Hormone Treatment for Weevils: Targetting Neuropeptides to Control Forest Pest Damage

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nEUROSTRESSPEP

Novel biocontrol agents for insect pests from neuroendocrinology

THE CHALLENGE

- Sustainable agriculture is required for Food Security for the predicted world population of 9 billion by 2050.
- Insect pests are a major cause of crop and tree losses and a major Food Security issue.
- Environmentally friendly insect control methods are urgently needed.
- There is an increasing need to reduce insecticide use due to regulatory and environmental pressures.

THE PROJECT

- A four year H2020 Research and Innovation Action project across 3 sectors (Agriculture, Horticulture and Forestry).
- Spans work from lab to field and forest. Consortium includes Researchers, Companies and Government advisors and agencies.
- Aims to develop novel biocontrol tools based on neuroendocrinology to reduce pest insect fitness against environmental stress
- Integrated pest management approach considering pests and beneficial insects

The need for 'greener' control methods

As insecticide resistance becomes more widespread in target insects, and legislation limits their use due to undesirable side-effects, so new and 'greener' control agents are needed for pests of agriculture, horticulture and forestry. A novel area of research aims to exploit the selective nature of neuropeptide signalling hormones for combating pest species, whilst remaining harmless to non-target insects. Neuropeptides are short amino acid chains synthesized by modified nerve cells, and regulate all critical processes in insects, including behaviour, reproduction, diuresis and energy metabolism. Neuropeptides specific to pest insects, and not found in beneficial species, therefore have great potential as targets in an integrated pest management context.

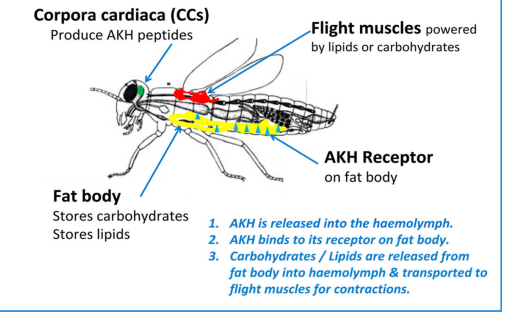
The forest pest

The pine weevil *Hylobius abietis* is a major pest of plantation forestry throughout Europe. Larvae develop in the bark of conifer root-stumps in recent clearfells, and adults emerge to feed on the bark of replanted seedlings, which are frequently girdled and killed. Feeding is necessary for the development of flight muscle; the adults disperse by flying to new clearfells, where they oviposit in the bark of fresh root-stumps. Mortality of seedlings is often very high, and for the new trees to establish they are usually chemically protected, typically with cypermethrin. Such insecticides have potential environmental side-effects and operator risks, and minimising their use is clearly desirable.

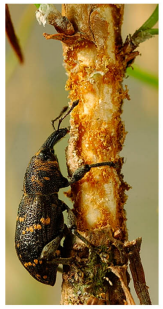
Insect Adipokinetic Hormones

Considerable energy is required for dispersal by flight. In other insects studied, energy may be mobilised from stored glycogen in the fat body, by a neuropeptide of the AKH family (adipokinetic / hyperglycaemic hormone) produced in the corpora cardiaca. After release into the haemolymph, the AKH activates an enzyme, glycogen phosphorylase, which converts glycogen into metabolically available sugars, such as the disaccharide trehalose (Figure 1).

Figure 1. The Adipokinetic Hormone (AKH) system in insects



1. *AKH is released into the haemolymph.*
2. *AKH binds to its receptor on fat body.*
3. *Carbohydrates / Lipids are released from fat body into haemolymph & transported to flight muscles for contractions.*



Initial Research

Ten adult pine weevils, kept at rest, each had 1 µl of their haemolymph sampled. Total carbohydrates were measured in half of the samples and total lipids in the others. Results indicated that pine weevils have a higher concentration of carbohydrates and may use these for dispersal. To search for the presence of an AKH peptide, we dissected the corpora cardiaca, extracted any peptides, and injected the extract into fresh weevils. We sampled the haemolymph and measured carbohydrates and lipids prior to and 90 min after injection. The results demonstrate that corpora cardiaca extract did not increase the lipid concentration (Fig. 2), but did increase the carbohydrate concentration significantly (Fig. 3). The peptide sequence from the corpora cardiaca was determined by mass spectrometry. An AKH peptide, Peram-CAH-I, with the sequence pGlu-Val-Asn-Phe-Ser-Pro-Asn-Trp amide was identified. Injection of the synthetic form of Peram-CAH-I into live adult weevils also increased carbohydrate concentration, while a control injection of water did not (Fig. 3).

Fig. 2. Lipid concentration in haemolymph (µg/µl) before and after injection of substances into pine weevils.

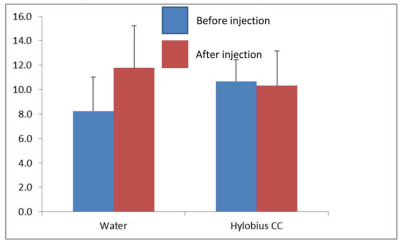
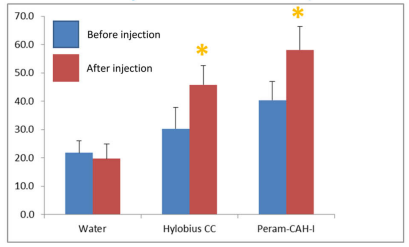


Fig. 3. Carbohydrate concentration in haemolymph (µg/µl) before and after injection of substances into pine weevils.



This work suggests that *H. abietis* uses stored glycogen as fuel for flight, mobilising it to the sugar trehalose with the help of this neuropeptide, Peram-CAH-I. It is known that the AKH peptide binds to its cognate receptor in the fat body to achieve its action of fuel mobilisation. A non-peptide substance may now be synthesised which can mimic the AKH peptide, but not degrade quickly in the insect body. Such a 'mimetic' could be an antagonist that could block the receptor binding sites (steric hindrance) and thus, interfere with the entire metabolic pathway so that trehalose cannot be released into the haemolymph – effectively draining fuel for flight dispersal.

Implications & future research

Pine weevil populations are mobile and quick to take advantage of newly created breeding sites (clearfells) in a managed forest mosaic. Under climate change, flight threshold temperatures are likely to be attained earlier and more frequently throughout the spring, further increasing opportunities for dispersal, and extending the period of risk from feeding damage. To combat this, knowledge of the structure and mode of action of weevil neuropeptides might be employed as part of an integrated pest management system. A synthetic antagonist used to prevent binding of AKH to its receptor would interfere with the mobilisation of energy reserves at the critical time, and prevent adult weevils from flying and colonising distant breeding sites. By limiting dispersal, population build-up and damage to newly establishing forest stands would be reduced. This in turn would reduce the need for conventional chemical insecticides.

Selected references

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http://www.forestry.gov.uk/fr/hylobius

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