UDC 004:591.5:612:616-006 https://doi.org/10.15407/biotech11.04.028

ELECTRONIC DATABASES OF ARTHROPODS: METHODS AND APPLICATIONS

O. M. KLYUCHKO[1], *Z. F. KLYUCHKO*[2]

[1]Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the National Academy of Sciences of Ukraine, Kyiv

[2]Schmalhauzen Institute of Zoology of the National Academy of Sciences of Ukraine, Kyiv

E-mail: kelenaXX@ukr.net

Received 29.12.2017

The purpose of the work was the examination of various databases construction as well as examination of possible errors. Peculiarities of biological objects which should be taken into account during databases design were analyzed. The methods for electronic collections with databases of biological organisms elaboration were studied. The appropriate algorithms for environmental conservation were analyzed and compared with some foreign analogs in order to study positive and negative experiences. The requirements for database with information about *Noctuidae* (*Lepidoptera*) and some *Araneidae* were formulated for the development of electronic information system "EcoIS". The description of developed relational database with information about insects with analysis of selected object area were suggested taking into concideration the characteristics of biological objects and characteristics of information systems analogues. Conclusions concerning described new means with bioobjects databases and their application on the example of "EcoIS" system were done as well as some recommendations for the construction of databases with the information about living organisms basing on our experience.

Key words: bioindicators, electronic information systems, databases of Arthropods, databases of insects, *Noctuidae* (*Lepidoptera*), *Araneidae*.

The importance of electronic information systems (IS) with databases (DB) have uprised during the last years for biotechnology and other biological disciplines: systematics, taxonomy, ecology, nature conservation, for their application for monitoring of polluted environment.

Networks with distributed databases for biotechnology,environmental protection of bioobjects. Electronic databases with access to the Internet with information about living organisms are technical information systems (ISs) invented during the last decades due to the progress in information and computer technologies (ICT). They were designed either for academic purposes — to maximize the accumulation of information about the groups of living organisms, or for the needs of the economy, in particular for biotechnology, for monitoring of polluted areas in industrial centers, and etc. [1–9]. Mathematic methods as well as models that we described in our previous articles and those published by other authors also may be used for ISs functioning or to be simulated in result of their functioning [9–81]. A spectrum of mathematic methods were used for the newest biomedical ISs elaboration [1, 11, 75, 77–146, 159]. Content for the databases described in this article was obtained usually from the results of biological and medical observations and experiments [10, 12–17, 24–44, 47–49, 61, 68, 71–74, 82–90, 94, 104, 106, 109, 111–113, 125–159]. All such technical information systems (tIS) are electronic databases (DB) distributed in networks today [1–11, 25–69, 90–109, 112–120, 159]. Present work was done after the analyzis of approximately 250 current publications in fields of biotechnology, other branches of biology and technology, including articles with original authors' works. Priority of authors' works was reflected in [160–162].

Development of electronic databases in biological sciences. Electronic ISs with DB for biological sciences should contain information about the diversity of living organisms and their evolution — the "Invention of the Nature". Another, alternative kind of diversity that has been invented by human — diversity of the data that appeared and evolved as a result of computer networks development, as well as new computational methods and methods of electronic information recording. The last one exists during only the last 20–25 years. However, there is a large chaos in biological ISs data. For today the most important is the way of data mining, recording and obtaining from DB, in which the data are logically organized and structured. As a result an alternative type of diversity appeared — diversity of DB [1, 112, 114, 159]. In this article we give the examples of how the variety of information and natural diversity could be correlated.

Prerequisites for the development of electronic information systems in Ukraine. In Ukraine, at the time of former USSR, numerical groups of scientists-biologists and other professionals had organized the network of bio-stations for the environment ecological state monitoring and environmental biodiversity protection. These means were enough perfect for those time. Due to the works of biologists of previous generations there were localized and stopped locusts'propagations in South Ukraine as well as some other environmental cataclysms. As continuation of these works we began to develop "EcoIS", a new electronic information system, which is based on bioorganisms DB development. As bioindicators we have chosen insects-moth *Noctuidae (Lepidoptera)* [152–159]. We see them as successful bioindicators for number of reasons, the most important of which are following: 1) there are more than 700 species in Ukraine; 2) these species are enough well studied; 3) these species can be determined enough well; 4) these moth are well visible during material gathering due to their morphological qualities; 5) collection of *Noctuidae* is carried out at night time and moth species dominate usually in collected material; 6) most *Noctuidae* species are pests in agriculture that make their studies necessary for economy [156–159]. Therefore their studying and use as bioindicators are useful for the solution of several problems of Ukrainian economy. Enough important argument is that during the monitoring of changes in *Noctuidae* quantitative and qualitative composition in industrial areas vicinity it is possible to make conclusions about environmental pollution harmful effects on living organisms' population. For the development of electronic information system "EcoIS" we used some results of Prof. Klyuchko Z.F studies of *Noctuidae* in Ukraine and at territories of border countries since 1961 [1, 156–159] (Fig. 1). Part of these works were carried out jointly by both authors in the extreme conditions of Caucasus Mountains at Elbrus region on 1997–2006 (Cabardin and Balkar region, Russia), and obtained results could be applied to high altitudes' influence studies

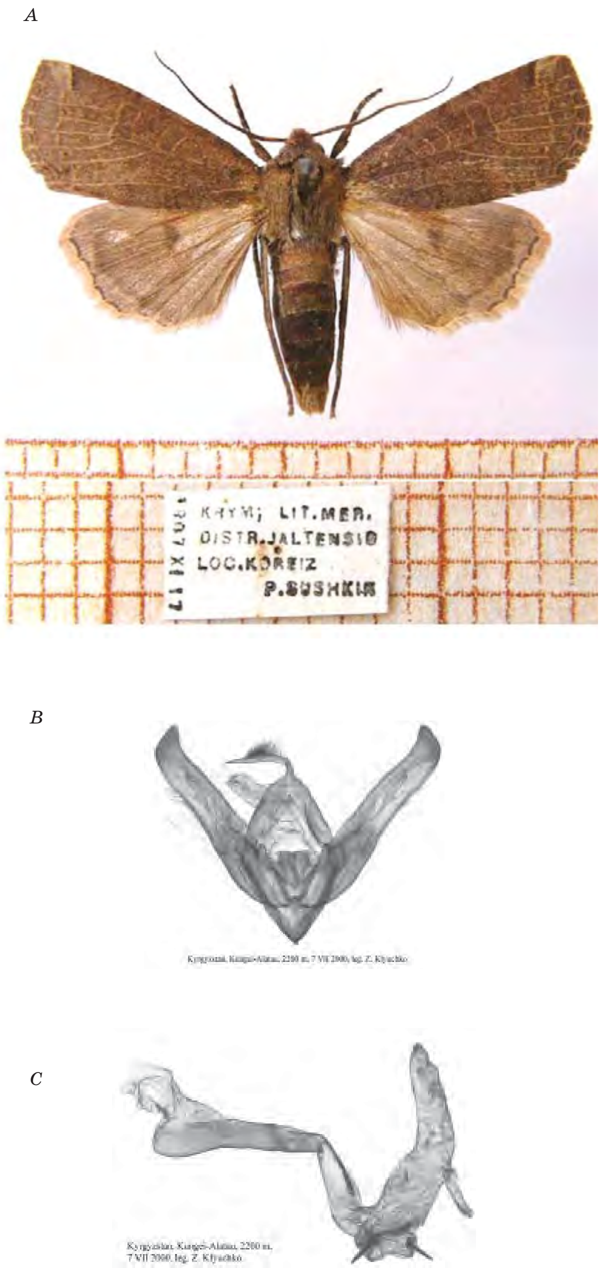

Fig. 1. **Materials from Prof. Zoya F. Klyuchko private laboratory:**
her preparations and collections that we have used for databases construction. Her notes about places where she collected some materials are seen as well

[1]. It is known that bioorganisms adaptation to extreme conditions occurs according the two strategies that are fundamentally different for organisms like higher mammals (and humans) and insects. Our developed electronic information system "EcoIS" is aimed on the second strategy of insect organism adaptation studies [1, 159].

Application of some mathematical methods for the work with bioobjects databases: methods of cluster analysis, neural networks and other [1–9, 57, 58, 67, 159]. The application of these methods in order to distinguish similar bioorganism characteristics for the development of biological DB and subsequent modeling have demonstrated good results [1–9, 159]. The use of methods of cluster analysis and neural networks for mathematical models development in ecology was used to study the distribution of organisms in different areas, pests penetration and spreading in bioorganisms' population, the influence of environmentally dangerous factors on living organisms' population. An important task is the elaboration of medical and biological DB, which enable to distinguish reliably the groups of objects according to their similar characteristics [1–9, 159].

From the obtained results one could see how it is possible to apply traditional methods of clusterization for the practical analysis of data sets registered on biological samples (for example, for different types of drawings on the wings of insects-moth) during databases construction [1–9, 159]. The similarity of measure was used in combination with one of four types of clustering algorithms: 1) method of agglomeration hierarchical clusterization with single linkages; 2) method of agglomeration hierarchical clusterization with complete linkages; 3) Ward method; 4) rough clustering method [1, 115]. The results demonstrated that clusters were generated usually according to two types of attributes that have a biological meaning; the best match was achieved using Ward method. During the elaboration of such DB, the nominal attributes were not included in the list of meaningful attributes [1, 115].

During the attributes defining for the elaboration of insect DB it was necessary to choose the right attributes [1–9, 159]. Today, for the development of entomological DB, the specially developed digital photographic equipment is used, which makes it possible to express the categories "more reddish", "less gray", and etc. in digital forms. Consequently, one can use the notion of numerical attributes with appropriate methodological consequences.

Basing on information about butterfly specimens that were ordered in electronic DB for museums or collected for species conservation, the possibility of two mathematical methods that are valid for actual number of species in the region was explored. Some authors suggested following two methods [1, 83, 88]: 1) phenomenological model based on the saturation curve of the number of collected insect specimens; 2) model based on the concept of species number increasing which is described by normal logarithmic law. Using these methods for the analysis of daytime butterflies for some regions, it was found that the location of places with large species diversity (calculated according to the asymptotic approximation) differs from what can be expected if to analyze only the raw data from collection [1, 83, 88]. In addition, it has been shown that there was a difference in the results of two different assessment procedures and these differences become significant for processing of results obtained for a small number of individuals. It was proved that the concept of normal logarithmic distribution of species should be preferred, since it allows to analyse much better the state of fauna, for example, it avoids risky inaccuracies in the estimations [1, 83, 88]. Finally, basing on DB data as well on calculated variables of butterflies' species diversity, it was demonstrated an interesting fact: the places with species-representatives of disappearing and small species are rarely the same as "hot spots" or biodiversity centers [1, 83, 88]. Consequently, some regions with species biodiversity, where the butterflies' protection have been already organized, in reality have not been co-located with those areas where the rare or disappearing butterflies' species have been registered. The Monte Carlo method was also used to analyze the data for some environmental conservation problems solution. Thus, the use of these theoretical methods have made significant corrections in nature conservation practice [1, 83, 88, 156–159].

Problems of network databases design for biotechnology, ecology and systematics. In biotechnology, systematics, taxonomy, during the analysis of characteristics of bioorganisms that need to be ordered in DB, one can reveal the regularities that determine the logical structure of these data in DB (or "data representation model"). According to their peculiarities, such biological objects form an ideal hierarchy, therefore, a hierarchical model of DB organization developed for technical sciences could be applied there successfully. However, the simple borrowing of this model was unsuccessfull due to the great individual bioorganisms' variability; so, for the development of such databases the special techniques invention was necessary. Let's analyze the suitability of such methods on the example of *Noctuidae (Lepidoptera*) and other insects, dividing these bioobjects into two groups respectively: those that do not contradict to DB construction according to hierarchical model and those that do not fit into such a model [1, 159].

Biological objects and their specificity in DB designing. Designing of the ISs that include the DB, is performed on the physical and logical levels. Solution of design problems at the physical level in many cases depends on the used DB management system (DBMS), which is automated and often is hidden from the user. In some cases, the user can regulate individual parameters of the system. [1, 159]. During the DB construction for systematics and taxonomy, the focus should be primarily on *logical construction*. In course of logical construction it was possible to determine the number and structure of the tables, to form the DB queries, to define types of accounting documents, to develop the algorithms of information processing, to determine forms for input and editing of DB data and to solve the number of other tasks.

The nature of biological objects was those specificity that determine the solution of problem of logical construction. The most important problem here was the data structuring. During the data structures construction it was necessary to distinguish three main approaches.

1 — Collection of information about the objects of solved tasks within the framework of one table (one relation) and its subsequent decomposition into several interconnected tables basing on the procedure of relations normalization.

2 — Formulation of knowledge about the system (definition of output data types and interconnections) and requirements for data processing, obtaining with the help of automation system for construction and development of DB, finished DB schema or even ready-made IS application.

3 — Information structuring for the use of IS in process of system analysis basing on a set of rules and recommendations.

Characterizing bioobjects specificity one could also emphasize the following. 1 — This is the complexity of bioobjects by themselves, in these objects the elements — their components determine often the properties of the whole object, but they are not the arithmetic sum of elements properties. 2 — Complexity and multiplicity of links between objects and between elements in objects. 3 — Hierarchy, which subordinates the largest majority of objects in nature and hierarchical connections. 4 — The presence of many weakly differentiated objects in nature, which, however, are not identical, but have individual characteristics, forming a homologous series of objects. Therefore in process of medical and biological ISs elaboration the problems of differentiation become a topical task.

Specificity of biological objects, collection of information about such objects during expeditions, field observations and their primary analysis play a key role in the design of biological DBs. Respectively, below we would like to analyse some characteristics of insects — moths (*Noctuidae, Lepidoptera)*. According to our plans this information about *Noctuidae* systematics and taxonomy has to be basic in course of the development of our electronic information system "EcoIS". Moths (*Noctuidae*, *Lepidoptera*) are night butterflies, many of which can be seen and collected at summer nights. Their place in Linnaeus hierarchy of living organisms [41] is shown on Fig. 2. The example of hierarchical position in classification of moth specie *Agrotis segetum* and spider specie *Argiope lobata* are represented. In fact, this figure demonstrates the classification data of these two species only from the level "Type — *Arthropoda*", which is the same to both species. At lower hierarchical level — at level of classes — the lines of *Noctuidae* and *Argiope* are divergent. Above the type of "*Arthropods*" the level "Kingdom of animals" has to be placed; and above it the "Domain of eukaryotes" has to be drawn (both one are not shown on Fig. 2) [1].

Such views about hierarchical classification of living organisms naturally fit into modern bioinformatics program methods based on the hierarchy of classes that have become widespread in modern ICTs, for example, in object-oriented programming. It would be necessary to provide the use of several languages in biomedical DB, developed for such industries as ecology, zoology, and etc. For example, for our purposes in Ukraine, in biological DB the information was given in Ukrainian and Latin, since all known bioorganism species have traditionally Latin names, and only a part of them also has the names at languages of population who lives at this territory.

Characteristics of bioobjects Noctuidae corresponding to DB construction according to hierarchical model. For classification of organisms in living nature, Carl Linnaeus proposed his scheme on 1761 [1, 41]. The information used for the registration of living organisms in biology (ecology, taxonomy, and etc.), at first glance, has been structured quite simply — it is a hierarchical structure of living organisms classification in systematics (Fig. 2) [1].

By opening any biological determinant (for example, for insects) [1], one can find the following information (our examples were written for Slavonic-speaking countries; for other groups of countries the determinant structure is the same):

– the name of species (Latin, Ukrainian or Russian); the names of the people who defined it and the publications in which the information on the species is given; the data of collection; the place of collections: parts of the world, country, region and settlement; the geographical area of its inhabitance; the

a	*b*	*c*
Type	*Arthropoda*	*Arthropoda*
Class	*Insecta*	*Spider-like*
Series	*Lepidoptera*	*Spiders*
Family	*Noctuidae*	*Spiders-colopods*
Genus	*Agrotis*	*Argiope*
Species	*Agrotis segetum* Denn&Shiff	*Argiope lobata*

	Spiders – Latin names
1	*Agelona labyrinthica*
2	*Araneus diadematus*
3	*Argiope lobata*
4	*Argyroneta agnatica*
5	*Atipus piceus*
6	*Dolomedes fimbriatus*
7	*Latrodectus tredecimguttatus*
8	*Lycosa singoriensis*
9	*Misumena vatia*
10	*Nephila clavata*
11	*Segestia senoculata*
12	*Tegenaria domestica*

Fig. 2. **Scheme for classification of Artropods by Linnaeus:**
a — the general hierarchy of classification units; *b* — example of hierarchy classification of insects: *Agrotis segetum* Denn & Shiff (Dennis & ShifferMuller); *c* — example of hierarchy classification of spider *Argiope lobata*; *d* — an example of the table fragment from the database of spiders from the system "EcoIS" (explanations see in text) [1, 41]

habitant biocenosis, the plants on which it is fed (including information whether it is a pest in agriculture); biological data on the number of generations during the season, periods of flight, and etc. Being standardized since the time of Linnaeus [41], these data could be structurized in the table easily (researchers — biologists also have organized these data in such a way), and it seems to be ideally adapted for the further transfer to the DB tables [1]. During our DB elaboration the names of species and other classification terms were written in Latin, Ukrainian and/or Russian languages (on Figs. 2–4 we have demonstrated only ones in Latin).

Characteristics of bioobjects, which complicate the traditional methods of database designing. The experience revealed that with each of these simple elements of the future DB contents the certain problems may be associated due to the peculiarities of living organisms [1]. Many of them have an unstable name and an unstable taxonomy. Thus, *Noctuidae* classification, which seemed to be established for decades, is being re-examined now [1]. Consequently, during the hierarchical model constructing, these facts lead to the errors as a result of ambiguity of parent and derivative elements selection. If insects were collected on certain plants, it is often not possible to conclude whether these plants are a source of their nutrition or a place of residence, or both ones at the same time.

Specialists solve a number of problems in connection with the species location registration, for example, during the development of the first electronic plants database in Ukraine by collaborators of Botanic Institute of the National Academy of Sciences of Ukraine named by Cholodny [1]. For our objects during DB construction, we had found the following. The exact location (important for DBs) may change its name: for example, the Kyiv region of Southern Borshchahivka did not exist fifty years ago, as well as the name of district Vyhurivshchyna in Kyiv appeared on the maps, and then disappeared again during XX c. The similar situation was with other regions of Ukraine — during different historical periods the administrative boundaries of individual regions have been changed. Even the names of countries could be changed during the different historical periods. Thus in Europe, some border territories from time to time were the parts of different countries (Friuli-Venezia Giulia province in modern Italy during its history was the part of Yugoslaviia, and before that — the part of Austrian Empire, and so on). Data of observations were considered unchanged often but… For example, materials from entomological collections of Russian Empire of XIX–early XX c, which were dated according to unformatted calendar require correction before their ordering in modern electronic databases. The names of observers could also be changed (for example, ladies' names after marriage). Consequently, even the simple and factual information that we consider sufficiently suitable for ordering in biologic DBs is characterized by instability, and this instability must necessarily be taken into account [1].

Difficulties in problems' solution during the elaboration of database of insects' adaptation characteristics in mountainous regions (one of the tasks discussed below) could be linked with the fact that during field observations a large number of heterogeneous data were recorded, which complicates the construction of object model. For example, for a few names of *Noctuidae* from the list of a few dozen names it was necessary to take into account many characteristics, and these data are difficult to divide into groups for the selection of objects and attributes [1].

Similar problems appeared also during the conducting of environmental works in the United Kingdom, when it became necessary to analyze the hundreds of thousands of insects' characteristics for different species and plants on which they feed. Such large-scale work was carried out using a large amount of the data that was pre-recorded in electronic databases, which were specially designed to solve this problem, while some data were lost due to the individual variability of studied living organisms. Data analysis was based on the Monte Carlo method [13]. As were noted by authors, even when trying to analyze a small number of insects, for example, only a few *Noctuidae* names from the list of several dozen, these data were difficult to subdivide into the groups for defining of objects and attributes [1]. Some important characteristics, such as changing of colors and shades of the wings, which are of primary importance for biologists, are difficult to express in the form suitable for the table (for example in cases when biologists use usually the expressions like "less dark olive", "reddish", and etc.) Below we will show that in order to take into account these peculiarities a number of special techniques should be used, among which there are the mathematical methods of cluster analysis (by means of which it is possible to distinguish between objects that differ slightly), the use of special high-quality digital photographic equipment, which allowed quantitative expression of characteristics, which previously were described only qualitatively and so on. The description of the behavior of living organism and its discretization for the purpose of placement in separate table fields is extremely difficult also, since behavioral acts are difficult to formalize.

Development of electronic database without duplications and ambiguity is still a prerequisite for a skilled approach to species conservation [1]. However, the quality of the most already constructed databases does not reach the necessary standards' levels required by the needs of nature conservation. This is true even for such regions, for which numerous records have been done even for easily identificable butterfly species [14].

Due to the complexity of biological objects and inaccuracies of many records made during the field observations, the problem of duplication appears quite seriously. According to the theory of databases, the dubbing is divided into *simple (non-excessive)* and *excessive duplication*. During the construction of relational tables, it is impossible to avoid *simple (non-excessive)* duplication if we describe, for example, several types of insects that were registered in one of the regions of Ukraine (Fig. 3). The presence of this type of duplication in database is permitted and the quality of information retrieval is not affected during the future use [1].

Excessive duplication of the data in database can lead to problems in data processing. It appears in situations when an information about any specie is replaced by a dash (as it is often done) relatively to the characteristics of above mentioned species (Fig. 4). During information retrieval in this case, the computer automatically begins to search for information that replaces the dash, and computer resources are spent consequently. In addition, computer memory is still allocated under attributes with dashes, so, there is no significant optimization for it. And finally, since the information in attributes with dashes is linked with pre-specified species, then its deletion in the future will result the loss of information for all types that have been unsuccessfully associated with it. Consequently, when making of relational tables in such databases, all episodes of excessive duplication have to be corrected.

Another problem is typical for all regions of the planet. This is the "spot-like" of fauna researches of different territories — in some regions it has been studied better, other regions, in fact, are "white spots" on natural maps. In addition, records for individual species contain many controversies [1].

However, it was difficult to achieve enough representative survey of both geographic and other one subject that reflects fauna changes during certain time. Such works are quite expensive and records' quality varies even for work performing accuratively. However, because of constant worsening of

Insect (Latin name)	Geography of collection	Described
Agrotis segetum	Kyiv region, Crimea	Den.&Schiff.
Autographa gamma	Kyiv region, Crimea	L.
Spudaea pontica	Crimea	Kl.
Periphanes treitschkei	Crimea	Fr.

Fig. 3. **The example of fragment of the table with simple (non-excessive) duplication**

environmental living conditions, constant climate changes, the quality and importance of insect changes studying is increasing (including moths, butterflies and etc.) It whould be remembered that in the past the quality of such research was lower, which may lead to a non-correct imagination about species distribution in the nature in past years.

So, during the elaboration of biological database with information about living organisms, it is necessary to take into account the above-mentioned features and factors, below we give the examples of such databases implementation.

Databases and electronic collections of organisms, bioindicators, representation of data in such databases in form of relational model. Making of collections of biological organisms (CBO) has always played a key role in the construction of monitoring systems because this is ability to record data sets about bioorganisms. In the époque of ICT, the logical development of collecting techniques was the construction of electronic CBO, when organisms data began to be organized into the databases in digital form. In fact, electronic CBOs are the kind of ISs with databases. On other hand, a well-done electronic CBO is a DB that can act by itself as element of IS. Below we will focus on the construction of such electronic CBO, especially we will be interested in what prototype methods could be used in developing of original database of *Noctuidae* for future its introduction into the electronic information system "EcoIS".

Construction of electronic collections of bioorganisms with databases. Some electronic biological databases have already been constructed and connected through the Internet network [1]. Only one of the largest information sources on the distribution of species, CBO [113] contains a unique combination of attributes, which includes:

– a large array of information resources about about 2.5 billion specimens of living organisms, each with information about their collection — the time and the place where this sample was collected;

– records that were considered as standard for a particular sample of specie, according to which one can identify and update the information about the identity of a sample if the nomenclature will be changed;

– records that contain valuable information about the restrictions that should be imposed during models construction using the data from electronic CBOs;

– historical data on the organisms spreading today and in the past (including paleontological data), so that it was possible to restore the dynamics of biodiversity changes before and after the start of anthropogenic influence;

– current taxonomy data, because the scientists who constructed and fill this database had knowledge in taxonomy, biodiversity (and, respectively, in phylogeny, environmental analysis and comparative genomics) [1].

Insect (Latin name)	Geography of collection	Described
Autographa gamma	Kyiv region, Crimea	L.
Spudaea pontica	Crimea	Kl.
Periphanes treitschkei	–	Fr.
Divaena haiwardi	–	Tams

Fig. 4. **The example of fragment of the table with excessive duplication**

Methods of modeling for CBO. Constructing of electronic CBO is the first among methods in the collection of the latest computer techniques in systematics and taxonomy [1, 113]. If an electronic CBO was elaborated then the data from its database can be used for the next solution of many problems, for example, such actual for industry task as simulation of species distribution [1, 113]. Methods of modeling of species distribution phenomena are very different; they can be distinguished according to the type of tasks for which they were used, to the data used from CBO, and also according to results of these data statistical processing. All applied methods of modeling could be divided into 3 groups: the first group included modeling methods which necessarily need to have data-characteristics of actually collected organisms of different species; in the second group — there were the methods used to solve problems of forecastings. In the third one there were methods used to solve problems that have the characteristics of the first two types and require both real data and solve forecasting problems; for them such methods as linear and additive models, 'trees' of alternatives in decision making, Bayes approaches, and etc. The last ones were filled with new content, since, by applying them, one can access the occurrence of differences between organisms, can apply expert evaluation and other preliminary information, and basing on all it is possible to predict changes of variables, in particular it is possible to predict changes in species distribution. In [1, 113] was propose the following software samples that can be applied for modeling according to these three groups of methods: for the first one — software BIOCLIM or DOMAIN; for the second one — GARP software, for the third one, respectively, the "mixed type" of software.

Model evaluation. For models evaluation it was necessary to select methods depending on the nature of the particular biological task [1, 113]. Some developers evaluate the models designed according to the CBO data, depending on the size of the structural elements that were put in base of the models. Other studies estimated the possibility of forecasting using models based on CBO data. Other ones have studied the effects of data errors and the existence of branching processes during the work with CBO, and if such a branch occurs, then it is necessary to inform the users who work with this CBO data. In the last case, some simulation and evaluation methods could be applied only to specific tasks and certain data sets, or in general, individual data can not be used for development of forecasting models.

Algorithms for development of biological databases distributed in networks. During the construction of biological databases distributed in networks, it is necessary to do numbers of analytically determined steps [1]. Below there are some algorithms that should be followed for the development of medical and biological databases.

The strategy of mathematical methods use for the construction of tIS with databases in medical and biological practice is determined generally by algorithms for specific tIS construction. In order to avoid errors, the data from CBO have to be used in context of the most comprehensive knowledge of taxonomy or history of systematics; in the case of the studied group of organisms it is recommended to study the insect sample from collection (Fig. 1). Spatial errors in simulation may be due to errors in recordings of geographic data of the place where a sample was collected, a visual inaccuracy of the placement of the record by itself, and errors made during the initial placement of this record [1]. These kinds of errors could be detected because they belong to collection samples that spatially droped out of geographic coordinates or natural zones or if there was a discrepancy between the field records of the person who collected the material and the records in collection. Spatial errors can be corrected by studying the collection sample by itself or corresponding field records, by removing or correcting non-correct records and performing a geographic description extremely accurately.

Warnings and limitations for using of the data from CBO collections. In process of spatial modeling in biology it is necessary to take into account three main features of CBO collections: errors, including taxonomic identification errors and geographic; data biases — primarily biases due to the geographic data and the description of the natural environment in special collections, the presence in many cases of the data that look like as "yes" and "no", which, in the case of modeling, determines the type of algorithm in advance.

Representation of the data in bioobjects' database in the form of relational model. One of our tasks was development of the database with information about insects, first of all *Noctuidae* (*Lepidoptera*) [1, 156–159]. Offering our approach to this problem solution, we based on the following considerations.

Elaborated relational database had to satisfy contemporary standards [1]. Primarily we have spoken about the technical standards — the database must have typical and understandable structure, the material should be accessible and clear, it could be added to the material from other tables from World Wide Web, if necessary, not only the developer, but professional-biologist would be able to make new records (but not worsening irreversibly the main content in cases of incorrect entries!), and etc. At the same time, it was important to comply existing biological standards of taxonomy — compliance with the standards of Latin, Ukrainian and Russian names of insects (for Slavonic-speaking countries), the standard division of material, its completeness for each specie, the compliance with high scientific criteria, and etc. We support these standards, comparing our results with published materials of well-known determinants in biology, current scientific publications of high quality [1, 156–159]. The formats in which the data are presented in scientific publications of various authors, often differ one from another: calculations are done according to different methods which complicates the comparison of these data and their ordering in one database. Data for such databases requires standardization, which does not really exist today in finished form. Although electronic databases may contain information of different formats, we must always keep this in mind using database data for comparisons [1].

Recommendations for the construction of DB of evolving organisms. Since database table contains material about living organisms that evolving and changing constantly, the prospect of its further modernization and development should be laid, if possible, in the possibility of adding of new fields, tables, and etc., without deep reorganization of the database by itself. We considered that it is necessary to make fields (or even to leave the the possibility of new tables adding) for the inclusion of observational materials that do not fit into the current biological standards of the database, but may become valuable in the future (analogous to Linnaeus “Chaos” [41]). In our case, there may be the fields “Comments” and “Other”. Actually, the very existence of such information in additional fields is the source of further development of the DB. In these fields you can also record following information. For example, some types of insects biologist could collect as unique sample, or he cannot collect them at all — but they may be collected and/or determined by other authors. Information about them is very important for biological analysis, but in the main fields of database tables this information will not be included — it may be recorded in “Comments” or “Other”. But if to record all single cases the base grows too much, successful searches in it became too complicated (because of effects associated with the complexity of living systems). It should be noted that, although the main task of our databases construction was solved successfully, it set a number of questions, which will be answered only by further work in this direction [1].

Relational database on bio-objects of the highlands of the Ukrainian Carpathians and the Caucasus (Russia). Below the results of electronic databases development with observation materials in zoology, ecology and adaptation biology of insects living on highlands were suggested. On the materials of insects observations and changes of some their characteristics according to their adaptation to different altitudes, an electronic relational database has been developed, which contains the relevant data. These databases could be described briefly by following provisions [1].

1. There are two databases were elaborated. 1) One DB for some insect species registered by the authors at Elbrus region (Kabardino-Balkar Autonomous Region, Russia) during the expeditionary seasons on 2002–2005; and 2) similar DB about some types of insects in the Ukrainian Carpathians (materials of many years studyings of Prof. Klyuchko Z. F.) Development of two databases gives a good opportunity to compare results to two geographically remote mountain regions and for appropriate generalizations.

2. The “core” of database — the main table with systematic data about insects that were collected during expeditions. The material for these table records — the standard data published in the corresponding academic determinants of high quality.

3. In the table containing the data about the adaptation characteristics of some types of insects, the data of the authors’ observations were recorded. This material is new, relative form has no developed standards, so the table could be modified with time.

4. The author plans the work on supplementing of described DB with other parts with materials of other (as well as ecologically different) regions.

5. The table with the data of altitudes could be supplemented with new records after the future studies at other altitudes with time.

6. In developing of this database structure, the author foresaw the necessity of its modification over time due to objective reasons (deepening of scientific knowledge in this field, and etc.) In the structure of the database the possibility of its development and further modification is expected.

Taking into account these problems, we propose the following approach. An electronic database with characteristics of insects first of all has to be based on already published information according to established standardized schemes. However, for database constructing, it is necessary to realize the possibility of its supplementing by additional fields for non-standard records that can be used in the future, or even the development of additional tables without a substantial re-design of the entire database. Of course, it is impossible to predict all future non-standard situations, but for a sufficiently high qualification of professionals involved in this construction, it is possible to minimize the amount of future corrections. This method was used in past by Karl Linnaeus [41], who, by creating of the first classification of living organisms, added the section "Chaos" for all organisms that were not included in his system. This his idea survived during centuries and, trying to "organize" in our practice our ever-evolving wildlife, we decided to use such historically proven techniques at the current level of our life, at modern ICT level [1].

Object area analysis and biological material that characterize mechanisms of insects adaptation to high altitude conditions [1]. During several years we studied the problem of living organisms' adaptation to different ecological conditions of highlands. We collected material that characterized the manifestation of insects' adaptation characteristics in the Caucasus Mountains at the region of Elbrus Mountain (Prielbrussie Region (Russia), at Elbrus Medical and Biological Station of the National Academy of Sciences of Ukraine). Field researches Dr. Klyuchko O. M. carried out on summer seasons, 2002–2005; the techniques of electronic databases construction there were applied directly. There were no regular targeted studies on this issue in the Ukrainian Carpathians, but during few decades of Carpathian insect studies by Prof. Klyuchko Z. F. since 1961 [1, 42] there were gathered enough biological material that we could choose to compare with the data from Elbrus [1, 23, 29–37]. Let's characterize briefly this material, and then — let's examine in details construction of developed DB. The object of research were insects with their variable characteristics (mainly *Noctuidae* (*Lepidoptera*), as well as some other groups of insects), collected in the zone of mountain forests (ZMF) of both regions, and at Elbrus Region — in ZMF and above this band. At Elbrus Mountain slopes the material was collected at three altitudes: 2100 m above sea level (m. s. l., village Terskol, ZMF), 2800 m.s.l. (Cheget mountain, subalpine meadows), 3100 m.s.l. (peak Terskol, the upper part of the subalpine meadow, the boundary of the mountain snow line). In the Carpathians, the insects of ZMF area were colected at altitudes of 1500–1600 m.s.l. (ZMF is located below here), and insects of subalpine meadows ("polonyny") — at heights approximately of 2000 m.s.l. (Chornohirskyi Range, Hoverla Mountain, Petros Mountain). From insects' characteristics that can reflect their adaptation ability to the highlands, we studied (for each of determined altitudes in each region) 1 — insects' species list; 2 — their quantitative co-relations; 3 — differences in insects behavior at different altitudes; 4 — differences in colors or drawings of insect wings at different altitudes [1, 35].

Insect species' composition at Elbrus Region. It has been found that in ZMF band at Elbrus Region some forestrial *Noctuidae* species are the same in both mountainous regions, both in the Caucasus and in the Carpathians; and they were common in most Palearctic regions: *Apamea illyria, Euchalcia variabilis, Xestia ohreago, Diachrysia chrysitis, Syngrapha interrogationis,* and etc. Some species we registered only in the Caucasus, but not in the Carpathians: *Cucullia propingua, Autographa aemula*. There was a small number of steppe species' representatives — some species *Cucullia, Acronicta euphorbiae*. At these altitudes some *Zygaenidae* species (*Z. lonicerae, Z. filipendulae*, and etc.) were well represented. Above 2800 m.s.l. there are only unique samples of *Macrolepidoptera* samples may be collected. At this attitude the number of all species significantly decreased. At the altitude of 3100 m.s.l. only *Muscidae* (including *M. domestica*) and several *Microlepidoptera* specimens were collected, representatives of other insect species disappeared at all [1, 35].

Insect species' composition at Ukrainian Carpathians. According to Prof. Klyuchko Z. F. data [1, 42], and alternatively to Elbrus slopes, the forest *Noctuidae* species dominated here (such as *Euchalcia variabilis,* *Autographa jota, Autographa pulchrina, Apamea illyria*, and etc.). From steppe species only *Hyssia cavernosa*, *Heliothis maritima* occurred occasionally. The subalpine zone is less revealed here than in the Caucasus, hence, the differences in fauna here were less visible. For example, *Noctuidae* there were collected both at the height of the ZMF and in the area of sub-alpine meadows. But we could be definitely sure that, like in the Caucasus, certain species of *Microlepidoptera* occur here mainly at the height of the sub-alpine meadows.

Quantitative composition of insects. Analyzing the total number of insects collected at different heights in both regions, it was possible to make preliminary conclusion that the changes in *Noctuidae* number with a height could be described by a curve with a maximum of about 2100 m.s.l. Above this mark the number of *Noctuidae* gradually decreased to zero at altitude of 3100 m.s.l. The curves of number decrease for *Microlepidoptera* and *Muscidae* at the right from the maximum (for the higher altitudes) and these curves were more lenient. It means that the representatives of these insect groups were registered at such altitudes, where *Noctuidae* were not present at all. In the Carpathians, various authors noted the gradual number decrease of insect species below 500 m.s.l. (in the zone of strong anthropogenic influence) [1, 42]. These data are in good correlation with the data of other authors, for other regions of the planet [88].

Differences in the behavior and colors (pattern) of insects. For today, we have registered reliably the behavioral differences only for insects (*Noctuidae*, to the less extent *Muscidae*) with altitude increase at Elbrus slopes. Thus, the samples of insect different species who demonstrated extremely active behavior at altitude 2100 m.s.l. were very passive at altitude 2800 m.s.l.; they stopped their activity even at day time with temperatures higher than 18 °C. (insects look like as “frozen”, or “paralysed” at plants). One can assume that oxygen deficiency and adaptation to this was the reason of such behavior. In attempts to collect the insects during the period of activity, they often “imitated a death”. Such reaction in the Caucasus above 2800 m.s.l. demonstrated the majority of insects, whereas with altitude decrease up to 2100 m.s.l. such behavior demonstrated only a few individual samples. In the Carpathians the behavior studies in dependence of altitude were not conducted [1, 35].

Development of relational database on bioorganisms’ collection materials in the extreme conditions of the Elbrus and Ukrainian Carpathians. Starting the design of relational database, one could see that it can be logically divided into two parts that are almost identical in structure: 1 — DB with materials from the Elbrus and 2 — DB with materials from the Ukrainian Carpathians. So, designing an object model, we will do it initially for one of the mountain regions, for example, for Elbrus, and then we can use this experience for a similar database for the Carpathians insects. Logical DB model was shown on Fig. 5. We propose to distinguish the following main objects: “Insect”, “Adaptation characteristics” and “Altitude”. On the communication lines between objects the power relations are indicated. For example, the power of the relation “Insect” — “Adaptation characteristics” was 1: 1, since each type of insect has its own set of adaptive characteristics (the reaction of organism is individual). The power of the relation “Insect” — “Atitude” was “many to many”, since many different insects are recorded at one altitude, and each insect specie lives in a certain band of altitudes. So, for the prevention of appearance of indefinite relation “many to many” in data model, we suggested to inquire a cross-reference table in the database [1].

Objects in our logical model were characterized by following attributes:

Object “Insect”
Attributes:
Primary key
The name of the insect (in Latin, Ukrainian and Russian).
Area of inhabitance.
Biotopes of inhabitance.
Plants of nutrition.
Number of generations during the season.
Periods of fly.
Data of collection.
References to literary sources.
Comments.
Other.

Object “Altitude”
Attributes:
Primary key
Altitudes (meters above sea level).
Natural zone, biotope.
Data of collection.
Comments.
Other.

Object "Adaptation characteristics"
Attributes:
Primary key
Number of insects collected per day.
Number of insects collected per season.
Demonstrates the changes in behavior (if so, then what).
Demonstrates the changes in color (if so, then what).
Demonstrates the changes in the pattern of wings (if so, then what).
Comments.
Other.

Basing on this analysis, we have designed Tables 1, 2, 3. Examples of tables' fragments we presented in our article as Table 1 ("Insects"), Table 2 ("Altitude") and Table 3 ("Adaptation characteristics"). To make tables, we suggested adding the field "Comments" (the biologist or amateur could record some comments) and "Other" (as were noted, the field observations provide often new material that did not fit into standard scheme). These two types of fields were considered as a source of future structural development and database modification [1].

Using this database in working mode, professional-biologist could find out easily what kind of insects live at studied altitude of each mountain region and which adaptive characteristics it reveals at each altitude. Besides of this, he could perform easily all those operations with data that were previously impossible for him: sorting, searching of particular records, data filtering, outputting the data in necessary format, and etc. These opportunities are very important in the daily routine professional work, since the one who works in this sphere almost every day or adds new information to the previous material (recording the data into a table), or makes the alphabet lists of species (by sorting), or output all species of one genus (by filtering), and etc.

Thus, according to the purpose of the work the detailed examination of various ways of ISs with databases design were done, as well as appeared errors were examined. Peculiarities of biological objects which should be taken into account during database design were analyzed as well. Also, the methods for electronic collections with DB of biological

Table 1. **Example of fragment of the Table "Insects"**

P.key	Insect name	Area of inhabitance	Biotopes	Feeding plants	Number of generations per season	Periods of fly	Data of collections	References	Commentary	Other

Table 2. **Example of fragment of the Table "Altitude"**

P.key	Altitude (meters above sea level)	Biotopes	Data of collections	Commentary	Other

Table 3. **Example of fragment of the Table "Adaptation characteristics"**

P.key	Number of insects collected per day	Number of insects collected per season	Changes in behavior	Color changes	Changes in wings' patterns	Commentary	Other

organisms' elaboration were analyzed; as well as appropriate algorithms (Fig. 6) were developed. In our studyings the algorithms for environmental conservation were analyzed and compared with some foreign analogs in order to study positive and negative experiences. The requirements for database with information about the moths were formulated for the development of electronic information system which we called "Ecological Information System" — "EcoIS". The description of the developed relational database with information about insect with the analysis of selected object area were suggested, taking into account the characteristics of biological objects and characteristics of IS analogues. Recommendations for the construction of DBs with information about living organisms basing on our experience were done as well.

In present article we also wrote briefly the information about our developed electronic network system with database about *Noctuidae* — "EcoIS". We reviewed the theoretical basis of "EcoIS" and did a brief analysis of the process of this system development. After the elaboration of databases with information about *Noctuidae* (*Lepidoptera*), the data from it could be used for many purposes. One of the most important, from the point of view of economy, areas of further application of these data is the development of a network system

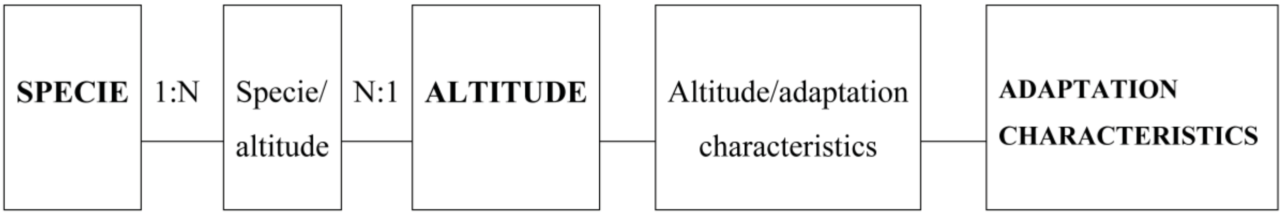

Fig. 5. **Logical model of DB about adaptation characteristics of insects in highlands**

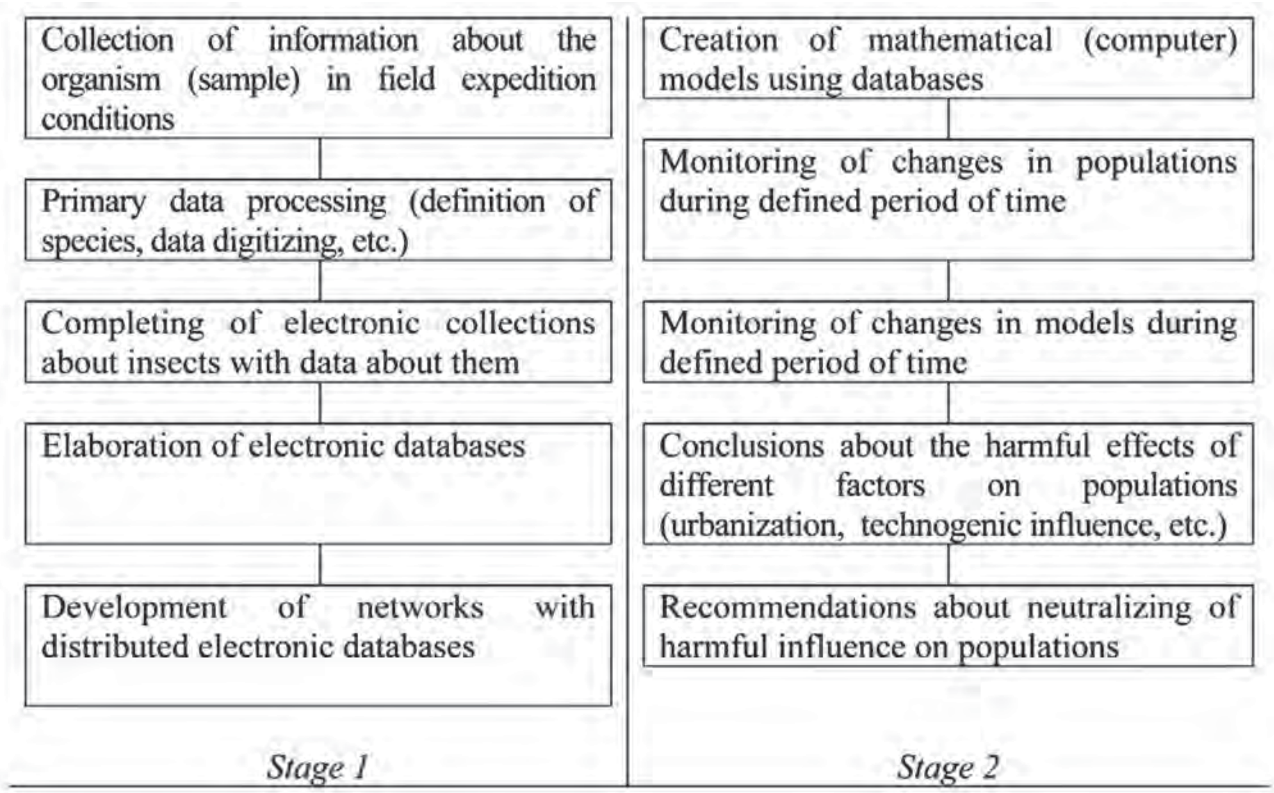

Fig. 6. **Two stages of ecomonitoring data processing using DB construction:**
Stage 1 — construction of CBO and electronic DB; *Stage 2* — monitoring of populations and areas of the species using the DB based models

for environmental monitoring of fauna at industrial regions of Ukraine. "EcoIS" there makes it possible to monitor harmful effects of industrial pollution on the population using *Noctuidae (Lepidoptera) as* good bioindicator. Besides of this, there are many pests of forest and crops among *Noctuidae*, and the practice shows that the spreading of such pests has to be monitored in order to prevent their mass reproduction and subsequent destruction of environment. In general, the use of the developed technical IS with DBs "EcoIS" is aimed on ecological monitoring of insect fauna of Ukraine, first of all, on eco-monitoring of bioindicator fauna (*Noctuidae, Lepidoptera*) for the purpose of better nature conservation and for the prevention of crops losses in agriculture, well as for minimization of risks for people health and lives in industrial polluted areas.

REFERENCES

1. *Klyuchko O. M.* Information and computer technologies in biology and medicine. *Kyiv: Nat. Acad. Scienc. Ukraine-druk*. 2008, 252 p. (In Ukrainian).
2. *Piatigorsky B. Ya., Zaitman G. A., Cherkasky V. L., Chinarov V. A.* Automatic electrophysiological experiment. *Kyiv: Nauk. dumka*. 1985, 216 p. (In Russian).
3. *Klyuchko O. M.* On the mathematical methods in biology and medicine. *Biotechnol. acta*. 2017, 10 (3), 31–40. https://doi.org/10.15407/biotech10.03.031
4. *Klyuchko O. M.* Application of artificial neural networks method in biotechnology. *Biotechnol. acta*. 2017, 10 (4), 5–13. https://doi.org/10.15407/biotech10.04.005
5. *Klyuchko O. M.* Cluster analysis in biotechnology. *Biotechnol. acta*. 2017, 10 (5), 5–18. https://doi.org/10.15407/biotech10.05.005
6. *Klyuchko O. M.* Technologies of brain images processing. *Biotechnol. acta*. 2017, 10 (6), 5–17. https://doi.org/10.15407/biotech10.05.005
7. *Klyuchko O. M., Onopchuk Yu. M.* Some trends in mathematical modeling for biotechnology. *Biotechnol. acta*. 2018, 11 (1), 39–57. https://doi.org/10.15407/biotech11.01.039
8. *Klyuchko O. M.* Electronic information systems in biotechnology. *Biotechnol. acta.* 2018, 11 (2), 5–22. https://doi.org/10.15407/biotech11.02.005
9. *Klyuchko O. M.* Information computer technologies for biotechnology: electronic medical information systems. *Biotechnol. acta.* 2018, 11 (3), 5–26. https://doi.org/10.15407/biotech11.03.005
10. *Schnase J. L., Cushing J., Frame M.* Information technology challenges of biodiversity and ecosystems informatics. *Inform. syst*. 2003, 28 (4), 339–345.
11. *Rana B. K., Insel P. A.* G-protein-coupled receptor websites. *Trend. Pharmacol. Sci.* 2002, 23 (11), 535–536. https://dx.doi.org/10.1016/S0165-6147(02)02113-2
12. *Patent* 1370136 USSR, МКИ C12N 5/00. The method for dissociation of hippocampal cells. *Klyuchko E. M., Tzyndrenko A. Ya*. Priority: 31. 01. 1986; Issued: 30. 01. 1988, Bull. N 4, 3 p.
13. *Hardy P. B., Sparks T. H., Isaak N. J.* Specialism for larval and adult consumer resources among Brittish butterflies: implications for conservation. *Biol. Conserv.* 2007, 138 (3–4), 440–452.
14. *Dennis R. L. H., Shreeve T. G., Sparks T. H.* A comparison of geographical and neighbourhood models for improving atlas databases. The case of the French butterfly atlas. *Biol. Conserv.* 2002, 108 (2), 143–159.
15. *Klyuchko O. M., Paskivsky A. O., Sheremet D. Y.* Computer modeling of some nanoelements for radio and television systems. *Electr. Contr. Syst.* 2012, 3 (33), 102–107. (In Ukrainian).
16. *Klyuchko O. M., Hayrutdinov R. R.* Modeling of electrical signals propagation in neurons and its nanostructures. *Electr. Contr. Syst.* 2011, 2 (28), 120–124. (In Ukrainian).
17. *Trinus K. F., Klyuchko E. M.* Mediators influence on motoneurons retrogradly marked by primulin. *Physiol. J.* 1984, 30 (6), 730–733. (In Russian).
18. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Algorithmic and program support for optimization of interval hypoxic training modes selection of pilots. *Electr. Contr. Syst*. 2017, 2 (52), 85–93.
19. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Mathematic and program models for investigation of reliability of operator professional activity in "Human-Machine" systems. *Electr. Contr. Syst.* 2017, 1 (51), 105–113.
20. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Mathematical model for research of organism restoring for operators of continuously interacted systems. *Electr. Contr. Syst*. 2016, 3 (49), 100–105.
21. *Aralova N. I., Klyuchko O. M., Mashkin V. I., Mashkina I. V.* Investigation of reliability of operators work at fluctuating temperature conditions. *Electr. Contr. Syst.* 2016, 2 (48), 132–139.
22. *Plakhotnij S. A., Klyuchko O. M., Krotinova M. V.* Information support for automatic industrial environment monitoring systems. *Electr. Contr. Syst*. 2016, 1 (47), 19–34.

23. *Onopchuk Yu. M., Aralova N. I., Klyuchko O. M., Beloshitsky P. V.* Mathematic models and integral estimation of organism systems reliability in extreme conditions. *Electr. Contr. Syst*. 2015, 4 (46), 109–115.
24. *Onopchuk Yu. M., Aralova N. I., Klyuchko O. M., Beloshitsky P. V.* Integral estimations of human reliability and working capacity in sports wrestling. *J. Engin. Acad*. 2015, 3, 145–148. (In Russian).
25. *Klyuchko O. M., Shutko V. N., Navrotskyi D. O., Mikolushko A. M.* The set of program models for ecological monitoring technical system based on principles of biophysics. *Electr. Contr. Syst.* 2014, 4 (42), 135–142.
26. *Klyuchko O. M., Sheremet D. Yu.* Computer simulation of biological nanogenerator functions. *Electr. Contr. Syst.* 2014, 2 (40), 103–111.
27. *Klyuchko O. M., Shutko V. N.* Computer modeling of auto-oscillating phenomena in neuron complexes. *Electr. Contr. Syst.* 2014, 1 (39), 127–132.
28. *Klyuchko O. M., Sheremet D. Yu.* Computer modeling of biologic voltage-activated nanostructures. *Electr. Contr. Syst*. 2014, 1 (39), 133–139.
29. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu. M.* Radiation damage of organism and its correction in conditions of adaptation to highmountain meteorological factors. *Bull. NASU*. 2010, N. 1, P. 224–231. (In Ukrainian).
30. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu., Makarenko M. V.* Estimation of psycho-physiological functions of a person and operator work in extreme conditions. *Bull. NASU*. 2009, N 3, P. 96–104. (In Ukrainian).
31. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu., Kolchinska A. Z.* Results of research of higher nervous activity problems by Ukrainian scientists in Prielbrussie. *Bull. NASU*. 2009, N 2, P. 105–112. (In Ukrainian).
32. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu*. Results of research of structural and functional interdependencies by Ukrainian scientists in Prielbrussie. *Bull. NASU*. 2009, N 1, P. 61–67. (In Ukrainian).
33. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of highlands factors influence on health and longevity by Ukrainian scientists in Prielbrussie. *Bull. NASU*. 2008, N 4, P. 108–117. (In Ukrainian).
34. *Onopchuk Yu. M., Klyuchko O. M., Beloshitsky P. V.* Development of mathematical models basing on researches of Ukrainian scientists at Elbrus. *Bull. NASU*. 2008, N 3, P. 146–155. (In Ukrainian).
35. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of adaptation problems by Ukrainian scientists in Prielbrussie. *Bull. NASU*. 2008, N 1, P. 102–108. (In Ukrainian).
36. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu.* Results of research of hypoxia problems by Ukrainian scientists in Elbrus region. *Bull. NASU*. 2007, N 3–4, P. 44–50. (In Ukrainian).
37. *Beloshitsky P. V., Klyuchko O. M., Onopchuk Yu*. Results of medical and biological research of Ukrainian scientists at Elbrus. *Bull. NASU*. 2007, N 2, P. 10–16. (In Ukrainian).
38. *Belan P. V., Gerasimenko O. V., Tepikin A. V., Petersen O. H.* Localization of Ca++ extrusion sites in pancreatic acinar cells. *J. Biol. Chem*. 1996, 271, 7615–7619.
39. *Belan P., Gardner J., Gerasimenko O.* Extracellular Ca++ spikes due to secretory events in salivary gland cells. *J. Biol. Chem*. 1998, 273, 4106–4111.
40. *Jabs R., Pivneva T., Huttmann K.* Synaptic transmission onto hyppocampal glial cells with hGFAP promoter activity. *J. Cell Sci*. 2005, 118, 3791–3803.
41. *Linne C.* Fauna Suecica. *Stocholmiac*. 1761, 578 p.
42. *Klyuchko Z. F.* Noctuidae of the Western regions of Ukraine. *Kyiv: Kyiv Univ. Publ*. 1963, 176 p. (In Russian).
43. *Baert P., Meesen G., De Schynkel S., Poffijn A., Oostveldt P. V.* Simultaneous in situ profiling of DNA lesion endpoints based on image cytometry and a single cell database approach. *Micron*. 2005, 36 (4), 321330. https://doi.org/10.1016/j.micron.2005.01.005
44. *Berks G., Ghassemi A., von Keyserlingk D. G.* Spatial registration of digital brain atlases based on fuzzy set theory. *Comp. Med. Imag. Graph*. 2001, 25 (1), 1–10. https://doi.org/10.1016/S0895-6111(00)00038 0.
45. *Nowinski W. L., Belov D.* The Cerefy Neuroradiology Atlas: a Talairach–Tournoux atlas-based tool for analysis of neuroimages available over the internet. *NeuroImage.* 2003, 20 (1), 50–57. https://doi.org/10.1016/S1053-8119(03)00252-0
46. *Chaplot S., Patnaik L. M., Jagannathan N. R.* Classification of magnetic resonance brain images using wavelets as input to support vector machine and neural network. *Biomed. Signal Proc. Contr*. 2006, 1 (1), 86–92. https://doi.org/10.1016/j.bspc.2006.05.002
47. *Kovalev V. A., Petrou M., Suckling J.* Detection of structural differences between the brains of schizophrenic patients and controls. *Psychiatry Research: Neuroimaging*. 2003, 124 (3), 177–189. https://doi.org/10.1016/S0925-4927(03)00070-2

48. *Araújo T.* Classification of breast cancer histology images using Convolutional Neural Networks. *PloS One.* 2017, 12 (6), e0177544.
49. *Vecht-Lifshitz S. E., Ison A. P.* Biotechnological applications of image analysis: present and future prospects. *J. Biotechnol.* 1992, 23 (1), 1–18.
50. *Toga A. W., Thompson P. M.* The role of image registration in brain mapping. *Image Vis. Comput.* 2001, 19 (1–2), 3–24.
51. *Carro S. A., Scharcanski J.* A framework for medical visual information exchange on the WEB. *Comput. Biol. Med.* 2006, 4, 327–338.
52. *Chakravarty M. M., Bertrand G., Hodge C. P., Sadikot A. F., Collins D. L.* The creation of a brain atlas for image guided neurosurgery using serial histological data. *NeuroImage.* 2006, 30 (2), 359–376. https://doi.org/10.1016/j.neuroimage.2005.09.041
53. *Dikshit A., Wu D., Wu C., Zhao W.* An online interactive simulation system for medical imaging education. *Comp. Med. Imag. Graph.* 2005, 29 (6), 395–404. https://doi.org/10.1016/j.compmedimag.2005.02.001
54. *Singh R., Schwarz N., Taesombut N., Lee D., Jeong B., Renambot L., Lin A. W., West R., Otsuka H., Naito S., Peltier S. T., Martone M. E., Nozaki K., Leigh J., Ellisman M. H.* Real-time multi-scale brain data acquisition, assembly, and analysis using an end-to-end. *OptIPuter Fut. Gener. Comput. Syst.* 2006, 22, 1032–1039.
55. *Stefanescu R., Pennec X., Ayache N.* Grid powered nonlinear image registration with locally adaptive regularization. *Med. Image Anal.* 2004, 8 (3), 325–342.
56. *Ma Y., Hof P. R., Grant S. C., Blackband S. J., Bennett R., Slatest L., McGuigan M. D., Benveniste H.* A three-dimensional digital atlas database of the adult C57BL/6J mouse brain by magnetic resonance microscopy. *Neuroscience.* 2005, 135 (4), 1203–1215. https://doi.org/10.1016/j.neuroscience.2005.07.014
57. *Yu-Len Huang.* Computer-aided Diagnosis Using Neural Networks and Support Vector Machines for Breast Ultrasonography. *J. Med. Ultrasound.* 2009, 17 (1), 17–24.
58. *Prachi Damodhar Shahare, Ram Nivas Giri.* Comparative Analysis of Artificial Neural Network and Support Vector Machine Classification for Breast Cancer Detection. *Int. Res. J. Engin. Technol. (IRJET).* 2015, 2 (9).
59. *Natrajan R., Sailem H., Mardakheh F. K., Garcia M. F., Tape C. G., Dowsett M., Bakal C., Yuan Y.* Microenvironmental heterogeneity parallels breast cancer progression: a histology–genomic integration analysis. *PLoS Med.* 2016, 13 (2), e1001961. https://doi.org/10.1371/journal.pmed.1001961
60. *Klyuchko O. M.* Brain images in information systems for neurosurgery and neurophysiology. *Electr. Contr. Syst.* 2009, 3 (21), 152–156. (In Ukrainian).
61. *Klyuchko O. M.* Using of images' databases for diagnostics of pathological changes in organism tissues. *Electr. Contr. Syst.* 2009, 2 (20), 62–68. (In Ukrainian).
62. *Klyuchko O. M.* Elements of different level organization of the brain as material for electronic databases with images. *Electr. Contr. Syst.* 2009, 1 (19), 69–75. (In Ukrainian).
63. *Steimann F.* On the representation of roles in object-oriented and conceptual modelling. *Data Know. Engin.* 2000, 35 (1), 83–106.
64. *Klyuchko O. M., Managadze Yu. L., Pashkivsky A. O.* Program models of 2D neuronal matrix for ecological monitoring and images' coding. *Bull. NASU.* 2013, N 3–4, P. 77–82. (In Ukrainian).
65. *Klyuchko O. M., Piatchanina T. V., Mazur M. G.* Combined use of relation databases of images for diagnostics, therapy and prognosis of oncology diseases. "*Integrated robototechnic complexes*". *X IIRTC-2017 Conference Proceedings.* 2017, 275–276. (In Ukrainian).
66. *Shutko V. M., Shutko O. M., Kolganova O. O.* Methods and means of compression of information. *Kyiv: Nauk. dumka.* 2012, 168 p. (In Ukrainian).
67. *Jecheva V., Nikolova E.* Some clusteringbased methodology applications to anomaly intrusion detection systems. *Int. J. Secur. Appl.* 2016, 10 (1), 215–228. http://dx.doi.org/10.14257/ijsia.2016.10.1.20.
68. *Iakovidis D. K., Maroulis D. E., Karkanis S. A.* Texture multichannel measurements for cancer precursors' identification using support vector machines. *Measurement.* 2004, 36, 297–313. https://doi.org/10.1016/j.measurement
69. *Nguyen H. Q., Carrieri-Kohlman V., Rankin S. H., Slaughter R, Stulbarg M. S.* Internet-based patient education and support interventions: a review of evaluation studies and directions for future research. *Comp. Biol. Med.* 2004, 34 (2), 95–112. https://doi.org/10.1016/S0010-4825(03)00046-5
70. *Jézéquel P., Loussouarn L., Guérin-Charbonnel C., Campion L., Vanier A., Gouraud W., Lasla H., Guette C., Valo I., Verrièle V. Campone M.* Gene-expression molecular subtyping of triple-negative breast cancer tumours: importance of immune response. *Breast Cancer Res.* 2015, 17 (1), 43. https://doi.org/10.1186/s13058-015-0550-y
71. *Bozhenko V. K.* Multivariable analysis of laboratory blood parameters for obtaining diagnostic information in experimental and clinical oncology. The dissertation author's abstract on scientific degree editions. *Dc. Med. Study. Moscow.* 2004. (In Russian).

72. *Ko J. H., Ko E. A., Gu W., Lim I., Bang H., Zhou T.* Expression profiling of ion channel genes predicts clinical outcome in breast cancer. *Mol. Cancer*. 2013, 12 (1), 106. https://doi.org/10.1186/1476-4598-12-106
73. *Kawai M., Nakashima A., Kamada S., Kikkawa U.* Midostaurin preferentially attenuates proliferation of triple-negative breast cancer cell lines through inhibition of Aurora kinase family. *J. Biomed. Sci*. 2015, 22 (1), 48. https://doi.org/10.1186/s12929-015-0150-2
74. *Uhr K., Wendy J. C., Prager-van der Smissen, Anouk A. J. Heine, Bahar Ozturk, Marcel Smid, Hinrich W. H. Göhlmann, Agnes Jager, John A. Foekens, John W. M. Martens.* Understanding drugs in breast cancer through drug sensitivity screening. *SpringerPlus*. 2015, 4(1), 611. https://doi.org/10.1186/s40064-015-1406-8
75. *Onopchuk Yu. M., Biloshitsky P. V., Klyuchko O. M.* Development of mathematical models based on the results of researches of Ukrainian scientists at Elbrus. *Bull. NASU*. 2008, N 3, P. 146–155. (In Ukrainian).
76. *Ankur Poudel, Dhruba Bahadur Thapa, Manoj Sapkota*. Cluster Analysis of Wheat (Triticum aestivum L.) Genotypes Based Upon Response to Terminal Heat Stress. *Int. J. Appl. Sci. Biotechnol*. 2017, 5 (2), 188–193. https://dx.doi.org/10.3126/ijasbt.v5i2.17614
77. *Zaslavsky L., Ciufo S., Fedorov B., Tatusova T.* Clustering analysis of proteins from microbial genomes at multiple levels of resolution. *BMC Bioinform*. 2016, 17 (8), 276. Published online 2016 Aug 31. https://doi.org/10.1186/s12859-016-1112-8
78. *Zhou J., Richardson A. J., Rudd K. E.* EcoGene-RefSeq: EcoGene tools applied to the RefSeq prokaryotic genomes. *Bioinformatics*. 2013, 29 (15), 1917–1918. Published: 04 June 2013. https://doi.org/10.1093/bioinformatics/btt302
79. *Zhang J., Wu G., Hu X., Li S., Hao S.* A Parallel Clustering Algorithm with MPI — MKmeans. *J. Comput*. 2013, 8 (1), 1017. https://doi.org/10.1109/PAAP.2011.17
80. *Tatusova T., Zaslavsky L., Fedorov B., Haddad D., Vatsan A., Ako-adjei D., Blinkova O., Ghazal H*. Protein Clusters. *The NCBI Handbook [Internet]. 2nd edition*. Available at www.ncbi.nlm.nih.gov/books/NBK242632
81. *Anderson J. G.* Evaluation in health informatics: computer simulation. *Comput. Biol. Med.* 2002, 32 (3), 151–164. https://doi.org/10.1016/S0010-4825(02)00012-4
82. *Aruna P., Puviarasan N., Palaniappan B.* An investigation of neuro-fuzzy systems in psychosomatic disorders. *Exp. Syst. Appl*. 2005, 28 (4), 673–679. https://doi.org/10.1016/j.eswa.2004.12.024
83. *Bange M. P., Deutscher S. A., Larsen D., Linsley D., Whiteside S.* A handheld decision support system to facilitate improved insect pest management in Australian cotton systems. *Comp. Electron. Agricult*. 2004, 43 (2), 131–147. https://doi.org/10.1016/j.compag.2003.12.003
84. *Beaulieu A.* From brainbank to database: the informational turn in the study of the brain. *Stud. Hist. Phil. Biol. Biomed. Sci.* 2004, 35, 367–390. https://doi.org/10.1016/j.shpsc.2004.03.011
85. *Horn W.* AI in medicine on its way from knowledge-intensive to data-intensive systems. *Artif. Intell. Med. Elsevier.* 2001, 23 (1), 512. https://doi.org/10.1016/S0933-3657(01)00072-0
86. *Brake I.* Unifying revisionary taxonomy: insect exemplar groups. *Abstr. XV SEL Congr. Berlin (Germany)*. 2007.
87. *Braxton S. M., Onstad D. W., Dockter D. E., Giordano R., Larsson R., Humber R. A.* Description and analysis of two internet-based databases of insect pathogens: EDWIP and VIDIL. *J. Invertebr. Pathol*. 2003, 83 (3), 185–195. https://doi.org/10.1016/S0022-2011(03)00089-2
88. *Breaux A., Cochrane S., Evens J., Martindaled M., Pavlike B., Suera L., Benner D.* Wetland ecological and compliance assessments in the San Francisco Bay Region, California, USA. *J. Environm. Manag*. 2005, 74 (3), 217–237.
89. *Budura A., Cudré-Mauroux P., Aberer K.* From bioinformatic web portals to semantically integrated Data Grid networks. *Fut. Gener. Comput. Syst*. 2007, 23 (3), 281–522. https://doi.org/10.1016/j.jenvman.2004.08.017
90. *Burns G., Stephan K. E., Ludäscher B., Gupta A., Kötter R.* Towards a federated neuroscientific knowledge management system using brain atlases. *Neurocomputing*. 2001, 3840, 1633–1641. https://doi.org/10.1016/S0925-2312(01)00520-3
91. *Butenko S., Wilhelm W. E.* Clique-detection models in computational biochemistry and genomics. *Eur. J. Oper. Res.* 2006, 173 (1), 117. https://doi.org/10.1016/j.ejor.2005.05.026
92. *Carro S. A., Scharcanski J.* Framework for medical visual information exchange on the WEB. *Comp. Biol. Med.* 2006, 36 (4), 327–338. https://doi.org/10.1016/j.compbiomed.2004.10.004
93. *Chau M., Huang Z., Qin J., Zhou Y., Chen H.* Building a scientific knowledge web portal: The NanoPort experience. *Dec. Sup. Syst*. 2006. https://doi.org/10.1016/j.dss.2006.01.004

94. *Chen M., Hofestädt R.* A medical bioinformatics approach for metabolic disorders: Biomedical data prediction, modeling, and systematic analysis. *J. Biomed. Inform.* 2006, 39 (2), 147–159. https://doi.org/10.1016/j.jbi.2005.05.005
95. *Chli M., De Wilde P.* Internet search: Subdivision-based interactive query expansion and the soft semantic web. *Appl. Soft Comput.* 2006. https://doi.org/10.1016/j.asoc.2005.11.003
96. *Despont-Gros C., Mueller H., Lovis C.* Evaluating user interactions with clinical information systems: A model based on human — computer interaction models. *J. Biomed. Inform.* 2005, 38 (3), 244–255. https://doi.org/10.1016/j.jbi.2004.12.004
97. *Marios D., Dikaiakos M. D.* Intermediary infrastructures for the World Wide Web. *Comp. Networks.* 2004, 45, 421–447. https://doi.org/10.1016/j.comnet.2004.02.008
98. *Dimitrov S. D., Mekenyan O. G., Sinks G. D., Schultz T. W.* Global modeling of narcotic chemicals: ciliate and fish toxicity. *J. Mol. Struc.: Theochem.* 2003, 622 (12), 63–70. https://doi.org/10.1016/S0166-1280(02)00618-8
99. *Dong Y., Zhuang Y., Chen K., Tai X.* A hierarchical clustering algorithm based on fuzzy graph connectedness. *Fuzzy Sets. Syst.* 2006, 157, 1760–1774. https://doi.org/10.1016/j.fss.2006.01.001
100. *Duan Y., Edwards J. S., Xu M. X.* Web-based expert systems: benefits and challenges. *Inf. Manag.* 2005, 42 (6), 799–811. https://doi.org/10.1016/j.im.2004.08.005
101. *Essen van D. C.* Windows on the brain: the emerging role of atlases and databases in neuroscience. *Curr. Opin. Neurobiol.* 2002, 12 (5), 574–579. https://doi.org/10.1016/S0959-4388(02)00361-6
102. *Fellbaum C., Hahn U., Smith B.* Towards new information resources for public health From Word Net to Medical Word Net. *J. Biomed. Inform.* 2006, 39 (3), 321–332. https://doi.org/10.1016/j.jbi.2005.09.004
103. *Ferraris M., Frixione P., Squarcia S.* Network oriented radiological and medical archive. *Comp. Physics Commun.* 2001, 140, 226–232. https://doi.org/10.1016/S0010-4655(01)00273-9
104. *Flower D. R., Attwood T. K.* Integrative bioinformatics for functional genome annotation: trawling for G protein-coupled receptors. Reviews 55 Semin. *Cell. Dev. Biol.* 2004, 15 (6), 693–701. https://doi.org/10.1016/j.semcdb.2004.09.008
105. *Fink E., Kokku P. K., Nikiforou S., Hall L. O., Goldgof D. B., Krischer J. P.* Selection of patients for clinical trials: an interactive webbased system. *Art. Intell. Med.* 2004, 31 (3), 241–254. https://doi.org/10.1016/j.artmed.2004.01.017
106. *Fitzpatrick M. J., Ben-Shahar Y., Smid H. M., Vet L. E., Robinson G. E., Sokolowski M. B.* Candidate genes for behavioural ecology. *Trend Ecol. Evol.* 2005, 20 (2), 96–104. https://doi.org/10.1016/j.tree.2004.11.017
107. *Fox J., Alabassi A., Patkar V., Rose T., Black E.* An ontological approach to modelling tasks and goals. *Comp. Biol. Med.* 2006, 36, 837–856. https://doi.org/10.1016/j.compbiomed.2005.04.011
108. *Fu Zetian, Xu Feng, Zhou Yun, Shuan X. Z.* Pig-vet: a web-based expert system for pig disease diagnosis. 2006. https://doi.org/10.1016/j.eswa.2005.01.011
109. *Gaulton A., Attwood T. K.* Bioinformatics approaches for the classification of G-protein-coupled receptors. *Curr. Opin. Pharmacol.* 2003, 3 (2), 114–120. https://doi.org/10.1016/S1471-4892(03)00005-5
110. *Palla K., Ghahramani Z., Knowles D. A.* A nonparametric variable clustering model. *Adv. Neur. Inform. Proc. Syst.* 2012, 2987–2995.
111. *Curtis C. Sohrab P. Shah, Suet-Feung Chin, Gulisa Turashvili, Oscar M. Rueda, Mark J. Dunning, Doug Speed, Andy G. Lynch, Shamith Samarajiwa, Yinyin Yuan, Stefan Gräf, Gavin Ha, Gholamreza Haffari, Ali Bashashati, Roslin Russell, Steven McKinney, METABRIC Group, Anita Langerød, Andrew Green, Elena Provenzano, Gordon Wishart, Sarah Pinder, Peter Watson, Florian Markowetz, Leigh Murphy, Ian Ellis, Arnie Purushotham, Anne-Lise Børresen-Dale, James D. Brenton, Simon Tavaré, Carlos Caldas, Samuel Aparicio* The genomic and transcriptomic architecture of 2,000 breast tumours reveals novel subgroups. *Nature.* 2012, 486 (7403), 346–352.
112. *Proceedings.* Of the second EuroLOOP Workshop, Amsterdam, 27–30 March 1995.
113. *Graham C. H., Ferrier S., Huettman F., Moritz C., Peterson A. T.* New developments in museum-based informatics and applications in biodiversity analysis. *Trend. Ecol. Evol.* 2004, 19 (9), 497–503. https://doi.org/10.1016/j.tree.2004.07.006
114. *Anokhin B., Hemmrich G.* Zoology www guide. *Zoology.* 2005, 108 (4), 673–679.
115. *Hirano S., Sun X., Tsumoto S.* Comparison of clustering methods for clinical databases. *Inform. Sci.* 2004, 159 (34), 155–165. https://doi.org/10.1016/j.ins.2003.03.011
116. *Hong Yu., Hatzivassiloglou V., Rzhetsky A., Wilbur W. J.* Automatically identifying gene/ protein terms in MEDLINE abstracts. *J. Biomed. Inform.* 2002, 35 (56), 322–330. https://doi.org/10.1016/S1532-0464(03)00032-7

117. *Bedathur S. J., Haritsa J. R., Sen U. S.* The building of BODHI, a bio-diversity database system. *Inform. Syst.* 2003, 28 (4), 347–367. https://doi.org/10.1016/S0306-4379(02)00073-X
118. *Hsi-Chieh Lee, Szu-Wei Huang, Li E. Y.* Mining protein–protein interaction information on the internet. *Exp. Syst. Appl. Elsevier.* 2006, 30 (1), 142–148. https://doi.org/10.1016/j.eswa.2005.09.083
119. *Young R.* Genetic toxicology: web-resources. *Toxicology.* 2002, 173 (1–2), 103–121.
120. *Johnson S. B., Friedman R.* Bridging the gap between biological and clinical informatics in a graduate training program. *J. Biomed. Inform.* 2007, 40 (1), 59–66. Epub. 2006 Mar 15. https://doi.org/10.1016/j.jbi.2006.02.011
121. *Kaiser M., Hilgetag C. C.* Modelling the development of cortical systems networks. *Neurocomputing.* 2004, 5860, 297–302. https://doi.org/10.1016/j.neucom.2004.01.059
122. *Kane M. D., Brewer J. L.* An information technology emphasis in biomedical informatics education. *J. Biomed. Inform.* 2007, 40 (1), 67–72. https://doi.org/10.1016/j.jbi.2006.02.006
123. *Kannathal N., Acharya U. R., Lim C. M., Sadasivan P. K.* Characterization of EEG. A comparative study. *Comp. Meth. Progr. Biomed.* 2005, 80 (1), 17–23. https://doi.org/10.1016/j.cmpb.2005.06.005
124. *Koh W., McCormick B. H.* Brain microstructure database system: an exoskeleton to 3D reconstruction and modelling. *Neurocomputing.* 2002, 4446, 1099–1105. https://doi.org/10.1016/S0925-2312(02)00426-5
125. *Koh W., McCormick B. H.* Registration of a 3D mouse brain atlas with brain microstructure data. *Neurocomputing.* 2003, 5254, 307–312. https://doi.org/10.1016/S0925-2312(02)00793-2
126. *Kulish V., Sourin A., Sourina O.* Human electro encephalograms seen as fractal time series: Mathematical analysis and visualization. *Comp. Biol. Med.* 2006, 36 (3), 291–302. https://doi.org/10.1016/j.compbiomed.2004.12.003
127. *Lubitz von D., Wickramasinghe N.* Networkcentric healthcare and bioinformatics: Unified operations within three domains of knowledge. *Exp. Syst. Appl.* 2006, 30 (1), 11–23. https://doi.org/10.1016/j.eswa.2005.09.069
128. *Martin-Sanchez F., Iakovidis I., Norager S., Maojo V., de Groen P., Van der Lei J., Jones T., Abraham-Fuchs K., Apweiler R., Babic A., Baud R., Breton V., Cinquin P., Doupi P., Dugas M., Eils R., Engelbrecht R., Ghazal P., Jehenson P., Kulikowski C., Lampe K., De Moor G., Orphanoudakis S., Rossing N., Sarachan B., Sousa A., Spekowius G., Thireos G., Zahlmann G., Zvárová J., Hermosilla I., Vicente F. J.* Synergy between medical informatics and bioinformatics: facilitating genomic medicine for future health care. *J. Biomed. Inform.* 2004, 37 (1), 30–42. https://doi.org/10.1016/j.jbi.2003.09.003
129. *Masseroli M., Visconti A., Bano S. G., Pinciroli F.* He@lthCo-op: a web-based system to support distributed healthcare co-operative work. *Comp. Biol. Med.* 2006, 36 (2), 109–127. https://doi.org/10.1016/j.compbiomed.2004.09.005
130. *Moon S., Byun Y., Han K.* FSDB: A frameshift signal database. *Comp. Biol. Chem.* 2007, 31 (4), 298–302. https://doi.org/10.1016/j.compbiolchem.2007.05.004
131. *Orgun B., Vu J.* HL7 ontology and mobile agents for interoperability in heterogeneous medical information systems. *Comp. Biol. Med.* 2006, 36 (78), 817–836. https://doi.org/10.1016/j.compbiomed.2005.04.010
132. *Pérez-Rey D., Maojo V., García-Remesal M., Alonso-Calvo R., Billhardt H., Martin-Sánchez F., Sousa A.* Ontofusion: Ontology-based integration of genomic and clinical databases. *Comp. Biol. Med.* 2006, 36 (78), 712–730. https://doi.org/10.1016/j.compbiomed.2005.02.004
133. *Krishtal O. A., Kiskin N. I., Tsyndrenko A. Ya., Klyuchko E. M.* Pharmacological properties of amino acid receptors in isolated hippocampal neurons. *In: Receptors and ion channels. Ed. By Ovchinnikov Y. A., Hucho F. Berlin-New York: Walter de Gruyter.* 1987, P. 127–137.
134. *Klyuchko E. M., Klyuchko Z. F., Beloshitsky P. V.* Some adaptation characteristics of insects in mountains of Prielbrussie. *Nalchik (Russia), "Hypoxia: automatic analysis of hypoxic states of healthy people and sick ones"*. 2005, 1, 137–140. (In Russian).
135. *Klyuchko Z. F., Klyuchko E. M.* Analysis of taxonomic structure of moth fauna (Lepidoptera: Noctuidae s.l.) of Ukraine according to monitoring data. *Eversmannia.* 2012, 3 (33), 41–45. (In Russian).
136. *Klyuchko Z. F., Klyuchko E. M.* Moth (Lepidoptera: Noctuidae s. l.) of Chercasska region of Ukraine according to results of many-year monitoring. *Eversmannia.* 2014, 37, 32–49. (In Russian).
137. *Gonchar O., Klyuchko O., Seredenko M., Oliynyk B.* Correction of metabolic disorders at hypoxia by new pharmacological preparations. *Mater. 3 FEPS Congress. Nice (France).* 2003, P. 228.
138. *Seredenko M., Gonchar O., Klyuchko O., Oliynyk S.* Peculiarities of prooxidant —

antioxidant balance of organism under hypoxia of different genesis and its corrections by new pharmacological preparations. *Acta Physiologica Hungarica. Budapest (Hungary)*. 2002, 89 (1–3), 292.

139. *Klyuchko O., Klyuchko Z., Lizunova A.* Electronic Noctuidae database: some problems and solutions. *Proceed. 16th European Congress of Lepidopterology. Cluj (Romania)*. 2009, P. 31–32.
140. *Klyuchko O., Klyuchko Z., Lizunova A.* Noctuidae fauna of Ukrainian Karpathy: results of monitoring (1956–2008). *Proceed. 16th European Congress of Lepidopterology. Cluj (Romania)*. 2009, P. 31.
141. *Klyuchko O. M., Beloshitsky P. V.* Investigation of insect adaptation characteristics in Prielbrussie in 2004–2005. *Mater. VIII World Congress of International Society for Adaptive Medicine (ISAM). Moskva (Russia)*. 2006, P. 165–166.
142. *Beloshitsky P. V., Klyuchko O. M.* Contribution of Sirotinin's school into adaptation medicine. *Mater. VIII World Congress of International Society for Adaptive Medicine (ISAM). Moskva (Russia)*. 2006, P. 158.
143. *Klyuchko O. M., Klyuchko Z. F.* Ukrainian Noctuidae Database. *Mater. Of XIV SEL Congress. Roma (Italy)*. 2005, P. 49.
144. *Klyuchko Z. F., Klyuchko O. M.* Noctuidae (Lepidoptera) of Donbass, Ukraine. *Mater. Of XIV SEL Congress. Roma (Italy)*. 2005, P. 41–42.
145. *Beloshitsky P., Klyuchko O., Onopchuck Yu., Onopchuck G.* Mathematic model for hypoxic states development for healthy people and ones with ischemic heart disease. *High altitude medicine and biology: Mater. ISMM Congress. Beijing (China)*. 2004, 5, 251.
146. *Beloshitsky P., Klyuchko O., Kostyuk O., Beloshitsky S.* Peculiarities of high mountain factors influence on organism. *High altitude medicine and biology: Mater. ISMM Congress. Beijing (China)*. 2004, 5, 250.
147. *Klyuchko O. M., Kiskin N. I., Krishtal O. A., Tsyndrenko A. Ya.* Araneidae toxins as antagonists of excitatory amino acid responses in isolated hippocampal neurons. *X School on biophysics of membrane transport. Szczyrk (Poland)*. 1990, 2, 271.
148. *Akaike N., Kawai N., Kiskin N. I., Krishtal O.A., Tsyndrenko A. Ya., Klyuchko O. M.* Spider toxin blocks excitatory amino acid responses in isolated hippocampal pyramidal neurons. *Neurosci. Lett.* 1987, 79, 326–330.
149. *Gonchar O., Klyuchko O., Beloshitsky P.* Ways of myocardial metabolic disorders correction at hypoxia by new pharmacological preparations. *High altitude medicine and biology: Mater. ISMM Congress. Beijing (China)*. 2004, 5, 249.
150. *Gonchar O., Klyuchko E., Mankovskaya I.* Role of complex nucleosides in the reversal of oxidative stress and metabolic disorders induced by acute nitrite poisoning. *Ind. J. Pharmac.* 2006, 38 (6), 414–418.
151. *Gonchar O., Klyuchko E., Seredenko M., Oliynik S.* Corrections of prooxidant — antioxidant homeostasis of organism under hypoxia of different genesis by yackton, new pharmacological preparation. *Acta Physiol. Pharmacol. Bulg.* 2003, 27, 53–58.
152. *Klyuchko O. M., Tzal-Tzalko V. I.* Elaboration of new monitoring system for Ukrainian Polissia conditions with data defence. *Bull. Engin. Acad.* 2014, V. 2, P. 239–246. (In Ukrainian).
153. *Klyuchko O. M., Piatchanina T. V., Mazur M. G., Basarak O. V.* Ontological methods in the development of biomedical information systems. *"Integrated intellectual robototechnical complexes" — "IIRTC-2018": Mater. XI Intl. Scient. Tech. Conference.* 2018, P. 270–272. (In Ukrainian).
154. *Klyuchko O. M., Piatchanina T. V., Mazur M. G., Basarak O. V.* Elaboration of network-based biomedical systems with databases. *"Integrated intellectual robototechnical complexes" — "IIRTC-2018": Mater. XI Intl. Scient. Tech. Conference.* 2018, P. 273–274. (In Ukrainian).
155. *Aralova N. I., Klyuchko O. M.* Mathematic modeling of functional self-organization of pilots' respiratory systems. *"Integrated intellectual robototechnical complexes" — "IIRTC-2018": Mater. XI Intl. Scient. Tech. Conference.* 2018, P. 268–269. (In Ukrainian).
156. *Klyuchko Z. F., Klyuchko O. M.* Moths (Lepidoptera: Noctuidae s. l.) of Cherkasska Region of Ukraine according to results of long-term monitoring. *Eversmannia*. 2014, 37, 32–49. (In Russian).
157. *Klyuchko Z. F., Klyuchko O. M.* Analysis of moth fauna taxonomic structure (Lepidoptera: Noctuidae s. l.) of Ukraine according to monitoring data. *Eversmannia*. 2014, 33 (3), 41–45. (In Russian).
158. *Klyuchko Z. F., Klyuchko O. M.* Monitoring of the diversity of Noctuidae (Lepidoptera) fauna in Ukrainian Polissia. *"Nature of Polissia: investigation and protection": Mater. Intl. Scient. Conference.* 2014, P. 498–502. (In Ukrainian).
159. *Klyuchko Z. F., Klyuchko O. M., Lizunova A. G.* Monitoring of Noctuidae fauna of Ukraine using electronic information systems. *"Nature of Polissia: investigation and*

protection": Mater. Intl. Scient. Conference. 2014, P. 261–265. (In Ukrainian).
160. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of bio-sensor test system application. *UA Patent G01N33/00, C12Q 1/02*. Priority: March 2018. *Method of application of biosensor test system*. (In Ukrainian).
161. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of application of biotechnical monitoring system with biosensor (biosensor test system). *UA Patent G01N33/00, C12Q 1/02*. Priority: March 2018. *Method of application of biotechnical monitoring system with biosensor (biosensor test system)*. (In Ukrainian).
162. *Klyuchko O. M., Biletsky A. Ya., Navrotskyi D. O.* Method of application of biotechnical monitoring system with biosensor and sub-system for optical registration. *UA Patent G01N33/00, C12Q 1/02, C12Q 1/02*. Priority: March 2018. *Method of application of biotechnical monitoring system with biosensor and subsystem of optical registration*. (In Ukrainian).

ЕЛЕКТРОННІ БАЗИ ДАНИХ ЧЛЕНИСТОНОГИХ: МЕТОДИ ТА ЗАСТОСУВАННЯ

О. М. Ключко[1], *З. Ф. Ключко*[2]

[1]Інститут експериментальної патології, онкології та радіобіології ім. Р. Є.Кавецького НАН України, Київ
[2]Інститут зоології ім. І. І. Шмальгаузена НАН України, Київ

E-mail: kelenaXX@ukr.net

Метою роботи був аналіз створення різних інформаційних систем з базами даних, а також помилок, що при цьому виникають. З'ясовано особливості біологічних об'єктів, які слід враховувати під час проектування баз даних. Описано також способи створення електронних колекцій біологічних організмів для вітчизняних потреб на основі баз даних з відповідними алгоритмами для природозбереження. Ці дані зіставлено з деякими зарубіжними аналогами з метою оцінювання позитивного та негативного досвіду. Сформульовано вимоги до баз даних з інформацією щодо нічниць-совок *Noctuidae* (*Lepidoptera*) та деяких павукоподібних *Araneidae* для розробленої нами електронної інформаційної системи «ЕкоІС». Подано опис створюваної реляційної бази даних з інформацією про комах та аналізом обраної об'єктної області, з урахуванням особливостей біологічних об'єктів і характеристик аналогів інформаційних систем. Зроблено висновки щодо нових засобів розроблення баз даних біооб'єктів та застосування їх на прикладі системи «ЕкоІС», а також наведено деякі рекомендації з конструювання баз даних з інформацією про живі організми.

Ключові слова: біоіндикатори, електронні інформаційні системи, бази даних членистоногих, бази даних комах *Noctuidae* (*Lepidoptera*), *Araneidae*.

ЭЛЕКТРОННЫЕ БАЗЫ ДАННЫХ ЧЛЕНИСТОНОГИХ: МЕТОДЫ И ПРИМЕНЕНИЕ

Е. М. Ключко[1], *З. Ф. Ключко*[2]

[1]Институт экспериментальной патологии, онкологии и радиобиологии им. Р. Е. Кавецкого НАН Украины, Киев
[2]Институт зоологии им. И. И. Шмальгаузена НАН Украины, Киев

E-mail: kelenaXX@ukr.net

Целью работы был анализ создания различных информационных систем с базами данных, а также возникающих при этом ошибок. Описаны особенности биологических объектов, которые следует учитывать при проектировании баз данных. Изложены также способы создания электронных коллекций биологических организмов для отечественных потребностей на основе баз данных с соответствующими алгоритмами для природосбережения. Эти данные сопоставлены с некоторыми зарубежными аналогами для оценки положительного и отрицательного опыта. Сформулированы требования к базам данных с информацией о бабочках *Noctuidae* (*Lepidoptera*) и некоторых паукоподобных (*Araneidae*) для разработанной нами электронной информационной системы «ЭкоИС». Приведено описание создаваемой реляционной базы данных с информацией о насекомых и анализом выбранной объектной области, с учетом особенностей биологических объектов и характеристик аналогов информационных систем. Сделаны выводы о новых средствах разработки баз данных биообъектов и их применении на примере системы «ЭкоИС», а также даны некоторые рекомендации по конструированию баз данных с информацией о живых организмах.

Ключевые слова: биоиндикаторы, электронные информационные системы, базы данных членистоногих, базы данных насекомых *Noctuidae* (*Lepidoptera*), *Araneidae*.