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Biological Indicators in Studies of Earthquake Precursors

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Time series of data on variations in the electric activity (EA) of four species of weakly electric fish Gnathonemus leopoldianus and moving activity (MA) of two cat-fishes Hoplosternum thoracatum and two groups of Columbian cockroaches Blaberus craniifer were analyzed. The observations were carried out in the Garm region of Tajikistan within the frameworks of the experiments aimed at searching for earthquake precursors. An automatic recording system continuously recorded EA and DA over a period of several years. Hourly means EA and MA values were processed. Approximately 100 different parameters were calculated on the basis of six initial EA and MA time series, which characterize different variations in the EA and DA structure: amplitude of the signal and fluctuations of activity, parameters of diurnal rhythms, correlated changes in the activity of various biological indicators, and others. A detailed analysis of the statistical structure of the total array of parametric time series obtained in the experiment showed that the behavior of all animals shows a strong temporal variability. All calculated parameters are unstable and subject to frequent changes. A comparison of the data obtained with seismicity allow us to make the following conclusions:
(1) The structure of variations in the studied parameters is represented by flicker noise or even a more complex process with permanent changes in its characteristics. Significant statistics are required to prove the cause-and-effect relationship of the specific features of such time series with seismicity.
(2) The calculation of the reconstruction statistics in the EA and MA series structure demonstrated an increase in their frequency in the last hours or a few days before the earthquake if the hypocenter distance is comparable to the source size. Sufficiently dramatic anomalies in the behavior of catfishes and cockroaches (changes in the amplitude of activity variation, distortions of diurnal rhythms, increase in the mismatch of coordination between the activity dynamics of one type of biological indicators) were observed in one case before the November 12, 1987, event at a hypocenter distance of 8 km from the observation point (i.e. the animals were located within the source zone).
(3) Changes observed before the earthquakes do not have any specific features and correspond quite well to the variations permanently observed without any relation to the earthquakes.
(4) The activity of individual specimens has specific features. This hampers the implication of the biological monitoring.
(5) The conclusions made here should not be considered absolute or extrapolated over all cases of observation of the behavior of animals, because the animals were kept under experimental (laboratory) conditions and could be screened from the influence of the stimuli of some modalities.