VERSITA DOI: 10.2478/cdem-2013-0023 CHEM DIDACT ECOL METROL. 2013;18(1-2):103-108

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EFFECT OF TEMPERATURE ON TOXICITY OF SELECTED INSECTICIDES TO FOREST BEETLE *Anoplotrupes stercorosus*

INTERAKCJA TEMPERATURY Z WYBRANYMI INSEKTYCYDAMI CHRZĄSZCZA LEŚNEGO *Anoplotrupes stercorosus*

Abstract: In 2007 and 2008 research on the impact of temperature, ranging from 14 to 39°C on the survivability of an adult *Anoplotrupes stercorosus* intoxicated by insecticide preparations from the group of phosphoorganic insecticides (diazinon), carbamate (pirimicarb), quinazolines (fenazaquin), oxadiazine (indoxacarb), benzoyl urea insecticides (teflubenzuron), neonicotinoids (acetamiprid) and pyrethroids (beta-cyfluthrin) was carried out. The results obtained indicate that all preparations used in tests had a positive temperature coefficient.

Keywords: *Anoplotrupes stercorosus*, temperature, synergism, insecticides

Introduction

The ambient temperature modifies the toxicity of xenobiotics to a crucial extent. It has an impact on their synthesis [1], spreading [2] and rate of decomposition in the environment [3]. Temperature determines the locomotor activity of the organism [4-8], that is, the probability of an animal contact with the poison. It also affects the dynamics of the xenobiotics penetration across the biological membranes [9-11], their spreading and deposition in the organism [3] as well as the metabolic rate of the body [12, 13]. It is also responsible for the occurrence of side effects of the exposure to chemical biocides and their consequences [14-17]. As one of the most important environmental stressors, it can modify the number of action potentials generated in excitable cells [18] - the main site of action of many synthetic biocides [19-21].

The aim of our study was to establish the effect of ambient temperature on the action of selected insecticides, belonging to various chemical groups, on adult forms of *Anoplotrupes stercorosus* beetle.

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Material and methods

Material

Experiments were carried out in the Ecotoxicology Chair in the Off-Mural Faculty of Biotechnology of the University of Rzeszow. Adult *Anoplotrupes stercorosus* beetles of both genders were used for the study. Animals were picked up in a forest near Werynia in the Podkarpackie Province. Prior to testing, these animals were acclimated for 5 days to the temperature of 22°C. A total number of 1152 individuals were used for the tests.

The following insecticides were used for the experiment:

Diazol 500 EW. Producer: Makhteshim-Agan Industries. Insecticide formulation belonging to organophosphorus compound (active substance: diazinon - 500 g in a 1 dm^3 of the agent) - the concentration of the usable liquid 0.083%.

Pirimor 500 WG. Producer: Syngenta Limited. Insecticide formulation belonging to carbamate compound (active substance: pirimicarb - 500 g in a 1 dm^3 of the agent) - the concentration of the usable liquid 0.005%.

Magus 200 SC. Producer: Dow AgroSciences Polska Sp. z o.o. Insecticide formulation belonging to quinazolin compound (active substance: fenazachin - 200 g in a 1 dm^3 of the agent) - the concentration of the usable liquid 0.04%.

Steward 30 WG. Producer: Du Pont de Nemours. Insecticide formulation belonging to oxadiazines compound (active substance: indoxacarb - 30 g in a 1 kilogram of the agent) - the concentration of the usable liquid 0.117%.

Nomolt 150 EC. Producer: BASF Agro B.V. Insecticide formulation belonging to benzoylphenyl urea compound (active substance: teflubenzuron - 150 g in a 1 dm^3 of the agent) - the concentration of the usable liquid 0.044%.

Mospilan 20 SP. Producer: Nippon Soda. Insecticide formulation belonging to neonicotinoids compound (active substance: acetamiprid - 200 g in a 1 dm^3 of the agent) - the concentration of the usable liquid 0.020%.

Bulldock 025 EC. Producer: Bayer AG. Insecticide formulation belonging to pyrethroids compound (active substance: beta-cyfluthrin - 25 g in a 1 dm^3 of the agent) - the concentration of the usable liquid 0.050%.

All insecticides that were used were water soluble formulations.

Methods

The laboratory tests of ambient temperature's impact on the effectiveness of the selected insecticides' action on adult individuals of *A. stercorosus* beetles were conducted in August 2007 and 2008. The animals tested were kept in a Q-cell ERC 0750 heater, in permanent darkness, with relative humidity of 75±5%, in ambient temperatures of: 14, 19, 24, 29 and 34°C adopted for individual groups of animals.

The intoxication was carried out through the individual treatment of animals with preparation solutions. A drop of the preparation (in the control sample – a drop of water) of a volume of 4 mm^3, was put with the use of an automatic pipette on the abdominal part of the insect, near the suboesophagal ring. The animals, in groups of four individuals, in plastic containers provided with feed and water, were placed in the heater with the temperature established earlier. Each test was repeated six times. The assumed time of a measurement cycle was 72 hours from the moment of animal's first contact with the preparation.

Statistics

The results were developed with the use of the Statistica for Windows software, version 10 with the use of multivariate analysis of ANOVA (Tukey's test). The effect of time of application was evaluated using one-way ANOVA (Tables 2 and 3).

Results and discussion

In the ambient temperature ranging from 14 to 34°C, 100% of individuals from the control group survived the test. All biocides used in the test in the doses applied proved to be harmful to *A. stercorosus* beetle (Tables 1 and 2). Irrespective of the preparation used, together with the increase in temperature, a drop in the insect survivability was noted. In the case of animal groups placed in ambient temperature of 34°C and treated with diazinon, pirimicarb, indoxacarb and beta-cyflutrin, none of the animals survived the experiment (Tables 1 and 3). These results are consistent with those obtained by other authors, according to which these substances such as phospho-organic substances, carbomates, derivatives of urea [22, 23] and of indeno-oxadiazine [24] are characterised by a positive temperature coefficient, in contrast to pyrethroids, which, as claimed by many authors have a negative temperature coefficient [22, 25, 26]. In our study, this phenomenon was observed exclusively in the case of survivability in the groups tested at temperatures of 24 and 29°C (Tables 1 and 3). Similar effects of pyrethroids activity in *Chilo suppressalis* are reported by Li et al [27]. It is interesting that teflubenzuron, which, as a chitin synthesis inhibitor, should not have toxic effect in the case of imago forms of insects, also proved to have negative temperature coefficient. This may indicate that another component of the preparation formula may cause the toxicity.

Table 1

Average survivability [%] of *A. stercorosus* intoxicated by selected insecticides, depending upon the ambient temperature

Tempera-ture	A	B	C	D	E	F	G	H	
14ºC	58.33 ± 1.21	95.83 ± 0.41	95.83 ±0.41	100.00 ± 0.00	95.83 ± 0.41	100.00 ± 0.00	87.50 ± 0.84	100.00 ± 0.00	Average survivability [%] Standard error
19ºC	29.17 ± 1.17	83.33 ± 0.82	79.17 ± 0.75	100.00 ± 0.00	83.33 ± 0.52	75.00 ± 0.89	54.17 ± 1.17	100.00 ± 0.00	Average survivability [%] Standard error
24ºC	20.83 ± 0.98	70.83 ± 0.75	62.50 ± 0.55	70.83 ± 0.41	70.83 ± 0.75	54.17 ± 0.98	20.83 ± 0.75	100.00 ± 0.00	Average survivability [%] Standard error
29ºC	16.67 ± 0.82	37.50 ± 1.05	45.83 ± 1.17	37.50 ± 0.84	29.17 ± 0.98	25.00 ± 0.89	33.33 ± 0.52	100.00 ± 0.00	Average survivability [%] Standard error
34ºC	0.00 ± 0.00	0.00 ± 0.00	12.50 ± 0.84	0.00 ± 0.00	4.17 ± 0.41	4.17 ± 0.41	0.00 ± 0.00	100.00 ± 0.00	Average survivability [%] Standard error

A - diazinon, B - pirimicarb, C - fenazaquin, D - indoxacarb, E - teflubenzuron, F - acetamiprid, G - beta-cyfluthrin, H - control

The beetles used in the tests originated from a forest environment or from areas with significant buffer properties, in terms of such atmospheric agents [28, 29] as temperature. It was probably the main reason for the high mortality of insects treated with biocides in higher temperatures - which do not occur naturally in the forests near the Carpathian Mountains. Gordon [18] indicates that the temperature, in particular, that close to the tolerance limit, may be a crucial factor, strengthening the action of environmental toxins, occurring already in very low concentrations. Approaching the thermal tolerance range is confirmed by the Q_{10} values (Table 4), constant in the control, but significantly decreasing with increasing temperature of the animals intoxicated with insecticides (in the temperature range from 29 to 34°C in the case of figure was teflubenzuron 0.02 and 0.03 acetamiprid).

Table 2

The specification of statistical differences in the survivability of *A. stercorosus*, intoxicated by selected insecticides, with reference to the control group

Temperature	**A**	**B**	**C**	**D**	**E**	**F**	**G**
14ºC	$P < 0.01$	-	-	-	-	-	-
19ºC	$P < 0.001$	-	-	-	-	-	$P < 0.001$
24ºC	$P < 0.001$	$P < 0.05$	$P < 0.01$	$P < 0.001$	$P < 0.05$	$P < 0.001$	$P < 0.001$
29ºC	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
34ºC	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

A - diazinon, B - pirimicarb, C - fenazaquin, D - indoxacarb, E - teflubenzuron, F - acetamiprid, G - beta-cyfluthrin

Table 3

The specification of statistical differences in the survivability of *A. stercorosus*, depending upon the temperature applied

A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
14-29ºC (P<0.05); 14-34ºC (P<0.01)	14-29ºC (P<0.001); 14-34ºC (P<0.001); 19-29ºC (P<0.01); 19-34ºC (P<0.001); 24-29ºC (P<0.05); 24-34ºC (P<0.001); 29-34ºC (P<0.01)	14-29ºC (P<0.01); 14-34ºC (P<0.001); 19-34ºC (P<0.001); 24-34ºC (P<0.01)	14-24ºC (P<0.001); 14-29ºC (P<0.001); 14-34ºC (P<0.001); 19-24ºC (P<0.001); 19-29ºC (P<0.001); 19-34ºC (P<0.001); 24-29ºC (P<0.001); 24-34ºC (P<0.001); 29-34ºC (P<0.001)	14-29ºC (P<0.001); 14-34ºC (P<0.001); 19-29ºC (P<0.001); 19-34ºC (P<0.001); 24-29ºC (P<0.01); 24-34ºC (P<0.001)	14-24ºC (P<0.01); 14-29ºC (P<0.001); 14-34ºC (P<0.001); 19-29ºC (P<0.001); 19-34ºC (P<0.001); 24-34ºC (P<0.001)	14-19ºC (P<0.05); 14-24ºC (P<0.001); 14-29ºC (P<0.001); 14-34ºC (P<0.001); 19-24ºC (P<0.05); 19-34ºC (P<0.001); 29-34ºC (P<0.05)	-

A - diazinon, B - pirimicarb, C - fenazaquin, D - indoxacarb, E - teflubenzuron, F - acetamiprid, G - beta-cyfluthrin, H - control

Forests, the most complex land ecosystems, which at the same time are a reservoir of natural raw materials used in numerous branches of economy, require extremely precise management, rational application of protective treatments, including the use of chemical agents. For this reason, the knowledge of each variable that could affect the effects of the treatment carried out is particularly important. The results above indicate that the temperature has significant synergetic properties, which shall be taken into account while planning protective treatments.

Table 4

The value of the Q_{10} survivability coefficient of *A. stercorosus* in control group and intoxicated by selected insecticides, depending upon the ambient temperature

Temperature	A	B	C	D	E	F	G	H
14-24ºC	0.36	0.74	0.65	0.71	0.74	0.54	0.24	1.00
19-29ºC	0.57	0.45	0.58	0.38	0.35	0.33	0.62	1.00
24-34ºC	-	-	0.20	-	0.06	0.08	-	1.00
14-19ºC	0.25	0.76	0.68	1.00	0.76	0.56	0.38	1.00
14-29ºC	0.43	0.53	0.61	0.52	0.45	0.40	0.53	1.00
19-34ºC	-	-	0.29	-	0.14	0.15	-	1.00
19-24ºC	0.51	0.72	0.62	0.50	0.72	0.52	0.15	1.00
14-34ºC	-	-	0.36	-	0.21	0.20	-	1.00
24-29ºC	0.64	0.28	0.54	0.28	0.17	0.21	2.56	1.00
29-34ºC	-	-	0.07	-	0.02	0.03	-	1.00

A - diazinon, B - pirimicarb, C - fenazaquin, D - indoxacarb, E - teflubenzuron, F - acetamiprid, G - beta-cyfluthrin, H - control

Conclusions

- ✓ During the tests, temperatures ranging from 14 to 34°C did not cause the death of any *A. stercorosus* beetles of the control sample.
- ✓ Diazinon, pirimicarb, fenazaquin, indoxacarb, teflubenzuron and acetamiprid, applied in form of solutions, proved to have a positive temperature coefficient in the range of temperatures applied.
- ✓ Beta-cyfluthrin from the group of synthetic pyrethroids was characterized by a negative temperature coefficient in the range from 24 to 29°C and a positive one in the higher temperature ranges.
- ✓ The temperature of 34°C proved to be a factor, strengthening the toxicity of all the preparations applied.

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INTERAKCJA TEMPERATURY Z WYBRANYMI INSEKTYCYDAMI CHRZĄSZCZA LEŚNEGO (*Anoplotrupes stercorosus*)

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Abstrakt: W 2007 i 2008 r. przeprowadzono badania wpływu temperatury w zakresie 14-34°C na przeżywalność dorosłych osobników *Anoplotrupes stercorosus* intoksykowanych preparatami owadobójczymi z grup: insektycydów fosfoorganicznych (diazynon), karbaminianów (pirymikarb), chinozalin (fenazachina), indenooksadiazyn (indoksakarb), pochodnych benzoilomocznika (teflubenzuron), neonikotynoidów (acetamipryd) i pyretroidów (beta-cyflutryna). Uzyskane wyniki wskazują, że wszystkie zastosowane preparaty charakteryzowały się dodatnim współczynnikiem temperaturowym. Temperatura 34°C okazała się być bardzo silnym synergetykiem dla wszystkich zastosowanych insektycydów.

Słowa kluczowe: *Anoplotrupes stercorosus*, temperatura, synergizm, insektycydy