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***Plodia interpunctella* (Hübner, 1813) (Lepidoptera: Pyralidae) associated with bottles of mineral water. Analysis of an underestimated problem**

Abstract: Pests are responsible for the loss of huge quantities of stored food, both in terms of weight reduction and contamination. The latter may also manifest itself when insects are found in the packaging of non-food products and, in general, when their presence is not associated with the packaging content, as is the case of infested bottles of mineral water. Although these contaminations do not affect the products themselves, they certainly discourage consumers from purchasing, eliciting an impression of poor hygienic conditions with health hazards. By taking a few precautionary measures, such consequences can be avoided.

Riassunto: *Plodia interpunctella* (Hubner, 1813) (Lepidoptera: Pyralidae) associata alle bottiglie di acqua minerale. Analisi di una problematica misconosciuta.

Gli infestanti animali sono responsabili della perdita, sia in termini quantitativi che qualitativi, di enormi quantità di alimenti conservati. I danni dovuti al deterioramento qualitativo possono manifestarsi anche quando gli insetti si trovano nelle confezioni di prodotti non alimentari e, in generale, quando la loro presenza non è associata al contenuto della confezione, come nel caso dell'infestazione delle bottiglie di acqua minerale. Sebbene queste contaminazioni non abbiano ripercussioni sui prodotti stessi, di certo scoraggiano i consumatori dall'acquisto, suscitando un'impressione di scarse condizioni igieniche con rischi per la salute. Adottando alcune misure precauzionali di tipo ambientale (pest proofing) e gestionale (corretta organizzazione delle diverse tipologie di derrate conservate) tali conseguenze possono essere evitate.

Key words: Contamination, pests of stored food, *Plodia interpunctella*, *Oryzaephilus surinamensis*, bottles of mineral water, MOCA.

INTRODUCTION

In developed countries, infesting arthropods cause some of the greatest losses in post-harvest agri-food production, ranging between 8 and 25% (Marriott *et al.*, 2006). The damage is caused by direct consumption, the fouling of food, and the risk these insects may act as vectors of human and animal pathogens due to their contamination of food, processing surfaces, and packaging.

Even if limited to external packaging, the presence of insects and the issues associated with contamination have a strong emotional impact on consumers, who consider the food unsafe.

Plodia interpunctella (Hübner, 1813) is a cosmopolitan moth generally found in warehouses (Pollini 2006), where it infests several substrates, especially cereals and dried fruit, although it can develop on a wide range of other food items (Mohandass *et al.*, 2007).

In some cases, *P. interpunctella* gained medical-veterinary importance and has been cited as a cause of scoleciasis in birds, cats (Pinckney *et al.*, 2001), and humans (Cammarata *et al.*, 2023).

Colonizing packaging arthropods are classified as i) invaders if they exploit openings (fissures and leaks) in the packaging and ii) penetrators if they can actively pierce the packaging material (Kelly, 2004).

P. interpunctella is a penetrating species (Kelly, 2004) whose larvae can actively pierce different types of plastic film packaging (polyethylene and polypropylene), both with and without microperforations, either to reach the foodstuff or to abandon it (Chung *et al.*, 2011; Scheff *et al.*, 2018; Süß *et al.*, 2020).

This paper analyses three cases of infestation in the primary packaging of polyethylene (PET) bottles of mineral water.

CASE STUDY ANALYSIS

In the years 2016, 2019, and 2021, lots of 1.5 l PET bottles (N=28) containing the mineral water bottled by different Companies in northern Italy were returned to the producers 90-120 days from the sale date following the discovery of insect larvae and adult beetles in their thread caps.

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The insects on the bottles (Tab. 1) were isolated, and after analyzing them under a stereomicroscope (Stemi 508, Zeiss, Oberkochen, Germany), some moth larvae were reared to obtain adults. The adult beetles and a few larvae were prepared for determination on the basis of the morphological characters proposed by Gorham (1987). The mouthparts of some larval specimens were dissected to identify them through the

conformation of mandibular teeth as proposed by Gilligan *et al.* (2014).

All the specimens of lepidopterans were identified as mature larvae of *P. interpunctella* (Hübner, 1813), and the adults emerging from the reared larvae confirmed this identification. The adult beetles were identified as *Oryzaephilus surinamensis* (Linnaeus, 1758) (Figs. 1, 2).



Fig. 1. *Oryzaephilus surinamensis* adults found on a bottle of the case id 1.



Fig. 2. *Plodia interpunctella* larvae and an *Oryzaephilus surinamensis* adult found on a bottle of the case id 1.

Tab. 1. Species found in the analyzed cases.

Case	n. bottles	Species	n.insects	Development stage
1	7	<i>Plodia interpunctella</i>	9	L
		<i>Plodia interpunctella</i>	3	C
		<i>Oryzaephilus surinamensis</i>	8	A
2	12	<i>Plodia interpunctella</i>	5	L
		<i>Plodia interpunctella</i>	7	C
		<i>Oryzaephilus surinamensis</i>	11	A
3	9	<i>Plodia interpunctella</i>	12	L
		<i>Plodia interpunctella</i>	3	C

A, adult; L, larvae; C, cocoon.

CONCLUSIONS

The cases described here are unusual because the aliment where the insects were found is seldom infested.

The presence of mature larvae and cocoons in thread caps is explained by the peculiar ability of *P. interpunctella* to abandon the substrate on which it has completed its larval development to migrate, looking for suitable cracks and fissures to carry out its metamorphosis into chrysalis. In the case id 1, because the larvae were found in September, they were traced back to wintering larvae.

The presence of *O. surinamensis* adults in cases 1 and 2 may be due to the fact that the bottles of mineral water were stored in the same rooms as items of food

already infested by this insect, like flour, wheat, pasta, etc. (Candura, 1954; Gelosi *et al.*, 1999). The presence of adult beetles in the bottle caps is probably due to the fact that *O. surinamensis*, at the adult stage, usually feeds on substances of animal origin (Candura, 1954), in this case, the larvae of *P. interpunctella*.

From a practical point of view, the analyzed infestations are purely opportunistic, occurring in intermediate warehouses or large-scale retail outlets, and therefore beyond the producers' control.

The use of shrink-wrap films that wrap around the bottle cap makes it possible to avoid the problem described, and consequently avoid major negative repercussions in terms of consumer confidence in food producers.

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