METHOD OF INDICATION OF SYSTEM CHANGES OF THE HABITAT UNDER THE INFLUENCE OF THE PATHOGENIC FACTOR ON THE BASIS OF THE SELF-ORGANIZATION ANALYSIS OF THE RANGE OF THE MELODY OF STRESSFUL SOUNDING OF THE BEE FAMILY

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Abstract. Pathogenic impact on the habitat of a bee family leads to a stressful state. It causes observed changes of informative qualifiers - characteristics of a melody of sounding of a beehive. For indication of changes methods of calculation of original indicators of the system organization before influence on the basis of the analysis of a range of sounding are offered. The synthesis algorithm of productional diagnostic rules based on self-organizational use of the JSM-method and allocation of informative frequency windows to the maximum of entropy is given Using changes of indicators for calculation of a measure of distinctions between states which is the carrier of function of belonging to classes, the diagnostic rule of a certain structure is projected and estimated the level of tension of the habitat on the basis of the offered scale. An example of use of characteristics of a melody of a beehive as bioindicator after processing of the site of melliferous collecting is reviewed by pesticides.

Keywords: pathogenic influence, habitat, system changes, beehive melody, indication.

Introduction

The problem of pathogenic impact of ecological factors on a state and behavior of biological systems of various hierarchical levels is permanently urgent [5, 15] as the technology of its permission makes backbone impact on quality external and automanagements of bioobjects in the habitat for the purpose of maintenance necessary for existence in the present and the future the level of life support and reproduction in the conditions of evolutionary and fluctuation and revolutionary development in time and space. In this regard, the intensification of scientific and practical researches in the field of synthesis of the universal indicators characterizing integrated influence various external on the environment of the "adjoining" dwelling and the person directly [2, 13] that is reflected in regulatory mechanisms from the state and society [1, 6, 7, 8] is observed now.

As arguments for the integrated indicators characterizing extent of impact of the environment on bioobjects are used: direct and latent indicators of anthropogenous or geocosmic or technical and chemical characters, biological indicators of genetic changes (for example, the frequency of congenital malformations – [2, 5]), different types of bioindication – for example, Balakliyets N. I. researches [11]. In the latter case, as bioindicators microorganisms or protozoa, disputes, mushrooms are used, as a rule. In difference from it, it is offered to use as the bioindicator not a bioobject, but society which in difference from an organism has the system, integrated intelligence defining purposeful activity with off-line control.

In our opinion, such society which stressful and distressful conditions can serve as the integrated indicator of adverse changes of the habitat live are communities rather element-wise of simple live organisms. Bee families concern to those. As honey bees are widespread practically on all to places of the planet where the person lives, it is simple to organize mass observation for them as reaction to changes of the habitat [4, 14]. Assuming that the sound created by a beehive has information qualities, it is possible to draw a conclusion that its spectral characteristics are qualifiers and can be used as indicators of ecological changes. Let's notice that various methods of application of the spectral characteristics published by an object acoustic (and not acoustic) noise and technology of artificial intelligence found broad application at identification of a state both technical [12], and biological objects [5, 10].

As scientific and practical researches in this direction are perspective, a research objective was development of a method of diagnostics of conditions of bees on changes of a melody of sounding of a beehive. In this case, characteristics of a melody (tone, power, speed, structure) of a bee family are considered as informative qualifiers of changes of conditions of the habitat of bees and occurring in a beehive and in out of changes. Objectively registered qualifiers are offered to be identified unambiguously on the basis of results of the classical analysis of Fourier, self-organizational modeling and binary coding of spectral functions in the frequency windows having informative classification properties – entropy maxima.

Methods of researches

Allocation of information characteristics from the acoustic signal published by a bee family for the purpose of fixing of the arising changes of a state depending on a number of ecological and internal factors belongs to "blind" processing of signals (BSP), the theory which methods and algorithms in technical and medical applied areas are presented in a number of foreign and domestic sources [12]. Features of realization of the declared research objective in the analysis of a condition of a bee family are differentiation of the state caused by pathogenic factors from not connected with those, and registration hindrances. The first feature is similar to a similar problem in medicine, the second is offered to be resolved by self-organizational allocation of several informative frequency ranges of spectral function.

The specified process is offered to be carried out on the following algorithm.

1. Registration of sound signals of a bee family. Formation of the training and control selections. Set of diagnostic frequency ranges $\{\mathrm{DFR}\} = \emptyset$. (Further stages of an algorithm if specially it is not specified, are carried out over the training selection).
2. Task in a random way the range of frequencies – df.
3. Definition of spectral characteristics of df – {SVdf}.
4. Definition of diagnostic opportunities {SVdf} by JSM [3] method with fixing of criterion of diagnostic opportunities (criterion of diagnostic opportunities - CDOdf).
5. If $\mathrm{CDOdf} \in \mathrm{tr}_{df}$, ($\mathrm{tr}_{df}$, – set by the user fashion designer the threshold range accepted for it in df, that df joins in {DFR} and transition to item 7 is carried out. Otherwise check is carried out – if process of formation {DFR} is finished, then transition to item 7, differently – transition to item 3.
6. If {DFR} significantly does not improve value of diagnostic criterion on control selection, then – transition to item 3.
7. Ordering {DFR} on increase of frequencies.
8. If restrictions for dimension {DFR} (the number of ranges), then {DFR} are used or decreases by means of an exception of ranges by the chosen criterion or increases – by transition to item 2

Remarks to an algorithm: a) in item 6 and item 8 the principle of external addition – obligatory attribute of self-organizational modeling is implemented; b) crossing, but not coincidence, the elements is allowed {DFR}.

Diagnostic rules are formed in a productional look. Certain characteristics of the allocated informative ranges of the sound frequencies – df act as arguments of conditions. Range of sound frequencies is identified by the central value and width. In each window (the central frequency of F, B width) the rated area of the spectral SF function is determined by formulas:

$$SF_a = \frac{\int_{f1}^{f2}(FS(f)df)}{B}, \qquad SF_d = \frac{\sum_{i=f1}^{f2} FS_i}{f2-f1} \quad , (1)$$

where *f1, f2* – initial and final numbers of frequencies of spectral function of a window width of *B=f2-f1, F=(f2+f1)/2* presented in analog *FS(F)* or discrete *{FSi}* forms.

The qualifier of a state is set as a vector of values of frequencies of emergence for a certain number of identical registration of a melody of a bee family in time with set by time steps (in this range Fourier's range is under construction) and, ordered by a certain rule, the codes characterizing comparison of ranges as follows. In each sound frequency range are determined the rated area of spectral function by a formula (1). The calculated values consistently are compared with each other and if the first comparable value is more than second, then on a certain place it is fixed "1", otherwise "0". Thus, the six-digit binary code turns out (if 4 ranges, generally a case – for n of ranges were used - we have n*(n-1)/2 of categories) which is convenient for representing in an octal code. For example, the octal 23 code corresponds binary "00100011" that means excess SF_d in the ranges of sound frequencies (on increase) — the first and second over the fourth and third over the fourth. The similar analysis is carried out on a signal range for 1 sec. More detailed the method of coding and use of a cyclic code of Gray is considered in works [9, 10].

Thus, the offered method is based not on the amplitude analysis of a range of noise of a bee family which is its individual integrated characteristic, and the comparative analysis of system changes of characteristics of a melody of a bee family in the informative ranges. The example is given in Table 1.

Table 1. Frequencies of emergence codes of comparison ranges of sound frequency ranges

Code k	*00*	*04*	*01*	*06*	*03*	*07*	*10*	*14*	*21*	*46*	*23*	*47*
p_k frequency	0	0,0104	0,0083	0,125	0,2125	0,2083	0,0021	0	0,0042	0,0354	0,0313	0,0833
Code k	*30*	*54*	*31*	*56*	*63*	*67*	*70*	*74*	*71*	*76*	*73*	*77*
frequency P_k	0	0	0,0125	0,0729	0,0333	0,0458	0	0	0	0,0063	0,0417	0,0667

Between the melodies of a bee family modulated by its stressful states which resulted from changes of an ecological situation it is offered to apply the following algorithm to definition of statistically significant distinctions:

1. For each code in various classes states confidential intervals of frequencies of loss on which the codes having classification potential at pair comparison of distances selektirutsya are defined.
2. By the chosen codes the discriminant function $(Y(p))$on the training selection is identified, and on examination thresholds of its values for decisive rules and the confidence coefficients equal to values of diagnostic spetsifichnost in each class k of conditions of bee families - $K1_k$ are defined
3. Values of indicators of the system organization (indicators of the system organization – ISOas, ISOex) (semantic analogs of asymmetry and an excess) are determined by formulas:

$$\mathrm{ISOas} = \frac{\sum_{i=1}^{Qr}(p_i - \bar{p})^3}{Qr \cdot \sigma^3}, \quad \mathrm{ISOex} = \frac{\sum_{i=1}^{Qr}(p_i - \bar{p})^4}{Qr \cdot \sigma^4}, \quad (2)$$

here: Qr – the number of realization of comparisons (in this case: $Qr = 8$; $\sigma 2$, $\bar{p}$ – dispersion and an average of frequencies of emergence, respectively, in a basic, standard state.

4. Function of accessory $K2_k$ on the carrier is based:

$$dISO_k^2 = (\mathrm{ISOas}_k - \mathrm{ISOas}_0)^2 + (\mathrm{ISOex}_k - \mathrm{ISOex}_0)^2, \qquad (3)$$

(the index k – corresponds to k-ohm to a condition of a bee family during ecological changes, 0 – to, i.e., "norm") which is distance between conditions of a bee family on the plane: $\mathrm{ISOas} \times \mathrm{ISOex}$.Functions $K2_k(dISO^2)$ are defined by an expert or analytical way for each of a state S_k taking into account size $dISO^2$and vector orientations $\overrightarrow{(\mathrm{ISOas}_k, \mathrm{ISOex}_k)}$. As analytical expression the formula is offered:

$$K2(dISO_k) = \begin{cases} th\left(\pi \cdot \frac{dISO_k}{db_k}\right) \cdot \cos\left(\left(\overrightarrow{\mathrm{ISOas}_k, \mathrm{ISOex}_k}\right), \left(\overrightarrow{\mathrm{ISOEas}_k, \mathrm{ISOEex}_k}\right)\right), if\ the\ state\ k - go\ standard\ is\ set\ SE_k \\ th\left(\pi \cdot \frac{dISO_k}{4}\right),\ otherwise \end{cases} ,(4)$$

here: $\overrightarrow{(\mathrm{ISOEas}_k, \mathrm{ISOEex}_k)}$ - vector reference (or average) statesS_k,

db_k – module $\overrightarrow{(\mathrm{ISOEas}_k, \mathrm{ISOEex}_k)}$.

also confidence is defined $K3_k$, on a formula:

$$K3_k = (\sqrt{K1_k} + \sqrt{K2(dISO_k)} - \sqrt{K1_k \cdot K2(dISO_k)})^2 . \qquad (5)$$

Display of states on the monitor screen is provided.

5. It is synthesized productional decisive rules of a look:

«IF($Y(p) \in D_k$) & (K2(dISO$_k$)>0.62) , THAT the bee family is in a stateS_k с уверенностью $K3_k$, ecological tension, characteristic of level LET_k».

Levels of ecological tension are recommended to be identified according to the table (2) and values received on a formula:

$$LET_k = \begin{cases} \log_2\left(\pi \cdot \frac{dISO_k}{db_k}\right), if\ the\ state\ k - go\ standard\ is\ set\ SE_k \\ \log_2(\pi \cdot dISO_k)\,, otherwise \end{cases}. \qquad (6)$$

Table 2. Levels of ecological tension

№	LET value (upper bound)	Degree of tension of regulatory systems of a bee family – the identifier of ecological tension
1	1.38	Optimum level (norm)
2	1.62	Normal level
3	2,38	Moderate tension
4	2,62	The expressed tension
5	3,38	Sharply expressed tension
6	3,62	Overstrain
7	4,38	Sharply expressed overstrain
8	4,62	Exhaustion of regulatory systems of a beehive
9	5,38	Sharply expressed exhaustion of regulatory systems of a beehive
10	> 6	Death of a bee family

Results of researches.

As natural data reaction of a bee family to processing of the area was considered by pesticides. Results of measurements and coding on the offered technique are presented in Table 1, after processing – in Table 3.

Table 3. Frequencies of emergence of codes of comparison of ranges of sound frequency ranges of a bee family after processing of the area pesticides.

Code k - Xnn	*00*	*04*	*01*	*06*	*03*	*07*	*10*	*14*	*21*	*46*	*23*	*47*
pk frequency	0	0,0229	0,0146	0,0896	0,1813	0,2021	0,0042	0	0,0083	0,0396	0,0313	0,0917
Code k - Xnn	*30*	*54*	*31*	*56*	*63*	*67*	*70*	*74*	*71*	*76*	*73*	*77*
Frequency Pk	0	0	0,0063	0,0792	0,0458	0,0417	0	0	0	0,0042	0,0625	0,075

For each code of Tables 1 and 3 confidential intervals for values of all frequencies p_k on which the following codes having the acceptable diagnostic potential (the minimum crossing of confidential intervals) were allocated were calculated: 06, 46, 47, 56, 63, 67. On frequencies of loss of the specified codes in 8 minute time steps for 60 seconds in each of the considered conditions of a bee family with the help of means of Statistica it is identified discriminant function and threshold values of a look:

$Y = 1.7 - 0.134 \cdot X06 + 0.035 \cdot X46 + 0.083 \cdot X47 - 0.064 \cdot X56 - 0.068 \cdot X63 - 0.357 \cdot X67$, (7)
here: X <nn> - the number of losses of the <nn> code for a time step of time of 60 seconds.

If Y> 0, then a bee family was in a state class in the territory after processing of the territory, otherwise – to.

Specificity made: $K1_0 = K1_1 = 0{,}75$. Between frequencies of p_k the following dependence with a statistical error of the first sort p was found <0.01: $pk_1 = 0.43 pk_0^{0.7}$

Calculated values of indicators of the system organization ISOas and ISOex for the analyzed experimental data made, respectively, for the classes "0" and "1": $\text{ISOas}_0 = 0{,}385$, $\text{ISOex}_0 = 1{,}95$ $\text{ISOas}_1 = -0{,}05$, $\text{ISOex}_1 = 0{,}975$. The distance size square between them is equal: $dISO_k^2 = 3.858$.

It agrees (4) K23,858=0,0912( ), - thus, value of function of accessory of a condition of a beehive to new after processing of the area pesticides is acceptable is high and specific. Value of level of ecological tension on (6) is equal: $LET_k = 2.62$ that corresponds to the upper bound to "the expressed tension" (see table 2).

It agrees (5) confidence $K3_k = 0.993$, what speaks about a possibility of use of the offered method for the analysis of ecological violations and proves the hypothesis of a possibility of creation of the automated system of the analysis of ecological changes made by us by the analysis of changes of characteristics of a melody of a beehive.

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