Record of natural parasitoids of the box tree moth, *Cydalima perspectalis* (Walker, 1859), in France (Lepidoptera, Crambidae)

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Abstract. – The present study aims to highlight the box tree moth, *Cydalima perspectalis* (Walker, 1859) (Lepidoptera: Crambidae), as a potential new host for European autochthonous parasitoids. Thus, 192 pupae showing signs of parasitism were collected *in situ*, to identify the possible emerging parasitoids in the laboratory. Seven parasitoids emerged: one Tachinidae belonging to the species *Compsilura concinnata* (Meigen, 1824) (Diptera); three Ichneumonidae belonging to the species *Theronia atalantae* (Poda, 1761) (Hymenoptera); and three Ichneumonidae belonging to the species *Pimpla turionellae* (Linnaeus, 1758) (Hymenoptera). The discovery of new species of natural parasitoids of *C. perspectalis* thus represents an interesting perspective in regulating of this pest in natural environments.

Résumé. – **Recensement de parasitoïdes naturels de la pyrale du buis, *Cydalima perspectalis* (Walker, 1859), en France (Lepidoptera, Crambidae)**. La présente étude a pour objectif de mettre en évidence la pyrale du buis, *Cydalima perspectalis* (Walker, 1859) (Lepidoptera : Crambidae), en tant que potentiel nouvel hôte pour des parasitoïdes autochtones européens. Ainsi, 192 chrysalides présentant des signes de parasitisme ont été prélevées *in situ*, afin d'identifier au laboratoire les éventuels parasitoïdes émergeants. Sept parasitoïdes ont émergé : une Tachinidae appartenant à l'espèce *Compsilura concinnata* (Meigen, 1824) (Diptera) ; trois Ichneumonidae appartenant à l'espèce *Theronia atalantae* (Poda, 1761) (Hymenoptera) ; et trois Ichneumonidae appartenant à l'espèce *Pimpla turionellae* (Linnaeus, 1758) (Hymenoptera). La découverte de nouvelles espèces de parasitoïdes naturels de *C. perspectalis* représente ainsi une perspective intéressante dans la régulation de ce ravageur en milieu naturel.

Keywords. – Box tree moth, parasitoids, Ichneumonidae, Tachinidae.

The box tree moth, *Cydalima perspectalis* (Walker, 1859) (Lepidoptera: Crambidae), is a Lepidoptera native from East Asia (Mally & Nuss, 2010), which was unintentionally introduced into Europe in 2007, through the trade and transport of infested boxwood (Leuthardt, 2010; Van der Straten & Muus, 2010), and was identified for the first time in France in 2008 (Feldtrauer *et al.*, 2009). This species has a strong invasive capacity.

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Due to its recent and rapid colonization of the European continent, few natural enemies have yet been identified (NACAMBO, 2012; WAN *et al.*, 2014).

Currently, several parasitoids and natural predators of the box tree moth are known (WAN *et al.*, 2014; GÖTTIG & HERZ, 2016; MARTINI *et al.*, 2019; BIRD *et al.*, 2020). In its native area, the parasitic complex of *C. perspectalis* is large and includes oophagous, larval and pupal parasitoids (WAN *et al.*, 2014). In Europe, two generalist parasitoids of Lepidoptera, *Pseudoperichaeta nigrolinerata* (Walker, 1853) (Diptera: Tachinidae) and *Apechthis compunctor* (Linnaeus, 1758) (Hymenoptera: Ichneumonidae), have been found in natural environment at very low levels of occurrence (NACAMBO, 2012; WAN *et al.*, 2014). In laboratory conditions, several species of *Trichogramma* Westwood, 1833 (Hymenoptera: Trichogrammatidae) have shown parasitism efficiency (GÖTTIG & HERZ, 2016), but this efficiency under natural conditions is not yet known. Alkaloids present in box tree moth larvae represent a brake on the development of the cycle of several parasitoids such as *Exorista larvanum* (Linnaeus, 1758) (Diptera: Tachinidae) (MARTINI *et al.*, 2019) or *Bracon hebetor* (Say, 1836) (Hymenoptera: Braconidae) (TUNCA COSIC *et al.*, 2023). This article presents the results of a study carried out in 2020, whose objectives were to highlight the box tree moth as a potential new host for autochthonous parasitoids and to expand the list of potential known biological regulators of this pest.

MATERIEL AND METHODS

Two samples of box tree moth were collected, on June 10th and 16th 2020, on the Col d'Ey, in the Drôme Provençale, France [44°18'N 5°16'E]. This forest site is located on a colonization front zone of the box tree moth and is particularly interesting to observe a possible ecological response in progress. A total of 192 pupae with sting marks, a sign of parasitism, were collected from this site during the two sessions. The pupae were then isolated in individual tubes in the laboratory and kept at a temperature of 22°C, 60% RH, and in natural photoperiod.

OBSERVATIONS

Of the 192 pupae collected from the natural environment, 148 (77%) resulted in the emergence of moths. Of the latter, 28 (19%) showed signs of disability and sting marks on adult bodies. Of the 44 pupae that did not produce moths, seven parasitoids emerged between the 26th June 2020 and the 6th July 2020. An individual was identified as belonging to the species *Compsilura concinnata* (Meigen, 1824) (Diptera: Tachinidae). Two species of Ichneumonidae (Hymenoptera) were also identified: three individuals (1 female and 2 male) were identified as belonging to the species *Theronia atalantae* (Poda, 1761) (Ichneumonidae: Pimplinae). In addition, three other individuals (3 females) were identified as being *Pimpla turionellae* (Linnaeus, 1758) (Ichneumonidae: Pimplinae).

DISCUSSION

Theronia atalantae is a common species and very widely distributed throughout the Palearctic region, including the occurrence area of *C. perspectalis* (UCHIDA, 1928). This species can be found both in an open environment (rich meadow, wasteland) and in a closed environment (deciduous woodlands). This species appears to be a hyperparasite of other Ichneumonidae Latreille, 1802, Braconidae Nees, 1811 or

Tachinidae Fleming, 1821, attacking Lepidoptera (Aubert, 1969; Kasparyan, 1981; Jacobs, 2009; Shaw *et al.*, 2009). *Theronia atalantae* therefore does not seem to be directly associated with *Cydalima perspectalis*, but with its parasitoids. In France, the known imago flight period extends from June to August (Robert, 2013), but the species seems active from May until October in Germany (Jacobs, 2009).

In Europe, among the subfamily Pimplinae Wesmael, 1845, *T. atalantae* can be recognized by: the smooth, unsculptured tergites; the very large tarsal claws, with a conspicuous long flattened bristle; and the body almost entirely orange (Fitton *et al.*, 1988; Kolarov, 1997; Varga, 2017) (fig. 1-6).

The second species, *Pimpla turionellae*, is also a common species and widely present in the Palaearctic, including the occurrence area of *C. perspectalis* (Uchida, 1928; Kim, 1955). Unlike the previous species, it seems more restricted to deciduous

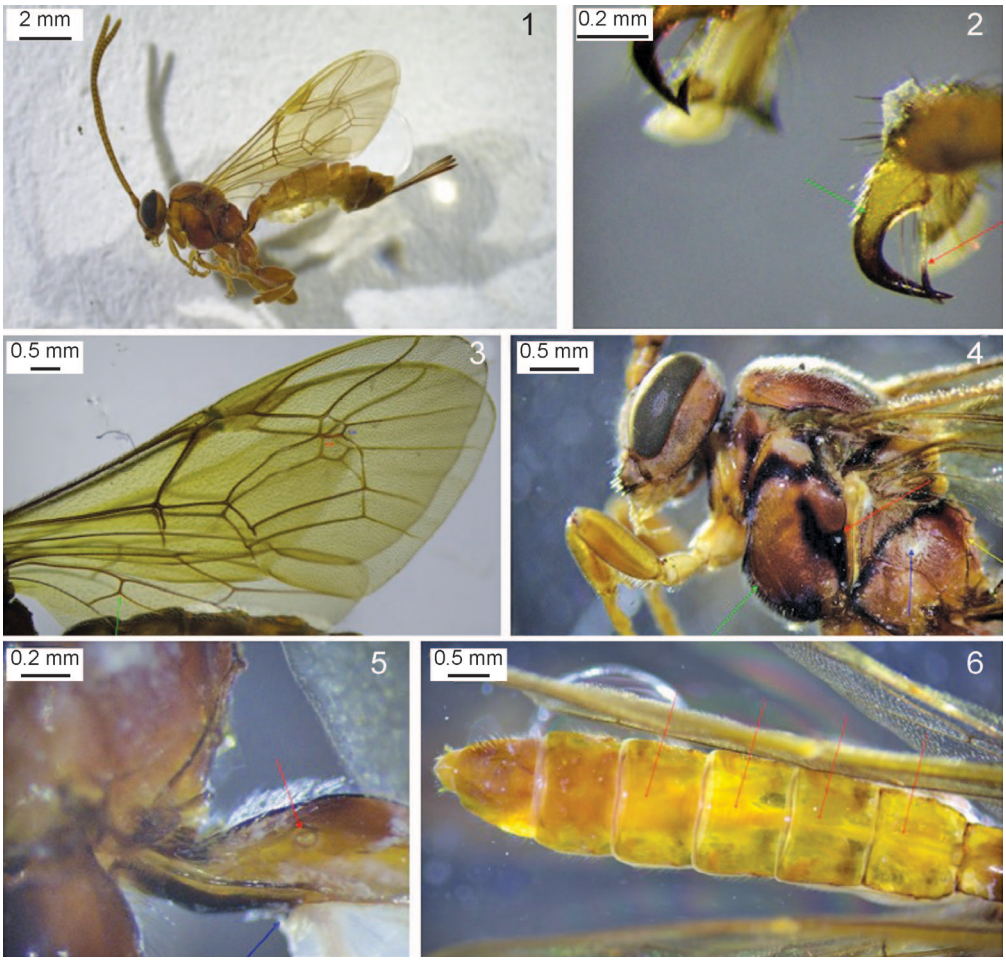

Fig. 1-6. – *Theronia atalantae* (Poda), some identification criteria. – **1**, Lateral habitus. – **2**, Large claws (in green), with silk that turns black at the tip (in red). – **3**, Forewing with sessile areolet, two bullae, and with the first segment of M (0.39 mm – in red) longer than the second (0.16 mm – in blue); hindwing view with 2/CU joining 1/CU closer to M than to 1A (in green). – **4**, Mesopleuron without sternaulus (in green) but with slightly angular mesopleural cleft (in red); propodeum with carinae (including transverse, in yellow) and elongated propodeal spiracle (in blue). – **5**, First abdominal segment short and thick, spiracle slightly before the middle (in red); sternite ending before the spiracle (in blue). – **6**, Dorsal view of tergites (in red).

woodlands and hedges, and it is more rarely found in open areas. This species is parasitic on a wide range of Lepidoptera among the Psychidae Boisduval, 1828, Yponomeutidae Stephens, 1829, Depressariidae Meyrick, 1883, Tortricidae Latreille, 1803, Pieridae Swainson, 1820, Lycaenidae Leach, 1815, Geometridae Leach, 1815, Lymantriidae Hampson, 1893, and Pyralidae Latreille, 1809 (AUBERT, 1969; FITTON *et*

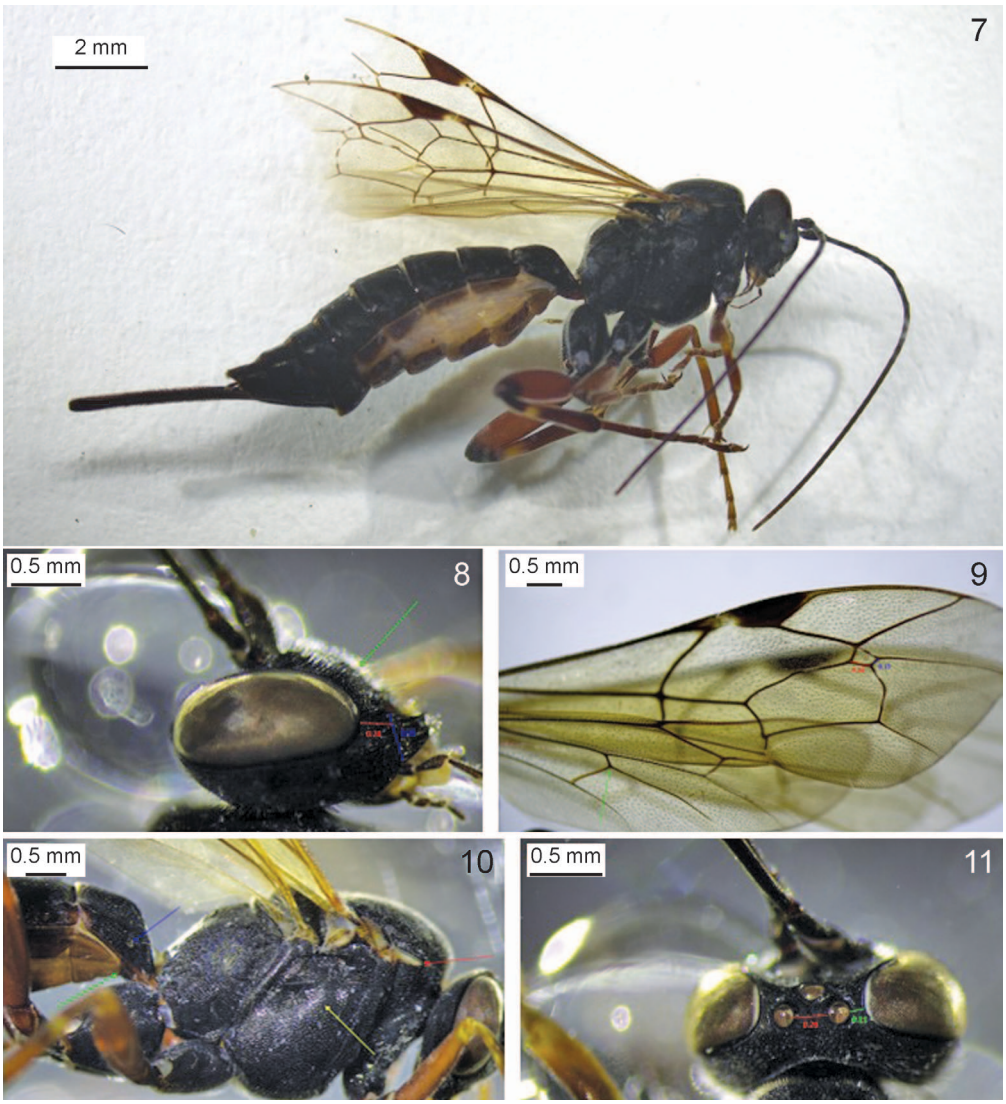

Fig. 7-11. – *Pimpla turionellae* (Linnaeus), some identification criteria. – **7**, Lateral habitus. – **8**, Lateral view of head, whitish pubescence (in green), malar space (0.24 mm – in red) smaller than the width of the base of the mandible (0.36 mm – in blue). – **9**, Forewing view with sessile areolet; two bullae and with the first segment of M (0.30 mm – in red) longer than the second (0.15 mm – in blue); hindwing view with 2/CU joining 1/CU closer to M than to 1A (in green). – **10**, Mesopleuron view of *P. turionellae*, deep and dense dots separated by spaces of the same diameter as the dots (in yellow); mesosoma entirely black (including coxae) except for a small white spot at the posterior corner of the pronotum (in red); first abdominal segment short, thick and black with spiracle before middle (in blue); sternite stopping before spiracle (in green). – **11**, Frontal view of head, distance between two ocelli (0.26 mm – in red) greater than between ocelli and adjacent eye (0.11mm- in green).

al., 1988; Varga, 2017). The female of *P. turionellae*, after being fertilized, generally by several males, lays a single egg per host when the latter is at the pupal stage (Meyer, 2009; Coskun & Kayis, 2017). The known imago flight period in France extends from June to September (Robert, 2013).

In Europe, among the subfamily Pimplinae, *P. turionellae* can be recognized by: the whitish pubescence on the head and the mesosoma; the mesopleura with strong and dense punctures; the hind tibia with a distinct subbasal pale ring; and the upper hind corner of the pronotum with a long yellow line (Fitton *et al.*, 1988; Kolarov, 1997; Varga, 2017) (fig. 7-11).

Another type of parasitism is found in *Compsilura concinnata* (Meigen, 1824), a well-known and widespread polyphagous tachinid. Native to Europa, this parasitoid is an extreme generalist, recorded hosts are currently about 275 species: >100 species in the Palearctic Region (Herting, 1960), at least 161 species in North America (Arnaud, 1978), and 59 species in Japan (Shima, 1999). Most of the hosts are lepidopterous larvae, but some sawflies and even coleopterans serve as their hosts (Ichiki & Shima, 2003). This species has already been recorded as a natural parasitoid of box tree moth in other countries like Japan and Iran (Wan *et al.*, 2014; Farahani *et al.*, 2018).

Conclusion

This study did not reveal the presence of any parasitoids with a significant impact on the *Cydalima perspectali*s population. However, the parasitoids that have emerged now include the box tree moth as a new host. Continued field research is, therefore, necessary to find a species with a marked trophic interaction with the box tree moth, demonstrating an adaptation of the local entomofauna to this invasive species. To allow natural regulation of this pest by parasitoids, it would also be interesting to include in the surveys parasitoids attacking pre-imaginal stages, in particular larval parasitoids.

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References

Arnaud P. H., 1978. – A host-parasite catalog of North American Tachinidae (Diptera). *United States Department of Agriculture Miscellaneous Publication*, **1319** : 1-860.

Aubert J.-F., 1969. – *Les Ichneumonides ouest-paléarctiques et leurs hôtes : Pimplinae, Xoridinae, Acaenitinae*. Alfortville : Éditions Quatre feuilles, 299 p.

Bird S., Raper C., Dale-Skey N. & Salisbury A., 2020. – First records of two natural enemies of box tree moth, *Cydalima perspectalis* (Lepitoptera : Crambidae), in Britain. *British Journal of Entomology & History*, **33** (1) : 67-70.

Coskun M. & Kayis T., 2017. – Change in number of males of Parasitoid *Pimpla turionellae* L. (Hymenoptera: Ichneumonidae) affect its progeny sex ratio, longevity and adult emergence. *Bahçe Kültürleri Araştırma Enstitüsü Adına Sahibi*, **16** (1) : 59-66.

Farahani S., Salehi M., Farashiani M., Gilasian E., Terujeni S. K. & Ahangaran Y., 2018. – *Compsilura concinnata* (Meigen), parasitoid of box tree moth, *Cydalima perspectalis* (Walker) from Iran. *Iranian Journal of Forest and Range Protection Research*, **16** (1) : 102-105.

Feldtrauer J.-F., Feldtrauer J.-J. & Brua C., 2009. – Premiers signalements en France de la Pyrale du buis *Diaphania perspectalis* (Walker, 1859), espèce exotique envahissante s'attaquant aux buis (Lepidoptera, Crambidae). *Bulletin de la Société entomologique de Mulhouse*, **65** (4) : 55-58.

Fitton M., Shaw M. R. & Gauld I. D., 1988. – Pimpline ichneumon-flies. Hymenoptera, Ichneumonidae (Pimplinae). *Handbooks for the identification of British Insects*, **7** (1) : 110 p.

GÖTTIG S. & HERZ A., 2016. – Are egg parasitoids of the genus *Trichogramma* (Hymenoptera: Trichogrammatidae) promising biological control agents for regulating the invasive Box tree pyralid, *Cydalima perspectalis* (Lepidoptera: Crambidae)? *Biocontrol Science and Technology*, **26** (11) : 1471-1488. https://doi.org/10.1080/09583157.2016.1211990

HERTING B., 1960. – Biologie der westpalaarktischen Raupenfliegen, Dipt., Tachinidae. *Monographien zur angewandte Entomologie*, **16** : 1–188.

ICHIKI R. & SHIMA H., 2003. – Immature Life of *Compsilura concinnata* (Meigen) (Diptera: Tachinidae). *Annals of the Entomological Society of America*, **96** (2) : 161-167. https://doi.org/10.1603/0013-8746(2003)096[0161:ILOCCM]2.0.CO;2

JACOBS H.-J., 2009. – *Theronia* Holmgren, 1859 in Deutschland (Hymenoptera, Ichneumonidae, Pimplinae). *Contributions to Entomology*, **59** (2) : 329-334. https://doi.org/10.21248/contrib.entomol.59.2.329-334

KASPARYAN D. R., 1981. – Sem. Ichneumonidae, Vvedenie, Podsemejstvo Pimplinae. *The definer of the European part of the USSR*, **3** : 7-97.

KIM C. W., 1955. – A study on the Ichneumon-flies in Korea (p. 423-498). *in* : *Commemoration These 15th Anniversary Korea University*. Seoul.

KOLAROV J. A., 1997. – *Hymenoptera, Ichneumonidae: Pimplinae, Xoridinae, Acaenitinae, Collyriinae.* Sofia : Academic Publishing House "Prof. Marin Drinov", 346 p.

LEUTHARDT., 2010. – Ausbreitung des Buchsbaumzünslers *Diaphania perspectalis* (Lepidoptera, Pyralidae) in der Region Basel–eine für die Schweiz neue Schädlingsart. *Entomo Helvetica*, **3** (1) : 51-57.

MALLY R. & NUSS M., 2010. – Phylogeny and nomenclature of the box tree moth, *Cydalima perspectalis* (Walker, 1859) comb. n., which was recently introduced into Europe (Lepidoptera: Pyraloidea: Crambidae: Spilomelinae). *European journal of Entomology*, **107** (3) : 393-400. https://doi.org/10.14411/eje.2010.048

MARTINI A., VITANTONIO C.-D. & DINDO M.-L., 2019. – Acceptance and suitability of the box tree moth *Cydalima perspectalis* as host for the tachinid parasitoid Exorista larvarum. *Bulletin of Insectology*, **72** (1) : 150-160.

MEYER N. F., 2009. – Zur Biologie und Morphologie von *Pimpla examinator* Fabr. (Hymenoptera, Ichneumonidae). *Zeitschrift für Angewandte Entomologie*, **11** (2) : 203-212. https://doi.org/10.1111/j.1439-0418.1925.tb00003.x

NACAMBO S., 2012. – *Parasitisme, développement, modèle climatique et impact de* Cydalima perspectalis *en Europe*. Switzerland : MSc-thesis University of Neuchâtel.

ROBERT T., 2013. – Contribution à la connaissance des Hyménoptères Ichneumonidae de Lorraine (sous-famille des Pimplinae). *L'Entomologiste*, **69** (2) : 97-104.

SHAW M. R., STEFANESCU C. & NOUHUYS S. VAN, 2009. – Parasitoids of European butterflies (p. 130-156). *In* : Settele J., Shreeve T., Konvicka M. & Van Dyck H. (eds), *Ecology of Butterflies in Europe.* Cambridge University Press.

SHIMA H., 1999. – Host-parasite catalog of Japanese Tachinidae (Diptera). *Makunagi/Acta Dipterologica*, **25** : 1-108.

TUNCA COSIC H., KANDIL C., ÇAYCI D., COSIC B. & TOPRAK Ö., 2023. – Effectiveness of potential biological control agent *Bracon hebetor* (Say) (Hymenoptera: Braconidae) on *Cydalima perspectalis* (Walker) (Lepidoptera: Crambidae). *Harran Tarım ve Gıda Bilimleri Dergisi*, **27** (3) : 362-371. http://doi.org/10.29050/harranziraat.1261385

UCHIDA T., 1928. – Dritter Beitrag zur Ichneumoniden-Fauna Japans. *Journal of the Faculty of Agriculture, Hokkaido Imperial University*, **25** (1) : 1-115.

VAN DER STRATEN M. & MUUS T., 2010. – The box tree pyralid (*Glyphodes perspectalis* (Walker, 1859), Lepidoptera: Crambidae); an invasive alien moth ruining box trees. *Proceedings of the Netherlands Entomological Society*, **21** : 107-111.

VARGA O., 2017. – A review of the tribe Pimplini Wesmael, 1845 (Hymenoptera, Ichneumonidae, Pimplinae) from the Carpathians, with new records for Romania and Ukraine. *Turkish Journal of Zoology*, **41** (2) : 354-362. https://doi.org/10.3906/zoo-1604-75

WAN H., HAYE T., KENIS M., NACAMBO S., XU H., ZHANG F. & LI H., 2014. – Biology and natural enemies of *Cydalima perspectalis* in Asia: Is there biological control potential in Europe? *Journal of Applied Entomology*, **138** (10) : 715-722. http://doi.org/10.1111/jen.12132