

Gypsy moth, *Lymantria dispar* (L.)

Introduction

The gypsy moth (GM) *Lymantria dispar* L. (Lep.: Erebidæ) is native to Eurasia. Larvae are known as defoliators of oaks and other broadleaved trees. Cyclic outbreaks occur throughout most of its host range, but are usually of short duration and trees are rarely killed. The European strain was accidentally introduced from France into Massachusetts, USA, in 1869. It gradually spread south, north and west to reach Canada in 1924. Today it is considered permanently established in all New England states to Virginia, West Virginia, Ohio and Wisconsin, and in the Canadian Provinces Ontario, Quebec, New Brunswick and Nova Scotia (CABI 2022). Damage level in its introduction range are considered more serious than in its native range, especially at the edge of its distribution. In North America, GM is considered one of the most damaging non-native forest pests. Incursions in other US States and Canadian Provinces are regularly eradicated. Females of the “European strain” don’t fly. However, females of the “Asian strain” are able to fly. Long distance spread is due to human transports. Egg masses can be laid on cars, trucks, trains or boats, on logs, or containers (CABI 2022).

History of classical biological control against *Lymantria dispar*

Following the introduction of GM into North America in 1869, it was the target of extensive biological control programmes. About 80 species of natural enemies, parasitoids, predators and pathogens were introduced from 1906 to the present but most have failed to establish (Doane and McManus 1981). Only 11 parasitoids, one predator and two pathogens established upon their release, some of which have become important mortality factors in North America. Among parasitoids, the most abundant species both in Europe and the Americas are the tachinid larval parasitoids *Parasetigena silvestris* (Robineau-Desvoidy), *Compsilura concinnata* (Meigen) and *Blepharipa pratensis* (Meigen). Other important parasitoids include the braconid larval parasitoid *Cotesia melanoscela* (Ratzeburg), the encyrtid egg parasitoid *Ooencyrtus kuvanae* (Howard), and the chalcidid pupal parasitoid *Brachymeria intermedia* (Nees) (Doane and Mc Manus 1981; Elkinton and Liebhold 1990). Among these, *C. concinnata* is known to attack over 200 moth species and is suspected as causing the decline of native saturniid moths in North America (Elkinton and Boettner 2012).

The two pathogens introduced from Eurasia also play an important role in the regulation of GM populations in North America and Eurasia. A nuclear polyhedrosis virus frequently causes epizootics that cause the collapse of outbreaks (Doane and Mc Manus 1981; Elkinton and Liebhold 1990). The fungal pathogen *Entomophaga maimaiga* Humber, Shimazu & Soper was probably introduced accidentally from eastern Asia in the 1980s. Since then, this pathogen has become an important natural enemy of the gypsy moth and it has recently been observed to have replaced the gypsy moth nuclear polyhedrosis virus as the dominant pathogen in outbreaking populations in the USA (Hajek et al., 2015). It was also introduced in Bulgaria in the period 1999-2005). From there, it spread to several Balkan countries, which shows a significant impact on GM populations (Pilarska et al. 2016). Classical biological control against GM has also been implemented in Morocco, where the egg parasitoid *Ooencyrtus kuvanae* and the nuclear polyhedrosis virus were introduced from Europe (Fraval and Villemant, 1995).



Preparedness in biological control of priority biosecurity threats

Most promising natural enemies for classical biological control

GM is attacked by many natural enemies. However, many are polyphagous and not suitable as classical biological control agents. The most specific and most efficient natural enemies in Eurasia and North America are:

The tachinid fly *Parasetigena silvestris*. (Robineau-Desvoidy) is usually considered as the most abundant parasitoid of GM in Europe and North America (Doane and Mc Manus 1981). It is specific to *Lymantria* spp. (Tschorsnig et Herting 1994).

The nuclear polyhedrosis virus of GM is specific to its host (Hayek et al. 1996). It is capable of causing important larval mortality and the collapse of outbreaks on its own, in both Europe and North America (Doane and Mc Manus 1981).

The Asian fungus *Entomophaga maimaiga* Humber, Shimazu & Soper is also an important pathogen of GM in North America and the Balkans, where it was introduced. While, in the laboratory, it is able to infect the larvae of several species of Lepidoptera, field surveys during GM outbreaks with high infestation by *E. maimaiga* showed hardly any infections on co-occurring Lepidoptera (Hajek et al. 1996).

Other natural enemies for classical biological control

Other parasitoids that could be considered as biological control agents are important parasitoids with a known host range limited to a few other species, such as the tachinids *Blepharipa pratensis* (Meigen) and *Blepharipa schineri* (Mesnil) (Tschorsnig and Herting 1994), or species that are apparently specific to GM but not that abundant in most samples, such as the ichneumonid *Phobocampe disparis* (Yu et al. 2016)

Another species of potential interest as classical biological control agent is the tachinid larval parasitoid, *Aphantorhaphopsis samarensis* (Villeneuve), which was found to be a main parasitoid of GM at low host density in Western Europe. It may play an important role in keeping host populations at endemic level and field and laboratory studies have shown that it is rather specific to GM (Fuester et al. 2001)

References

- Doane CC, McManus ML, 1981. The gypsy moth: research towards integrated pest management. USDA Forestry Service Technical Bulletin No. 1585.
- Elkinton JS, Liebhold AM, 1990. Population dynamics of gypsy moth in North America. Annual Review of Entomology, 35:571-596
- Elkinton JS, Boettner GH (2012) Benefits and harm caused by the introduced generalist tachinid, *Compsilura concinnata*, in North America. Biocontrol 57:277–288
- Fuester, R. W., Kenis, M., Swan, K. S., Kingsley, P. C., Lopez-Vaamonde, C., & Hérard, F. (2001). Host range of *Aphantorhaphopsis samarensis* (Diptera: Tachinidae), a larval parasite of the gypsy moth (Lepidoptera: Lymantriidae). Environmental Entomology, 30(3), 605-611.
- Fraval A, Villemant C, 1995. La lutte biologique contre le bombyx disparate *Porthetria dispar* (L.) (Lep. Lymantriidae) au Maroc. IOBC wprs Bulletin, 18(6):83-86.

Preparedness in biological control of priority biosecurity threats

Hajek, A. E., Butler, L., Walsh, S. R., Silver, J. C., Hain, F. P., Hastings, F. L., ... & Smitley, D. R. (1996). Host range of the gypsy moth (Lepidoptera: Lymantriidae) pathogen *Entomophaga maimaiga* (Zygomycetes: Entomophthorales) in the field versus laboratory. *Environmental Entomology*, 25(4), 709-721.

Hajek AE, Tobin PC, Haynes KJ, 2015. Replacement of a dominant viral pathogen by a fungal pathogen does not alter the collapse of a regional forest insect outbreak. *Oecologia*, 177(3):785-797.

Pilarska, D., Georgiev, G., Golemansky, V., Pilarski, P., Mirchev, P., Georgieva, M., ... & Vafeidis, P. (2016). *Entomophaga maimaiga* (Entomophthorales: Entomophthoraceae) in Balkan Peninsula—An overview. *Silva balcanica*, 17(1), 31-40.

Tschorsnig, H.P. and Herting, B. (1994) Die Raupenfliegen (Diptera: Tachinidae) Mitteleuropas: Bestimmungstabellen und Angaben zur Verbreitung und Ökologie der einzelnen Arten. *Stuttgarter Beiträge zur Naturkunde (A)*, 506, 1-170.

Yu, D. S., Van Achterberg, K., & Horstmann, K. (2016). *World Ichneumonoidea Taxonomy, Biology, Morphology and Distribution*. Taxapad, Vancouver, BC, Canada. Flash drive.