Both species are called competing.

Mutualism is a symbiotic relationship where both cohabiting species benefit each other.

Collaboration - both types form a community. It is not necessary, since each species can exist separately, in isolation, but life in the community benefits them both.

Commensalism is the relationship of species in which one of the partners benefits without harming the other.

Amensalism is a type of interspecific relationship in which, in a collaborative environment, one species suppresses the existence of another species without experiencing opposition.

Parasitism is a form of relationship between species, in which organisms of one species (parasite, consumer) live off the nutrients or tissues of the body of another species (host) for a certain time.

Predation is a type of relationship in which representatives of one species eat (destroy) representatives of another, that is, organisms of one species serve as food for another.

Among mutually beneficial relationships (+, +) among species (populations), in addition to mutualism, symbiosis and proto-cooperation are distinguished.

Symbiosis is an inseparable, mutually beneficial relationship of two types, implying mandatory close coexistence of organisms, sometimes even with elements of parasitism.

Proto-cooperation is a simple type of symbiotic relationship. In this form, coexistence is beneficial for both species, but not necessary for them, that is, it is not an indispensable condition for the survival of species (populations).

Under *commensalism*, neutral relationships (+, 0) are distinguished as freeloading, commensality, and lodging.

Freeloading is the consumption of the remnants of the host's food, for example, the relationship of sharks with sticky fish.

Commensality is the consumption of different substances or parts of the same resource. For example, the relationship between different types of soil bacteria-saprophytes, which process various organic substances from decayed plant residues, and higher plants that consume the mineral salts formed in this process.

Lodging - the use of certain types of others (their bodies or their dwellings) as a refuge or dwelling.

5.2 Zoogenic factors

Living organisms live surrounded by many others, enter into various relationships with them, both with negative and positive consequences for themselves and as a result cannot exist without this living environment. Communication with other organisms is a necessary condition for nutrition and reproduction, the ability to protect, mitigate adverse environmental conditions, on the other hand - the danger of damage, and often an immediate threat to the existence of the individual. The immediate living environment of the body is its biotic environment. Each species can exist only in such a biotic environment, where connections with other organisms provide normal conditions for their life. It follows that they are diverse. Living organisms are not found on our planet in any combination but form certain communities, which include species adapted for cohabitation.

Interactions between individuals of the same species, the so-called homotypic reactions, as noted earlier, are manifested in group and mass effects, intraspecific competition.

The term *group effect* Grasse, Chauvin (1944) denotes changes associated with the association of animals in groups of two or more individuals. Currently, the existence of a group effect is known in many orders of insects and vertebrates. An important consequence of this is a significant acceleration of growth.

The *group effect* is manifested in many species that can reproduce and survive normally only if they are represented by large enough populations. For example, for the survival of African elephants, a herd must consist of at least 25 individuals, and a herd of reindeer must consist of at least 300-400 heads. The "principle of minimum population size" explains why species that are too rare cannot be saved. It is known that the white crane in North America, despite all the efforts that have been undertaken for many years, currently numbers no more than 30-50 individuals.

When living together, the search for food and the fight against enemies is facilitated. The group effect is more clearly manifested in the presence of phase nature in animals, i.e., the existence of a species simultaneously in two phases: single individuals and individuals combined into herds. So, the locust is a classic example of phasing.

The presence of phases has been established in various species of butterflies, beetles, aphids, cockroach, Prusaka, crickets, haymakers, etc. In all cases, significant changes are observed in fertility, the rate of development, and often in the morphological and physiological characteristics of animals.

Mass effect. Indicates the effect caused by the overpopulation of the environment. In most cases, there are transitions between group and mass effects. As a rule, the mass effect entails consequences harmful to animals, while the group effect favourably affects them.

Intraspecific competition. With intraspecific competition between individuals, relationships are preserved in which they can reproduce and ensure the transfer of their inherited properties.

Intraspecific competition occurs in territorial behaviour when an animal protects its nesting place or a known area in its district. So, during the breeding season of birds, the male protects a certain territory, on which, apart from his female, he does not allow a single individual of his species. The same picture can be observed in many fish (for example, sticklebacks).

A manifestation of intraspecific competition is the existence in animals of a social hierarchy, which is characterized by the appearance in the population of dominant and subordinate individuals. For example, in the May beetle, larvae of three years of age suppress larvae of one and two years of age. This is the reason that the emergence of adult beetles is observed only once every three years, while in other insects (for example, the sowing nutcracker *Agriotes*), the larval stage also lasts for three years, the adult emerges annually due to the lack of competition between the larvae.

The relationships between individuals of different species, or heterotypic reactions, are manifested in the form of neutralism, interspecific competition, mutualism, cooperation, commensalism, parasitism and predation.

Under neutralism, individuals are not directly related to each other, and their cohabitation in one territory does not entail either positive or negative consequences for them but depends on the state of the community as a whole. So, moose and squirrels living in the same forest practically do not contact each other. Relations such as neutralism are developed in species-saturated communities.

Interspecific competition is the active search for two or more types of the same food resources of the habitat. Competitive relationships tend to arise between species with similar environmental requirements. When living together, each of them is at a disadvantage due to the fact that the presence of another species reduces the ability to acquire food resources, shelters and other livelihoods available in the habitat. Competition refers to a form of environmental relationship that adversely affects interacting partners.

Competitive relationships can be very different, from direct physical struggle to peaceful coexistence. And at the same time, if two species with the same ecological needs find themselves in the same community, then one competitor is surely crowding out the other. This is one of the general environmental rules, called the "law of competitive exclusion", formulated by G. F. Gauze (1910-1986) based on the results of experiments on the maintenance of two types of ciliates on the same limited diet.

More often, competition is manifested indirectly, is insignificant, since different species do not equally perceive the same environmental factors. The more diverse the ability of organisms, the less intense competition will be.

Predation and parasitism. A predator is a free-living organism that eats other animal organisms or plant foods. The parasite does not lead a free life, and at least at one stage of its development, it is associated with the surface (ectoparasite) or with the internal organs (endoparasite) of another organism, which is its owner.

The predator, as a rule, first catches the prey, kills it, and then eats. For this, it has special devices.

The preys also historically developed protective properties in the form of anatomical, morphological, physiological, biochemical and other features.

For example, body outgrowths, spikes, thorns, shells, protective colouring, poisonous glands, as well as the ability to quickly hide, dig into loose soil, build shelters inaccessible to predators, and resort to danger alerts. As a result of such mutual adaptations, certain groups of organisms are formed in the form of specialized predators and specialized victims. So, the main food of *Felis lynx* is the hare, and *Canis lupus* is a typical polyphagous predator.

Among the insects with complete transformation, there are parasite species that at first behave like parasites, sparing the vital organs of their master, and at the end of development, eating their master, become real predators. Both a predator and a parasite can exist due to one or more species. The following types are distinguished.

Oligophagous - living at the expense of several, often close species., The Colorado potato beetle eats potatoes and other plants related mainly to nightshade. Echinococcus tapeworm parasitizes in humans, pigs, various carnivores and rodents.

Monophages - living at the expense of only one owner. Monophagy is the rule for many parasitic insects, for examples, such as aphelinus (*Aphelinus mali*) on the aphid, pear beetle (*Anthonomus pyri*) on the pear, and silkworm on the mulberry tree.

Polyphages - attacking a large number of species. These include many carnivorous mammals and insects (Figure 5.2.).



Figure 5.2 Polyphages

Insect phytophages feed on a wide variety of plants. So, the caterpillar of the stem moth *Pyrausta nubilabis* infects more than 200 species of plants.

Commensalism. Relations in which one of the partners' benefits without harming the other, as noted earlier, is called commensalism. Commensalism, based on the consumption of the remnants of the food of the owners, is also called parasitism. Such, for example, the

relationship of lions and hyenas, picking up the remnants of half-eaten food, or sharks with fish-sticks

A good example of commensalism is given by some barnacle crustaceans that attach to the skin of a whale. At the same time, they get an advantage - faster movement, and the whale does not cause almost any inconvenience. In general, partners do not have any common interests, and each one perfectly exists on its own.

Commensalism is especially common among marine animals. The relationships between some fish and sharks are well known. Pilotfish feeding on leftovers from the shark's "table" are constantly scurrying with small slopes near its nose. Another example is animals, the hole of which serves as a refuge for various "guests", eating leftovers from the host table. In mammalian burrows, bird nests, and public insect dwellings, commensal insects are represented by a large number of species (for example, in alpine groundhog burrows, up to 110 beetle species).

Mutualism, symbiosis. Numerous examples of mutualism, or mutually beneficial relationships of individuals of different species, can be cited. Such, for example, the relationship between birds and rhino. Birds feed on parasitic insects on the skin of the rhino, and their take-off serves as a signal of danger.

Symbiosis is an inseparable, mutually beneficial relationship of two types, implying mandatory close coexistence of organisms, sometimes even with elements of parasitism. The classic examples of symbiosis are the cohabitation of hermit crab (*Pagurus bembardus*) and sea anemone.

5.3. Anthropogenic factors

The anthropogenic factor is the result of a direct human impact on the natural environment, leading to the disruption of natural ecosystems

The currently most significant group of factors that are actively changing the environment is directly related to the versatile human activities.

Human development on the planet has always been associated with environmental impacts, but today this process has accelerated significantly.

Anthropogenic factors include any impact (both direct and indirect) of a person on the environment - organisms, biogeocenoses, landscapes, the biosphere.

Altering nature and adapting it to one's needs, a person changes the environment of animals and plants, thereby affecting their lives. The impact can be direct, indirect and random.

Direct exposure is directed directly to living organisms. For example, the irrational use of fishing and hunting has sharply reduced the number of species. The growing strength and accelerated rate of change in nature by man make it necessary to protect it.

The indirect impact is carried out by changing landscapes, climate, physical condition and chemistry of the atmosphere and water bodies, the structure of the earth's surface, soil, vegetation and wildlife. Man consciously and unconsciously exterminates or supplants some species of plants and animals, spreads others, or creates favourable conditions for them. For cultivated plants and domestic animals, man has created a significantly new environment, repeatedly increasing the productivity of the developed lands. But this ruled out the possibility of the existence of many wild species.

Random factors include effects that occur in nature under the influence of human activity. They were not previously planned and planned by him: the spread of pests, parasites, the accidental delivery of various organisms with a load, unforeseen consequences caused by conscious actions in nature, for example, undesirable effects caused by drainage of swamps, construction of dams, tilling of wildland, etc.

In fairness, it should be said that many species of animals and plants disappeared from the face of the Earth without human intervention. Each species, as well as an individual organism, has its youth, flowering, old age and death - a natural process. But in nature, this happens slowly, and usually, the outgoing species have time to give way to new, more adapted to living conditions.

Man, however, accelerated the extinction process to such a pace that evolution gave way to revolutionary, irreversible transformations of ecosystems [1,5,14, 22].

Questions for self-control

1. What is mutualism?
2. In what year did Clements and Shelford name the interactions between the various organisms that inhabit this environment?
3. Describe the environmental rule, called the "Law of Competitive Exclusion."
4. What is an anthropogenic factor?
5. Who are monophages and oligophages?
6. Who divided the biotic factors into 4 groups by type of interaction?

Theme 6

Biological rhythms

The cyclical processes that occur in living nature are one of its most important properties.

Celestial bodies and living organisms are interconnected and closely intertwined. Living organisms grow and multiply in a certain rhythm. The phenomena occurring in nature are assimilated by living matter and they have acquired the property of changing their state periodically.

The uniform alternation of the state of organisms in science is called biological rhythm. There are external and internal rhythms of the body.

6.1 External rhythms

External rhythms are associated with the rotation of the Earth and have a geographical nature. Many environmental factors on Earth during rotation are subject to a regular change. Cosmic rhythms also influence the living. Solar radiation also affects the climate of our Earth.

6.2 Internal physiological rhythms

Internal rhythms have arisen historically. Activity in a living organism occurs in a certain rhythm. For example cell division, muscle contraction, palpitations, respiration. Each of them has a period. Change this period is possible only within certain limits, sometimes impossible. Therefore, this rhythm is called endogenous. A living organism, as it were, records the time, exercising rhythmically its physiological functions. Time is the main measurer of the next phase.

Changes in a living organism coincide with geographical cycles.

Such important biological functions of organisms as nutrition, growth and reproduction coincide with the favourable days of this time of day and year.

Daily rhythms - changes in processes and phenomena with daily periodicity. For example, animal activity or leaf position in plants. A person has more than 100 physiological changes that occur with daily intervals. If the natural rhythm of the environment is disturbed, daily rhythms lose synchronism. For example, if you breed animals or plants in artificial conditions, if the person is in a different time zone, all of this can cause a topology in a living organism.

Lunar rhythms correspond to the cycle of the phases of the moon. They can be observed in the rhythm of the release of insect dolls, in the cycle, the reproduction of the palolo worm.

Lunar rhythms can be observed in nocturnal bats, bats, which are manifested active behaviour. Lunar rhythms are preserved in laboratory conditions, which indicates their endogenous nature.

Tidal rhythms also belong to internal rhythms. They can be observed in the life of aquatic organisms and oceans. These are the tides that occur during the attraction of the Moon and the Sun. This is the rhythm of the subordinate fish, which, during the tide, is washed ashore and lays eggs, and the male fertilizes it, then returns to the sea. Fry go through all stages of development and wait for the next tide.

6.3. Seasonal rhythms

This is the frequency of the most common phenomena in wildlife. As a result of the adaptation of animals and plants to meteorological

conditions, a certain periodicity appears. That is, they develop the rhythm of life: the period of reproduction, the period of growth, vegetation. A major role in seasonal periodicity is played by the length of the day. In summer, the day is longer and the night is shorter. For example, the saturnian butterfly dolls sleep for 8 hours, and as the day becomes longer, special hormones cause them to awaken.

Changing the season affects the reproduction of animals. For example, cows, horses, sheep breed in the spring, as summer is ahead and there is a lot of food. Although this rhythm is not observed in small mammals. In nature, there is a long-term periodicity of biological phenomena. Under the influence of the solar system, a productive or lean year is determined.

6.4. The biological clock

A living organism can sense time.

A biological clock is a mechanism responsible for the periodic activity. The biological clock controls the life of animals and plants. In wildlife, reproduction, nutrition is subordinated to the biological clock: legume leaves wake up in the daytime, straighten out, and sleep or wilt at night. House flies hatch in the morning. Even if you make conditions for it - lighting, humidity, she will abide by her behaviour. Many animals or birds are well oriented in their travels in the heavenly bodies.

6.5. Photoperiodism

Photoperiodism is a change in the length of daylight hours. The longitude of the day is one of the main signals of the seasonal restructuring of life.

What role does photoperiodism play in animal life?

Insects are especially sensitive to the longitude of the day: locusts, scoops, silkworms develop in a short day, and white cabbage or birch moths are organisms of a long day. An adverse seasonal phenomenon of some animals in hibernation. Some migrate, some earlier, some later.

Photoperiod is not the only factor regulating biological rhythms [1,14,16,17].

Questions for self-control

1. What body rhythms are exogenous?
2. Under what violations do the diurnal rhythms lose synchronism?
3. What effect does the moon have on the life of organisms?
4. What is the decisive factor for seasonal periodicity?
5. What is the significance of photoperiodism in plant life?
6. What is the significance of photoperiodism in animal life?

Theme 7

Vital factors of organisms

The complex of environmental factors that make up the specifics of a given habitat requires specific adaptations from the organisms that inhabit this habitat. Such a set of adaptations is expressed in the formation of a similar appearance and plan of the structure of organisms, even if they belong to different systematic groups.

The life form is the appearance and biological features that reflect the adaptability of the body to certain environmental conditions. Appearance, reflecting its adaptability to certain environmental conditions. The general view of the organism, which determines this or that life form, is the result of adaptation in the process of evolution to certain aspects of the environment. The variety of classifications of life forms reflects one or another feature of the living environment of organisms and their adaptability to it. Various types of structures reflect the relationship of various species to the habitat. All types of communities (both systematically close and distant) can be combined into groups according to life forms - the similarity of types of adaptation (adaptation) to similar environmental conditions.

The life forms of animals are very diverse. Their form of existence directly depends on the search and the way they obtain food. The exception is individual animals of the aquatic environment. Groups of animals living in the same environment have similar morphological and ecological adaptations.

7.1. Morphological adaptations of organisms to environmental conditions

Morphological adaptations in the life of animals play an important role as adaptations to the environment, especially such as features of the external structure that contribute to the survival and successful functioning of organisms in their usual conditions. At the same time, the internal features of the structure of organisms, their general plan of structure, remain unchanged, reflecting the kinship and origin of species. The influence of environmental factors on the morphology of organisms can be considered when studying the following factors such as temperature, humidity, the density of the medium, the movement of water and air, the volume suitable for living in space, etc. The more severe the physical conditions of the environment, the more limited the way of adaptation to it. The same principles for studying the environment can develop similar morphological adaptations in different species that are very different in the plan of their structure. The total number of possible morphological adaptations to the same medium is limited.

The morphological type of adaptation of the animal to the main factors of the habitat environment and a certain lifestyle is called the life form of the organism.

7.2 Classification of animal life forms

The life forms of animals are diverse, and their classification is also diverse. The life forms of animals are distinguished by different signs for different systematic groups. In addition to the habitat in animals, one of the main signs for highlighting life forms is considered to be methods of movement (walking, running, jumping, swimming, crawling).

For example, jumping animals - Asian jerboas, Australian kangaroos, African jumpers, etc., living on different continents, have a compact body with elongated hind limbs and short forelimbs. They have well-developed muscles - extensors of the back, which increase the power of the push. Their tail is a balancer, a rudder, and an additional fulcrum.

The life forms of birds are distinguished by the type of their habitat and the method of obtaining food, in fish - by the shape of the body and the method of obtaining food. Inhabitants of water bodies - according to the type of their habitat (plankton, benthos).

The classification of life forms of animals was proposed in 1938 by D.N. Kashkarov (1878-1941).

In connection with the influence of the most important climatic factor - temperature - animals are divided into the following groups:

I. Poikilothermic (cold-blooded):

1) active all year

2) active part of the year: 1) summer-sleeping, 2) winter-sleeping.

II. Homoyothermal (warm-blooded):

Settlers: 1) active all year; 2) active part of the year: a) sleeping, b) wintering.

Seasonal: 1) nesting, 2) winter, 3) summer, 4) migratory.

By the means of movement in different habitats, the following life forms are distinguished:

I. Floating forms.

1. Pure water:

a) nekton; b) plankton; c) extracting only food from the water.

2. Semi-aquatic:

a) diving; b) non-diving; c) extracting only food from the water.

II. Burrowing forms.

1. Absolute excavation (spend his whole life underground).

2. Relative excavation (go to the surface of the earth).

III. Ground forms.

1. Not making holes:

a) running; b) jumping; c) crawling.

2. Making holes: a) running; b) jumping; c) crawling.

3. Animals of the rocks.

IV. Woody, climbing forms: a) not descending from trees; b) only climbing trees.

V. Airborne forms: a) producing food in the air; b) looking out for it from the air.

According to the type of food, D. Kashkarov distinguishes herbivorous, omnivorous, predatory, grave diggers (corpses). At the

breeding place - those breeding underground, on the surface of the earth, in tiers of grasses, in shrubs, on trees.

Life forms of animals are distinguished according to different signs and for different systematic groups (mammals, birds, insects).

A.M. Formozov distinguishes the following types of mammalian life forms in connection with their movement in different environments:

1) land, 2) underground (earthmoving), 3) wood, 4) air, 5) water. Among the life forms of birds, according to the type of their habitat and movement during food production, the following birds are distinguished: 1) woody vegetation, 2) open land spaces, 3) swamps and shallows, 4) water spaces.

Within each group, the features of the translational movement and lifestyle form more specific adaptive forms. So, terrestrial mammals move mainly through walking, running and jumping, which is manifested in their external appearance. For example, jumping animals: kangaroos, jerboas, jumpers, kangaroo rats - are distinguished by a compact body with elongated hind limbs and significantly shortened front ones. Muscles are very strongly developed - extensors of the back, increasing the power of the push. The long tail plays the role of a balancer and a rudder, allowing you to dramatically change the direction of movement. In sitting animals, it serves as an additional fulcrum. Some extinct Mesozoic dinosaurs had a similar type of movement and appearance. Naturally, in addition to common adaptive characters, each species differs in the details of its external structure depending on the environmental specifics.

Life forms are clearly distinguished within any large taxonomic group of animals characterized by ecological diversity of species.

In the external appearance of birds (Figure 7.1), their confinement to certain types of habitats and the nature of movement during food extraction are most pronounced.

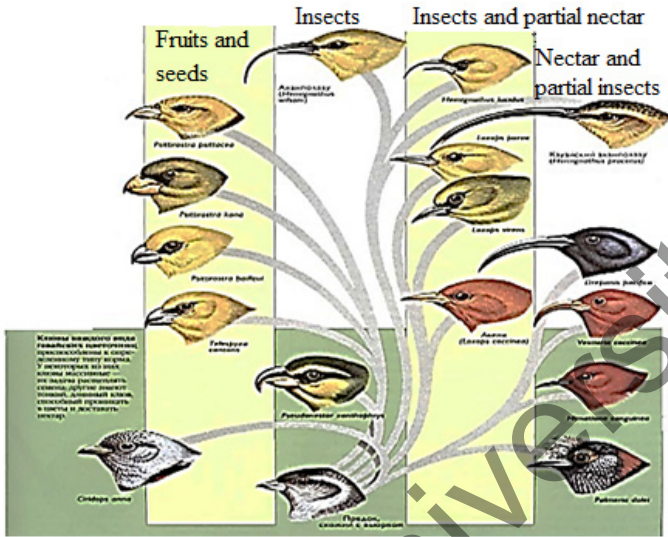


Fig. 7.1. The adaptation of the beak to a certain type of food.

In each of these groups, specific forms are distinguished:

a) birds that get food by climbing (many pigeons, parrots, cuckoos, woodpeckers, passerines);

b) birds catching food in-flight (owls, goats, etc. in the forests, charadriiformes in the open spaces, long-winged birds, tube-nosed birds above the water, etc.);

c) birds feeding while travelling on the ground (forest - the majority of chicken, cassowary, kiwi, etc., in open spaces - ostriches, rhea, crane, in swamps and shoals - ankle, flamingo, some passerines);

d) food by swimming and diving (penguins, loons, toadstools, some tube-noses, most copepods and geese, etc.).

In this regard, the birds are distinguished:

- 1) woody vegetation,
- 2) open spaces of land,
- 3) swamps and shallows,
- 4) water spaces.

The life forms of such small soil arthropods as collembola are distinguished based on their confinement to certain layers of the soil

profile, since in the soil the whole range of living conditions changes sharply with depth: cavity sizes, illumination, temperature and humidity conditions, etc.

Atmobionts - species that inhabit the upper layers of the litter and can rise to the lower parts of plants, are characterized by larger sizes, fully developed eyes, relatively long appendages (antennas, legs and jumping fork), well-defined pigmentation.

Euedaphic species - inhabitants of the mineral thin-porous soil layers - are distinguished by their small size, strong shortening of the appendages, reduction of the fork, and the complete absence of eyes and pigment.

Hemiadaphic forms are characterized by intermediate features: partial reduction of the eyes, diffuse pigment, shortened fork, etc.

Among the locusts in shape - body configuration, head structure, limb structure, aircraft, type of protective colour, are well distinguished:

tamnobionts - inhabitants of shrubs and trees;

hortobionts - inhabiting the grassy layer;

herpetobionts - inhabitants of the subsoil layer of organic residues;

inhabitants of open areas of soil:

eremobionts - on the surface of dense clay soils;

psammobionts - on the sand;

pathobionts - on rocky areas with sparse vegetation.

Similar life forms are found in similar living conditions in different zoogeographic areas and on different continents (for example, Eurasian jerboas, Australian kangaroo rats, African jumpers). Life form indicates the lifestyle of the species.

Entomologist V.V. Yakhontov proposed different categories of life forms of insects relative to their environment (Figure 7.2):

1) *geobionts* - inhabitants of the soil;

2) *epigeobionts* - inhabitants of open areas of soil;

3) *herpetobionts* - living on the surface of the soil under fallen leaves (in the litter);

4) *hortobionts* - inhabitants of the grass cover;

5) *tamnobionts and dendrobionts* - inhabitants of shrubs and trees;

6) *xylobionts* - inhabitants of wood;

7) *hydrobionts* - water insects.

An analysis of the life forms of animals allows us to judge the characteristics of the environment and the ways of adaptive changes in organisms - adaptations (Latin *Adaptatio* - adaptation). Adaptations of living things provide the ability to survive in certain conditions. The life form is one of the adaptations of living beings to a complex of living conditions.

The concept of life form should be distinguished from the concept of the ecological group of organisms. The life form reflects the whole range of environmental factors to which one or another organism adapts, and characterizes the specifics of a particular habitat.

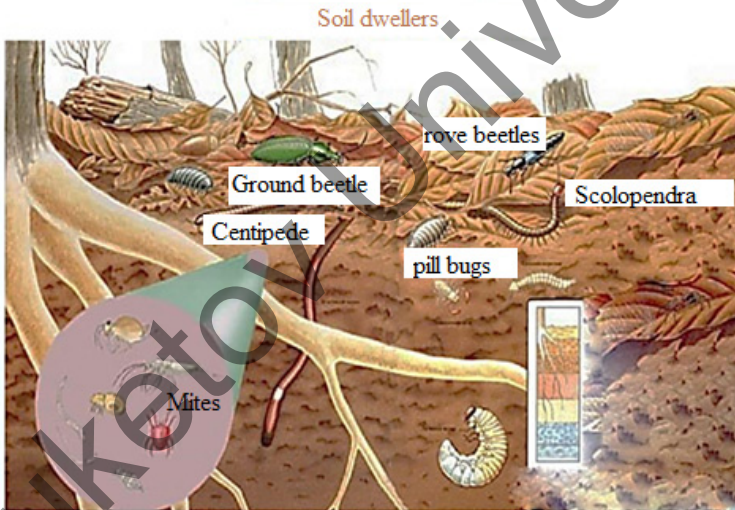


Figure 7.2 Geobionts

An environmental group is usually narrowly specialized in relation to a single environmental factor: light, moisture, heat, etc. (oligotrophs, mesotrophs, eutrophs - groups of organisms concerning the trophy, soil fertility) [1,14,15,17].

Questions for self-control

1. What is the life form of organisms?
2. How do the physical conditions of the environment (temperature, humidity) affect organisms' adaptation?
3. What are the main groups of animals divided according to the classification of D. N. Kashkarov?
4. What is the peculiarity of movement in terrestrial animals?
5. What should be considered when classifying animal life forms?
6. What is the main difference between the concept of "Life form of organisms" from the concept of "Ecological group of organisms"?

Theme 8

The structure and dynamics of the population

8.1. The concept of a population. Spatial units of the population

In the living world, every creature has a special and complex system. Each creature has an intraspecific group, which are characterized by their structure, physiology and behaviour. Such an association of individuals is called a "population."

In 1903, the Danish scientist Johansen introduced the term "population" to define a mixture of individuals of the same species, but heterogeneous in genetics. This term has acquired ecological significance and began to designate the population of a species that occupies a certain territory. In 1980, S.S. Schwartz determined that a population is a detachment of certain species of individuals that are ready to maintain their numbers for a long time, despite changing environmental conditions.

At present, the population in the narrow sense is an intraspecific grouping, and in the broad sense is the isolation of groups regardless of what territory they occupy. Also, a population can be called a

genetic unit in which the evolution of species takes place. A population has its structure and function.

The population structure is determined by the composition of its individuals and their location on the territory. The functions of a population are similar to other functions of biological creatures. It includes growth, development, the ability to adapt. The range of the population may be different for one and different species. The expansion of the population range can be seen in the mobility of individuals or the radius of individual activity. If the radius is small, then the range of the population is also small.

Argali eats actively in the evening, in lactating females, nutrition increases. In summer, the nature of daily nutrition has a great cyclical nature. Argalis begin to graze with an early sunrise until late in the evening. Compared to males, females graze in a hot summer. In inclement weather, argali activity occurs in the daytime.

The observation shows that in August 66% of argali grazed from 5 a.m. to 11 a.m., and from 4 to 7 p.m. from 7 to 10 p.m. their activity increases. On very hot days, argalis hide in the shade in shrubs or the forest.

In June-October, you can see the cycle of daily activity. Already in November, argali grazes at any time of the day. At this time, the movement of argali increases. They are looking for females or rivals, so they eat little.

In winter, argalis graze more than in summer. Active feeding in the morning and rest was observed in December and January from 13h to 16h, in February from 11h to 13h.

Micropopulation is a species of individuals that occupy a uniform area. They include only homogeneous individuals. If conditions allow, the number of micro populations increases. The more uniform they are, the fewer micro populations and vice versa. Micropopulation has its differences: genetic identity, phenological characteristics, the ability to accumulate nutrients in behaviour. They differ in their habitat.

Ecological populations are intraspecific groups. It has its characteristics, which differ from neighbouring populations. For example, squirrels, although they live in the forest, they are “pine”, “spruce”, “fir”, “spruce-fir”.

Geographical population - a detachment of individuals that inhabits an area with uniform geographical conditions. This group is characterized by fecundity, size of individuals, physiological and behavioural characteristics. With a geographical population, genetic exchange occurs, although rarely, but it does. When crossed, they acquire a common morphological type, distinguishing from neighbouring populations. For example, the narrow-cranled vole, which lives in the steppe regions and the tundra, is sharply different from each other: tundra are larger, prolific, breed early.

The rules of combining into a population indicate that individuals of any living species are always presented not in isolation, but a combination. There are three types of distribution of individuals:

Uniform;

Random;

Group:

Uniform distributions are found in predatory fish. Most often associated with intense competition between species.

Random distribution is characteristic of aphids. As the aphids multiply, a group or a spotted character can be seen.

Group distribution is characteristic of arctic foxes. They lead a mobile lifestyle.

The number and density of the population depend on fertility or fertility and mortality. Fertility is the ability of a population to increase in numbers. There is an absolute and specific birth rate. Absolute is the number of new individuals that appeared per unit of time. Specific - is expressed as the number of individuals per individual per unit time. As a rule, the ability of adapted species to adverse conditions mortality at a young larval age is offset by significant fecundity. In herbivorous insects, fertility is high, in predators and parasites it is low. Fertility depends on the rate of puberty, the number of generation during the season on the state of females and males. Maximum fertility - the limit that is characteristic of the rate of increase in the number of individuals in a population.

The number and density of a population depend on its mortality. The mortality rate of a population is the number of individuals who died in a given period.

There are 3 types of mortality: the first is the same mortality at all ages, this type occurs only in populations, this type is rare.

The second type of mortality is the death of individuals in the early stages. This is characteristic of most plants and animals.

The third type refers to the death of adults, old individuals.

Mortality plays a major role in controlling population size.

A population as a biological unit has a certain structure and function (Figure 8.1).

The population structure is characterized by its constituent individuals and their distribution in space. The functions of a population are similar to those of other biological systems. They are characterized by growth, development, the ability to maintain existence in constantly changing conditions, i.e. populations have specific genetic and environmental characteristics. Space or area occupied by the population can be different both for different species and within the same species. The size of the population range is determined to a large extent by the mobility of individuals or the radius of individual activity. If the radius of activity is small, the population range is usually also small.

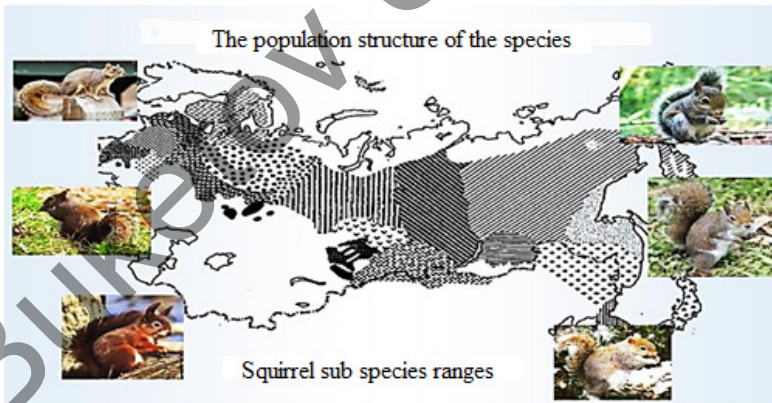


Figure 8.1. Population structure of the species (range of protein subspecies)

For example, in the evening argali feed very actively. In lactating females, food activity increases.

In summer, the nature of daily activity has a pronounced cyclicity. The argalis begin to graze early in the morning at sunrise (Figure 8.2) and late in the evening.

Females, unlike males, often graze even on a hot summer day. The morning peak of activity usually lasts 2 hours longer, and evening grazing begins earlier. In July, argalis are active early in the morning (from 5 to 8 hours), when the air temperature is still low, and in the evening (from 19 to 22 hours), when the daytime heat drops. In the evening, only 43% of the animals met were fed, the rest were lying. In cloudy and rainy weather, their activity falls on all daylight hours.

In August, argali activity increases: of the number of animals we met in the morning (from 5 to 11), animals grazed 66%. In the evening, they begin to feed on from 16 to 17, and at dusk (from 19 to 22) their activity increases. On very hot days, argali at 7 o'clock already lie down or hide in the shade under the rocks, in the bush or the forest. During the rest, some individuals rise, feed for an average of 9-12 minutes and lie down again, changing their place, but not moving away from the previous bed by more than 25-30m.



Figure 8.2. Grazing of mountain sheep (female).

The pronounced cyclic nature of the daily activity is in June-October.

In November, grazing argali can be found at any time of the day. During this period, the motor activity of males increases. They seek females or rivals and feed little (Berber et al. 1998).

In winter, argalis spend more time grazing than in summer. Intensive feeding occurs in the morning, and the largest percentage of tourists is recorded in December and January from 13 to 16 hours, and in February from 11 to 13 hours.

Elementary, or micro-population, is a collection of individuals of a species occupying a small area of a homogeneous area. Their composition usually includes genetically homogeneous individuals. The number of elementary populations into which the species breaks up depends on the heterogeneity of environmental conditions: the more uniform they are, the less elementary populations, and vice versa. There are always some differences between elementary populations, manifested in genetic identity, phenological characteristics, ability to accumulate nutrients, metabolic rate, behaviour patterns, or each elementary population is morphophysiological and ethologically (behaviorally) specific, the differences between them are determined by their genetic identity and environmental habitat. However, often the mixing of special elementary populations that occurs in nature erases the boundaries between them.

An ecological population is formed as a set of elementary populations. These are mainly intraspecific groups, poorly isolated from other ecological populations of the species; therefore, the exchange of genetic information between them occurs relatively often, but less frequently than between elementary populations. The ecological population has special features that distinguish it in something from another neighbouring population. So, squirrels (*Sciurus vulgaris*) inhabit various types of forests, and "pine", "spruce", "fir", "spruce-fir" and their other ecological populations can be distinguished.

The identification of the properties of individual ecological populations is an important task in understanding the properties of a species and in determining its role in a particular habitat.

The geographical population covers a group of individuals inhabiting an area with geographically homogeneous living conditions. Geographical populations occupy a relatively large territory, are quite thoroughly delimited and relatively isolated. They differ in fecundity, size of individuals, some environmental, physiological, behavioural and other features. The geographical population is characterized by genetic exchange, and although it may be rare, it is still possible. In crossbreeding, individuals of each population acquire a common morphological type, somewhat different from the neighbouring geographical population, with which there is no regular contact. For example, a narrow-skull vole occupies a large range. It is found in the steppe regions of our country and far to the north in the tundra zone. Geographical populations from those and other areas have significant differences among themselves in physiology and animal size. The tundra ones, unlike the steppe ones, are larger, start to breed much earlier, have higher fecundity and accumulate more fat. The differences are so pronounced that for a long time these groups were considered different species. However, experiments showed that both forms of voles easily interbreed and produce prolific offspring, therefore, they belong to the same type of genetic and ecological unity. The fragmentation of the species into many small territorial groups is adaptive to a wide variety of local conditions, which increases the genetic diversity of the species and enriches its gene pool. Thus, the most general rule is that individuals of any living species are always represented not by isolated individuals, but by their organized groups in a certain way. This rule was formulated in 1903 by S. S. Chetverikov (1880-1959) and was called the rule of association in a population.

8.2. The number and density of the population. Fertility and mortality

The main indicators of the structure of populations are the number and distribution of organisms in space and the ratio of different-quality individuals. In connection with the size of the range of populations, the number of individuals in populations can also vary significantly.

The population is the total number of individuals in a given territory or a given volume. It depends on the ratio of the intensity of reproduction (fertility) and mortality. During the breeding season, population growth occurs. Mortality, on the contrary, leads to a reduction in its number.

The population density is determined by the number of individuals or biomass per unit area or volume, for example, 400 trees per 1 ha, 0.5 g of cyclops in 1 m³ of water. It is often important to distinguish between average density, i.e. abundance or biomass per unit of habitable space, the available volume area, which can be occupied by volume horses, which can be occupied by a population.

The population density is variable and depends on its size. With an increase in numbers, an increase in density is not observed only in the case when the distribution of the population, the expansion of its range is possible.

The individuals that make up the population have different types of spatial distribution, expressing their reactions to various influences, for example, prey and favourable physical conditions or competitive reactions, Figure 8.3. The main types of distribution of individuals in a population:

This type of distribution is noted in predatory fish and sticklebacks with their territorial instinct and a purely individual character.

There are three types of distribution or resettlement of individuals within the population: uniform, random and group (Figure 8.3).

A - uniform distribution;

B - random distribution;

C - group distribution.

The uniform distribution in nature is more often associated with intense competition between different individuals.

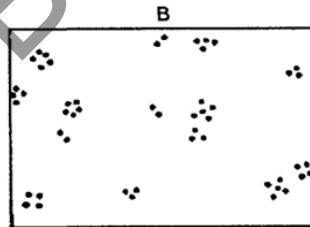
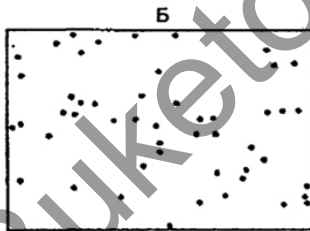
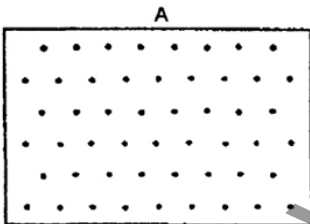
Random distribution takes place only in a homogeneous medium. So at first, aphids are distributed on the field. As it multiplies, the distribution acquires a group or spotty character.

Group distribution is most common. Animals leading a mobile lifestyle, as a rule, are actively distributed, which leads to intensive mixing of populations and blurring of the boundaries between them.

For example, very mobile and actively moving polar foxes, other animals, birds have huge ranges without sharp boundaries between populations.

In passively moving and sedentary organisms, on the contrary, populations are delineated even in a relatively small area. Such are the populations of terrestrial molluscs, many amphibians. The size of the range of a population depends on the size of the individuals that make it up. Small individuals occupy relatively small areas, while in species with large individuals they are extensive. However, this rule has many exceptions. So, the territory occupied by the population of the fast-moving lizard *Lacer taagilis* can vary from 0.1 to several hectares.

With a uniform distribution, the variance S^2 is zero, since the number of individuals in each sample is constant and equal to the average. In the case of a random distribution, the mean m and variance S^2 are equal.



With a group distribution, the scattering of S^2 is above average and the difference between them is greater, the stronger the tendency of animals to form clusters.

The dynamics of the number and density of populations is closely dependent on fertility or fertileness and mortality

Fertility is the ability of a population to increase in numbers. It characterizes the frequency of emergence of new individuals in the population. There are absolute and specific birth rates. Absolute (total) fertility - the number of new individuals (ΔN_n) that appeared per unit time (Δt). The specific birth rate is expressed as the number of individuals per individual per unit time:

$$b = \frac{\Delta N_n}{\Delta t N}$$

Thus, for human populations, the number of children born per year per 1000 people is used as an indicator of specific birth rate. In living organisms, there is a huge opportunity for reproduction and is confirmed by the rule of maximum fertility (reproduction): in the population, there is a tendency to form the theoretically maximum possible number of new individuals. It is achieved under ideal conditions when there are no limiting environmental factors and reproduction is limited only by the physiological characteristics of the species. Bacteria divide every 20 minutes. At this rate, one cell in 36 hours can produce offspring that will cover our entire planet with a continuous layer. Usually, there is an ecological or marketable birth rate that occurs under normal or specific environmental conditions. The average value of fertility has been developed historically as a device that provides replenishment of population decline. d mortality at a young (larval) age is offset by significant fecundity.

Among insects, the highest fecundity is among herbivorous forms, and the lowest - among predators and parasites. Under favourable conditions, fertility is usually low. The nature of fertility also depends on the rate of puberty, the number of generations during the season, and the state in the population of females and males. If a species reproduces at a high speed and sensitively reacts to changes in environmental conditions, then its population number changes rapidly and significantly. This applies to many insects and mouse rodents. Thus, the maximum birth rate or fertility is a constant determined by calculation, for example, by multiplying the average number of nests that a female bird can build per year by the same number of eggs that it can lay in the most favourable part of the season of the year. Maximum fertility is the limit that is characteristic of the rate of increase in the number of individuals in a population. The rule of maximum fertility (reproduction) is a special case of the law of maximum biogenic energy (entropy) by V.I. Vernadsky - E.S. Bauer.

The number and density of a population depend on its mortality. The mortality rate of a population is the number of individuals that have died over a given period. Absolute (total) mortality is the number of individuals killed per unit time (ΔNm).

Specific mortality (d) is expressed as the ratio of absolute mortality to population:

$$d = \frac{\Delta Nm}{\Delta t N}$$

Absolute and specific characterize the rate of decrease in population due to the death of individuals from predators, diseases, old age, etc.

There are three types of mortality. The first type of mortality is characterized by the same mortality at all ages. It is expressed by an exponential curve (decreasing geometric progression). This type of mortality is rare and only in populations that are constantly in optimal conditions.

The second type of mortality is characterized by increased death of individuals in the early stages of development and is characteristic of most plants and animals. The maximum death of animals occurs in the larval phase or at a young age, in many plants - at the stage of growing seeds and seedlings. In insects, 0.3-0.5% of laid eggs will survive to adults, in many fish - 1-2% of the number of eggs laid.

The third type of mortality is characterized by increased death of adults, primarily old ones. It differs in insects, the larvae of which live in soil, water, wood, as well as in other places with favourable conditions.

Placing the life span on the abscissa as a percentage of the total life span, we can compare the survival curves of organisms whose life spans have significant differences. Based on such curves, it is possible to determine the periods during which a particular species is particularly vulnerable. Since mortality is subject to more dramatic fluctuations and is more dependent on environmental factors than fertility, it plays a major role in regulating the population size.

8.3 Age structure of the population

The number, birth rate and mortality of a population depend on the age structure. The population consists of individuals of different ages and sexes. Each group and within species has its age characteristics. There are 3 environmental ages:

1. Pre-reproductive
2. Reproductive
3. Post-reproductive

According to tables 8.1, 8.2, we can say that the number of argalis increased due to favourable factors.

The pre-production period is very long in many animals.

The reproductive period lasts several days, this is the breeding time of adults. There is no post-reproductive period. The population grows in number providing individuals have a short preproduction period of the population, where there are old individuals that go to decline, as it is not able to reproduce. And if the individuals are young, then you can observe the growth of their numbers. If the group contains individuals of different ages, then their numbers are preserved and stabilized. For example, the population of moose consists of 10-11 adult groups, but individuals begin to breed from the 5th age group.

Table 8.1
Abundance, sex and age structure of argali stock on the territory of RSE "State National Natural Park Buyratau" in 2012-2014.

Type of record	2012				2013				2014			
	Recorded (individuals)				Recorded (individuals)				Recorded (individuals)			
	m (%)	♂f (%)	♂c (%)	Und. Abs. (%)	♂m (%)	♂f (%)	♂y (%)	Und. Abs. (%)	♂m (%)	♂f (%)	♂y (%)	Und. Abs. (%)
WRC	5 (16)	79 (52)	1 (15)	1 (17)	9 (20)	31 (34)	1 (23)	1 (23)	9 (19)	31 (32)	9 (23)	07 (26)
	Total: 346 individuals				Total: 392 individuals				Total: 411 individuals			

Rutting season	0 (23)	53 (39)	03 (27)	4 (11)	9 (14)	85 (44)	07 (24)	5 (18)	6 (11)	68 (41)	9 (17)	25 (31)
	Total: 390 individuals				Total: 421 individuals				Total: 408 individuals *			

*m - male, f - female, y – young (this year's brood), **Abs** – absolute data of ocular record. **Und** – undefined.

*WRC – winter route census

* **Note:** During the survey, due to the sharp deterioration in weather conditions, it was not possible to examine the tracts of the Agdym, Ortanzhal, and “Gorelyi” mountains, where, according to our periodic stationary observations, 25-30 individuals of argali constantly live, so we can assume that during the argali race in 2014, its stock in the park was at least 430 bions.

As can be seen from table -1, the average herd numbers of herds according to argali counts in 2012-2014 are shown. During ZMU and during the rutting season, when the herds were mostly mixed, the average herd rate in these seasons was quite high and amounted to 12.4 individuals. Herds of up to 50 or more goals were found, loners were rarely observed.

Table 8.2.

The dynamics of the number of indicators of WRC (winter route census) of RSE “State National Natural Park Buyratau” from 2012 to 2016

Year	WRC 2012	WRC 2013	WRC 2014	WRC 2015	WRC 2016
Total bions	360	390	411	420	436

The results indicate that in recent years to 2012, the number of argali in the territory of “State National Natural Park Buyratau” has

normalized and has a tendency to increase. Favourable factors contribute to the annual increase in the number of argalis.

A. Loki's rule is acceptable only to higher organisms with an age structure of populations and does not have universality, although in a broader biosystem sense it is universal. The rule of stability of the age structure of populations for many organisms should be supplemented by the rule of stability of the sex ratio, if gender differentiation exists at all, which is not always the case. Together, these two rules make up the rule of stability of the sex and age structure of the population.

To describe the age structure in the population, age groups consisting of organisms of the same age are distinguished and the size of each of these groups is estimated. If in the population reproduction occurs continuously, then the age structure determines whether the number decreases or increases. If the base of the pyramid is wide, this means that more offspring are born, the birth rate exceeds mortality and the number is growing. If individuals of younger age groups are smaller than older ones, then the number will decrease.

8.4. Sexual composition of the population. Genetic population processes

The genetic mechanism for determining sex provides splitting offspring by sex in a 1: 1 ratio, the so-called sex ratio. But it does not follow from this that the same ratio is characteristic of the population as a whole. Sex-linked traits often determine significant differences in the physiology, ecology, and behaviour of females and males. Due to the different viability of male and female organisms, this primary ratio often differs from the secondary and especially from the tertiary one, which is typical for adults. Thus, the age and sex structure of argali groups living in various mountain systems vary significantly.

In the mountains of Temirshi, Edrey, Sarykulzha in the spring of 1990, the ratio of males and females was 3.8: 1; 1.4: 1; 1.6: 1, respectively, while in the mountains of Ermentau, Karakulbaldy, Zhamantas (Besobinsky), Zhamantas (Ulyanovsky), Koshubay, Arkaly, Ulken-Dogolan, Arkalyk prevailed: 1: 2.7; 1: 3.8; 1: 2.3; 1: 4; 1: 5; 1:11; 1: 2.3; 1: 5.8, respectively.

Environmental and behavioural differences between males can be strongly expressed. So, male mosquitoes of the Culicidae family, unlike blood-sucking females in the imaginal period, either do not eat at all, or are limited to dew licking, or consume plant nectar. Even if the lifestyle of males and females are similar, they differ in many physiological characteristics: growth rate, puberty, resistance to temperature changes, fasting, etc.

The secondary and tertiary sex ratios in animals and plants can fluctuate in very small limits in different species. There are populations, for example in some flies, consisting entirely of females. Females consist of a number of parthenogenetic species of insects and many other animals. Moreover, the proportion of parthenogenetic females in different populations can vary significantly. In some species, gender is initially determined not by genetic, but by environmental factors. The influence of environmental conditions on the sexual structure of populations in species with alternating sexual and parthenogenetic generations is observed. At the optimum temperature, daphnia (*Daphniamagna*) breed parthenogenetically, and at higher or lower temperatures males appear in populations. The appearance of a bisexual generation in aphids can occur due to the length of daylight hours, temperature, increase in population density and other factors.

The genetic study of populations was initiated by the work of V. Johansen, "On Inheritance in Populations and Clean Lines," published in 1903, where the effectiveness of selection in a heterogeneous mixture of genotypes (all-natural populations) was experimentally proven. The ineffectiveness of the selection effect in clean lines was demonstrated - genotypically homogeneous (homozygous) offspring originally obtained from one self-pollinating or self-fertilizing individual.

Genetic heterogeneity of populations can be considered in two aspects:

- 1) as the complexity of the general gene pool of a population, expressed by the variety of manifestations of various properties (genetic polymorphism);

- 2) as the complexity of the genome of each individual, characterizing the degree of heterozygosity for many signs. The first

property determines the resistance of the population to changing environmental conditions, the second - maintaining the complexity of the gene pool during the selective elimination of temporarily inactive phenotypes. At the same time, the formation of a complex and adapted population gene pool is an evolutionary (microevolutionary) phenomenon, while maintaining a sufficiently high level of heterozygosity is an ecological process that is constantly being implemented at the level of a specific population. In its most general form, this process can be represented as a system of specific intrapopulation relationships aimed at reducing inbreeding.

In classical genetics, a high degree of heterozygosity is considered to be a “genetic burden”, fraught with the accumulation of lethal and inactive adaptive alleles in a recessive state. Besides, a heterozygous population always consists of different individuals, while a homozygous population consists of individuals with “maximum fitness”. This idea has developed in the study of model objects in stable laboratory conditions. In natural populations, stability is practically absent, therefore, “maximum fitness” should be coupled with the labile response of the population to changes in average conditions. Long-term closely related mating reduces the level of variability and thus reduces the population's resistance to fluctuating environmental conditions. Therefore, in nature, the normal existence of populations with a high probability of inbreeding and a reduced level of heterozygosity is recorded only as an exception, in rare cases, the stability of conditions. An example is the cavefish of the genus *Astyanax*, which inhabit underground water bodies with very stable living conditions. In strictly troglobiontic representatives of this genus, the degree of heterozygosity is reduced according to many biochemical characteristics, and the rudimentary organs (in particular, the eyes) are almost homozygous (Avise and Selander, 1972; Peters and Peters, 1973). Under the usual conditions of environmental variability for most species, maintaining a sufficiently high level of variability and heterozygosity is an important environmental task.

The provision on the genetic unity of the population is one of the most important conclusions of population genetics: any population represents a complex genetic system in dynamic equilibrium [1,3,7,14,15,17,18].

Questions for self-control

1. What is a population?
2. What types of the population are distinguished depending on the size of the occupied territory according to N. P. Naumov (1963)?
3. What are the main indicators of population structure?
4. What determines the age structure of the population?
5. How do the genetic processes of a population affect the sexual composition of a population?
6. What does heterozygous and adaptive polymorphism mean?

Theme 9

Intraspecific and interspecific relationships in populations, homeostasis and environmental strategies

9.1. Intraspecific Relations

The diverse population of the population constantly interacts with each other. Satisfying nutritional needs, distributing fodder land, choosing a place to build a nest, mating, raising offspring, protecting the occupied territory, resettlement, etc. carried out with the constant interaction of individuals within each population, which ensures its existence.

These relations took shape as the species was formed and developed as an integrated system. Therefore, all individuals included in the population have a common origin and numerous specific adaptations to live together.

Such devices called S.A. Severtsov (1951) *congruences* encompass morphophysiological and ethological (behavioural) traits. These include structural features, ensuring the meeting of heterosexual individuals; reproduction; growing young animals; devices providing resettlement or associations in flocks (for migrations or the winter). Also, various "signals" - smells, colour, voice, behaviour and everything that attracts or distracts individuals, warns them of the occupied territory.

These devices can be like individual and group contacts. They are carried out in different ways at different stages of the development of organisms and can change during the life of an individual, in different seasons of the year, as well as in connection with changes in living conditions.

The relationship between populations depends on the lifestyle: single or group, characteristic of this species. The forms of existence of individuals in a population are extremely different.

A solitary lifestyle. Individuals of the population are isolated and independent of each other. For many species, it is more characteristic, mainly at certain stages of the life cycle. The completely solitary existence of organisms does not occur in nature. The reason for this is the inability to carry out their main vital function - reproduction. However, some species are characterized by very weak contacts between co-living individuals. So, in species with internal fertilization, meetings between males and females can be very short-term, for the implementation of copulation. The rest of the time animals live separately, independently of each other, for example, predatory beetles, ground beetles, ladybugs and many other insects. A similar lifestyle is led by individual aquatic inhabitants (single anemones) with a disturbing method of fertilization, in which there is no need for a direct meeting of partners. Often species with a single lifestyle form temporary clusters of individuals during the breeding season, in wintering places, etc. Butterfly hives gather in large numbers in attics in late autumn, ladybugs and ground beetles - near stumps and clumps of trees in the dry litter, pikes and catfish - in wintering pits at the bottom of the reservoir. However, such clusters are not accompanied by the establishment of close ties between animals. Each of them is relatively independent of the rest.

The complication of relations within populations occurs in two directions: a) the strengthening of communication between sexual partners; b) the emergence of contacts between parent and daughter generations. In populations on this basis, families are formed that are diverse in composition and duration of existence. Parent couples can be created for the short or long term, and in some species - for the entire life of adults. Among black grouse birds, wood grouse do not form stable couples. In many passerines, the female and male stick

together throughout the entire nesting period. Family pairs of swans, cranes, pigeons are preserved for many years. The choice of partners in animals is accompanied by special mating behaviour, often of great complexity - "dancing", "courtship", etc.

In many insects, birds and mammals, courtship often prevents aggressive and defensive reactions of individuals of the opposite sex, leads to synchronization of puberty, stimulates readiness for mating, which is of great importance for reproduction, for which the male and female should be ready at the same time.

In the period of choosing sexual partners in animal populations, competitive relationships intensify. Many animals have male fights, ritual demonstrations and other types of specialized behaviour that are aimed at eliminating competitors.

Despite the frequent fierceness, these clashes rarely lead to great injuries to rivals, for the most part, they are limited to the expulsion of one of them from the territory where the female is located. The current turukhans quickly rush at each other, and then suddenly freeze with a ruffled "collar", after which the throws are repeated. In such battles, a ritual of threat prevails in fish or opponents bite each other in the mouth - the least vulnerable part of the body, but do not inflict more dangerous bites on the side.

Consequently, the period preceding reproduction in animal populations is characterized by an active search and a sharp increase in contacts between individuals.

Family lifestyle. Enhances communication between parents and their offspring. The simplest type of such a connection is, for example, the care of one of the parents about the laid eggs - the protection of masonry, incubation, additional aeration, etc.

In birds, the care of the chicks continues until they are raised to the wing, and in some large mammals, such as bears, tigers, cubs are raised in family groups until their puberty, for several years. Depending on which of the parents takes care of the offspring, the families of the paternal, maternal and family types are distinguished (Figure 9.1).

Both male and female are usually involved in the protection and feeding of offspring in families with sustainable pairing.

Colonies are group settlements of settled animals that can exist for a long time or be created for the breeding period, as in birds (geese, rooks, loons, gulls, etc.).

Animal colonies are diverse - from simple territorial clusters of single forms to associations, where individual members, as organs in an integrated organism, perform different functions of species life. So, the Salacia siphonophore - a single, at first glance, individual - is formed by many separate specialized individuals and represents a colony.

The development of the colony begins with one individual, which propagates by budding. Individual budding individuals can either lead an independent life or become specialized parts of the maternal colony.



Figure 9.1 Parental cares for offspring

Animal settlements, where some of the functions of their life are performed together, which increases the likelihood of survival of individual individuals, is a more complex form of the colony. These common functions of the colony are most often a defence against enemies and warning alarms. Seagulls, swallows, geese and other birds loudly attack the predator, threatening clutches of chicks. An alarm raised by a bird noticing danger mobilizes the rest. Together, the birds manage to drive out large predators that they could not manage alone - owls, hawks, arctic foxes, etc. Individual nesting sites

are often preserved in colonial bird settlements. Thus, in silver gulls, colonies are loose, between nests a distance of 3-5 m is maintained.

Urban swallows often sculpt their nests close to one another. Territorial instincts are not manifested here at all. Public weavers build on trees a large common nest of grass with numerous holes leading to individual nesting cavities.

Colonies of mammals (marmots, viscachas, pestles, and pikas) more often arise based on the growth of family groups, with the preservation of relations between budding families.

Flocks/ schools are temporary associations of animals that exhibit biologically useful organization of actions. Flocks facilitate the performance of any functions in the life of the species: food production, protection from enemies, migration. Flocking is most widespread among fish and birds, among mammals - many canines. In flocks, imitative reactions and orientation toward neighbours are highly developed.

The actions of the flock according to the methods of coordination of actions are divided into two categories: 1) equipotential without the expressed dominance of individual members; 2) flocks with leaders, where animals are guided by the behaviour of one or more, as a rule, the most experienced individuals. Associations of the first type are known in fish, small birds, migratory locusts. In large birds and mammals, the second type of flock is usually found.

Schools of fish are variable in magnitude, shape, density, often re-formed several times a day. Fishes are grouped in schools during daylight hours, with eye contact with other individuals, and dispersed overnight. The protective role of schooling associations of fish is great. In danger, a school of fish manoeuvres quickly, flowing around a predator, which, for example, rushing into its middle, finds itself in the desert. The behaviour of fish in the school is characterized by a simulated reflex - imitation of the actions of neighbours.

Flocks in birds form during seasonal flights or in settled and nomadic forms, during winter feeding. When migrating, flocks form those species that are characterized by colonial nesting or collective feeding. Single breeding and feeding species of flocks in flight do not form.

Herds are longer and more constant associations of animals in comparison with schools. Here, all the basic functions of the life of a species are realized: obtaining food, protecting from predators, migration, breeding, raising young animals, etc. The group behaviour of animals in herds is based on dominance-subordination relationships based on individual differences between individuals. One of the options for organizing herds is with temporary or relatively permanent leaders. These are individuals on which the attention of others is concentrated, and they, in turn, determine by their behaviour the direction of movement, feeding places, reaction to a predator, etc. The leader's activity is not aimed directly at subordinating other individuals. The leader is a more experienced member of the herd. The herd acts as a whole, imitating the leader. So, reindeer herds, as a rule, are led by old leaders (Figure 9.2).

They are better oriented than others during migrations and attacks of predators because they have to deal with this alone constantly.



Figure 9.2 Reindeers

The most difficult is the behavioural organization of herds with leaders and hierarchical subordination of individuals. Unlike leaders,

leaders are characterized by behaviour aimed directly at actively managing the herd: special signals, threats, and direct attacks. This often leads to the separation of “rights” and “duties” and more complex forms of social behaviour that are beneficial to the group as a whole. In the herd, the rank of each individual is determined by many reasons: age, physical strength, experience and hereditary qualities of the animal. As a rule, the weak are dominated by the strong and experienced, with a stable type of nervous system. This is manifested in the right to a female, an advantage in eating food, movement in a group, etc.

Domination-submission is very different in different species. The main ones are the “linear” hierarchy of the “triangle” type, despotism. With a linear hierarchy in a series of ranks A-B-C, etc., individuals belonging to each are subordinate to the previous ones but dominate the subsequent ones. In this series, the last animals are the most disenfranchised in the group. So, the leaders in packs of sledge dogs actively subjugate the whole pack, threatening and asking the bashing naughty. Animals of the lowest rank behave obediently before all the others, come to food last. They are expelled from the best places of rest, are not allowed to reach females, etc.

In some animals, hierarchical subordination is carried out according to the type of “triangle”: A attacks B, B attacks C, and C subjugates A. This ratio can remain in the group for a long time. The next version of the hierarchy is despotism or the dominance of one animal over all other members of the group.

The rank of the animal in the group is determined by clashes between individuals in the form of a direct struggle or ritual threats. After establishing the rank of all group members, direct collisions between them cease and the order is maintained by signal or ritual behaviour. A hierarchically organized herd is characterized by a regular order of movement, a certain organization during protection, location on recreation sites, etc. For example, when predators begin to loom, female elephants form a circle around the cubs to protect them from attackers

Group effect. Many animal species, as already noted, develop normally only when they unite in fairly large groups. For example, cormorants (*Phalacrocorax bougainvillaea*) can exist in a colony that

has at least 10,000 individuals and were at least 3 nests per 1 m³. Life in a group affects many physiological processes in the animal's body, such as the nervous and hormonal systems. Close communication of individuals using smells, sounds, behaviour specifics is observed. Thanks to a complex alarm system in individuals and their mutual exchange of information, the functioning of the group increase to meet the important life needs of all its members. Optimization of physiological processes, leading to increased viability with coexistence, is called the "group effect". The effect of the group manifests itself as a psychophysiological reaction of an individual to the presence of other individuals of its species. For example, in sheep outside the herd, pulse and respiration become more frequent. At the sight of an approaching herd, these processes normalize. The effect of the group is manifested in accelerated growth rates of animals, increased fertility, the faster formation of conditioned reflexes, the increased average life expectancy of an individual, etc. Animals in a group are usually able to maintain optimal temperature, for example, during earthing, in nests, in hives. Outside the group, many animals do not realize fertility.

An equally important indicator of the effect of the group is phase variability. It was first discovered by B.P. Uvarov in 1921 in locusts, and later also in beetles, Lepidoptera, and other insects. In locusts, two forms of variability are clearly distinguished: single and herd.

The main reason here is the different density of individuals in the population. Their great crowding determines the formation of the herd form. Individuals of both forms differ in colour, behaviour, speed of development, structure. Each form has a specific activity. Individuals in herd form are very mobile and tend to migrate. This is a means of regulating the number of locusts in its reserves.

A crowded lifestyle at an increasing pace leads to a contraction of the egg tubes. Therefore, the higher the herd rate, the lower the fecundity, i.e. fecundity of herd locusts is inversely proportional to population density. Isolated females of Asian locusts lay 1,000 to 1,200 eggs, while those in severe congestion lay only 300. However, in the latter, the mass of hatching larvae, their survival rate, and overall viability is much higher. The effect of the group and its highest

manifestation in locusts - phase variability - are functionally related to population density and serve as a mechanism for regulating their numbers. Mutual stimulation of individuals causes the formation of a herd form, which is characterized by a decrease in fertility, a reduction in mortality at an early age, an increase in the rate of development and an increase in an activity.

Aggression, intraspecific parasitism and competition.

Aggression is a form of communication characterized by the extermination of individuals of its species. Among intraspecific relationships, various forms of aggression are quite common. Thus, the extermination of some individuals of a species by others helps to maintain the population size, its density on the occupied territory and ensures the high vitality of surviving individuals. In some cases, aggression is represented by cannibalism or the devouring of individuals of its kind. Therefore, in the American salamander-cryptogamous, the male protects the laid eggs. Protecting it from others, it eats it to maintain strength. Another form of cannibalism in salmonids. Adult spawning fish enter rivers and usually rise to the uppermost sources. In shallow water, in conditions of well-aerated water, they spawn, exhausted die. Spawning occurs in late autumn and shallow water, the corpses of fish are not carried away by the stream of water but freeze in ice. In the spring, with the melting of ice, the corpses of the fish thaw, their decomposition begins. By this time, juveniles usually already appear from caviar. Gluttonous fry attack the softened corpses of fish and eat them. This allows most fry to survive and grow quickly in places where there is no other food available to them. In general, cannibalism is widespread in fish. At cod, burbot, Balkhash perch, adult fish eat their juveniles. Similar is observed in insects. Cannibalism was observed in ants, in predatory larvae of some mosquitoes. In all these cases, aggression is useful to the mind, providing a kind of example of "mutually beneficial ties."

Equally useful it is possible to evaluate the phenomenon of *intraspecific parasitization* that occurs in some animals. It can be in the form of ectoparasitism (external parasitism) and endoparasitism (internal parasitism).

Intraspecific ectoparasitism is especially pronounced in deep-sea anglerfish. As a device to ensure the fertilization of eggs, the

female constantly wears a male. A dwarf male (male 1.5–2 cm in size, 9–10 cm in female) is still attached to the female in the juvenile stage: in some species, to a particular process on the gill cover, in others, to the abdomen or forehead.

The skin of the male at the attachment sites fuses with the skin of the female, as if plunging into it, interpenetration and some fusion of the blood vessels of both organisms occur. Becoming an integral part of the female, the male moves at the expense of her. At the same time, the male's intestines are underdeveloped, the teeth are reduced, while the gills, kidneys, heart, and reproductive system remain sufficiently developed.

Intraspecific endoparasitism is observed, for example, in *Bonellia*, a ringed worm living in the Mediterranean Sea. The male is an internal parasite of the female, settling in her tubules of the nephridia, through which the eggs that are brought out. Even at the stage of larvae, the male enters the mouth, and then into the oesophagus and later through the tissues reaches the nephridia, where it remains to live. Both cases of intraspecific parasitism arose in the conditions of feed poverty, with a very low population density, as an adaptation to the restoration of offspring, where the meeting of males and females is quite rare. The transition to parasitization in these species is usually carried out during the larval stages when the newly hatched fry and larvae still hold together in one flock. With a relatively high density of young individuals under such conditions, the occurrence of male and female occurs frequently. This and several other species features allow the species to ensure its reproduction and long-term existence in the fight against other species.

Intraspecific competition (for food, sexual partner, living space, a place for reproduction, etc.) increases with increasing population density and the degree of specialization of the species. Most often, the competition begins for food, when as a result of reproduction with a still sufficient supply of food, population density increases. Malnutrition can often lead to a decrease in fertility, while a decrease in population does not allow the species to multiply again.

Territoriality.

Territorial behaviour is found in a wide range of animals, including some fish, reptiles, birds, mammals, and social insects. This

phenomenon is based on the individual's innate desire for freedom of movement over a certain minimum area.

The first step in the development of territoriality is the individual space surrounding each individual. It is visible, for example, in swallows seated on a telephone wire, or in starlings in a flying flock. An individual protects it from invasion and opens to another individual only after courtship ceremonies before mating. The second stage is a defended place for life, rest or sleep in the middle of an undefended zone of activity (among many predators of a hunting area). Animals standing on the second stage are distributed almost evenly.

The most rational use of space is noted at the third stage of territoriality, where real territories are formed - areas from which other individuals are expelled. The owner of the site psychologically dominates it, and in most cases, demonstrations, threats, and persecution are enough to expel, at most, feigned attacks that stop at the boundaries of the site, marked visually, acoustically or by smell (olfactory)

In birds nesting in colonies, an individual protects only its nest, and the entire colony and its environs as a whole are defended by the entire population.

9.2. Interspecific relationships. Fluctuations in numbers

They may be indifferent, harmful or beneficial to partners. Under neutralism, both species live on the same territory without entering into relations with each other. For example, woodpeckers near thrushes in a beech forest or hydroid polyps on a mollusc shell. There may be competition for the same food or living space. For example, two species of warbler and nightingale.

Mutualism benefits both partners - in case of symbiosis it is vital, in the case of proto-cooperation it is not very significant. So, ruminants and microorganisms of their rumen cannot exist without each other, and the hydra, on the contrary, can live without the chlorella algae, as well as the one without it.

Often the benefits and harms are one-sided. It doesn't matter for a lion whether vultures and jackals eat the remains of his food (*commensalism*); for dung beetles, it is immaterial that in-flight they

transfer nematode coprophages to new dung heaps — their substrate. With parasitism and predation, one of the partners' benefits for itself to the detriment of the other. These two types of relationships, as noted earlier, differ in that in the first case the attacking organism is smaller than its victim, and in the second it is larger. The reproductive potential, as a rule, the parasite has more than the host, and the predator less than the prey.

Relationship predator-prey. In an environment that does not have shelters for breeding, a predator sooner or later destroys the prey population and after that dies out itself. Under natural conditions, the following temporary and causal chain arises reproduction of prey - reproduction of predator - a sharp decrease of prey's number - a decrease in the number of a predator reproduction of prey, etc. (Figure 9.3).



Figure 9.3 Predator-Prey

This negative feedback cybernetic system leads to a stable equilibrium. The fluctuation waves of the predator and the prey follow each other with a constant phase shift, and on average, the number of both the predator and the prey remains constant.

Defense from enemies can be active. For example bites, injections, strokes, including electric ones (in stingrays and other fish), spraying secrets, etc.

The use of shelters, and more often passive, which includes a masking (mimetic) appearance, warning appearance (so-called mimicry), masking or warning behaviour.

The masking appearance consists in the imitation of inedible objects (sticks and caterpillars of moths imitate knots) or visual fusion with the surrounding background: green colouring of the inhabitants of the foliage (caterpillars, bugs, grasshoppers, etc.), brown in the land inhabitants (larks, and birds). Adaptation to the colour and pattern of the substrate can be carried out by the physiological change in body colour (flounder, cuttlefish, tree frogs, stingrays) or by changing the colour during the next moult, for example, grasshoppers.

A warning appearance can be used to scare away the aggressor with an unusual pattern, with eyespots appearing in many butterflies when they open their wings, imitating a snake head (present in many caterpillars) or animals dangerous to the attacker (scaring appearance). Another use of a precautionary appearance is a warning with bright signal colours and a striking pattern about the victim's real negative properties for the attacker: bitter taste, inedibility, toxicity, the ability to bite or sting. Examples include ladybugs, harlequin bugs, colourful caterpillars, wasps. It should be noted that at the same time some part of the population is sacrificed, on which the aggressor learns the bitter experience. Harmless organisms often imitate the warning colouration of hazardous species. For example, beetle flies, hawthorn butterflies, many barbel beetles imitate the appearance of wasps. This mimicry is nothing but a hoax.

This is the principle of the minimum size of populations. The minimum number of populations ensuring the existence of a species is specific for different species. Going beyond the minimum threatens death for the population. Further reduction, for example, of a tiger in the Far East, will inevitably lead to their automatic extinction because the remaining units, not finding partners for breeding with a sufficient frequency, will die out within a few generations. Rare plants, such as an orchid, a “venus slipper”, and others, may find themselves in the same situation.

The population maximum rule concretizes two generalizations. The first is known as the theory of H. G. Andrevart - L. K. Birch (1954), or the theory of population limits: the number of natural populations is limited by depletion of food resources and breeding conditions, the inaccessibility of these resources and too short a period of accelerated population growth. The second generalization

supplements the first and is called the theory of biocenosis regulation of the population size, which is the result of a complex of influences of the abiotic and biotic environment in the habitat of the species.

The combination of all factors contributing to an increase in population is called the biotic potential. Although the components of the biotic potential are not the same in different species, there is a common property: in all species, it is high enough for a rapid increase in numbers under favourable environmental conditions. Population growth can be so rapid that it can lead to a population explosion. However, it should be noted that an increase in the population density above the optimal one harms them since their food base is drying up, living space is being reduced, epizootics appear

Periodic fluctuations in population numbers usually occur within one season or several years. Cyclic changes with an increase in numbers after an average of four years were recorded in animals living in the tundra - lemmings, polar owl, Arctic fox. Seasonal fluctuations in numbers are also characteristic of many insects, mouse-like rodents, birds, and small aquatic organisms.

In vivo, the likelihood that all conditions are favourable for the population is very low.

As a rule, one or several abiotic (non-optimal temperature, acidity, salinity, humidity) and biotic (presence of predators, parasites, pathogens, lack of food) factors become limiting. The combination of these limiting (limiting) factors is called environmental resistance.

Environmental resistance is most likely to affect young individuals, who are more affected by predators, diseases, lack of water and food, or other adverse conditions.

Maintaining a certain number or an equilibrium state is called the homeostasis of populations. The growth, decrease or constancy of the number of populations depends on the ratio between the biotic potential (addition of individuals) and environmental resistance (death of individuals).

Hence, the principle of changing populations can be formulated as follows: changing a population of a species is the result of an imbalance between its biotic potential and environmental resistance. This equilibrium is called dynamic or continuously regulated since the resistance factors of the medium rarely remain unchanged for a long

time. In one year, the population can significantly reduce its number due to drought, and in subsequent years with normal moisture, completely restore it. Such cyclic oscillations usually last indefinitely. This explains the general rule of maximum size fluctuations in the density of the population. "There are certain upper and lower limits for average population sizes that are observed in nature or which could theoretically exist for an arbitrarily long period." Yu. Odum (1975) rightly remarks that there can be 100 birds per 1 ha and 20,000 soil arthropods per 1 m², but there are never 20,000 birds per 1 m² and 100 arthropods per 1 ha. The rule of the maximum size of fluctuations in the density of the population can be called the law of quantitative constancy of the population. This pattern indicates the average systemic number of individuals per unit area. Deviation from this law, or rule, indicates an unfavourable situation in the region, is a bio-indicator of the discrepancy in its ecosystems. The absence or suppression of the abundance of a species due to biotic and abiotic relationships will entail a chain of consequences, the results of which should be foreseen.

9.3. Environmental Population Strategies

Adaptations of individuals in the population, ultimately, are aimed at increasing the likelihood of survival and abandonment of offspring. Among the devices stands out a complex called environmental strategy. The ecological strategy of a population is its general characteristic of growth and reproduction. This includes the growth rate of its individuals, the time to achieve puberty, fertility, the frequency of reproduction, etc.

Ecological strategies of populations are very diverse. Thus, when describing the population growth material and growth curves, the symbols r and K were used. Fast-breeding species have a high r -value and are called r -species. These are, as a rule, pioneering (often called "opportunistic") species of disturbed habitats. These habitats are called r -screeners, as they favour an increase in the number of r -species.

Species with a relatively low r -value are called K -species. The rate of their reproduction is sensitive to population density and remains close to the equilibrium level determined by K .

These two types of species are said to use the r -strategy and the K -strategy, respectively.

These two strategies essentially represent two different solutions to the same problem - long-term survival of the species. Species with the r -strategy quickly populate disturbed habitats (exposed rock, forest felling, burned-out areas, etc.) than species with the K -strategy, because they are easier to spread and reproduce faster. Species with a K -strategy are more competitive, and they usually crowd out r -species, which meanwhile move to other disturbed habitats. The high reproductive potential of r -species indicates that, if left in any habitat, they would quickly use available resources and exceed the supporting capacity of the medium, and then the population would die. Species with r -strategy occupy this habitat during the life of one or, at most, several generations. In the future, they are relocated to a new place. Individual populations may die out regularly, but the species moves and survives. In general, this strategy can be described as a strategy of "struggle and flight" [1,15, 22].

Questions for self-control

1. What are the main forms of coexistence of individuals in a population? Indicate the characteristics of the relationship of animals in families, colonies, flocks and herds.
2. What does intraspecific ectoparasitism mean?
3. What do you need to know about a species to predict its abundance with sufficient probability?
4. What is the population homeostasis? What are the main intrapopulation mechanisms for regulating the population size?
5. What interspecies relationships highlight?
6. What does r - and K - environmental strategies mean?

Theme 10

Biocenosis

10.1. The concept of biocenosis. Species structure of biocenosis

Biocenosis is a historically established group of plants, animals, fungi and microorganisms that inhabit a relatively homogeneous living space (a land or water site) (Figure 10.1).

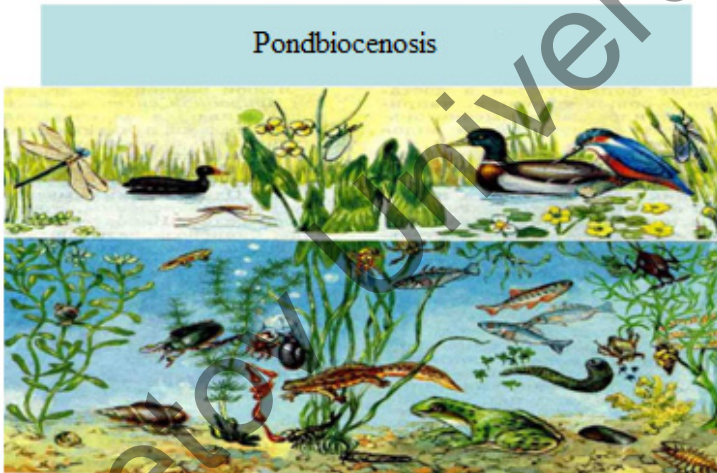


Figure 10.1 Pond biocenosis

So, each biocenosis consists of a certain set of living organisms belonging to different species. But it is known that individuals of the same species are combined into natural systems called populations.

Therefore, biocenosis can also be defined as the totality of populations of all types of living organisms that inhabit common habitats.

It should be noted that the term “biocenosis” has become widespread in the scientific literature in German and Russian, and in

English-speaking countries, it corresponds to the term “community”. However, strictly speaking, the term “community” is not synonymous with the term “biocenosis”. If the biocenosis can be called a multi-species community, then the population (an integral part of the biocenosis) is a single species community.

The composition of the biocenosis includes:

- A) a set of plants in a certain territory - phytocenosis;
- B) the totality of animals living within the limits of phytocenosis - zoocenosis;
- C) microbiota - the totality of microorganisms that inhabit the soil;
- D) sometimes as a separate constituent element in the biocenosis include a mycocenosis set of fungi.

Examples of biocenoses are deciduous, spruce, pine or mixed forests, meadows, swamps, etc.

The homogeneous natural living space (part of the abiotic environment) occupied by the biocenosis is called the biotype. This may be a plot of land or a reservoir, a seashore or a mountainside. A biotype is an inorganic environment, which is a necessary condition for the existence of a biocenosis. Biocenosis and biotype closely interact with each other.

A specific biocenosis includes not only organisms that constantly live in a particular territory, but also those that have a significant impact on it. For example, many insects breed in water bodies, where they serve as an important source of nutrition for fish and some other animals. At a young age, the state leads a land-based lifestyle, i.e. act as elements of land biocenoses. Hares can eat in the meadow, and live in the forest. The same applies to many species of forest birds that seek food not only in the forest but also in adjacent meadows or swamps.

10.2. The spatial structure of biocenosis

Biocenoses are characterized by a certain structure. The species, spatial and ecological structure of the biocenosis is distinguished.

The species structure of the biocenosis is the totality of its constituent species. The species diversity of the biocenosis depends on the heterogeneity of the environment and increases at the boundaries of biotypes. In some biocenoses, animal species may predominate (for example, the biocenosis of a coral reef), in other biocenoses, the main role is played by plants: the biocenosis of the floodplain meadow, feather grass steppe, spruce, birch, and oak forest. The number of species (species diversity) in different biocenoses is different and depends on their geographical location. The most famous pattern of change in species diversity is its decrease from the tropics towards high latitudes. The closer to the equator, the richer the diversity of flora and fauna. This applies to all flora of life, from algae and lichens to flowering plants, from insects to birds and mammals.

Species diversity is the number of species in a given community. There are poor and species-rich biocenoses. Species diversity depends on the age of the community (young communities are poorer than mature ones) and on the favourable nature of the main environmental factors - temperature, humidity, food resources (biocenoses of high latitudes, deserts and highlands are poor in species).

R. Whittaker suggested distinguishing the following types of biodiversity: α -diversity - species diversity in a given habitat in a given area; β -diversity - the sum of all types of species of all habitats in a given area; γ -diversity - landscape diversity (a combination of α - and β -diversity).

To assess the quantitative ratio of the types of biocenosis, various indices or a percentage are used. The dominant species are dominant in the community. Dominants dominate the community and make up its "species core." Among dominants, edificatory species ("builders") are distinguished, which have the greatest impact on the existence of the community.

Rare and small species are also very important for biocenosis. They create its species richness, increase the diversity of biocenotic connections and increase the stability of the biocenosis.

To assess the role of a particular species in the species structure of the biocenosis, the following indicators are used:

A) species abundance - the number of individuals of a given species per unit area or volume of occupied space; can also be characterized as the ratio of the number of individuals of the species to the total number of individuals of all species of the community and expressed as a percentage;

B) the frequency of occurrence - is calculated as a percentage of the number of samples or reference sites where the species occurs and the total number of such samples or sites;

C) the degree of dominance is an indicator that reflects the ratio of the number of individuals of a given species to the total number of all individuals of the community; according to the generally accepted Renkonen scale, species with a degree of dominance of 5% or more are attributed to dominant, 2.5% to the subdominant, and less than 2% to reference.

The species composition of biocenoses, besides, depends on the duration of their existence, the history of each biocenosis. Young, only emerging communities usually include a smaller set of species than mature, mature ones. Biocenoses created by man (fields, gardens, kitchen gardens) are also poorer in species than natural systems similar to them (forest, steppe, meadow).

However, even the poorest biocenoses include at least hundreds of species of organisms belonging to different systematic and ecological groups. In the agrocenosis of a wheat field, in addition to wheat, it includes, at least in a minimal amount, various weeds, wheat pests and predators that feed on phytophages, mouse-like rodents, invertebrates - inhabitants of the soil and soil layer, microscopic organisms, pathogenic fungi, and many others. Species-rich natural communities include thousands and even tens of thousands of species, united by a complex system of diverse relationships.

The spatial structure of the biocenosis characterizes the distribution of species in the biotype. The vertical distribution is determined primarily by the addition of its plant part - phytocenosis, primarily in layering (Figure 10.2).

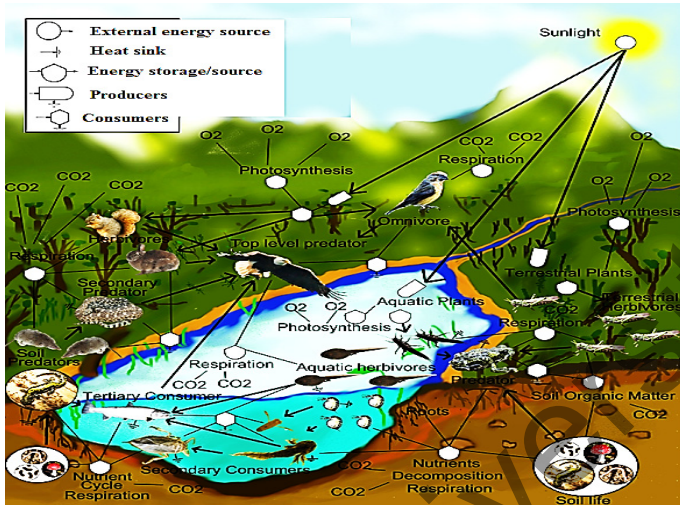


Figure 10.2 Biocenosis, Vertical tier.

So, each biocenosis consists of a defined set of living organisms belonging to different species. But it is known that individuals of one species unite in the natural system, which is called populations. Animals are also predominantly confined to a certain layer of vegetation.

For example, the following groups are distinguished among insects:

- 1) Geobium-dwellers of the soil;
- 2) Herpetobium-inhabitants of the surface, surface layer;
- 3) Phyllobium-inhabitants of the grass stand;
- 4) Aerobic inhabitants of higher tiers.

Also, among birds some species nest only on the ground (black grouse, oatmeal), others in the shrub layer (bullfinches, warblers, song thrushes) or the crowns of trees (finches, goldfinch, and predators).

The horizontal vegetation of the biocenosis is called mosaic and is determined by abiotic and biotic factors.

Microcenosis (from the Greek Micro-small) is the smallest structural unit of horizontal division of the community, which includes all tiers. Almost every community includes a complex of micro-communities or microcenoses.

Microgrouping is the condensation of individuals of one or more species within the tier, the inner-tiled mosaic spots. For example, in the moss layer, various spots of mosses with the dominance of one or more species can be distinguished. In the herbaceous-shrub layer, there are blueberry, blueberry-sour, blueberry-sphagnum micro-groups.

The presence of mosaic is of great importance for the life of the community. Mosaic allows more fully to use various types of micro-habitats.

Individuals forming groups are characterized by high survival rates; they most efficiently use food resources. This leads to an increase and diversity of species of biocenosis, contributes to its stability and vitality.

10.3. Ecological structure of biocenosis

The ecological structure of a biocenosis is understood as a definite correlation of ecological groups of organisms (Figure 10.3). For example, the ratio of the ecological groups of organisms concerning humidity is hygrophile (hygrophytes), mesophylls (mesophytes) and xerophiles (xerophytes). Ecological groups of organisms, occupying similar ecological niches, in different biocenoses can have different species composition. So, in humid areas, hygrophytes dominate, in dry arid conditions sclerophytes and succulents dominate. It reflects the ecological structure of the biocenosis and the correspondence of groups of organisms that are united by a similar type of nutrition. For example, saprophages prevail in forests, and phytophages prevail in steppe and semi-desert zones.

In the depths of the ocean, the main type of animal nutrition is predation, while in the surface zone of the pelagic zone, which is more illuminated, there are many filtrates or species with a mixed nature of nutrition.

Differences in the ecological structure of the biocenosis are most pronounced when comparing the communities of organisms in similar biotypes of different regions. For example, marten in European and sable in Asian taiga, wild horses and kulans in the steppes of Asia occupy similar ecological niches and perform the same functions.

These species determine the ecological structure of the community and are called “replacing” vicarial.

Thus, the ecological structure of the biocenosis is its composition of ecological groups of organisms that perform certain functions in the community in each ecological niche.

The ecological structure of the biocenosis serves as its microscopic characteristic.in a complex of species and spatial, with the features of the ecological niche.

A macroscopic characteristic, in contrast to a microscopic characteristic that gives an idea of the relationships of each population and species in a community, makes it possible to determine the properties of a particular biocenosis, to determine its stability in space and time, and also to predict the consequences of changes caused by the influence of anthropogenic factors.

10.4. The ratio of organisms in biocenoses

A variety of interspecific relationships arise between organisms in biocenoses (Figure 10.3).

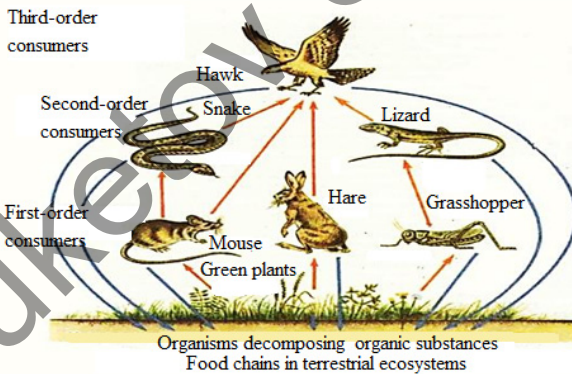


Figure 10.3 Food chains (zoophages and phytophages)

According to the classification of the famous domestic zoologist V.N. Beklemisheva, there are four types of biological relationships in communities.

1. Trophic connections - food relations in which one species eats others: either living individuals, or their dead remains (Figure 10.4), or waste products.

Animals by type of food are divided into several ecological groups:

- Predators, or zoophages (eat animal food);
- saprophagous (feed on rotting substances);
- nectophore (feed on animal corpses);
- coprophages (eat excrement);
- phytophages (eat plant food).

Among phytophages distinguish:

- phytophages (feed on leaves),
- coprophagous (feed on fruits),
- xylophagous (feed on wood),
- rhizophagous (feed on roots).

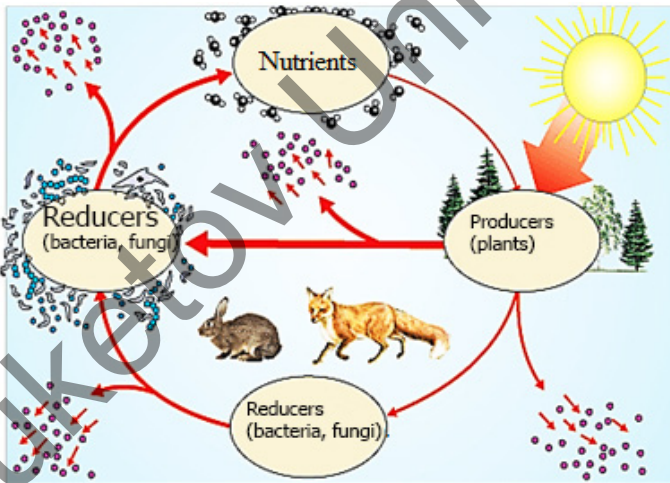


Figure 10.4 Interspecific Biotic Factor

According to the degree of selectivity of food objects, three groups of organisms are distinguished:

- 1) mononuclear;
- 2) oligophages-restricted-eating;
- 3) polyphages-polyphagous.

2. Tropical connections - relationships related to habitat. For example, competition for a place of feeding, breeding, nest construction.

3. Phoric ties - relationships associated with the participation of one species in the distribution of another (from the word phoresia - the transfer of animals by others). For example, sticky fish attach to sharks or turtles and use them as a "transport". Gamasid mites are often used similarly by various insects. The seeds of many plants are carried by various animals.

4. Fabric relations - relationships in which one species uses other organisms or their residues for their structures. Birds use various plants, fluff, wool and other building materials of biological origin for the construction of nests.

According to another classification, six basic types of ecological relationships are possible between organisms in biocenoses (corresponding designations are given for each type of relationship):

1) Mutualism - mutualistic, or symbiotic, relationships;

Examples of mutualistic, or symbiotic, relationships:

- lichens (symbiosis of fungi and algae; fungi receive nutrients, algae - water and minerals);
- intestinal endosymbionts (bacteria, protozoa)
- host animals (ruminant mammals, termites);
- legumes - nodule bacteria (nitrogen fixatives);
- trees - mushrooms;

2) Commensalism - the one-sided use of one kind of another without harm to the latter (+; 0). This relationship is that the activity of one species delivers food or shelter to another.

Examples of commensalism:

- sticking fish on sharks or turtles;
- Settlement of epiphytic plants on tree bark;
- gamasid mites on various insects;
- Egyptian heron - cattle (feeds on insects scared by cattle);
- a bumblebee flies in nests of bumblebees (eat various garbage);

3) Neutralism - the independent existence of species, in which species bring each other neither harm nor benefit (0; 0);

4) Amensalism - the interaction of species in which one does not receive any harm or benefit, but for the other this relationship is

negative. Light-loving plants growing under the spruce are oppressed, but for the spruce this relationship is indifferent (-; 0);

5) Competition is a form of environmental relationship that adversely affects both interacting species (- ; -). Competition arises between species for different resources (trophic, topical);

6) Predation and parasitism - one-sided use by one species (predator, parasite) of another (host), in which the first destroys or exploits the other (+ ; -). Predation and parasitism are related to food relationships.

Predators, for a normal existence, need adaptations to successfully hunt prey. Therefore, in predator populations, natural selection will increase the efficiency of searching, fishing, and eating prey. At the same time, in the prey population, those individuals who successfully avoid predators will usually have a selective advantage. The long-term co-evolution (modern evolution) of the predator and the prey improves the adaptations of the species included in this pair. This includes both complex morphological and behavioural adaptations.

The coevolution of the parasite and the host, as in the case of a predator-prey pair, leads to the development of various adaptations on both sides. For the host, this is mainly the immune system, for the parasite - a whole complex of morphological, physiological and behavioural adaptations. Parasitism, in contrast to predation, is characterized by a narrower specialization of species, since the degree of adaptation to a particular host species determines the success of the parasite's survival [1-8, 14, 16, 17, 20].

Questions for self-control

1. What is a biocenosis? Give examples of biocenoses.
2. What species are called dominant in the biocenosis?
3. What is a biotype?
4. What is the spatial structure of the biocenosis?
5. What are the main tiers that make up the vertical structure of the biocenosis? What types of interspecific interactions in a biocenosis do you know?

Theme 11

Ecosystems

11.1. The concept of ecosystems. Classification and structure of ecosystems

The term “ecosystem” was first proposed by the English ecologist A. Tensley in 1935, but the very idea of the ecosystem arose much earlier. The mention of the unity of organisms and the environment is found in the earliest works. First, let's define the concept of “system”.

A system is a real or conceivable object whose integral properties can be represented as a result of the interaction of its constituent parts. The main properties of the system are unity, integrity and the relationship between its components.

The ecosystem is a combination of different species of organisms living together and their conditions of existence, which are in a regular relationship. The components of the ecosystem are meadow, forest, river, ocean, rotting tree trunk, biological ponds for wastewater treatment (Figure 11.1).



Figure 11.1 Ecosystem Structure

Biocenosis is a terrestrial ecosystem, including rivers, meadow, forests, etc. Any biocenosis is an ecosystem, but not every ecosystem can be a biocenosis (Figure 11.2). Biogeocenosis (hereinafter referred to as the ecosystem) consists of an ecotope of biocenosis.

Ecotope is a combination of abiotic factors (soil, water, atmosphere, climate, etc.). Biocenosis - a set of living organisms: vegetation, animals, microorganisms.

The main property of an ecosystem is the interconnection and interdependence of all its components. The arrows in the diagram show this relationship.

Consider the example of a forest ecosystem, the relationship of its constituent components

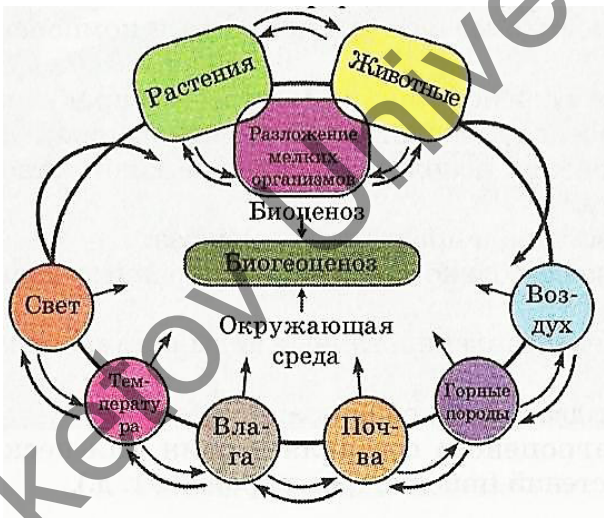


Figure 11.2 Biogeocenosis

Climate is affected by water, air, temperature conditions of soils, the type of vegetation, the rate of creation of organic matter, the activity of microorganisms.

The climate is affected by soil. Various chemical elements are released into the atmosphere from the soil.

Vegetation from the soil takes water, nutrients, humus; from the atmosphere - carbon dioxide, solar energy; releases oxygen into the atmosphere, and after it dies, detritus enters the soil. At the same time, the vegetation provides animal nutrition; the soil is a favourable habitat; animal waste products enter the soil, soil microorganisms process them to the source of carbon dioxide, water, humus and other mineral compounds.

Thus, the ecosystem is an integrated, functioning, self-regulatory system.

For a specialist, there is not nature, but an ecosystem. Man cuts down not a forest, but an ecosystem throws waste, not into the environment, but ecosystems.

At first glance, it might seem that there is no connection between different ecosystems, for example, between a meadow, a forest, and a pond. However, upon closer examination, it can be noted that: soil particles, humus, dead vegetation are washed out by the surface runoff of sediments from a neighbouring meadow into the pond; part of the fallen leaves in the autumn is transferred from the forest to the pond, where it decomposes and becomes food for some aquatic organisms. Insect larvae live in the pond, adults leave the aquatic environment and settle in a meadow or the forest.

Large terrestrial ecosystems are called biomes. These include the tundra, taiga, rainforests, savannas, etc. Each biome consists of many ecosystems that are interconnected.

The global ecosystem of the Earth is the biosphere.

The structure of ecosystems. The totality of organisms and the totality of inanimate (abiotic) environmental factors form an ecosystem. The ecotope includes climate in all its diverse manifestations and the geological environment (soils and soils), called the edaphotope (from Greek soil). The ecotope is where the biocenosis draws its means of subsistence from and where it allocates its waste products. The structure of the living part of the biocenosis is determined by trail-energy bonds and relationships, following which there are three main functional components:

1. A set of autotrophic organisms of producers providing organic matter and energy to other organisms (phytocenosis (green plants), as well as photo and chemo-synthesizing bacteria);

2. A complex of heterotrophic organisms of consumers living at the expense of nutrients, creatures by producers (zoocenosis (animals), as well as chlorophyll-free plants);

3. A complex of organisms of reducers that decompose organic compounds to a mineral state (microbocenosis, as well as rice and other organisms that feed on dead organic matter).

The ecosystem is represented by two groups of components: abiotic and biotic.

Abiotic components include:

- elements involved in the metabolism between living and dead matter (carbon dioxide, water, oxygen, calcium, magnesium, potassium, sodium, reinforced concrete, nitrogen, phosphorus, sulfur, chlorine, etc.);

- organic substances that bind the abiotic and biotic parts of ecosystems (carbohydrates, fats, amino acids, proteins, humic substances, etc.);

- air, water and solid habitat; the climatic regime, etc.

Biotic components consist of three functional groups: producers, consumers and reducers.

11.2. The sun as a source of energy. Cycles of substances.

The sun is the primary source of energy for ecosystems. According to T.A. Akimova and V.V. Khaskin (1994), the flow of energy sent by the sun to our planet exceeds 20 million Edge. in year. Due to the spherical shape of the Earth, only a quarter of this stream reaches the border of the entire atmosphere. About 70% of this part is absorbed by the atmosphere and emitted in the form of long-wave infrared radiation. Solar radiation reaching the Earth's surface is 1.55 million Edge. in year. Such an amount of energy is 5,000 times higher than the entire energy of humanity at the end of the 20th century and 5.5 times higher than the energy of all available resources of fossil fuels of organic origin accumulated over at least 100 million years.

In the process of their life, all living organisms constantly interact with the environment. The essence of this interaction is reduced to the exchange of matter and energy. The vital activity of the

ecosystem and the cycle of substances in it are possible only under the condition of a constant influx of energy. The main source of energy on Earth is solar radiation. The energy of the Sun is translated by photosynthetic organisms into the energy of chemical bonds of organic compounds. Energy transfer along food chains obeys the second law of thermodynamics: the conversion of one type of energy to another is accompanied by the loss of part of the energy. At the same time, redistribution does not obey a strict regularity: the energy received by the ecosystem and consumed by producers is dissipated or, together with their biomass, is irreversibly transferred to consumers of the first, second and other orders, and then to reducers with a decrease in the energy flow at each trophic level, so there is no energy cycle.

The circular consumption and transformation of substances make it possible to use them repeatedly, unlike the energy used in the ecosystem once. This cycle is carried out by living organisms of the ecosystem (producers, consumers, reducers) and is called the biological cycle of substances. **The biological cycle** is understood as the entry of chemical elements from the soil and atmosphere into living organisms, in which the incoming elements are converted into new complex compounds and their return to the soil and atmosphere in the process of life.

In addition to solar energy, the ecological systems of land and the oceans bind and redistribute solar energy, carbohydrates, the atmosphere and other elements.

The vital activity of plant organisms (producers) and their interaction with animals (consumers), microorganisms (reducers) and inanimate nature provides a mechanism for the accumulation and redistribution of solar energy entering the Earth.

The most important aspect of the existence of life on Earth is the cycles (biogeochemical cycles), in which water and the main biogenic chemical elements are involved. All cycles consist of two phases: **organic** (during which the substance or element is part of living organisms) and **inorganic**. Subsequent transitions of a substance from one phase to another take place countless times. So, for example, it passes through the organic phase every year and returns to the inorganic $1/7$ part of all carbon dioxide and $1/4500$ part of the oxygen

in the atmosphere. Scientists estimate that the water cycle is carried out for 2 million years. This is due to evaporation, the movement of water vapour in the atmosphere, its condensation, precipitation and the presence of effluents. The cycle begins with the evaporation of water from the underlying surface of reservoirs. With air currents, water vapour moves from one area to another. Most of the water evaporates from the surface of the oceans and when condensed in the form of precipitation returns. A smaller fraction of the evaporated water is transferred to land by air sweeps. Water evaporating over land and carried by air currents into the ocean is insignificant in volume. Thus, during evaporation, the seas and oceans lose significantly more water than they receive moisture when precipitation occurs, on land - vice versa. However, the flow of river water regularly enters the seas and oceans from the continents, which ensures the constancy of the volume of water on the planet.

In connection with moisture condensation, precipitation occurs. Part of the atmospheric precipitation moisture evaporates, partly forms temporary or permanent drains and water bodies. A certain mass fraction of atmospheric precipitation moisture seeps into the ground, forming groundwater.

Depending on the place where the moisture has evaporated and where precipitation has occurred, large (world) and small (oceanic and continental) water cycles are distinguished. In nature, there are several types of the water cycle. With a large cycle, the water vapour formed over the seas and oceans is carried by air currents to the continents, condenses there with precipitation, and moisture again enters the ocean in the form of drains. This type of cycle is accompanied by a change in the quality of water, since, by evaporating, saltwater becomes fresh, and dirty water is purified.

The biotic cycle of substances as a closed system has been worked out in the process of evolution over several billion years. Dead animals and plants are processed by insects, protozoa, fungi, bacteria and other destructors (reducers), which destroy them, turning them into mineral or simple organic compounds that enter the soil and are consumed by plants again. The decay and decomposition of the final products ensure the continuity, isolation of this process. Under the influence of the biotic cycle of substances, the concentration of

phosphorus in the soil is noticeably higher (on average 0.1-0.3%) than in the earth's crust. A large amount of phosphorus (106-107t) is retained in the biosphere. The content of this element in the phytomass of natural meadow steppes reaches 30 kg/ha. This level of phosphorus in fodder plants is quite sufficient for wild herbivorous mammals. According to the energy principle of studying the biotic cycle of matter, energy, unlike matter, does not disappear in the chain of trophic (food) transformations, but passes from one form to another. The energy of the Sun is transformed during the biotic cycle of matter at each stage and level. Solar energy is directly consumed by green plants during photosynthesis. Plants create organic matter from carbon dioxide (CO₂) and water as if accumulating energy. In certain ecologically specific periods, the balance of the biotic circulation of substances was disturbed: surpluses that were deposited in the form of oil, coal, gas, limestone and other minerals of organic origin were removed from it. It is important to note that these surplus deposits deposited from the biotic cycle in the past not only did not clog the biosphere but also did not harm the process itself.

Animals play a large role in the cycle of matter and energy. One species is not able in any biocenosis to break down the organic matter of plants into final products. Each species uses only part of the plants and some organic substances contained in them. This is how chains and food networks are formed that sequentially extract substances and energy from photosynthetic plants. Therefore, the atmosphere in the biocenosis plays a significant role in maintaining the biotic circulation of substances and ensuring water balance.

Carbon cycle. All earthly life is based on carbon. Each molecule of a living organism is built based on a carbon skeleton. Carbon atoms are constantly moving from one part of the biosphere to another.

The main carbon reserves on our planet are in the form of carbon dioxide contained in the atmosphere and dissolved in the oceans, that is, carbon dioxide (CO₂).

Throughout the Earth's existence, the carbon removed was replaced by carbon dioxide, which entered the atmosphere during volcanic eruptions and other geothermal processes. Currently, emissions from the burning of fossil fuels by humans are also added to these natural factors.

The oxygen cycle. In this cycle, the active geochemical activity of living matter and its primary role are clearly expressed. The biogeochemical cycle of oxygen is a planetary process connecting the atmosphere and hydrosphere with the earth's crust.

Ozone is closely associated with the oxygen cycle. In high atmospheric layers, under the influence of the ultraviolet part of the solar spectrum, some oxygen molecules are ionized and atomic oxygen is formed, which immediately joins the oxygen molecules, forming ozone-triatomic oxygen. The action of hard ultraviolet light destroys many structures of molecules of living organisms. Ozone, absorbing during the formation of most of the hard ultraviolet radiation, plays a protective role for the entire biosphere.

The nitrogen cycle. Almost all natural nitrogen is in a free state in atmospheric air, the content of which is 78%, but its share in the total mass of chemical elements on the planet is very small - 0.04%.

Nitrogen is necessary for every living cell and can be absorbed only by nitrogen-fixing microorganisms. Nitrogen is a part of all proteins and nucleic acids and is the most limiting of all other biogenic elements. Bacteria (anaerobic and cyanobacteria) convert free nitrogen into the conjugated form: NH_3 , NO_2 nitrites, NO_3 nitrates. They are the basis for the nutrition of plants, fungi and microorganisms that form amino acids, peptides and proteins.

Thus, nitrogen passes into all living organisms, where it makes up 1% of dry biomass.

In the cycle of nitrogen compounds, microorganisms are of primary importance: nitrogen-fixers, nitrification and denitrification.

Modern disturbances in the nitrogen cycle in the biosphere are a consequence of anthropogenic activity, i.e. burning mineral fuels (in transport, in the power system) and the production of nitrogen fertilizers.

11.3. The flow of energy in ecosystems. Food chains and nets, trophic levels

Maintenance of the life of organisms and the circulation of matter in ecosystems, i.e. the existence of ecosystems depends on the

constant influx of energy needed by all organisms for their life and self-reproduction.

Although substances are continuously moving along the blocks of the ecosystem, they can be used repeatedly and enter the cycle. Unlike substances, energy is used once, linear flow of energy occurs through ecosystems.

As a result of the laws of thermodynamics, a one-sided influx of energy occurs. According to the first law, energy can transform from one form (for example, light) to another (for example, the potential energy of food), but cannot be created or destroyed. The second law proves that in any process when energy is converted, a certain part of it is lost. A certain amount of energy in such transformations is dissipated into inaccessible thermal energy, and therefore is lost. Hence, there can be no transformations, for example, of food substances into the substance of which the body of an organism consists, coming with 100% efficiency.

Thus, living organisms are energy converters. And every time the energy is converted, part of it is lost in the form of heat. Ultimately, all the energy entering the biotic cycle of the ecosystem is dissipated in the form of heat. Instead of heat, living organisms use light and chemical energy as a source of energy for work.

Food chains and nets, trophic levels. Inside the ecosystem, energy-containing substances are created by autotrophic organisms and serve as food for heterotrophs. Nutritional connections are the mechanisms of energy transfer from one organism to another.

This is observed when animals eat plants. In turn, this animal itself can be eaten by another animal. In this way, energy is transferred through several organisms - each subsequent organism is fed by the previous one, which supplies it with raw materials and energy.

This sequence of energy transfer is called the food (trophic) chain, or the food chain. The location of each link in the food chain is a trophic level. The first trophic level, as already noted, is occupied by autotrophic, or so-called primary producers. Organisms of the second trophic level are called *primary consumers*, *third-secondary consumers*, etc.

Three types of food chains are usually distinguished. The food chain of predators begins with plants and passes from small organisms

to organisms of ever-larger sizes. On land, food chains consist of three to four links.

Food chains, including parasites, differ from the given ones and go from large to small organisms. In some cases, taxonomic organisms significantly remote from each other, develop one inside the body of the other, which feeds on plants, forms a zoocenosis of parasites and predators that form numerous food chains, where the host is the initial link.

The given types of pasture chains begin with photosynthetic organisms and are called pasture chains (either the introduction chain or the consumption chain).

The third type of food chain, starting from the dead remains of plants, carcasses and animal excrement, is referred to as detrital (saprophytic) food chains or detrital propagation chains. In the detrital food chains of terrestrial ecosystems, deciduous forests play an important role, most of the leaves of which are not eaten by herbivores and go into the litter of fallen leaves. Leaves are crushed by numerous detrophages - fungi, bacteria, insects (for example, collembolan), etc., then are swallowed by earth (rain) worms, which distribute humus in the surface layer of the Earth evenly, forming the so-called mullah.

At this level, mycelium is laid in the fungi. Decomposing microorganisms that complete the chains produce the final mineralization of dead organic residues. In general, the typical detrital and food chains of our forests can be represented as follows:

- leaf litter - earthworm - blackbird - hawk;
- a dead animal - larvae of pedal flies - a grass frog - an ordinary one.

In the considered schemes of food chains, each organism is presented as feeding on other organisms of one type. Real food connections in the ecosystem are much more complicated since the animal can feed on organisms of different types from the same food chain or different food chains, for example, predators of the upper trophic levels. Often animals feed on both plants and other animals. They are called omnivores. Thus, all three types of food chains are always intersecting food bonds, and together they form a food (trophic) network.

Food networks in ecosystems are very complex, and it can be concluded that the energy entering them migrates for a long time from one organism to another [1,16,17, 21].

Questions for self-control

1. What is an ecosystem?
2. What is the main property of a miscellaneous ecosystem?
3. Why can not every ecosystem be a biocenosis?
4. How is the cycle of energy and substances in ecosystems?

Give examples.

5. Explain the concepts of "food chains and nets, trophic levels."
6. What are the types of food chains?

Theme 12

Human impact on the environment

The impact of human activities on nature at different stages of development of human society.

12.1 Types of human exposure to nature

Mankind was in the niches of primitive gatherers and fishers with a minimum biological energy consumption of 200 thousand years; in niches of primitive agriculture, cattle breeding and hunting with energy consumption 2 times greater - 10 thousand years. In the niche of traditional agriculture with livestock with 5 times energy consumption - 1000 years; in the niche of the industrial world with 20 times energy consumption -100 years.

This acceleration of the change in the qualitative stages of progress and the acceleration of energy growth are among the main causes of the ecological crisis.

Humanity in its development has experienced a series of environmental crises and the subsequent environmental revolutions. The most important of them are the crises of ancient gathering and fishing (primitive hunters played a decisive role in the extinction of

such large mammals like the mammoth, woolly rhinoceros, cave bear, cave lion, tarpan, and some others), which caused the transition to a manufacturing economy, and the crisis of producers, those. the exhaustion of the most accessible wood resources for fuel and construction, as well as the achievement of productivity limits before machine agriculture. These circumstances became one of the incentives for the industrial revolution and the development of industrial civilization, which led to the modern crisis. The modern ecological crisis is called the crisis of reducers because the whole set of reducers of the biosphere can no longer cope with the destruction of the enormous mass of anthropogenic pollution of the environment. This is combined with a shortage and threat of exhaustion of many mineral resources.

Technogenesis is the process of changing natural complexes under the influence of human production activities. The change in the stages of technogenesis, the main types of human technology occurs immeasurably faster than the "technology" of the biotic cycle in the evolution of the biosphere. There is an estimate of the difference between these speeds –7–8 orders of magnitude. Therefore, biological evolution cannot (does not have time) to adapt to technological progress.

The impact of man on nature can be as follows:

1. The withdrawal from the nature of its components, the use of natural resources.
2. In the discharge into the natural environment of economic waste, pollution of this environment.
3. In the transformation of natural complexes for economic purposes.

Distinguish:

Direct impact - direct action to any components of nature (cut down the forest; ploughed up the steppe - became a field; mastered the virgin lands - got the crop).

Indirect exposure is a consequence of direct exposure (as a result, the soil becomes poor, due to ploughing, soil erosion occurs, the steppe turns into a desert).

Combined exposure is a combination of these two forms. Usually, any impact on nature upon careful consideration is combined.

Natural resources - objects, conditions and processes of nature used (or which can be used) by human society to satisfy the material, scientific and cultural needs of society. Natural resources are divided into exhaustible (non-renewable, relatively renewable, renewable) and inexhaustible (climate, space, water) (Figure 12.1).

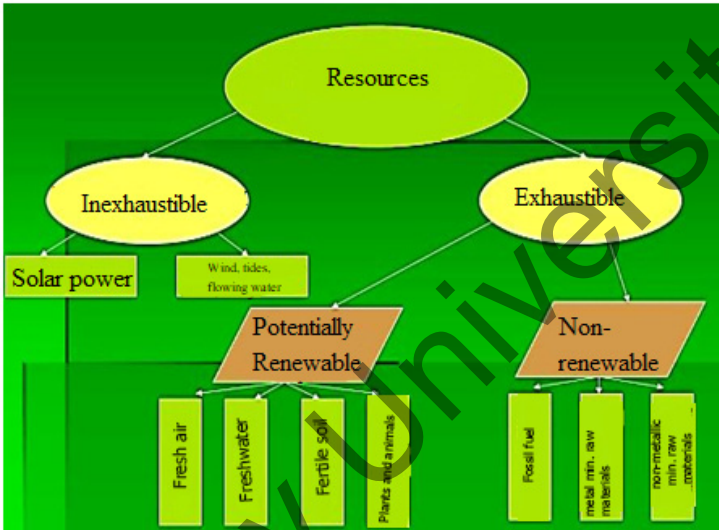


Figure 12.1 Resources

If the rate of use of exhaustible resources exceeds the speed of their recovery, they may be lost. A person cannot have a significant impact on the number of inexhaustible resources but can affect their quality because the amount of incoming solar energy, water pollution, etc. depends on the transparency of the atmosphere. The technogenic type of environmental, socio-economic development is characterized by the intensive use of non-renewable types of natural resources and the exploitation of renewable resources at a speed exceeding the ability to reproduce them.

Natural resources are divided into interchangeable and non-interchangeable. Interchangeables include oil, gas, etc. They are interchangeable within certain limits. Indispensable are sunlight, air, water, and genetic resources.

Concerning the total volume of a disposed of a natural substance in Russia, the final product is only 2–4%.

12.2 Types of human environmental pollution

Pollution - the introduction into the environment or the emergence in it of new, usually not characteristic physical, chemical, biological agents, as well as the excess of the agents present in the environment of their natural level.

1. By distribution scale - local, regional and global. For the atmosphere, local pollution is considered to affect the environment within a radius of 80 km, regional - 90-800 km, global - more than 800 km.

Regional soil pollution - soil pollution resulting from the transport of a pollutant in the atmosphere to distances of more than 40 km from industrial and more than 10 km from agricultural sources of pollution.

2. By duration of exposure - short-term and long-term. Short-term pollution - single emissions into the atmosphere - explosions, leaks of gas, oil products. Long-term pollution - permanent or long-term sources of pollution (industrial enterprises, thermal power plants, hydraulic structures, etc.) can lead to significant changes in environmental components.

3. By the nature of the effect - physical, biological and chemical.

Physical pollution - thermal heating, noise, electromagnetic and radioactive radiation (changes the direct physical characteristics of the medium) by exposure duration - short-term and long-term. Short-term pollution - single emissions into the atmosphere - explosions, leaks of gas, oil products. Long-term pollution - permanent or long-term sources of pollution (industrial enterprises, thermal power plants, hydraulic structures, etc.) can lead to significant changes in environmental components.

Chemical pollution - sulfur, nitrogen oxides, hydrocarbons, heavy metals, fluoride compounds and other chemicals - changing the chemical composition of the atmosphere, hydrosphere, soil.

Biological contaminants are uncharacteristic and undesirable for this ecosystem living organisms (viruses, bacteria, etc. - for example, the Colorado potato beetle).

By source:

Natural - arising as a result of the activity of bacteria, natural disasters, natural geological processes;

Anthropogenic - the sources of which are energy, transport, agriculture, utilities.

Natural pollution occurs as a result of natural processes (volcanic eruptions, etc.). Natural pollution of the biosphere is usually able to overcome due to the processes of self-regulation and self-healing (self-cleaning).

Artificial pollution (anthropogenic) is the result of human activities, their biosphere usually cannot be completely processed for several reasons:

- the amount of anthropogenic pollution is very large;
- Among anthropogenic pollution, some substances are not characteristic of nature in its normal state - xenobiotics (most synthetic substances). Xenobiotics do not fit into the natural cycle of substances and cannot be recycled by nature;
- many anthropogenic pollutants suppress the natural processes of self-cleaning and self-healing, including many xenobiotics, surfactants, etc.

12.3 Sustainability of pollution (pollutants) in the environment

Pollution (pollutants) in nature can accumulate unchanged, and can be subjected to transformation - change. During the transformation of pollutants under the influence of chemical and physical factors, both simpler substances and more complex substances can form.

Transformation of pollutants in the environment - the conversion of chemical compounds under the influence of chemical, physical and biological factors. For example, in the upper atmosphere under the influence of sunlight, freons decompose with the release of atomic chlorine; sulphurous gases (SO₂ and SO₃) produce sulphurous and sulfuric acid (acid rain), etc in the humid air.

The transformation of pollutants under the influence of biological factors (biotransformation) is isolated.

Biotransformation occurs in the process of advancing pollutants along food chains, and lead to biodegradation, bio-amplification or bioaccumulation of the original pollutants.

Biodegradation - decomposition (for example, biodegradable organic substances under the influence of aerobic bacteria turn into CO₂, H₂O, phosphates, etc.).

Bio-amplification is the process of converting the original pollutant into a more dangerous substance (under the influence of bacteria, metallic mercury turns into methyl or ethyl mercury, which are much more dangerous).

Bioaccumulation is the gradual accumulation by organisms of harmful substances during their habitat in a polluted environment due to the incomplete release of pollutants from the body. The concentration of bioaccumulative substances increases as you move along the food chains (DDT, mercury, etc.).

The persistence of a soil polluting substance is the duration of the activity of a soil polluting substance, which characterizes the degree of its resistance to decomposition and transformation processes.

Rationing of environmental pollution.

Due to the inevitability of environmental pollution in the course of human activities, the problem of rationing pollution arises under their danger to the living.

Toxicity - toxicity, the ability of a substance to harm living organisms. Toxicity is determined by a lethal dose of 50 (LD₅₀) - the dose of a substance that causes the death of 50% of experimental animals. Based on toxicity, as well as on the characteristics of the behaviour of the substance in the environment, appropriate hygienic standards are developed - MPC.

MPC - the maximum permissible concentration - is established taking into account LD₅₀, the stability of the pollutant in the environment, and with a certain margin.

MPC_m - the maximum single concentration of a substance (in the air of populated areas - when inhaled for 30 minutes, it should not cause reflex reactions from the human body).

MPC_{ad} - the average daily MPC - should not cause direct or indirect harm to human health under unlimited long exposure.

The main disadvantage when using MPC is the inability to take into account the accumulation of pollution - the summation of the harmful effects of various pollutants. At the same time, they distinguish:

- additive effect - if the total effect is equal to the sum of the effects of all pollutants separately (for example, tobacco smoke in a room with already polluted air);
- antagonistic effect - if the overall effect is less than the sum of the individual effects from pollutants (reaction product: ammonia + hydrogen chloride → ammonium chloride — less toxic than both starting materials separately);
- synergistic effect - the overall effect is greater than the sum of the effects.

Currently, MPCs have been established for several thousand individual substances in different environments and different recipients. MPCs are not an international standard and may vary slightly from country to country. There are serious doubts about the very suitability of MPC as the basis of environmental regulation (through MPE and MPD) based on the following:

- far from all real pollutants, MPCs are established;
- there is no MPC for many combinations of different pollutants, possible interactions between pollutants, the formation of secondary products and the combined effects do not allow calculating the "complexes" of MPE (maximum permissible emissions);
- MPC of substances for some valuable plants and animals may be lower than for humans;
- the calculation of the majority of MPE is done based on the maximum one-time MPC, which can be an order of magnitude higher than the average daily MPC [14,16,17].

Questions for self-control

1. Why is the modern environmental crisis called the crisis of reducers?
2. How does modern man affect nature?
3. What types of resources are distinguished?
4. What are the types of human pollution of the natural environment?

5. What hygiene standards (MPC - maximum permissible concentration) of environmental pollution are allowed by their danger to the living?

6. What is the main disadvantage when using MPC?

Theme 13

The importance of animals in the biosphere and human life

13.1. The importance of animals in the biosphere

The animal world is an important part of the biosphere of our planet. Together with plants, animals play an exceptional role in the migration of chemical elements that underlie the relationships that exist in nature.

According to scientists, animals with more than 1.8 million species are currently consumers of organic matter created by plants from inorganic matter through solar energy. Eating plants and each other, animals participate in the biological circulation of substances and the circulation of substances of the planet. It follows that their role in the development and life of nature is great and diverse.

One species of animal is not able in any ecosystem to break down the organic matter of plants into final products. Each species uses only part of the plants and some organic substances contained in them. Unsuitable plants for this species or still rich in plant residues are used by other animal species. Thus, complex and complex chains and power networks are formed that sequentially extract substances and energy from photosynthetic plants. In the process of evolution, animal species have adapted to the most efficient use of a specific set of food items. Each of the species at the population level is adapted to the fact that it is food for several other species. The most diverse and numerous group of animals (two-thirds) are insects, which are of the greatest importance in ecosystems.

Many birds, fish exist due to insects. Animals also play a large role in soil formation. Other invertebrates are of diverse importance in

ecosystems, as the role of earthworms is well-known, contributing to soil aeration, humus distribution in it, and the creation of its structure. Of great importance are earth mites, nematodes, woodlice, millipedes, and many others that increase soil fertility. The value of molluscs as a source of food for other animals is great and diverse, as well as water filters that ensure its purification. With the participation of animals, the chemical composition of groundwater and groundwater is formed, a special surface-atmosphere arises. Participating in the cycle of substances in nature, influencing the state and development of its other components, animals play an important role in the life of the biosphere, especially in maintaining the “system of dynamic equilibrium” in living nature. A huge role is played by animals in human life. Many of them serve as important sources of food and technical raw materials, both for artisanal and industrial production. These are farm animals, fur-bearing animals, fish, various game, etc.

13.2. The value of animals in human life

Wildlife fauna is an inexhaustible source of domestication.

At present, fur-bearing animals (fox, mink, arctic fox, sable, and others) are intensively domesticated, experiments are being conducted with the taming of moose, antelopes, partridge, etc. When breeding new breeds and to improve their qualities, their close wild relatives are used for crossing with domestic animals. In addition to environmental significance, animals have aesthetic, scientific, medical, recreational, ethical significance. The aesthetic value of animals is well known - birds, aquarium fish, mammals. Animals are a source of beauty, surprise, joy and pleasure for most people, especially when communicating with them on vacation, in natural conditions. Watching the robin feeding the chick, admiring the eagle soaring overhead, stroking the thorns of the hedgehog - these are just some of the joys that animals bring us, without which nature would be half dead. Animals are the subject of scientific research, including medical research. Many species of wild animals are tested for drugs, vaccines, the toxicity of chemical compounds, surgical operations, which expands our knowledge about human health and diseases. For these

purposes, mainly use guinea pigs, dogs, rats, mice, chimpanzees, rhesus monkeys, frogs, etc.

Until recently, the protection of animals (primarily wild species) was explained by their existing or potential benefits as rhesuses necessary for humans. Today it is believed that the acceleration of the extinction of any species from an ethical point of view is an injustice on our part. Not only species but each creation of nature has the right to survive without human intervention, just as every person has the right to survive.

However, certain types of animals can also act as pests and pathogens of agricultural diseases, as well as wild plants and animals useful for humans. Some species are involved in the maintenance of natural focal human diseases, they are the hosts of blood-sucking parasites.

Other animals are exterminators of these pests, thereby bringing great benefit to humans.

In nature, all species are associated with others, and the destruction of one can lead to completely unforeseen consequences. One example of this relationship is the use in many regions of the recent past in the control of locust hexachloran. At the same time, the number of such predatory insects as ladybugs and lacewings was significantly reduced. As a result, the reproduction of scale insects, whiteflies, bedbugs, thrips, and ticks increased on the crops of legumes, fruit and citrus crops. The principle of interconnection in wildlife was clearly illustrated.

Another important principle is the principle of equilibrium. Populations of individual species living together make up a biocenosis - an elementary "brick" of the biosphere.

The quality of natural waters, the composition of air, soil fertility, etc. depending on his work. A remarkable property of natural biocenoses, biogeocenoses (ecosystems) - their stability - can be violated by the destruction of some life forms within the ecosystem or, on the contrary, the introduction of new animal or plant species into existing systems.

The unwillingness of extermination of at least one single species, no matter how unnecessary or even harmful this species may seem to a person, is justified by the principle of potential utility. A

person is often able to foresee what significance this or that form may have for people in the future. For example, if the Steller's cow, a marine herbivorous mammal from the lilac order that lived about 200 years ago in the waters of the Kamandor Islands, was not exterminated, the problem of the animal in the Far Eastern regions of the country could be solved differently than now.

From both biological and economic points of view, it would be quite feasible at present to organize numerous highly productive farms of these animals based on huge reserves of seaweed along the entire coast of the Far Eastern seas.

In recent years, the principle of irreplaceability has become increasingly important. It can be formulated as follows - products of natural origin can never be completely replaced by artificial ones. The principle of the indispensability of natural products is now clearly confirmed by the wide distribution of various kinds of allergic diseases, which in terms of number and severity are almost one of the first places in developed countries. Allergic diseases appear and intensify in parallel with the saturation of our food with artificial additives, human life - products that the human body is not evolutionarily adapted to (synthetic tissues, films, etc.). Furs, fabrics, medicines and many other products can never be completely replaced by-products of artificial origin that are equivalent in quality and suitability for humans.

The principle of diversity in importance and content differs from all of the above and is associated with human communication with nature (fishing, hunting, tourism, work in a personal garden, garden plot, in your household, etc.), the need for living diversity. This stems from the genetic uniqueness of each individual, which determines the uniqueness of each person's inclinations, and from here the unique set of living organisms, communication with which will be adequate for this person, with his unique genotype.

All of the above does not cover all the arguments in favour of the preservation of wildlife in all its diversity given to humanity by evolution. At the same time, the above arguments are sufficient for an unambiguous conclusion: it is necessary to preserve not only individual species but all species varieties. It is necessary to preserve the fauna and flora of our planet.

The living world is not only an important component of the natural ecological system but also a valuable biological resource. At the same time, the animal world has great economic significance: as a source of food products, industrial, technical, medicinal raw materials and other material values. Therefore, it acts as a natural resource for St. John's wort, whaling, fishing and other types of fishing. Certain types of animals have great cultural, scientific, aesthetic, educational, medical significance.

Mammals such as elk, reindeer, wild boar, saiga, fur seal, sable, squirrel are of commercial importance. Some of them by the beginning of the twentieth century. became rare species, and their extraction in our time has become impossible only thanks to the great work to protect them, including the complete prohibition of hunting for them.

13.3. The importance of birds in nature and human life

Birds are adapted to various habitats, and this is the reason for the emergence of ecological groups among them. Each group is tied to its habitats, uses the food inherent to them and has certain adaptations to their production.

The following environmental groups are distinguished:

1. Birds of parks and gardens live near human habitation, destroying harmful insects. These are numerous representatives of the order of passerines: tits, sparrows, swallows.

2. Birds of meadows and fields nest and feed on the ground. They bring together representatives of many groups:

a) larks, wagtails (sparrow squad); b) lapwings (sandpiper squad), cranes (crane-squad); c) partridges and quail (chicken squad); d) corncrake (shepherdess squad).

3. Birds of swamps and coasts forage from the surface of the earth, from the bottom or moist soil, in connection with which some of them have shaded legs and fingers, thin without membranes (herons and storks are stork-like squads), others have webbed feet (swans, geese, geese, ducks, teals, dives - Anseriformes). Curlew, turukhtan, plover, snipe are found on swamps and coasts from the sandpiper

detachment; copepods, pelicans and cormorants, are found from the detachment.

4. Birds of deserts and steppes - inhabitants of vast open spaces with sparse vegetation. It is difficult to find shelter here, and therefore many birds living in the steppes and deserts have long legs and necks (ostriches, bustards, little bustard, saj, hazel grouse).

5. Forest birds - the largest group. Its representatives have various forms of communication with the forest environment. Numerous representatives of the order of daytime birds of prey (kestrel, hawk, red fox), as well as from the orders of the cuckoo, passerine, chicken (pheasant, black grouse, capercaillie, grouse, etc.) and owls are the subject of fishing.

The importance of birds in nature and human life is very great. Many birds are of great importance for humans from an economic point of view, they include commercial and hunting species, mainly hunting for chicken birds - partridges, grouse, black grouse, pheasants, and ducks and geese from waterfowl.

The vast majority of birds feed on insects. With a large amount of food consumed, birds exterminate countless insects - pests. Of considerable benefit are birds of prey, which feed on weakened animals and are orderlies in nature. Many birds, eating fruits and seeds, contribute to their distribution. By their beauty and singing, birds give people aesthetic pleasure. Farm birds also play a significant role in human life [1 - 13].

Questions for self-control

1. How did animals adapt to the most efficient use of a particular set of feed items?
2. How do animals participate in the formation of ecosystems?
3. What is the significance of animals in human life?
4. What does the “principle of interconnection” and “the principle of equilibrium” mean in living nature?
5. What ecological groups of birds emit?
6. What is the significance of birds in nature and human life?

Theme 14

Human effects on animals, causes of their extinction

14.1. Human exposure to animals

Organic residues and other evidence indicate that on Earth over the past 500 million. Five or six catastrophic extinctions of predominantly numerous species of animals occurred. Perhaps we will never know the true cause of these mass extinctions. One thing is known that this was not caused by man.

In parallel with the development of human civilization, scientific and technological progress, a decrease in the number of many animal species is observed today. Human exposure to animals occurs in two ways: direct — direct pursuit and extermination, or resettlement, and indirect — change in living conditions.

In 1850 prominent ornithologist A. Wilson watched a single flock of wandering pigeons cover the sky for more than four hours. According to his calculations, the number of flocks exceeded 2 billion. birds, its length was 240 miles, and its width was 1 mile. By 1914 the wandering dove has disappeared forever. The main reason for the extinction of this species was uncontrolled fishing. Another example. In 1976 only in the USA 32 million fells and skins, taken from slaughtered animals, were imported, and 91 million products from representatives of the wild fauna. In recent years, the number of not only large, commercial animals, but also amphibians (frogs, newts, salamanders), and many insects has been reduced. In the vicinity of large cities, day butterflies became rare: mourning, peacock eye, sash, swallowtail and others that were intensively caught. The threat to the survival of many species was insufficiently thought out measures for the introduction of animals into established ecosystems. The example of rabbits brought to Australia, catastrophically breeding and devastating large areas in Australia is well known. They undermined the feed base of goats and caused their death. Sander released into Lake Balkhash as a stronger predator by the mid-70s of XX century completely replaced the Balkhash perch common only in this basin. Unfortunately, there are many such examples on other continents.

The reduction of most species of living organisms was affected by the inclusion of an increasing part of the territories in vigorous economic activity: ploughing fields, paving roads, expanding the territory of towns and cities (Figure 14.1).

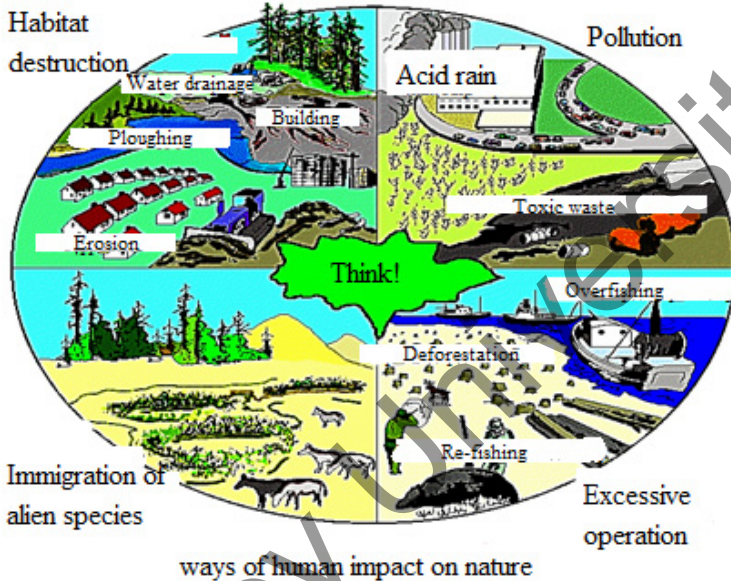


Figure 14.1. Human Impact on the Organic World

Increasingly frequent visits by people to previously uninhabited, uninhabited areas of the tundra, taiga, highlands and deserts led to a reduction in the number of animals.

The urbanization of the biosphere is often favourable for some species of animals and birds, for example, rats, house mice, sparrows, crows, pigeons, some species of cave spiders, house flies, moths, etc.

Anxiety about the decline in numbers and the complete extermination of many species is not far-fetched. Direct and indirect extermination of vertebrate species from the beginning of the 17th to the end of the 20th century.

From the beginning of the XVII to the end of the XX century. 68 species of mammals, 130 species of birds, 28 species of reptiles, 6

species of fish and 6 species of amphibians disappeared from the face of the Earth.

According to the International Union for Conservation of Nature (IUCN), on average, one planet or subspecies of vertebrate animals disappears on our planet annually.

In addition to the complete and widespread extinction of species, partial extinction, i.e., extinction in individual countries and regions, is widespread. Thus, 7 species of kangaroos disappeared in Australia, 14 species of birds in Scotland, 26 species of birds, or 60% of their entire fauna, died out in the Hawaiian Islands.

In Russia and the Caucasus, with the assistance of humans, 9 species of animals died out: lion, wild bull-tour, kulan, cheetah, beaver, elk, tarpan, bison and tiger. In other areas, there are many steppe vertebrate species: bustard, strep, groundhog, etc.

Once upon a time, musk ox, along with mammoths, woolly rhinos, and reindeer, inhabited the tundra steppes of northern Eurasia. 20-30 thousand years ago, they entered the Arctic of the New World and disappeared in Eurasia. Scientists believe that in Russia musk oxen were exterminated only 150-200 years ago, in Alaska - even later, in 1860 - 1870.

At the dawn of the history of European nations everywhere lived one of the largest bulls in the world - the bison. They lived in the forests and the steppe, from the Baltic states, Belarus, covering its entire European part, the entire basin of the Don and Dnieper, the North Caucasus, reached the shores of the Azov and Black Seas. Bison bones were found near the mouth of the Kama River and in the Southern Urals. Bison everywhere exterminated. In France, there were no bison in the VI century. The last bison was killed in Romania in 1762, in Germany (in Saxony) in 1798, and in the Baltic states (formerly East Prussia) in 1755. The last time bison were seen on the Don in 1709.

By the end of the XX century. Bison were saved from people only in the forests of Belovezhskaya Pushcha (Belarus) and the North Caucasus. By 1921 not a single bison remained in the Bialowieza Forest, in the Caucasus the last bison was destroyed by poachers in 1927. Similar examples can be given to other animals. A direct relationship has been established between the increase in the population of the Earth and the number of destruction of animal species.

687 species and 207 subspecies of vertebrates that are on the verge of extinction are listed in the International Red Book (Table 17.1).

Table 17.1

The number of species and subspecies of various classes of vertebrates, included in the International Red Book of Facts (1979).

Class	Species	Subspecies
Mammals	226	79
Birds	181	77
Reptiles	77	21
Amphibian	35	5
Fish-shaped	168	25
Total	687	207

In the 90s. XX century in Russia, the species composition of wild animals was represented by the following number of species: mammals - 328, birds - 720, reptiles - 66, amphibians - 26, sea fish - 2400, freshwater fish - about 400, aquatic invertebrates - up to 12,000, insects - up to 80,000.

The Red Book of Russia includes 65 species and subspecies of mammals, 63 species of birds, 21 species of reptiles, 8 species of amphibians.

In 1978, 87 species and subspecies of vertebrates were listed in the Red Book of Kazakhstan: 31 - mammals, 43 species of birds, 8 - reptiles, 3 species of amphibians and 16 species of fish.

In 1991, the second edition of the Red Book contained 129 species and subspecies of vertebrates: 42 — mammals, 58 species of birds, 10 — reptiles, 1 species of amphibians, and 4 species of fish.

The third edition of the 1996 Red Book of Kazakhstan includes species and subspecies of vertebrates: 40 - mammals, 56 - birds, 10 - reptiles, 3 amphibians and 16 species of fish.

The main reason for the continued extinction of animal species is the increase in anthropogenic impact. Among the factors that threaten vertebrates, it should be noted:

- destruction or degradation of the habitat;
- re-exploitation;
- the impact of introduced species;
- loss, reduction or deterioration of the food supply;
- destruction of domestic animals, objects of trade for the protection of crops;
- random mining.

The influence of the main factors threatening vertebrates has a different effect both in different regions of the planet (including Kazakhstan) and to different groups of animals.

In Russia, a decrease in the number of marine commercial mammals is noted. Pollution of coastal areas of the seas and a decrease in the food supply of pinnipeds, as well as poaching, which increased from 1986 to 1991. The number of walruses decreased from 200 to 100 thousand, fur seal - from 500 to 300 thousand, sea lion - from 250 to 50 thousand. The number of seals in Lake Ladoga is declining, and the Caspian seal in the Caspian. In the Sea of Azov, the mass invasion of ctenophore undermined the fish feed base.

Violation of sanitary norms, existing methods of farming and storage of food stocks led to an increase in the number of harmful rodents. The range of the sewer rat is rapidly expanding, especially in the industrial development areas of the North and North-East regions of Russia. Rodents destroy large amounts of food and are a source of dangerous infectious diseases. According to experts, only in Moscow, sewer rats eat and spoil 60 - 80 thousand tons of food per year. Besides, there is a decrease in the number of cranes, carnivorous species, Anseriformes (in northeastern Russia), ptarmigan, hazel grouse, bustard, etc. Many species of insects, primarily pollinators and entomophages, are on the verge of extinction.

A lot of animals are in the so-called "ecological limit." The number of some of them is only a few hundred.

The tragedy of wild animals consists not only in hunting them, but in the careless handling of their possessions during ill-conceived cutting of forests, drainage of swamps, the expansion of pasture for livestock, and the chemization of agriculture.

The intense onset of man on the virgin nature takes away from many animals the last centre of living space. Numerous tourists trample the grass, destroy the undergrowth - this is the most affected birds nesting on the ground.

The responsibility of each of us for the conservation of nature can be expressed in the words of Goethe: "Nature knows no jokes, it is always true, always strict, it is always right. Mistakes and errors come from people."

14.2. Human impacts on the number of animals in Kazakhstan

The economic activity of man greatly affects animals, causing an increase in the number of some, a decrease in the populations of others, and the extinction of the third. Human exposure to animals can be direct or indirect (Figure 14.2).

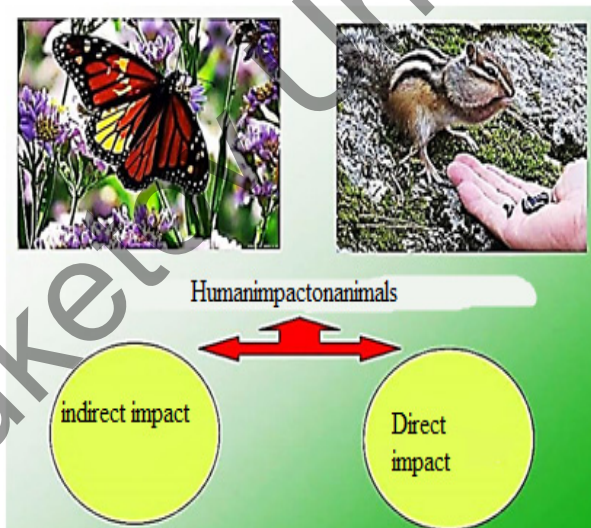


Figure 14.2 Human effects on animals

The direct impact (persecution, extermination and resettlement) is predominantly on game animals, which are hunted for the

production of fur, meat, horn, fat, etc. As a result, their number decreases (saiga, red deer, argali, etc.), and individual species disappear (Figure 14.3).



Figure 14.3. Saiga (Saiga - tatarica)

The direct human effects on animals include their death from chemicals used to combat agricultural pests and weeds. At the same time, not only pests but also animals useful to humans, often die. Numerous facts of the poisoning of fish and other animals with fertilizers and toxic substances of wastewater discharged by industrial and domestic enterprises should be attributed to these cases (Figure 14.4).



Figure 14.4 Saiga death of the Betpakdalin population 2015

Indirect human influence on animals is associated with a change in habitat (during deforestation, ploughing of the steppes, drainage of marshes, construction of dams, construction of cities, villages, roads) and vegetation (as a result of pollution of the atmosphere, water, soil, etc.), when fundamentally transforming natural landscapes and animal living conditions.

Among the factors limiting the number of animals are droughts, severe multi-snowy frosty winters, sleet, jute, predators and roaming dogs presses, poaching, over-fishing, infectious and invasions, economic development of the territory (military and space rocket accidents, laying highways, grazing cattle farmers for springs and other watering places) [1,13,14,17].

Questions for self-control

1. Why with the development of human civilization and scientific and technological progress is there a decrease in the number of many animal species today?
2. In what ways does a person act on animals? Give examples.
3. What does the Red Book talk about?
4. How does human economic activity affect the number of animals in Kazakhstan?
5. Give examples of direct human exposure to animals.
6. Give examples of indirect human exposure to animals.

Theme 15

Animal Welfare Measures

15.1. Animal Welfare Measures

In the past, when human influence on the number and variety of animals was much less than in our time, animal protection could be carried out based on intuitive knowledge, for example, by simply banning or restricting fishing. The calculation of the internal hidden forces of nature was usually justified. The decrease

in fishing load helped to restore the abundance of the species. However, not always a simple decrease in fishing was enough. There were cases when, despite the efforts of people to keep their last representatives, the species died. This is evidenced by the disappeared species of wingless eider, wandering pigeon, tarpan, etc.

The consequence of reducing the number of species of animals below a certain level is the automatic extinction of the species. Consequently, the fate of other species is influenced by the fate of other species living nearby, etc. This has influenced the development of the theory of fauna conservation. The complexity, versatility and "multi-leveiling" involved in the orbit of the protection of living processes and phenomena is that in world science the system of principles in this area has not been sufficiently formed.

When considering the general directions of research, three approaches are distinguished:

- 1) environmental - it is based on the principle of interdependence in the living nature surrounding us;
- 2) system-structural - proceeds from the principle of maintaining the qualitative diversity of wildlife;
- 3) population-genetic - is evidence of the possibility of conservation of any species only as a system of interconnected populations.

General principles make it possible to assert that life can exist only in the form of communities of living organisms (biocenoses). The sustainability of these communities depends on the degree of complexity:

- 1) the need to preserve biocenoses.
- 2) the need to preserve the evolutionarily achieved complexity for the long-term preservation of biocenoses. Each species has a unique gene pool and represents a unique evolutionary result. It is impossible to predict the importance of the gene pool for humans in the future: previously considered harmful or useless species are now extremely important and worth preserving. Therefore, it is very important and relevant to maintain species diversity and maintain the diverse quality of wildlife.

3) to preserve individual species, it is necessary to preserve the communities (biocenoses and ecosystems), which include the species of interest to us. All species in nature are closely interconnected. It is impossible to preserve one species without preserving the species associated with it (in food chains and as important components of the environment).

4) the need to maintain or create an interconnected system of populations within a single species for its conservation. Each species is a system of evolutionarily integrated populations. A species cannot exist for a long time, being represented by only one isolated population.

5) small populations are at risk of extinction and need special protection.

Due to the inevitable fluctuations in numbers, small groups by the number of individuals sooner or later reach zero. To do this, it is enough that the number of individuals of only one of the sexes drops to zero (in bisexual organisms) or that the frequency of encounters of individuals of different sexes decreases so that the reproduction is not ensured.

The International Union for the Conservation of Nature and Its Resources (IUCN), with the support of the United Nations Environment Program (HNEP) and the assistance of the World Wildlife Fund (WWE), has developed a World Conservation Strategy. The purpose of this Strategy is to contribute to the speedy and fullest achievement of satisfactory protection of living natural resources, on which the survival and well-being of mankind on Earth depends.

The strategy makes it possible to determine the priority tasks in solving the problems of protecting most groups of animals in any region of the planet and to help determine the sequence for the implementation of the necessary measures to protect nature in a fairly tense balance of forces and means both in the global economy and at the level of individual countries. One of the most important tasks of the “strategy” is the coordination of efforts of governmental, public, national and international organizations in the protection of living natural resources.

The minimum program for certain animal species includes:

- preservation from the destruction of any kind;
- preservation of the full volume of intraspecific variability of each species, which is associated with the preservation of a sufficient number of viable populations;
- ensuring the possibility for each exploited population of a given species to be restored to the level of “maximum sustainable production”.

The main criterion for determining the value of an endangered species and the criterion for choosing areas of activity in the field of organizational activities is considered the value of the possible genetic loss caused by its disappearance.

The loss of this species deprives us of a whole family of animals, which is more catastrophic and undesirable than the loss of any subspecies. Consequently, with the equality of other conditions, a disappearing detachment has an advantage over a species - a representative of a disappearing family:

- a) a species representing an entire endangered family takes precedence over a species representing an endangered genus;
- b) the species representing the endangered genus has an advantage in organizing rescue measures over the species entering the genus where there are other species, and finally, the endangered species has an advantage over the endangered subspecies.

The second criterion in determining the priority of conservation measures is geographical: a species that is threatened with extinction is in a difficult situation throughout its range or on the territory of one country or even a separate region of a country.

The practical application of this criterion means that species listed in the International Red Book should have an advantage over species included only in the Russian Red Book, and species included in the Russian Red Book should have an advantage over species included in the Red Books of the Autonomous Republics, regions, territories and regions.

The third criterion is the degree of danger of the extinction of this species. In the Red Book of Russia, there are 5 categories of rare species:

1. Species (subspecies) threatened with extinction, the rescue of which is impossible without the implementation of special measures.

2. Species (subspecies), the number of which is still relatively high, but is decreasing catastrophically quickly, which shortly may put them at risk of extinction.

3. Rare species (subspecies) that are not under direct threat of extinction, but are found in small numbers or such limited territories that they can soon disappear.

4. Uncertain species (subspecies) - little-known, insufficiently studied, possibly endangered, but the lack of information does not allow them to be attributed to one of the first three categories.

5. Restored species (subspecies), the state of which under the influence of the taken protection measures does not cause more concern. Their numbers began to increase. But they are not yet subject to commercial use and their condition still needs to be constantly monitored.

Prioritization of animal protection measures requires compliance with 2 factors. Firstly, the general condition of the species is not only in nature but also in captivity. If a species reproduces well in captivity (Przhevalsky's horse, Amur tiger, etc.), then the danger of its loss is much lower than that of species that cannot be reproduced in captivity.

Secondly, the role of the species in question as an indispensable component in the formation of the ecological niche of other rare or highly specialized species. So, if a species is the only source of nutrition for another organism, then it will have a priority in terms of its protection in comparison with a similar species, which is not an indispensable food supply.

An important prerequisite for preserving the entire diversity of living things is the fundamental conclusion about the possible coexistence of humanity with all forms of living without exception. Man is not antagonistic to the living world, and there are many such examples. Swallows, tits, swifts and other insectivorous birds have been living in cities, towns and villages in many countries for hundreds of years. With the cessation of hunting, ponds of cities inhabit different types of ducks and even geese. Peregrine Falcon -

a large bird of prey - successfully nests on the building of Moscow University on the Sparrow Hills. Many mammals successfully adapt to living close to humans. The example of squirrels living in Moscow parks, on the territory of the Novosibirsk Academgorodok, in many cities of the world, is well known. This kind of adaptation is associated with selection for the absence of fear for humans that occurred among animal populations, on the one hand, and the use of new food sources and shelters, on the other.

Another direction of preserving the diversity of animal species is the restoration of their quantitative composition with further settlement. By the beginning of the 20th century abruptly reduced the number of sables in Siberia and the Far East due to its predatory prey.

In 1927, Barguzinsky and Kondo-Sosvinsky in the reserves began mass events to restore sable. Currently, sable is widespread in Siberia and the Far East. The area of the sable range exceeds 430 million ha of forest land. Until recently, the river beaver was one of the rare animals in Russia. At the beginning of the XX century, they were found in few places of their past range, in total there were about 1000 individuals. To restore them in 1934, beaver reserves were organized. Currently, this species has been restored and settled in 48 regions of Russia, Belarus, Ukraine, the Baltic republics and Kazakhstan.

To preserve the diversity of the living, work on the further domestication of animals is becoming increasingly important.

Serious and high-quality work has been done by different countries in the domestication of ungulates such as moose, deer, caribou, wildebeests, etc., as well as birds of wild turkeys, capercaillie, bustards, partridges, quails, ostriches, etc. Many species have a complex of truly remarkable properties. For example, springbok has adapted perfectly to the desert conditions of South Africa. It feeds on succulents and plants poisonous to livestock. It can do without water for several days. In the first seven months of life, the female reaches 80% of the adult mass.

Many countries practice breeding on the farms of large species of game animals, including exotic ones. Most often,

European fallow deer and mouflon, axis and sika deer, Indian wildebeest and others are bred. In the past, the park (zoos, zoos, inner-city recreation areas) keeping animals was considered mainly from the aesthetic positions of museum educational activities. Currently, the role of parks has become wider. Now they act not only as cultural and educational enterprises but also as centres of reproduction of animal species, the number of which in nature has reached a critical state. Thanks to them, the famous David deer (milu) in China, the Hawaiian goose in England, were saved from complete extinction. After the successful breeding of Przewalski's horse in many zoos in the world, there was some certainty that this species, which had disappeared in nature, would be preserved.

Seven forms of mammals exist in our days only in zoos. There has been an increase in the number of species, the only effective measure to preserve which remains their content in zoos is continuously growing.

To expand the species composition of fish in natural reservoirs of Russia, their acclimatization is carried out. So, pink salmon was brought from Sakhalin to the Murmansk coast. The Baikal omul is acclimatized in Lake Onega. Ladoga and Chudsky whitefish migrated to the lakes of the central regions of Russia, the Urals, Belarus, the Baltic states, Ukraine.

In recent years, aquaculture, i.e. breeding of living organisms in ponds to replenish stocks and expand the range. Among the important cultivated species are representatives of the cyprinid family, brook and rainbow trout, salmon, mullet, eel, catfish, perch, oysters, various types of shrimp and others. In some regions, aquaculture is more productive than fishing in lakes and rivers.

There are 3 main areas of aquaculture:

1) recreational aquaculture involves fish farming in natural reservoirs, the release of fry grown under special conditions to maintain and increase natural reserves. For this purpose, sturgeon, salmon plants, spawning-growing farms and hatcheries are working.

2) pasture aquaculture is aimed at introducing new objects into the natural or regulated bodies of water - invertebrates and

fish for acclimatization or feeding. For example, the acclimatization of mullet in the Caspian Sea.

3) industrial fisheries - the release of juvenile fish and invertebrates into the fenced sections of the sea for feeding. For example, the cultivation of mussels, scallops, trepangs on artificially created banks, feeding mullets in closed estuaries.

Growing fish and invertebrates in cages installed in seawater, and installations with a closed type of water supply.

Preservation of the animal world is inextricably linked with the solution of legal issues, international cooperation, the implementation of all work on a scientific basis. The protection of wildlife is aimed at performing the following scientific tasks:

1) study of the biology of rare and endangered species of animals, as well as the search for optimal ways of their conservation and reproduction;

2) further development of the foundations, conservation of natural communities. This problem goes beyond the protection of the animal world and includes many more specific tasks;

3) development of biological foundations for the creation of territorially integrated schemes for the protection of nature;

4) development of recommendations for the creation of new reserves, wildlife sanctuaries and other protected areas and water areas;

5) assessment of the consequences of environmental pollution;

6) development of principles for maintaining the qualitative diversity of the living and genetic resources of the biosphere;

7) the development of safe biological methods for managing the number of species that damage the national economy;

8) solving the problems of the legal protection of flora and fauna;

9) the development of new forms of environmental education.

15.2. Animal Welfare Measures in Kazakhstan

The government of Kazakhstan has taken measures aimed at protecting wildlife. Basic animal welfare requirements have been put forward

1. Activities that affect or may affect the state of the animal world, habitat, breeding conditions and ways of migration of animals should be carried out in compliance with requirements, including environmental, ensuring the preservation and reproduction of the animal world, its habitat and compensation for applied and applied harm, including the inevitable.

2. Activities affecting the state of the animal world and the environment should ensure compliance with the basic requirements:

1) the conservation of biological diversity and the integrity of the animal communities in a state of natural freedom;

2) the safety of the habitat, breeding conditions, migration paths and places of concentration of objects of the animal world;

3) use and reproduce objects of the animal world scientifically sound and rational;

4) regulation of the number of objects of the animal world to maintain biological equilibrium in nature;

5) reproduction of the animal world, including artificial breeding of animals, including rare and endangered species, with their subsequent release into the environment.

3. When developing state, sectoral (sectoral) and regional programs for the protection, reproduction and use of the animal world, regulatory legal acts, the basic requirements specified in clause 2 of this article must be taken into account.

Ways to implement wildlife protection:

1) the establishment and observance of rules and norms for the protection, reproduction and use of objects of the animal world;

2) the establishment of restrictions and prohibitions on the use of the animal world;

3) protection of rare and endangered species of animals;

4) prevention of violations of the established rules for the use of wildlife;

5) the organization of the protection of the habitat, breeding conditions, migration routes and places of concentration of animals;

6) securing territories, water areas for users of the animal world with the assignment of duties to them to protect objects of the animal world;

7) the creation of specially protected natural areas;

8) artificial breeding of animals;

9) assisting animals in case of diseases, the threat of death during natural disasters and due to other reasons;

10) the organization of scientific research in the field of protection, reproduction and use of the animal world;

11) propaganda of ideas for the protection and sustainable use of wildlife;

12) stimulating the activities of individuals and legal entities to protect the wildlife;

13) educating citizens in the spirit of a humane and respectful attitude to the animal world.

Protection of rare and endangered species of animals

1. Rare and endangered species of animals are recorded in the Red Book of the Republic of Kazakhstan in the manner prescribed by the legislation of the Republic of Kazakhstan.

2. The protection of animal species listed in the Red Book of the Republic of Kazakhstan is carried out by the state. Individuals and legal entities are required to take measures to protect species of animals listed in the Red Book of the Republic of Kazakhstan.

3. The removal of rare and endangered species of animals, including their eggs and eggs, is allowed in exceptional cases by decision of the Government of the Republic of Kazakhstan for breeding in specially created conditions and subsequent release into the environment for scientific and other purposes determined by the Government of the Republic Kazakhstan.

4. Actions that may lead to the death, population reduction or disturbance of the habitat of rare and endangered species of animals are not allowed.

5. The keeping, carriage, sale, putting up for sale and purchase of rare and endangered species of animals, as well as their import and export without the permission of the administrative authority, are prohibited [1-20].

15.3. Protected areas of Kazakhstan

By Decree of the Council of Ministers of the USSR of February 14, 1990 No. 189 “On ensuring the implementation of the decision of the Supreme Council of the USSR“ On urgent measures for the ecological improvement of the country ”and Decree of the Council of Ministers of the Kazakh SSR of April 16, 1990 No. 150 it was entrusted to develop proposals for the creation of specially protected territories, including resort areas and recreation areas.

Specially protected natural territories of Kazakhstan are land, water surface and air space above them, where natural complexes and objects are located that have special environmental, scientific, cultural, aesthetic, recreational and health-improving significance. By decisions of state authorities that have been completely or partially withdrawn from economic use and for which a special protection regime has been established. It has a unique set of landscape complexes: from deserts to highlands and ecosystems of inland seas. In the context of the growing pace of the country's economic development and increased use of natural resources, the issue of further improving the system of territorial nature conservation is becoming relevant. The same conditions determine the need for further development of specially protected natural territories of the Republic of Kazakhstan (hereinafter - SPNA), as an effective system of conservation of the biological diversity of the state.

Today in Kazakhstan there are: 10 reserves; National Natural Park - 12; natural reserves - 5; reserves - 50; natural monuments - 26; botanical garden-5; zoos - 4.

In 1926 (Figure 15.1), the Aksu-Dzhabagly reserve was created in Kazakhstan. In 1931 Nauruzum and Almaty nature reserves opened. The following reserves: Barsakelmesky (1939); Ustyurt (1984); Kurgaldzhinsky (1958); Markakolsky (1976); West Altai (1992); Alakolsky (1998) and Karatau (2004).

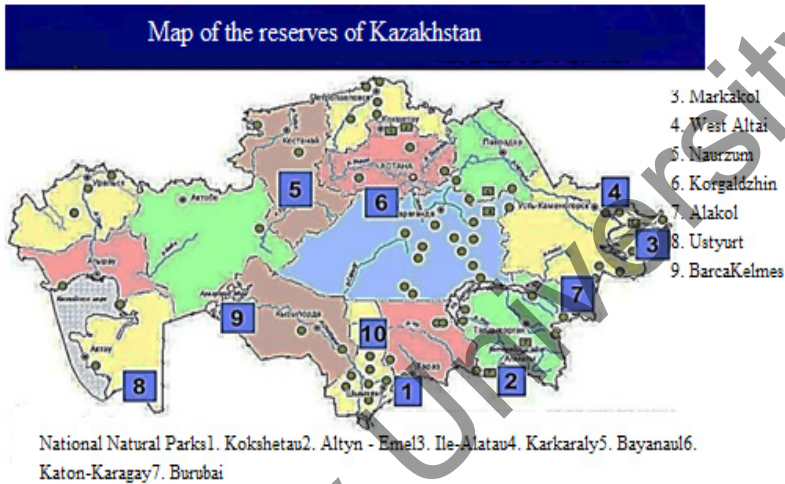


Figure 15.1 Map of Kazakhstan's nature reserves (10th - Karatau Nature Reserve).

The reserve is a specially protected natural area with the status of a conservation and scientific institution. The nature reserves' activity is to preserve the study and restoration on its territory of the natural course of natural processes and phenomena, plant and animal life objects, individual species and communities of plants and animals, and typical and unique ecological systems.

The State National Natural Park is a specially protected natural area with the status of an environmental and scientific institution designed to preserve biological and landscape diversity. It is used for environmental, ecological, educational, scientific, tourist and recreational purposes of unique natural complexes and objects of the

state nature reserve fund that have special environmental, scientific, historical, cultural and recreational value.

The State Nature Reserve is a specially protected natural area with the status of an environmental and scientific institution, including terrestrial and aquatic ecological systems. The reserve's activity is aimed at protecting, protecting, restoring and maintaining the biological diversity of natural complexes and related natural and historical-cultural objects.

Zakazniks - territories are created for the protection of populations and landscapes without taking land from production, only with the regulation of economic activity on them. There are 3 types of reserves in Kazakhstan:

- zoological reserves - 32
- botanical reserves - 11
- complex reserves - 7

Kazakhstan, as a party adhering to the Convention on the Conservation of Biological Diversity (Resolution of the Cabinet of Ministers of the Republic of Kazakhstan dated August 19, 1994 No. 918), has its obligations aimed at the conservation of biological diversity. Legislation in the field of protected areas is based on the Constitution of the Republic of Kazakhstan, the Law of the Republic of Kazakhstan “On Specially Protected Natural Territories”, the Concept of Development and Location of Specially Protected Natural Territories until 2030, approved by Decree of the Government of the Republic of Kazakhstan dated November 10, 2000 No. 1692.

In 1997, the Development Strategy of the Republic of Kazakhstan until 2030 was proclaimed, announcing that Kazakhstan by 2030 should become a clean and green country, with fresh air and clear water. One of the tools to achieve these goals is the creation of a system of protected areas [1-17].

Questions for self-control

1. How was human influence on the number and diversity of animals in the past limited?
2. Why the number of species of animals can not be reduced below a certain level?

3. What is the essence of the World Conservation Strategy?
4. What are the requirements for the protection of wildlife in Kazakhstan?
5. What is the protection of wildlife in Kazakhstan?
6. What specially protected natural areas are there in Kazakhstan? What is their significance?

Test questions for self-control

1. What is the term used to refer to the regulation of metabolism in animals:
 - A) respiratory rate
 - B) Energy balance
 - C) Reflex balance
 - D) Relativity
 - E) Passivity
2. In what ways do environmental factors affect the animal organism:
 - A) Reflexively
 - B) passively
 - C) indirect path
 - D) The close path
 - E) The long way
3. Among the factors affecting the livelihoods of animals, name stable:
 - A) Food
 - B) diseases
 - C) predators
 - D) Composition and properties of the atmosphere
 - E) Precipitation
4. Protein living in the fir forest and squirrel living in the spruce forest are:
 - A) One population of one species.

- B) Two populations of the same species.
- C) Two populations of two species
- D) One population of two species.
- E) Two populations of different species.

5. Old individuals make up a large share in:

- A) Fast-growing populations.
- B) In populations in a stable state.
- C) In populations with decreasing numbers.
- D) In populations in which there is no clear pattern of growth.
- E) In stable populations.

6. Among the factors affecting the livelihoods of animals, name the following:

- A) Seasonal population dynamics
- B) gravity
- C) Solar constant
- D) Atmospheric properties
- E) Hydrosphere Properties

7. Where does the bulk of animals live:

- A) in water
- B) in the air
- C) in the soil
- D) In places of contact of water, land, air
- E) In hot springs

8. Which of the environmental factors are indifferent elements for the life of animals:

- A) Stockpiles of substances
- B) Climatic conditions
- C) Density and pressure of the medium
- D) Wind reinforcement
- E) Removal of metabolic products

9. What class of consumers include animals that eat vegetative parts of plants:

- A) Zoophages

- B) Saprophages
- C) Phytophages
- D) Carnivores
- E) Detritus

10. What zones are located between the optimum zone and the animal endurance limits:

- A) Limiting.
- B) Restrictive.
- C) Tolerance.
- D) Oppression.
- E) Stamina.

11. In what writings Aristotle described more than 500 species of animals:

- A) The Philosophy of Zoology.
- B) "Zoogeography".
- C) "The story of animals."
- D) "Ideas about the geography of plants."
- E) "Origin of Species".

12. The founder of animal ecology is:

- A) C. Darwin.
- B) A. Humbolt.
- C) C. Roulier.
- D) E. Haeckel.
- E) J.B. Lamarck.

13. Adaptive body reactions are called:

- A) Tolerance.
- B) Homeostasis.
- C) Parasitism
- D) Limiting factors.
- E) Adaptation.

14. In what works of Zh.B. Lamarck gives the evolutionary rationale for the "creature ladder":

- A) The Philosophy of Zoology.
- B) "Zoogeography".
- C) "The story of animals."
- D) "Ideas about the geography of plants."
- E) "Origin of Species".

15. In what writings of C. Darwin the "struggle for existence" is a driving factor in evolution:

- A) The Philosophy of Zoology.
- B) "Zoogeography".
- C) "The story of animals."
- D) "Ideas about the geography of plants."
- E) "Origin of Species".

16. What branch of ecology studies individuals and the influence of environmental factors on them:

- A) Autecology.
- B) Demecology.
- C) Synecology.
- D) Global ecology.
- E) Geographic ecology.

17. What branch of ecology studies populations and the environment:

- A) Autecology.
- B) Demecology.
- C) Synecology.
- D) Global ecology.
- E) Geographic ecology.

18. Which individuals relate to geoxenes:

- A) Sometimes visiting soil for temporary shelter.
- B) Permanently living in the soil.
- C) Part of the life cycle of which takes place in the soil.
- D) Part of the body which is in the water, the other is above the water.
- E) Inhabiting the water column.

19. Among the factors affecting the livelihoods of animals, name the following:

- A) Seasonal population dynamics
- B) Atmospheric properties
- C) Solar constant
- D) Atmospheric properties
- E) Hydrosphere Properties

20. Where does the bulk of animals live?

- A) in water
- B) in the air
- C) in the soil
- D) In places of contact of water, land, air
- E) In hot springs

21. Which of the environmental factors are indifferent elements for the life of animals:

- A) Stockpiles of substances
- B) Climatic conditions
- C) Density and pressure of the medium
- D) Wind reinforcement
- E) Removal of metabolic products

22. What are the group settlements of settled animals of the same population:

- A) Colonies.
- B) Packs.
- C) Herds.
- D) Biocenoses.
- E) Communities.

23. The animal community is called:

- A) Biocenosis.
- B) Phytocenosis.
- C) By zoocenosis.
- D) Microbiocenosis.
- E) Biotope.

24. If an animal is a carrier of a smaller animal, this phenomenon is called:

- A) Zoohoria.
- B) Phoresia
- C) Symbiosis.
- D) Hijacking.
- E) Protooperation.

25. The organization of the Red Book can be considered as an example of a factor:

- A) abiotic
- B) biotic
- C) man-made
- D) not at all environmental
- E) abiotic and biotic
- F) man-made
- G) limiting

26. Organisms that settle in the dwellings of other organisms without harming them and without bringing benefits are called:

- A) commensals.
- B) Competitors.
- C) parasites
- D) Victims
- E) Predators.

27. Environmental factors are:

- A) The set of necessary habitat elements.
- B) Individual elements of the environment that affect organisms.
- C) The part of nature surrounding living organisms
- D) Natural resources.
- E) Environmental niches.

28. What substances were synthesized at the first stage of the origin of life:

- A) Inorganic.
- B) Organic.
- C) DNA and RNA.

- D) Gases released in volcanoes.
- E) Water and mineral salts.

29. What is the name of the branch of ecology that studies the biosphere:

- A) Autecology.
- B) Demecology.
- C) Synecology.
- D) Global ecology.
- E) Geographic ecology.

30. What problems does the socio-political aspect of nature protection solve:

- A) Enactment of laws on nature conservation.
- B) Creation of non-waste technologies.
- C) Determining the prognosis of public health
- D) Global environmental issues.
- E) Conservation of biodiversity.

31. Ozone-depleting substances:

- A) Nitrogen and sulfur oxides
- B) Carbon dioxide and methane.
- C) Freons.
- D) Car exhaust
- E) Ionizing radiation.

32. What is the average life expectancy of a species:

- A) 10-30 million years.
- B) 10-30 thousand years.
- C) 10-30 years.
- D) 100-300 years.
- E) 10-30 billion years.

33. What are the names of long-term and constant associations of animals of one population:

- A) Colonies.
- B) Packs.

- C) Herds.
- D) Biocenoses.
- E) Communities.

34. The totality of the habitat elements necessary for the organism is:

- A) Wednesday.
- B) Living conditions.
Biotope.
- D) Environmental factors.
- E) Biogeocenosis.

35. Postproduction individuals make up a large proportion of the populations:

- A) Fast-growing.
- B) Stable.
- C) With decreasing numbers.
- D) In which there is no clear pattern of growth.
- E) Growing exponentially.

36. When one species uses for its structures products of isolation of individuals of another species, the following are observed:

- A) Phoric communications.
- B) Topical connections.
- C) Trophic connections.
- 3. D) Fabric communications.
- E) Abiotic connections.

№	Correct answers	№	Correct answers
1	B	19	A
2	A	20	D
3	D	21	D
4	B	22	A
5	C	23	C

6	A	24	B
7	D	25	CF
8	D	26	A
9	C	27	B
10	D	28	A
11	C	29	D
12	C	30	D
13	E	31	C
14	A	32	A
15	E	33	C
16	A	34	B
17	B	35	C
18	A	36	D

TERMS AND CONCEPTS

Abiotic factors - a complex of inorganic environment conditions that directly or indirectly affect the animal organism.

Adaptation is the adaptation of organisms to the environment.

Aggression is a form of animal behaviour aimed at protecting oneself, offspring, and partner. And this behaviour is characterized by the extermination of individuals of its species.

Amensalism (-, 0) is a type of interspecific relationship in which one species suppresses the existence of another species without experiencing opposition. For example, amensalism between animals and microorganisms is the *Atta sexdens*, a leaf-cutting ant that "grows" mushrooms used in food in its nests.

Anthropogenic landscape - a landscape transformed by human economic activity to such an extent that the relationship of natural (environmental) components is changed to the extent leading to the addition of a new (compared to the previously existing at this place) natural complex.

Area is a part of the earth's surface, within which one or another species is common.

Atmosphere - the gaseous shell of the planet, consisting of a mixture of various gases, water vapour and dust.

Autecology is a section of ecology that studies the relationships of individuals (organisms) with the environment.

Autotrophs are organisms that take the chemical elements necessary for life from the inert matter surrounding them and do not require ready-made organic compounds of another organism to build their body. The main source of energy used by autotrophs is the Sun.

Benthos - the bottom of the ocean as a habitat for bottom organisms.

Benthos - a combination of plants (phytobenthos) and animals (zoobenthos) leading a bottom lifestyle.

Biocenosis is a set of populations of all types of living organisms inhabiting a certain geographical territory, which differs from other neighbouring territories in the chemical composition of soils, waters, as well as in many physical indicators (altitude, the magnitude of solar radiation, etc.).

Biocosal substance - is created in the biosphere by simultaneously living organisms and inert processes, representing systems of dynamic equilibrium of both (soil, weathering crust, natural waters, whose properties depend on the activity of living matter on Earth).

Biogenic substance - is created and processed by life, by aggregates of living organisms, for example, oil, coal, limestones, etc.

Biogeochemical cycle (biogeochemical cycle) - the exchange of chemical elements between living organisms and inorganic environment.

Biomass pyramid - a graphic representation of the relationship between producers and consumers of different orders, expressed in units of biomass.

Biome - a set of communities of organisms (ecosystems) of any large territory, for example, the natural zone: biomes of the tundra, taiga, etc.

Biosphere - a kind of shell of the Earth - containing the entire totality of living organisms and that part of the planet's substance that is in continuous exchange with these organisms.

Biota - a set of species of organisms of any large territory, for example, the biota of the tundra, etc.

Biotic (biological) circulation - the circulation of substances between soil, plants, animals and microorganisms.

Biotic factors are the totality of the influence of the activity of some organisms on others.

Biotope is an ecologically homogeneous part of the earth's surface (territory or water area) occupied by a single biocenosis.

Cannibalism is the devouring of individuals of its species.

Capacity of the environment is a quantitative characteristic of a set of conditions that limit the growth of the population.

Chemosynthesis is the synthesis of organic substances in chemoautotrophic bacteria that use the oxidation of certain inorganic substances as energy sources.

Climax is a relatively stable state of the biocenosis (ecosystem).

Collaboration - both types form a community. It is not necessary, since each species can exist separately, in isolation, but life in the community benefits them both.

Commensalism (+, 0) - the relationship of organisms - in which one of the partners' benefits, without harming the other. For example, the largest predator in the ecosystem of the African savannah is a lion, it has many commensals: hyenas, jackals, carrion birds and others eating the leftovers that this predator leaves.

Commensality is the consumption of different substances or parts of their the same resource. For example, the relationship between different types of soil bacteria - saprophytes, which process various organic substances from decayed plant debris, and higher plants that consume the mineral salts formed in this process.

Competition (-, -) each of the species has an unfavourable effect on the other species. Species compete in search of food, shelter, egg-laying, etc.-

Consortia - a set of populations of organisms whose vital activity within the same biocenosis is trophic or topical associated with a central species, an autotrophic organism.

Consumables, or phagotrophic, are heterotrophic organisms, mainly animals that feed on other organisms or particles of organic matter.

Convergence is an external similarity that arises among representatives of different unrelated groups and species as a result of a similar lifestyle.

Demecology is a section of ecology that studies the relationship between a population, a species, and the environment.

Detrital (saprophytic) food chains - food chains starting with dead plant debris, animal corpses.

Detritofagi- organisms that feed on detritus.

Detritus - small particles of the remains of organisms and their secretions.

Ecological catastrophe is a natural anomaly (prolonged drought, mass pest, for example, livestock, etc.), often arising based on direct or indirect effects of human activity on natural processes and leading to acute adverse economic consequences or mass deaths of the population of a certain region, etc.

Ecological crisis is a reversible change in the equilibrium state of natural complexes.

Ecological expertise is a system of a comprehensive assessment of all possible environmental and socio-economic consequences of the implementation of projects, the functioning of national economic facilities.

Ecological forecast - prediction of changes in the natural environment as a result of the impact of economic activity on it.

Ecological niche is the position of the species that they occupy in the general system of biocenosis, the complex of its biocenotic connections and requirements for abiotic environmental factors.

Ecological plasticity is the property of species to adapt to one or another range of environmental factors.

Ecological situation - local or regional - environmental degradation, considered as socially unjustified or dangerous.

Ecological strategy of a population is its general characteristic of growth and reproduction.

Ecological structure of a biocenosis is its composition of ecological groups of organisms that perform certain functions in the community in each ecological niche.

Ecology - a science that studies the relationships of organisms between themselves and with the environment, or science that studies

the living conditions of living organisms, their relationships with the environment in which they live.

Ecosystem - any community of living creatures and its environment, combined into a single functional whole, arising based on the interdependence and cause-effect relationships existing between individual environmental components.

Edaphon - the totality of the living population of the soil.

Effect of the group is the optimization of physiological processes leading to an increase in the viability of individuals with coexistence.

Environment is a part of nature that surrounds living organisms and exerts a direct or indirect effect on them.

Environmental monitoring - regular, performed according to a given program of observation of natural environments, natural resources, flora and fauna, allowing to highlight their condition and the processes occurring in them under the influence of anthropogenic activities.

Environmental pollution - any introduction into an ecological system of non-characteristic living or non-living components, physical or structural changes that interrupt or disrupt the processes of circulation and metabolism, energy flows with a decrease in productivity or the destruction of a given ecosystem.

Environmental protection is a system of measures aimed at maintaining a rational interaction between human activities and the natural environment, ensuring the conservation and restoration of natural resources, the rational use of natural resources, preventing the direct and indirect harmful effects of society on human nature and health.

Environmental quality - the degree to which environmental conditions meet the needs of people or other living organisms.

Eurybionts are ecologically hardy species.

Fauna - a collection of animal communities of any territory.

Fauna - a set of species of animals that live in a particular territory.

Food (trophic) chain is a sequence of energy transfer in an ecosystem.

Food (trophic) network - the plexus of food (trophic) chains in a complex community.

Gallophils are animals adapted to live on saline soils.

Geobionts are animals that constantly live in the soil.

Geobiosphere - the upper part of the earth's crust - the lithosphere, inhabited by geobionts.

Geophilous are animals, part of the development cycle of which (usually one of the phases) necessarily takes place in the soil.

Geoxenes are animals that occasionally visit the soil for temporary shelter or shelter.

Heterotrophs are organisms that need organic matter formed by other organisms for their nutrition.

Heterotypic reactions are interactions between individuals of different species.

Hijacking is the consumption of residues of the host's food, for example, the relationship of sharks with sticky fish.

Homeostasis is a dynamic balance of processes occurring in the body, population, biocenosis, ecosystem.

Homotypic reactions are interactions between individuals of the same species.

Humus - an organic matter of the soil, consisting of dead remains of plants and animals.

Hydrobiosphere is the global world of water (the water shell of the Earth without groundwater), inhabited by hydrobionts.

Landscape - a natural boundary of the earth's surface, within which all-natural components (rocks, terrain, water, soil, flora and fauna) form an interconnected unity.

Law of minimum (J. Liebig) - the vitality of an organism is determined by the weakest link in the chain of its environmental needs. Yu. Liebig formulated this law as follows: "The substance at the minimum controls the crop and determines the size and stability of the latter in time."

Law of the constancy of the amount of living matter of the biosphere (V. I. Vernadsky) - the amount of living matter- (biomass of all organisms) of the biosphere is constant for a given geological era.

Law of the irreversibility of evolution (L. Pollo) - evolution is irreversible; an organism (population, species) cannot return to its former state, already implemented among its ancestors.

Law of tolerance (V. Shelford) - the prosperity of the body is limited to the zones of maximum and minimum of certain environmental factors. Between them is the optimum zone. Each species is characterized by its tolerance - the ability to tolerate deviations of environmental factors from optimal ones.

Laws of Ecology (B. Kommoner) - 1. Everything is connected with everything; 2. B – e must go somewhere; 3. Nature knows better; 4. Nothing is given for nothing.

Layering - vertical stratification of biocenoses into equally high structural parts.

Life form of an organism is a morphological type of adaptation of a plant or animal to the main factors of habitat and a certain lifestyle.

Limiting (limiting) factor is a factor whose level, in a qualitative or quantitative sense (deficiency or excess), is close to the endurance limits of a given organism.

Lithosphere is the upper “hard” shell of the Earth, gradually transforming with depth into spheres with a lower strength of matter. Includes the earth's crust and the upper mantle of the Earth.

Living conditions (conditions of existence) - a set of environmental elements necessary for an organism with which it is in indissoluble unity and without which it cannot exist.

Living matter, according to V.I. Vernadsky is the totality of all living organisms in the modern biosphere.

Lodging is the use by some species of others (their bodies or their dwellings) as a refuge or dwelling.

Macrobotype (macrobiota) - large soil animals with body sizes from 2 to 20 mm.

Megabiotype (megabiota) - mainly from among mammals, for example, large excavations.

Mesobnotype (mesobiota) - a set of relatively small, easily moving animals from the soil (soil nematodes, insect larvae, mites, ticks, etc.).

Microbiotype (microbiota) - soil microorganisms that make up the main link of the detrital food chain, are, as it were, an intermediate link between plant residues and soil animals.

Mutualism (+, +) is a symbiotic relationship when both cohabiting species benefit from each other. For example, between flowering plants and insects and birds pollinating them (mutually beneficial).

National parks - sections of the territory (water area) allocated for the conservation of nature for aesthetic, recreational, scientific, cultural and educational purposes.

Natural monuments are separate irreplaceable natural objects of scientific, historical and cultural-aesthetic value.

Necton - a set of pelagic actively moving animals that do not have a direct connection with the bottom (whales, squids, pinnipeds, fish).

Noosphere is the sphere of the mind. The hypothetical stage of development of the biosphere, when intelligent human activity will become the main determining factor in its sustainable development.

Nutritional ties are mechanisms of energy transfer from one organism to another.

Ornitophily - pollination of plants with the help of birds.

PAR - the photosynthetic activity of solar radiation.

Parasitism is a form of relationships between species in which organisms of one species (parasite, consumer) live off of the nutrients or tissues of the body of another species (host) for a certain time.

Partial reserve - areas of a territory or water area where certain species of animals, plants, or part of a natural complex are preserved for many years or constantly in certain seasons or year-round.

Pasture - fodder land used for grazing herds of farm animals.

Pathogen is an agent that causes pathological processes in the body.

Pelagial - the thickness of water in the ocean or sea, the habitat of pelagic organisms, plankton and nekton.

Phoric communications are the participation of one species in the distribution of another.

Phytophages are animals that feed on the tissues of living plants.

Plankton - a set of pelagic organisms that cannot fast active movements. These are small animals - zooplankton and plants - phytoplankton, which can not withstand currents.

Population - the total number of individuals in a given territory or a given volume.

Population is an elementary grouping of organisms of a certain type, which has all the necessary conditions for maintaining its population for an unimaginably long time in constantly changing environmental conditions.

Predation is a type of relationship between populations in which representatives of one species eat (destroy) representatives of another, i.e., the organisms of one population serve as food for the organisms of another population.

Primary succession is the process of development and change of ecosystems in previously uninhabited areas, starting with their colonization.

Reserves - areas of land and water spaces, removed in the prescribed manner from any economic use and properly protected.

Restoration of natural resources - a set of measures aimed at obtaining natural resources in a previously naturally observed amount using artificial measures, after a period of complete or partial depletion of these resources as a result of anthropogenic impact.

Secondary succession is the restoration of an ecosystem that once existed in this territory.

Soil - part of the natural environment surrounding man, arose as a result of the complex interaction of the atmosphere, hydrosphere, lithosphere, flora and fauna.

Stenobionts are environmentally low tolerant species.

Succession is a successive change of one biocenosis to another.

Symbiosis - inseparable mutually beneficial - ties of two kinds, suggesting the obligatory close co-existence of organisms, sometimes even with elements of parasitism.

Synecology is a section of ecology that studies the relationship between communities and ecosystems.

Tolerance - the endurance of a species to the impact on it of certain environmental factors.

Topical connections - characterize any physical or chemical change in the living conditions of one species as a result of the activity of another.

Trophic connections - are observed when one species eats another - either living individuals, or their dead remains, or products of their vital functions.

Trophic level is the place of each link in the food chain.

UV - ultraviolet radiation.

Zoogamy - pollination of plants by mammals.

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ЭКОЛОГИЯ ЖИВОТНЫХ

(на английском языке)

Отпечатано с оригинала авторов