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COMPARATIVE EXAMINATIONS OF MAGNETIC FIELD EFFECTS ON PUPAL DEVELOPMENT IN THREE HOLOMETABOLOUS INSECT SPECIES

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The development of new technologies in the last decades has actuated researches on effects of magnetic and electromagnetic fields on individual performance and physiological reactions in living systems. Our work is based on the model of pupal development and compares insect species belonging to different orders: *Tenebrio molitor* (Coleoptera), *Drosophila melanogaster* (Diptera) and *Apis melifica* (Hymenoptera). A highly significant increase in the rate of adult eclosion was detected in all examined species reared under constant external magnetic field suggesting unique mechanisms of magnetic field influence on development of three evolutionary distant insect species.

KEY WORDS: magnetic field, pupal development, *Tenebrio molitor*, *Drosophila melanogaster, Apis melifica*

The earth magnetic (geomagnetic) field, originating from the Earth's core, is an ubiquitous factor that has affected living world from the beginning of its evolution. Up to now, magnetic field effects have been poorly studied compared to effects of other environmental factors. However, it has attracted considerable attention lately due to the development of new technologies that increased intensity of external magnetic field several times above geomagnetic field.

Various responses to external magnetic field have been described in the maybags (SCHNEIDER, 1975), termites (BECKER, 1976), hornets (KISLIUK & ISHAY, 1977), bees (MARTIN & LINDAUER, 1977; KILBERT, 1979), fruit flies (RAMIREZ *et al*., 1983; MA & CHU, 1993). Physiological mechanisms of magnetoreception are

Table I

Mean values of pupal development time (PDT) and half time of adult eclosion (PDT_{50}) in control group (C) and insects exposed to magnetic field (MF). Chi-square (x^2) test was applied for comparison between the groups.

	PDT (days)		PDT_{50}(days)			
	C	MF	C	MF	χ^2	P
Apis mellifera (autumn)	7.6±0.7	5.9±0.6	8.0	5.5	510.18	**0.0001**
Apis mellifera (spring)	8.5±1.0	6.6±1.1	9.0	5.3	248.75	**0.0001**
Drosophila melanogaster	15.7±0.2	14.4±0.3	15.2	13.8	79.03	**0.001**
Tenebrio molitor	19.1±0.6	16.0±0.6	19.1	16.1	31.95	**0.0008**

still unknown. GOULD *et al*. (1978; 1980) have suggested the existence of biogenic magnetic material in bees, while SCHIF (1991) has pointed to the involvement of magnetite crystals in sensing hairs of bees in generating and modulation of action potentials. Magnetic field is known to change insect behavior (KISLIUK & ISHAY, 1977), physiology (VACHA, 1997), development (RAMIREZ *et al*., 1983), and has mutagenic effect (GIORGI *et al*., 1992).

To elucidate mechanisms of interaction of living systems with magnetic field, we investigated the influence of a permanent, inhomogenous, strong magnetic field on pupa-adult metamorphosis in three insect species belonging to different orders: *Tenebrio molitor* (Coleoptera), *Drosophila melanogaster* (Diptera) and *Apis melifica* (Hymenoptera).

Perculated comb in *A. melifica*, and pupal stage in *D. melanogaster* and *T. molitor* were exposed to inhomogenous magnetic field (magnetic induction B=130-180mT) created by using permanent alnico Raytheon magnets, model 6002. Adult eclosion was monitored daily both in control insects (C) (in the absence of magnetic field) and insects exposed to magnetic field (MF). Other factors were kept constant (temperature T=30±1°C for *D. melanogaster* and *A. melifica* and T=19±1°C for *T. molitor*, relative humidity r=70-80%). Mean value of pupal development time (PDT) and half time of adult eclosion i.e. the time needed for 50% of adult eclosion (PDT_{50}) were determined. Chi-square (x^2) test was applied for comparison between the groups.

The results presented in Table I show that magnetic field induced similar changes in the dynamics of metamorphosis in all examined insect species. Pupal-adult metamorphosis is more rapid in MF than control group. Seasonal changes in geomagnetic field did not significantly affect our results.

Increased DNA damage and developmental errors are considered to be the costs of rapid growth and development (ARENDT, 1997). It is also well known that MF increase frequency of genetic loads (PROLIĆ & ANĐELKOVIĆ, 1992) and may have mutagenic effect, especially on genes that control cell proliferation (GOODMAN *et al*., 1991; GIORGI *et al*., 1992). However, in contrast to findings of other authors (RAMIREZ *et al*., 1983; MARTIN, 1988; MA & CHU, 1993), our results did not show drastic effects on pupal mortality. Apparently, intensity of applied MF is within the physiological range determined by the genome of the species.

External magnetic field interacts with the internal electromagnetic equilibrium of a living system modulating dynamics of calcium ions (BLACKMAN & MOST, 1993; BLACKMAN, 1994) as well as basic electric processes and motion of charged and/or polar molecules (KOLIN, 1968). As neural system is the most responsive structure of an organism (ROSEN, 1992; 1993) we can suppose that MF effects on insect metamorphosis, observed in our experiment, are caused by changes at the level of neuroendocrine system.

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УПОРЕДНА ИСПИТИВАЊА ЕФЕКАТА МАГНЕТНОГ ПОЉА НА РАЗВИЋЕ ЛУТКЕ КОД ТРИ ВРСТЕ ХОЛОМЕТАБОЛНИХ ИНСЕКАТА

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И з в о д

Развој нових технологија последњих деценија је покренуо истраживања ефеката магнетних и електромагнетних поља на индивидуалну перформансу и физиолошке реакције у живим системима. Наш рад је базиран на моделу луткиног развића и пореди три еволутивно удаљене врсте инсеката које припадају различитим редовима: *Tenebrio molitor* (Coleoptera), *Drosophila melanogaster* (Diptera) и *Apis mellifera* (Hymenoptera). Код свих проучаваних врста је уочен статистички значајан пораст брзине излегања адулта под утицајем спољшњег магнетног поља што указује на јединствене механизме деловања на процесе развиће код три удаљене врсте инсеката.

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