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Climbing ability of *Tribolium castaneum* (Herbst) and *T. confusum* J. du Val on food packaging materials (*)

Abstract - Climbing ability of *Tribolium castaneum* and *T. confusum* was tested by placing on wood props with different angles (0, 30, 45, 60 and 90°) stripes (5x10 cm) of packaging materials. Tests were carried out at 22±1°C and at 27±1°C, 60±10% r.h., in a chamber with natural light, conditions usually recorded in stores and processing departments. The two species climbed corrugated paper placed on wood props with angles of 30, 45, 60, and 90°. On the other tested materials, from an angle of 30°, they showed a scarce ability to climb. Sometimes the two species appeared to display different climbing ability. However this indication was not supported by the results of the statistical analysis.

Riassunto - *Capacità di spostamento di adulti di* Tribolium castaneum *(Herbst) e* T. confusum *J. du Val su materiali per l'imballaggio di alimenti*

La capacità di spostamento di *Tribolium castaneum* e *T. confusum* è stata verificata posizionando su supporti in legno con diverse inclinazioni (0, 30, 45, 60 e 90°) strisce (5x10 cm) di materiali per imballaggi. Le prove sono state condotte a 22±1°C e 27±1°C, 60±10% U.R., in presenza di illuminazione naturale, condizioni che si riscontrano in magazzini e industrie alimentari. Le due specie risalgono la carta ondulata posta su supporti con inclinazioni di 30, 45, 60 e 90°. Sugli altri materiali saggiati, a partire da un'inclinazione di 30°, mostrano difficoltà di spostamento. In alcuni casi le due specie hanno presentato comportamento discordante, ma dall'elaborazione statistica non si evince una maggiore abilità di una specie rispetto all'altra.

Key words: Red flour beetle, Confused flour beetle, movement, materials.

INTRODUCTION

Several stored product insects can attack food packaging (Cline, 1978; Cline and Highland, 1981; Locatelli and Garavaglia,1994; Khamrunissa *et al.*, 2007); others, such as *Tribolium castaneum* (Herbst) and *T. confusum* J. du Val, are less able to pierce, as their mandibles are less strong. Hillerton *et al.* (1984) and Morgan *et al.* (2003) have

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shown that *T. castaneum*, detritivorous insect, has less zinc content in the cutting edges of mandibles while stored product insects that can pierce grain have a higher zinc content. Cardboard boxes with glue unevenly spread, microholes in packaging to permit aeration and mechanical rupture can favour the entrance of detritivorous insects (Locatelli and Gambaro, 1999; Navarro *et al.*, 2004). Cline and Highland (1981) observed that adults of *T. castaneum* can enter holes with a diameter less than 1.35 mm.

Food infestation depends on the ability of the insect to climb packaging surface, often steep, in order to reach openings. Cline and Highland (1976) observed the ability of some adult beetles to cling or to climb different flexible packaging materials. *T. castaneum* and *T. confusum* are able to climb paper vertically oriented while on materials such as polypropylene, aluminium foil, teflon, tefzel and glass they can climb only to an angle of 15°.

In this work the climbing ability of *T. castaneum* and *T. confusum* on different food packaging materials was tested.

MATERIALS AND METHODS

Tribolium castaneum and *T. confusum* were placed on wood props with different angles (0, 30, 45, 60 and 90°) covered with stripes (5x10 cm) obtained from different packaging materials (thickness included between 0.5 and 1 mm): thin cardboard, printed thin cardboard, corrugated paper (front, back, vertical and horizontal plane), polyethylene (PE) (smooth and coarse), polyethylenetereftalate (PET) (smooth), polystyrene (PS) (smooth and coarse), polystyrene foam, polyvinyl-chloride (PVC) (smooth), polyester (smooth), coextruded biaxially oriented polypropylene (BOPP COEX), coextruded biaxially oriented polypropylene acrylic coated (BOPP COEX acrylic coated), plastic wrap, aluminium foil (smooth and coarse), and glass.

In the tests, groups of twenty adults of *T. castaneum* and groups of twenty adults of *T. confusum*, 4-8 days old, were used. Adults were individually placed on the width of the rectangle material and stimulated with a paintbrush.

The climbing ability of insects was valued: A) the insect covers rapidly the distance; B) the insect moves tentatively and it frequently slips or it doesn't move even when stimulated, anyway it doesn't cover the distance.

In order to observe the influence of temperature on the movement of *T. castaneum* and *T. confusum*, tests were carried out at 22±1°C and at 27±1°C, 60±10% r.h., in a chamber with natural light, conditions usually recorded in stores and processing departments.

Data were submitted to Fisher test and to logistic regression model (R version 2.6.0).

RESULTS

Tribolium castaneum J. du Val and *T. confusum* (Herbst) covered rapidly the distance when all the materials were horizontally placed. The two species could easily climb also

Tab. 1 - Percentage of adults of Tribolium castaneum *(Herbst) and* T. confusum *J. du Val that climb (A*) or not climb (B**) the different materials at 22 and 27°C.*

Materials	Species	°C	Angles					
			30°		45°		60°	
			A	B	A	B	A	B
Thin cardboard	*T. castaneum*	22	85	15	5	95	0	100
		27	100	0	50	50	15	85
	T. confusum	22	25	75	20	80	0	100
		27	70	30	50	50	10	90
PE smooth	*T. castaneum*	22	0	100	0	100	0	100
		27	45	55	0	100	0	100
	T. confusum	22	0	100	0	100	0	100
		27	20	80	0	100	0	100
PE rough	*T. castaneum*	22	65	35	20	80	0	100
		27	85	15	80	20	35	65
	T. confusum	22	50	50	10	90	5	95
		27	90	10	90	10	85	100
PP smooth	*T. castaneum*	22	0	100	0	100	0	100
		27	10	90	0	100	0	100
	T. confusum	22	0	100	0	100	0	100
		27	10	90	0	100	0	100
PP rough	*T. castaneum*	22	0	100	0	100	0	100
		27	60	40	10	90	5	95
	T. confusum	22	5	95	0	100	0	100
		27	50	50	10	90	0	100
PS rough	*T. castaneum*	22	0	100	0	100	0	100
		27	5	95	0	100	0	100
	T. confusum	22	0	100	0	100	0	100
		27	40	60	0	100	0	100
Foam	*T. castaneum*	22	0	100	0	100	0	100
		27	25	75	15	85	0	100
	T. confusum	22	0	100	0	100	0	100
		27	0	100	5	95	0	100

* A: The insect covers rapidly the distance;
** B: The insects moves tentatively and frequently slips or it doesn't move even when stimulated, anyway it doesn't cover the distance.

corrugated paper (front, back, vertical and horizontal plane) with all the angles tested.

They were not able to move on printed thin cardboard, aluminium foil (smooth and coarse), PET, PVC, plastic wrap, polyester, glass, smooth polystyrene (PS), BOPP COEX and BOPP COEX acrylic coated placed with an angle of 30°, and on smooth and coarse polystyrene (PS) and PVC with an angle of 45°.

The two species showed a different behaviour on some materials (Table 1).

In *T. castaneum* a best climbing ability was observed at 27°C ($P \simeq 0$), unless in the case of PS rough where the temperatures did not influence the behaviour (P=0.06). Also *T. confusum* showed a better climbing ability at 27°C, unless on foam with angles of 30° and 60° (P=1), and of 45° (P=0.06).

At 22°C the two species showed the same behaviour except on thin carboard with an angle of 30° ($P \simeq 0$), where *T. castaneum* was more efficient, while with an angle of 45° *T. confusum* showed a better climbing ability.

At 27°C the two species showed the same behaviour except at 30° on PE smooth ($P \simeq 0$), and on foam ($P \simeq 0$), where *T. castaneum* was more efficient, while on PE rough at 60° and PS rough at 30° *T. confusum* was more efficient.

Logistic regression models confirmed the great importance of material and temperature.

CONCLUSIONS

Tribolium castaneum J. du Val and *T. confusum* (Herbst) climbed corrugated paper placed on wood props with angles of 30, 45, 60, and 90°. On the other tested materials, from an angle of 30°, they showed a scarce ability to climb. The legs of the two species, observed with electronic microscope, do not present arolium or pulvilli.

Thin cardboard allowed climbing more than printed thin cardboard, that presents a smooth surface due to the printing process.

The climbing ability of *Tribolium* spp. on foam was scarce, even if the surface is rough. Foam is constituted by little spheres and the crevices among them can trap tarsi.

Cline and Highland (1976) observed the same behaviour in *T. castaneum* and in *T. confusum* in tests carried out at 27°C; data on glass, polyethylene, PVC, polypropylene and aluminium foil observed in our research agree with the observation of these Authors.

Though *T. confusum* thrives under slightly cooler conditions than *T. castaneum* (2.5°C lower minima and maxima) (Hill, 1990; Champ and Dyte, 1976; Hagstrum *et al.*, 1996), the results of tests carried out at 22 and 27°C did not show differences in the behaviour among the two species. Both the species presented a better climbing ability at 27°C, in fact it is well known that insect mobility enhances when temperature increases.

Sometimes the two species appeared to display different climbing ability. However this indication was not supported by the results of the statistical analysis.

BIBLIOGRAFIA

CHAMP B.R., DYTE C.E., 1976 - Rapport de l'enquete mondiale de la FAO sur les insectes des cereales entreposées et leur sensibilite aux insecticides. Collection FAO: production végétale et protection des plantes, Collection FAO: Production végétale et Protection des plantes, 5, pp. 374.

CLINE L.D., HIGHLAND H.A., 1976 - Climbing and clinging ability of adults of several stored-products beetles on flexible packaging material. J. Econ. Ent., 69: 709-710.

CLINE L.D., HIGHLAND H.A., 1978 - Climbing and clinging ability of larvae of eleven species of stored product insects on nine flexible packaging material and glass. J. Econ. Ent., 71: 689-691.

CLINE L.D., 1978 - Penetration of seven common flexible packaging materials by larvae and adults of eleven specie sof stored product insects. J. Econ. Ent., 71: 726-729.

CLINE L.D., HIGHLAND H.A., 1981 - Minimum size of holes allowing passage of adults of stored-products Coleoptera. J. Georgia Ent. Soc., 16: 525-531.

HAGSTRUM D.W., FLINN P.W., HOWARD R.W., 1996 - Ecology. In: Integrated management of insects in stored products Eds. B. Subramanyam & D.W. Hagstrum, New York, pp. 426.

HILL D.S., 1990 - Pests of stored products and their control. Behaven Press, London, pp. 274.

HILLERTON J.E., ROBERTSON B., VINCENT J.F.V., 1984 - The presence of zinc or manganese as the predominant metal in the mandibles of adult stored-product beetles. J. Stored Prod. Res., 20 (3): 133-137.

KHAMRUNISSA B., VANITA REDDY P., LEELAJA B.C., RAJASHEKAR Y., RAJENDRAN S., 2007 - Studies on insect infestation in chocolates. J. Stored Prod. Res., 43 (2): 118-122.

LOCATELLI D.P., GAMBARO I., 1999 - Suscettibilità di confezioni di pasta alimentare all'attacco di alcuni insetti infestanti. Tecnica Molitoria, 5: 525-530.

LOCATELLI D.P., GARAVAGLIA E., 1994 - Suscettibilità di confezioni per prodotti dolciari all'attacco di alcuni insetti. Workshop "Imballaggio funzionale per una migliore qualità degli alimenti confezionati", Milano 3-4 febbraio 1994: 147-152.

MORGAN T.D., BAKER P., KRAMER K.J., BASIBUYUK H.H., QUICKE D.L.J., 2003 - Metals in mandibles of stored product insects: do zinc and manganese enhance the ability of larvae to infest seeds? J. Stored Prod. Res., 39 (1): 65-75.

NAVARRO S., ADLER C., SCHOLLER M., EMEKCI M., FERIZLI A.G., HANSEN L.S., 2004 - Significance of hermetic seals, controlled ventilation, and wire-mesh screens to prevent the immigration of stored product pests. Bulletin OILB/SROP, 27 (9): 13-16.

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