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The Use of an Express Method for Determining the Electromagnetic Radiation Levels in the Training of Ecology and Biotechnology Applicants

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***Abstract* – The expediency of implementation an original biotesting method to determine the levels of electromagnetic radiation in the educational process of training applicants in the specialties of ecology and biotechnology has been proved. The content of the express method is to determine the reaction of model organisms to the action of a different intensity stress factor (electromagnetic radiation).**

Keywords – electromagnetic radiation, biotesting, model organisms, higher education, ecology, biotechnology.

I. Introduction

Today, the priority of natural and technical training of specialists is the subject of heated discussions between representatives of different areas of academic science. Relying on the opinion of N. Reimers that "modern ecology has become an independent cycle of knowledge", it can be stated that the latest environmental and biotechnological education should contain not only the fundamental principles of environmental protection, but also other applied areas of science about environmental protection and nature management [1].

The concept of environmental and biotechnological education in Ukraine pays special attention to higher education, which should become differentiated, diverse, cover all levels of professional training, taking into account the needs of the individual, regions and the state, which is declared in the Law of Ukraine "On Higher Education" [2]. The methods of practical implementation of the provisions of this Law are aimed simultaneously at changing the structure of educational programs, which should ensure the interdisciplinary nature of education, as well as at changing teaching methods in the direction of increasing the amount of independent work [3].

These and other conceptual documents related to issues of professional education, provide for the mandatory introduction of the basics of environmental and biotechnical knowledge into the curricula of professional training for various specialties. However, for higher education institutions (HEI) of a technical profile, in addition to basic ecological knowledge, it is relevant to introduce into work curricula, applied aspects (ensure the ability to realize rights and obligations ties as a member of society), in addition to the basics of theoretical ecology or biotechnology (ensure understanding of the subject area place in the general system of knowledge about nature). They are formed taking into account the time requirements, valid standards and international principles, the profile and capabilities of HEI, the specifics of industrial and economic activity and the region's needs.

Environmental education should focus on the active interaction of human with nature, built on a scientific basis, on the evaluation of human as a nature part. Ecological knowledge, supplemented by value orientations, should become the basis of ecological culture and thinking. They should contribute to the awareness of values, help to solve the complex nature protection problems facing humanity, ensure the comfort of its living in the future, preserve and increase the unique biological diversity at the genetic, species and ecosystem level.

The development of innovative technologies requires a new understanding, a radical revision of the ecological and biotechnological training of future specialists. The purpose of the paper is to prove the feasibility of implementation the original method of determining the levels of electromagnetic radiation into the educational process of training students in the fields of ecology and biotechnology.

II. Materials and Methods of Research

The leading direction of an environmental education modernization, as well as the educational system of Ukraine as a whole, is determined by the competence strategy. It is based on a fundamentally new goal setting in the pedagogical process, which consists in shifting the emphasis from knowledge and skills as learning outcomes to the competency's formation.

The formation of professional and practical competencies is most relevant for specialists in the fields of nature management [4–6], electrical engineering, techniques and technologies [7–9, 17, 18], management [10, 11] and

nature protection [12–14]. And also, for future specialists in medical, psychological, pedagogical and agricultural specialties [14–16].

The metric of using the standards of technical regulation of international and national measurements in the professional training of future specialists in ecology and biotechnology in HEI is based on the quality management system (ISO 9001), improvement procedures (ISO 9004), requirements for testing (research) laboratories (ISO 17025), social responsibility (ISO 26000, SA 8000), food products safety management (ISO 22000, HACCP, FSSC), occupational safety management (OHSAS 18001) and environmental management (ISO 14001).

Previously, the priority of four substantive components of national standards of higher education was also substantiated [19]:

– technical expectations of the profession (skills and knowledge necessary to ensure the professional function);
– the ability to adapt and change in different circumstances (including the ability to respond to unpredictable and extraordinary circumstances);
– the ability to coordinate and manage different aspects of the labor role (performing different types of activities);
– compliance with the requirements of the "environment" of the profession (physical characteristics, interaction with others, operational standards and quality requirements, and work organization and culture).

The standardization of Ukrainian higher education is based mostly on the principles of the activity approach, the main feature of which is the subordination of teachers' actions not to the process of assimilation of knowledge, abilities and skills, but to the organization of students' activities. It is important that the standardization of higher education has an anticipatory nature and changes in accordance with real socio-cultural, educational changes at the regional, state and global levels.

Competency-based learning should focus not on students' awareness, but on their ability to use information to solve problems that arise in all activities and areas of relationships. Therefore, an urgent need to change the priorities of higher education is to strengthen its practical orientation [20]. A competency-based approach in environmental and biotechnological education requires the search for effective ways and mechanisms of its implementation, prompts rethinking and transformation of the methodological system of teaching environmental or biotechnological disciplines.

In order to form students' key educational competencies, it is proposed to implement an express method for determining the levels of electromagnetic pollution of the environment in the system of education of ecologists or biotechnologists. At the same time, in the educational components of ecology educational programs, this method is proposed to be used, in particular, to determine the risk of environmental hazard. In the disciplines that future biotechnologists study, it is considered as an environmental protection technology.

The procedure of the original biotesting technique consists in determining the response of model organisms (MO) to the action of a stress factor of different intensity. In this case, the stress factor is electromagnetic radiation (EMR). When testing, it is necessary to maintain stable conditions: temperature, ventilation, duration and brightness of lighting, humidity, atmospheric pressure. The following indicators are taken as the norm: temperature 22–25 °C; pressure 756–762 mmHg; humidity is 40–50 %.

The criteria for establishing the conditional degrees of *Daphnia magna* Straus activity were the movement speed, the trajectory and the duration of immobilization. When determining the degree of *Drosophila melanogaster* L. activity, such parameters as the movement speed, the number of flights and the duration of rest were considered. On a nutrient agar medium, which included sugar, semolina, dry yeast, apple cider vinegar and ampicillin, two individuals of each sex of *Drosophila melanogaster* L. were settled [21–23].

To measure the degrees of MO activity, the average obtained values of the selected criteria were taken into account. To determine the characteristics of movement, graph paper, a stopwatch, a microscope, a video camera and a camera were used. The trajectory of movement was described on the basis of visual observation and serial photographic recording of movement (Fig. 1).

Motion change was studied based on the analysis of video frames obtained by storyboarding using computer programs Adobe Premier pro, Windows Movie Maker and serial photographs. When analyzing motion based on photographs, the positions of organisms on each frame were determined, separate sections of the motion trajectory were identified, which are a broken line with links of different lengths, which are characterized by rectilinear motion. Taking into account the correspondence of each frame to a certain period of time (depending on the type of shooting), the calculation of the speed of movement for individual individuals was made. Depending on the influence of physical factors, the interval of movement speed is set.

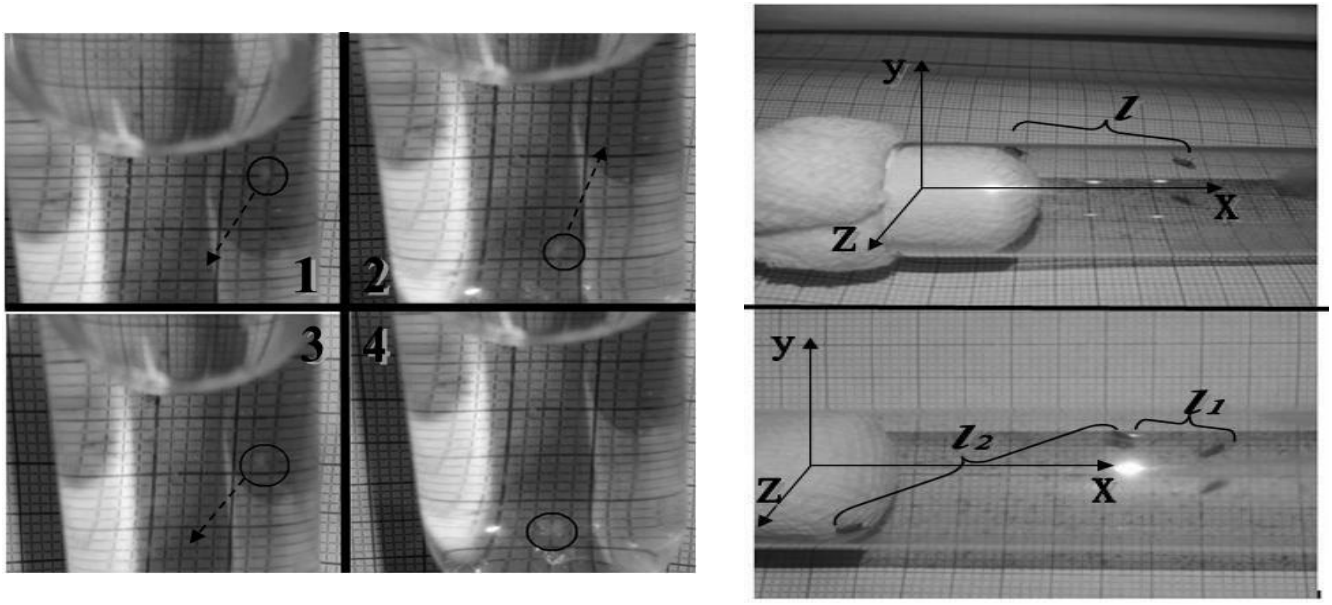
Based on the generalization of literature data and original results of studies of the birth rate of MO under normal conditions, it was found that the reproduction of *Daphnia magna* Straus is 75–84 individuals and *Drosophila melanogaster* L. is 193–210 (under the selected research conditions) [24]. The end point is the average value for the entire MO population.

III. Results

In order to ensure continuity and continue the formation of environmental and biotechnological competencies, in particular, two educational and professional master's programs "Environmental Biotechnology and Bioenergy" and "Environmental Protection Technologies" at Kremenchuk Mykhailo Ostrohradskyi National University are licensed. Also, research continues on physiological changes in the MO caused by EMR, with the participation of first-year higher education applicants, while studying the discipline "Biology", then "Fundamentals of Cytology and Genetics" in the second year of study, and then with the participation of undergraduates within the discipline "Systemic analysis of the quality of environmental components" using the author's methodology [25].

The algorithm for registering the ethological dynamics of MO depending on the EMR intensity (Fig. 2), in addition to training future ecologists or biotechnologists, is also recommended to be used when teaching educational components of engineering, in particular electrical

specialties, to determine the safety level of laboratory equipment or a device or other industrial equipment [26].



a b

Fig. 1. *An example of determining the trajectory and movement speed of model organisms: a – storyboard of the spatial movement of Daphnia magna Straus;*
b – determination of the activity levels of Drosophila melanogaster L. by the method of photo overlay

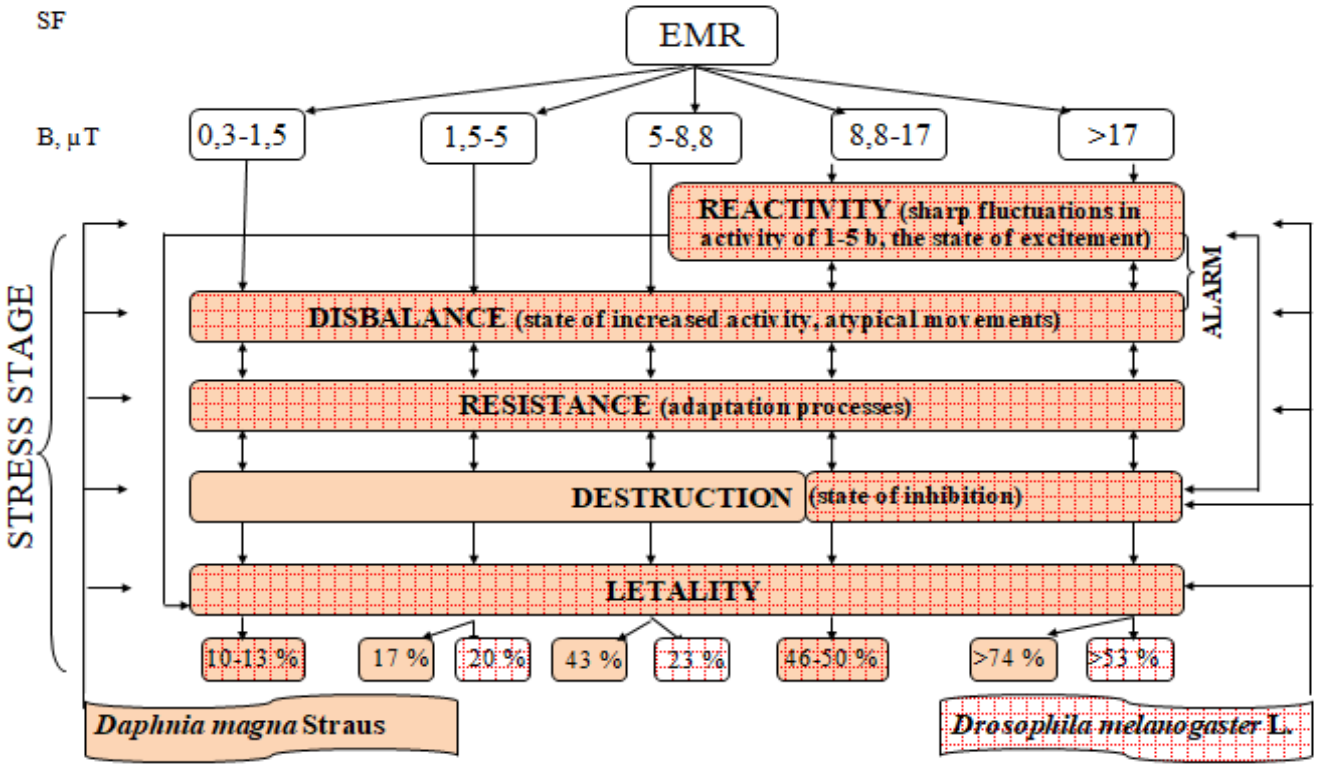


Fig. 2. *Scheme of stages of model organisms stress on the action of electromagnetic radiation*

The proposed levels can also be taken as a basis for developing criteria for assessing the MO activity in response to the action of stress factors of a different origin. In particular, similar criteria for the response of hydro- and aerobionts to different noise levels (acoustic pollution of the environment) have already been created.

The results of the original research are used by the authors to conduct laboratory work "Mutational variability on the example of Drosophila" and "Types of teratology and inducing factors of mutagenesis" when teaching the educational component "Fundamentals of Cytology and Genetics". It is also proposed to consider the types of MO teratologies artificially induced by EMR (Fig. 3) [27] as part of the study of the informative module material "General Genetics. Biological variability and dynamics of the genetic structure of a population".

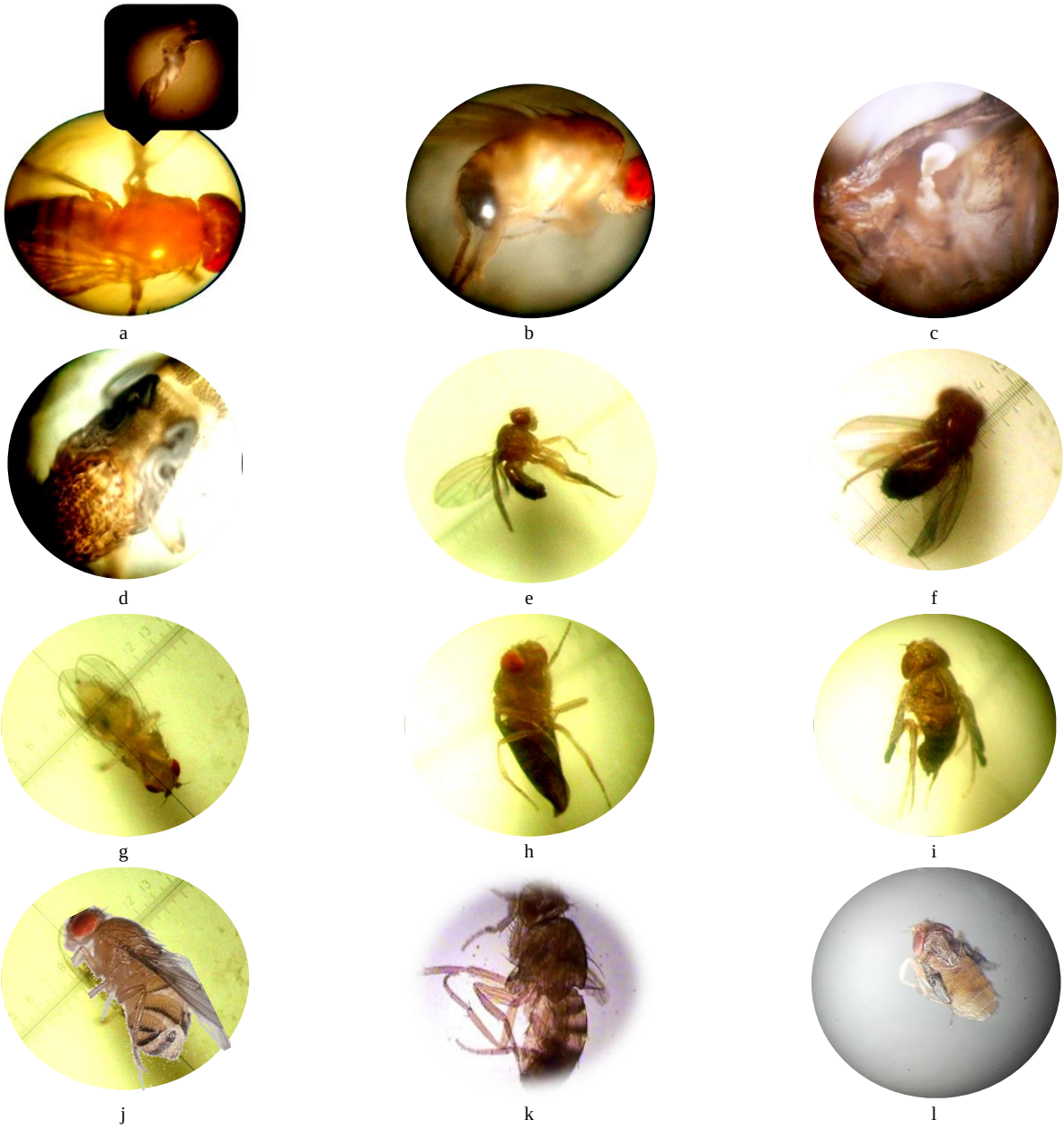


Fig. 3. *Types of teratology and other anomalies of Drosophila melanogaster L. induced by electromagnetic radiation (magnification from 10^x to 48^x) in individuals of the first generation F_1: a – wing deformation; b – deformation of the body; in individuals of the second generation F_2: c – underdeveloped wing, d – deformity of both wings; in individuals of the third generation F_3: e – deformation of the wing and narrowed abdomen, f – deformation of the wing, g – lack of pigmentation of the body (albinism), h – deformation of the wings and a narrowed abdomen, i – deformation of the wings and body, j – disproportionate parts of the body, k – wingless form, l – deformation of the wings and legs.*

This will ensure the implementation of the program results of the discipline, in particular, it will contribute to the ability of applicants for education to carry out basic genetic and cytological studies to improve and increase the biosynthetic ability of biological agents, taking into account the principles of biosafety, biosecurity and bioethics (induced mutagenesis using physical and chemical accumulations, transfer of genetic information and etc.).

When studying the disciplines of the ecological and biotechnological areas, students independently measure the levels of technogenic load, including EMR, at selected objects, experimentally study changes in the MO activity using video storyboards. At the same time, at the request of applicants for higher education, it is possible to study and investigate various characteristics of electromagnetic fields of asynchronous electric motors [28].

It is recommended to analyze the experiment results on the MO response to the EMR influence when studying the discipline "Fundamentals of Scientific Research and Intellectual Property". Also consider the issues of planning the experiment and the features of presentation of results. Various aspects of this original methodology can be applied as part of the study by undergraduates of the educational component "Sustainable Development Strategy and Legal Framework for Environmental Policy".

IV. Conclusions

An integral part of educational activities aimed at integrating scientific, educational and industrial components in the higher education system is scientific, scientific, technical and innovative activities, which provide for the

creation and implementation of new competitive technologies, in particular biological and nature-like ones.

Modern requirements for the training of applicants for higher education should ensure the formation of critical thinking in them by creating problem situations. The activity approach activates the educational and research work of students, their positive motivation for future professional activities, develops attention, imagination and the ability to find solutions in non-standard situations, and also generates an individual style of professional activity.

The competence-based approach in teaching and studying the educational components of the ecological and biotechnological cycles contributes to the formation of a competent, creative, in-demand and competitive specialist.

One of the means of realization the activity and competence-based approaches in the implementation of the latest educational technologies for the training of applicants for higher education in the specialties of ecology and biotechnology is the use of an original biotesting methodology to determine the levels of EMR.

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