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THE POSSIBLE EFFECTS OF OSCILLATIONS OF TREE-LOCATED MAGPIE (PICA PICA L.) NESTS

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МОЖЛИВІ ЕФЕКТИ КОЛИВАНЬ ГНІЗД СОРОК *PICA PICA L.* НА ДЕРЕВАХ

Досліджено частоти та амплітуди коливань сорочачих гнізд на стовбурах та гілках дерев. Гнізда, розташовані на різних висотах, різняться за частотою та амплітудою коливань. У цілому на більш високих (понад 8 м) деревах частота коливань є меншою за 0,7 Гц, а на низьких – вищою. Установлено, що час зменшення температури яєць з 37 ºС до температури повітря 9 ºС при коливаннях є удвічі меншим за умов нерухомості. З'ясовано, що при дії наднизьких коливань протягом 30 хвилин на 10%-вий розчин альбуміну змінюється ширина спектру ЯМР-сигналу, що свідчить про ступінь зв'язку води з білковими молекулами.

Ключові слова: *гніздо, дерево, коливання, яйце, температура, білок.*

At present time the preservation of biological diversity goes beyond biological and environmental issues and is one of the foreground tasks of the modern society (Емельянов, 1999). In this respect great attention is paid to the thorough investigation of maintenance mechanisms and dynamics of biodiversity, its role in functional stability of ecosystems, in evolution etc. However, in spite of great interest in this problem, some questions remain underresearched. For example, it is not quite clear how functioning of biocenosis is affected by the great variety of elastomechanical properties of trees. The architectonics and type of wood texture imply that leaves, branches, roots and trunks of trees have different natural oscillation frequencies (Гришин, 2001; Нецветов, 2003). The oscillation range of the same element depends on the deflecting force applied and the distance between the deflecting point and the attachment point, and physical features of the element itself (Никитин, 1990; Dreyer, 1964) largely determine the frequency. It is known as well, that even weak mechanical oscillations have pronounced biological effects, which depend on their parameters, for example, their frequency (Лытаев, Шангин, 1999; Вибрационная биомеханика, 1989; Netsvetov, 2003), and most develop when interacting with other factors (Нецветов и др., 2001). Thus variety of characteristics of tree oscillations can be of different importance when interacting with other organisms to a certain degree associated with trees. For example, if nest-building by birds of certain species is possible either on different trees, or on different heights, then it should be supposed that embryos and nestlings would be under different physical conditions at least due to change of microclimate in consequence of blowing round while swaying.

Considering that the response of biosystems on external action develops as a rule from lower levels of organization, primarily it can be expected that oscillatory effects would develop at the biochemical level. In addition, it is quite obvious that the change of microclimatic conditions can result in intensification of heat loss in eggs. In this respect the objective of this work was to determine the character of oscillation of tree elements with magpie nests on them, and investigation of effect of such oscillations on intensity of heat loss in eggs and the protein-water system response to these oscillations.

MATERIALS AND METHODS

1. Oscillation frequencies of trunks and branches of trees with magpie nests were measured visually with stopwatch timer, and then they

were averaged with 5–10 replications. With different wind strength the amount of branch or trunk deflection was determined in the point of the nest location. Also the nest location height was measured. The investigation was carried out in the tree plantation in the southeastern city outskirts of Donetsk.

2. M o d e l e x p e r i m e n t s o n e f f e c t o f m e c h a n i c a l o s c i l l a t i o n s o n t h e t e m p e r a t u r e l o s s of 10 eggs (quail) sized 3,3 × 2,5 cm was measured by way of introduction of thermocouple by 1,5 cm from the air-chamber side. The eggs were placed one by one on paper tissues at the bottom of clay trays with the diameter of 15 cm and the depth of 8 cm. The pendulum motion had the frequency f = 0,5 Hz and the maximum deviation amplitude from the balance point at the reference time was 0,5 m, which damped as shown in Fig. 1. Alongside with that the temperature of eggs in fixed trays was measured. The research was carried out in the open field at the air temperature of 9 ºC, humidity of 80 % in windless cloudy weather. The preheated eggs were kept in a thermos flask before the experiment.

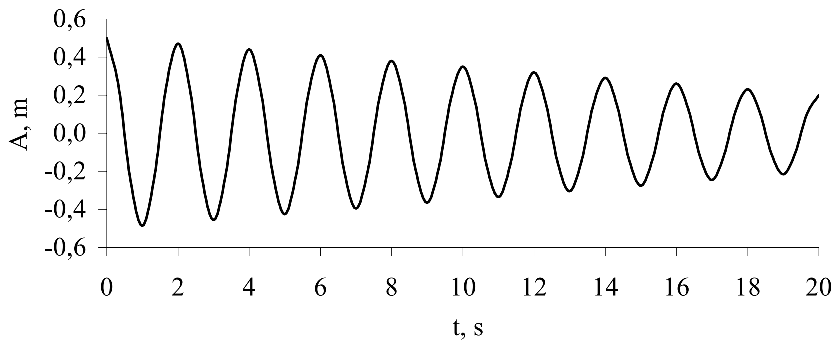

Fig. 1. **Variation of amplitude** (A) **of pendulum deviation from the balance point with time** (t)

3. M o d e l e x p e r i m e n t s o n e f f e c t o f m e c h a n i c a l o s c i l l a t i o n s o n t h e c o n d i t i o n o f t h e p r o t e i n - w a t e r s y s t e m were carried out with 10 % albumin solution. The solution in amount of 5 ml in a 6 ml container was placed on the vibration stand and during 30 min was exposed to pulsating mechanical oscillations with frequencies of 1,5; 24 and 50 Hz and amplitudes up to 3 mm. Alternating current was supplied to the vibration stand from the generator G6-28. After exposure the solution was placed in the process chamber of NMR-spectrometer. The NMR-spectrum line width of solutions was evaluated.

RESULTS AND DISCUSSIONS

1. It was found during the research, that the height h of magpie nests is closely related (r~ (–0,6)) to the frequency f of oscillations of the trunk, on which they are located (mainly in the crutch). In whole the data received are in conformity with theoretical mechanics (Никитин, 1990), one of the postulates of which is the inverse relation of the frequency of the pendulum motion to its length, though at first sight a greater correlation between f and h values could be expected. In case of such complex systems as trees, elasticity of wood, mass and geometrical arrangement of branches, presence of leaves, trunk (branch) geometry, extent of root growth in the soil as well as some other parameters are of great importance in determining frequency. The great variety of the above factors results in possible deviations from the general trend (Fig. 2).

After analysis of the relation f (h) and finding of "jumping out" points the correlation coefficient increased (r > 0,7). The Fig. 3 shows that maples, used for nest-building more often than other trees, are distinguished by the widest spectrum of oscillation frequencies within which frequencies of all other trees are located. Oscillation frequency of trunks and branches with the nest for all trees averaged ~ 0,76 Hz, but the most observed value was close to 1 Hz. It should be noted that the oscillation range of ash-tree is significantly ($p < 0{,}05$) different from the range of the other trees.

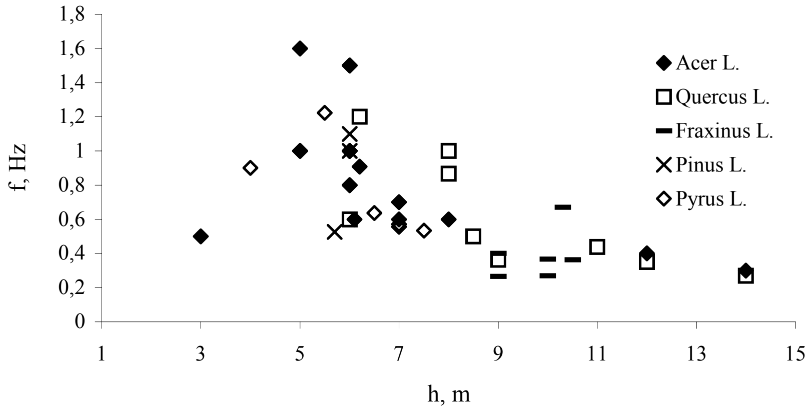

Fig. 2. **Frequency** (f) **variation with the height h of magpie** (Pica pica L.) **nests location**

The amount of trunk deflection, i. e. the oscillation amplitude, depends on the tree height. In this respect, even with strong wind in the open field the deflection of trunks (in meters) from the balance point is limited by its length. In the forest stand small trees of lower layers are exposed to significantly less wind force in comparison with higher trees. According to our observations when the oscillation amplitudes are of the order of some centimeters, which are specific for small trees, maximum deflections of trunks in the nest location point (> 8 m) reached 0,5 m and more on high trees. Thus, the places chosen for nest building by magpies can be divided in terms of oscillation frequency and deflection amplitude in the nest location into relatively high-amplitude and low-frequency ($f < 0{,}7$) and low-amplitude and more high-frequency ($f > 0{,}7$–1 Hz). That is why it is reasonable to consider possible consequences of location choice for nest building on relatively greater height.

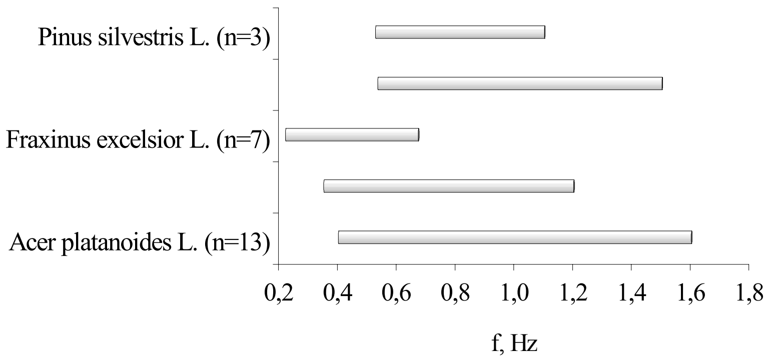

Fig. 3. **Frequency ranges** (f) **of oscillation of elements of trees of various species with magpie** (Pica pica L.) **nests located on them**

2. The swaying effect can be manifested in two main ways: 1) through the change in the nest microclimate and 2) through the direct effect of acceleration on embryos and nestlings. Nest oscillation on a branch or a trunk is its displacement in space, which in absence of the nester with lack of balance between temperatures of the nest and the air should result in intensification of heat exchange and gas exchange between them. In this connection let us examine the time of temperature decrease of the eggs pre-heated to T = = 37 ºC in the fixed (control) and the swaying "nest" (clay tray) in the experiment, carried out in the open air at T = 9 ºC. Parameters of the amplitude attenuating oscillation have been chosen according to the aforesaid results: frequency f = 0,5 Hz, reference time deflection A = 0,5 m. Fig. 4 shows that whilst getting cold the differences between the control and experimental relations T (t) increase. The eggs temperature arrives at the air temperature almost two times faster in the experiment, than in the control.

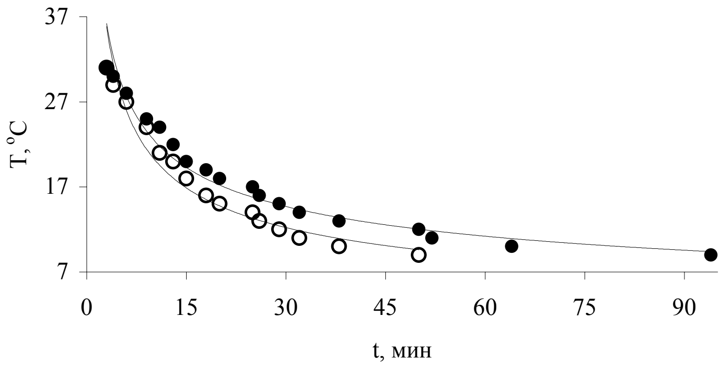

Fig. 4. **Variation of temperature** T **with time** t

● – temperature of control eggs in the fixed "nest", ○ – temperature of experimental eggs in the swaying "nest"

3. As mentioned above, when oscillating the egg (embryo) or nestling is exposed to direction and value variable acceleration. Thereat primary reaction should be most probably expected on lower hierarchical levels (Емельянов, 1999), for example, on the state of macromolecules. On possibilities of effect of oscillations on proteins we can judge by NMR-spectra, half-width of which reflects the state of water in the protein-water system – a wider spectrum indicates the increase of amount of water, bound to the protein molecule (Габуда, Ржавин, 1976). In this connection we carried out a model experiment in which the protein (albumin) solution during 30 minutes was exposed to ultralow-frequency pulsating oscillations with ultralow frequencies from 1,5; 24 and 50 Hz and the amplitude < 3 mm, and then took NMR-spectrum readings and compared them to the control – the solution not exposed to oscillations. Fig. 5 shows that the effect of the 30 minute oscillation can consist both of increase (24 Hz) and decrease (1,5 and 50 Hz) of the protein bound water.

As a possible cause of this effect the relatively short time of exposition can be noted. The initial protein dehydration is supposedly followed by further hydration (or vice versa). If the frequency of 24 Hz is closer to the frequency of parametric resonance of the vibration stand with the test tube, then with this frequency the alternation of the mentioned processes happens faster, than with 50 and 1,5 Hz. To obtain more accurate and clear result special investigation should be carried out. However, in any case the obtained results indicate the change of hydration degree with which the functional state of protein is associated (Габуда, Ржавин, 1976). Thus, when interpreting the obtained data it can be supposed that the oscillations affect the membrane transmission capacity, the intensity of metabolism and many other processes, which are especially important without regulation on the part of the nervous system at early stages of embryogenesis.

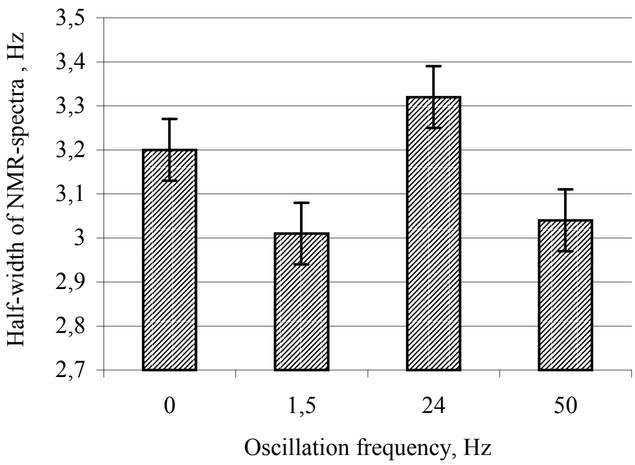

Fig. 5. **Variation of half-width of NMR-spectra of albumin solutions after exposure to mechanical oscillations of different frequencies and in the control** (oscillation frequency = 0)

The presented data of the model experiments do not afford ground to speak of a simple negative effect of oscillations on embryos and nestling. It is known, that ultralow-frequency vibrations cause stress and activation of peroxide lipid oxidation (PLO), especially in young animals (Макаров, 1991), but with their continuous exposure the adaptation begins with recovery of biochemical and physiological indexes (Ильин и др., 1991). If limiting factors are present, the values of which, as it is known, vary with height in the forest stand, their combination with oscillations can affect elimination in two ways, by analogy with other physical factors of low intensity (Нецветов и др., 2001). Influence of other kind can be involved as well. D. Hubel and co-authors have shown in their work on monocular deprivation that level of development of corresponding analyzers depends on intensity of stimulation of the retina (Hubel et al., 1977), and in a number of further works the necessity of stimulation of neuronal activity for full development of the brain was demonstrated (see reviews (Хьюбел и др., 1988; Шатц, 1992)). Hence besides the training effect with the brain fully developed it can be expected that stimulation of the vestibular system of nestlings in swaying nests would accelerate the development of the corresponding analyzer, establishment of necessary connections with moto neurons and thus improvement of coordination of body position in space, fly training and ultimately time of nest leaving. Due to more austere selection at early development stages such nestlings should have certain advantages over those developed in less swaying nests especially in difficult existence condition.

Regardless of the cause of nesting height choice its possibility as such indicates the significant part of flexibility in behavior of magpies and efficacy of environmental resources utilization. It can be assumed that the choice of the maximum possible heights can have effect on polymorphism because of significantly different physical and chemical conditions including characteristics of the nest oscillations.

CONCLUSIONS

1. Magpie nests, located on different heights, differ by the character of oscillations, which is due to physical properties of trees and different wind speed in higher and lower

layers. With the nests located on the extreme heights the nest swaying is maximal in terms of amplitude and period.

2. Ultralow-frequency attenuating oscillations result in decrease of getting cold time of eggs at low air temperatures.

3. Oscillation with frequency close to the natural frequency of tree trunks with the nests located on them results in change of the degree of water binding with protein molecules in solution.

BIBLOGRAPHIC INDEX

Hubel D. H., Wiesel T. N., Levay S. Plasticity of ocular dominance columns in monkey striat comrtex // Philosophical trancactions of the royal society of London, series B. – 1977. – Vol. 278, № 961. – P. 377-409.

Dreyer G. Festigkeitslehre und Elastizitatslehre. – Leipzig: Vebfachbuchverlag, 1962 – 416 p.

Netsvetov M. et al. 50 Hz vibration effect on mice's ethology and nervous tissue's ionic balance // International Crimean Conference "Cosmos and Biosphere". Abstr. – Partenit, Crimea, Ukraine. – 2003. – P. 179-181

Вибрационная биомеханика. Использование вибрации в биологии и медицине / К. В. Фролов, А. С. Миркин, В. Ф. Машанский и др. – М.: Наука, 1989. – 142 с.

Габуда С. П., Ржавин А. Ф. Ядерный магнитный резонанс в кристаллогидратах и гидратационных белках. – Новосибирск: Наука, 1976. – 238 с.

Гришин А. М., Голованов А. Н., Медведев В. В. О возникновении колебаний элементов лесных горючих материалов и их влиянии на режимы воспламенения и горения // Прикладная механика и техническая физика. – 2001. – Т. 42, № 4. – С. 127-135.

Емельянов И. Г. Разнообразие и его роль в функциональной устойчивости и эволюции экосистем. – К.: ИПЦ «Международный Соломонов университет», 1999. – 168 с.

Ильин И. И., Насибулин Б. А., Жеребицкий В. А. Изменения структуры нейронов и активности некоторых окислительно-восстановительных ферментов в мозжечке при непрерывном длительном действии общей низкочастотной вибрации // Архив анатомии, гистологии и эмбриологии. – 1991. – Т. 100, № 2. – С. 9-15.

Лытаев С. А. Шангин А. Б. Физиологические механизмы действия на организм инфра- и низкочастотной вибрации // Вестник новых медицинских технологий. – 1999. – Т. 4, № 2. – С. 11-14.

Макаров В. Г., Тимофеева В. М. Возрастные особенности состояния антиоксидантной системы тканей крыс при действии на них кратковременной вибрации // Вопросы медицинской химии. – 1991. – Т. 37, № 4. – С. 48-51.

Нецветов М.В. Вибрации в лесу под действием ветра (теоретический аспект оценки частот) // Екологія та ноосферологія. – 2003. – Т. 13, № 1-2. – С. 87-92.

Нецветов М. В., Кузик А. В., Хиженков П. К. К вопросу о механизме влияния низко- и сверхнизкочастотных механических колебаний на проницаемость растительных мембран // Матеріали Всеукр. конф. студ., аспір. та молодих учених. «Біорізноманіття природних та техногенних біотопів України». – Донецьк, 2001. – С. 14-16.

Никитин Н. Н. Курс теоретической механики. – М.: Высш. шк., 1990. – 607 с.

Романов С. Н. Биологическое действие механических колебаний. – Ленинград: Наука, 1983. – 208 с.

Хьюбел Д., Стивенс Ч., Кендэл Э. и др. Мозг. – М.: Мир, 1984. – 280 с.

Шатц К. Дж. Развивающийся мозг // В мире науки. – 1992. – № 11-12. – С. 23-30.

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