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Managing Bumblebee Imports to Maintain Pollinator Diversity

Key external stakeholders:

Producers of pollinated horticultural crops; Policymakers; Bee researchers; Commercial bumblebee suppliers; Environmental and biodiversity stakeholders.

Practical implications for stakeholders:

The outcome/technology or information/recommendation is:

- The current practice of importing bumblebee colonies for pollination of horticultural crops is effective but poses serious risks to native populations and possibly biodiversity.
- Drift from imported bumblebee colonies poses a significant disease transmission and hybridisation risk requiring industry/legislative action to reduce these risks. Developing effective policies/actions is challenging however, as they are likely to impact negatively on the effective pollination provided by commercial bumblebee colonies.
- The development of novel genetic markers will be a valuable tool for: bumblebee rearing companies; environmental protection agencies and researchers.

Main results:

- The effectiveness of bumblebees as pollinators has been determined and the economic benefits of bumblebee pollination in strawberries can now be quantified through the establishment of plant abundance and hive density effects.
- Disease transmission and hybridisation risks are real and question current bumblebee colony importation and management practices
- The use of existing and development of novel genetic techniques has allowed effective and detailed population and movement studies to be carried out.

Opportunity / Benefit:

This study provides information which will allow new bumblebee pollinator management practices and polices to be developed. These policies should target the protection of our native bumblebee populations, while recognizing the utility of commercial bumblebee colonies for pollination of horticultural crops. The genetic marker techniques developed will prove an invaluable tool in reliably differentiating between native and non-native bumblebee populations and offers scope to be developed into a rapid screening tool of benefit to bumblebee rearing companies and environmental monitoring agencies.

Collaborating Institutions:

Institute of Technology, Carlow

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1. Project background:

Bees are the most important insect pollinators, pollinating over 90% of the world's 254,000 flowering plant species. Bee pollination generated €14.4 million of horticultural produce in Ireland in 2008 in addition to honey sales of €992,000. Bee pollinators also facilitate the maintenance of sexual reproduction in a host of wild flowers and trees which provide a myriad of other services. In total pollination is estimated to be worth from €52-200 million p.a. to the Irish economy

The International Pollinators Initiative (IPI) was set up in 2000 to address concern about declines in pollinator populations worldwide. IPI research has confirmed that the abundance and diversity of wild bees are in decline. In Europe, Britain and the Netherlands have lost 52% and 67%, respectively, of their bee biodiversity since 1980; and 25% of bee species in France and Belgium are in decline. In Ireland, 30% of our 101 bee species are considered threatened. Reliance on a single bee species for commercial crop pollination is unsustainable. About 20 years ago the horticultural industry responded by domesticating bumblebees (alternative group) with now over one million bumblebee hives exported worldwide each year worth over €55 million. In Europe, Bombus terrestris, a species that naturally occurs throughout Europe and North Africa, is commercially reared, for year-round export. B. terrestris includes a recognised number of subspecies, in particular B. terrestris audax which is found only in Ireland and Britain. Currently, the breeding-stock of commercial bumblebees is not native to Ireland and unregulated importation could pose a serious risk to our native species of bees. Studies in both Canada and Japan have shown that imported bumblebees have been responsible for spreading both diseases and parasites to native bumblebees. Imported bumblebees can also escape from glasshouses and successfully compete with native bumblebees. Finally, imported bumblebees may successfully breed with native B. terrestris audax and over time it may lose any unique physiological adaptations to Irish conditions through genetic dilution.

2. Questions addressed by the project:

In recognition of the need of Irish growers to import bumblebees for pollination and the risks involved in importing non-native bees, the following questions were addressed:

- Can management of imported bumblebees be improved to increase pollination efficiency;
- Can we reduce drift between hives and escapes from areas of importation;
- What level of genetic differentiation exists between B. terrestris audax and non-native B. terrestris;
- What is the risk of hybridization and establishment of non-native bumblebees;
- What is the disease and parasite load of imported bumblebees and the risk to native bumblebees.

3. The experimental studies:

A survey of 137 horticultural growers was carried out to establish the extent of bumblebee importation, and to assess the impact of our recommendations on bumblebee management. To establish the population genetics of European B. terrestris, novel genetic screening protocols were applied to over 630 bees sampled from 20 countries across Europe, and 2 commercial populations from the Netherlands.
Polytunnel trials with strawberry crops allowed determination of: optimal plant/bee density for pollination and fruit production; and the pollination efficiency of bumblebee vs. honeybees. Field studies were conducted at six strawberry production sites along the East coast. At 5 discreet distances: 250 m, 500 m 1 km, 2 km, and 10 km from the sites, 2700 wild bumblebees were sampled. Imported bees from 68 hives were also sampled. These wild-caught and hive samples were then screened for disease and genetically screened to identify native, hybrid and imported bumblebees. Four nuclear and a novel mitochondrial marker were used, facilitating the rapid identification of native, hybrid and imported genotypes. Also 540 pollen samples were collected from imported bumblebees at each site to determine the impact of cropping system (glasshouse, polytunnel or open field) on bee escape and to assess the level of competition between imported and native bees. Finally, using our drift, permeability, disease and hybridisation results, a risk-assessment was conducted on imported B. terrestris using the UK Non-Native Organism Assessment Scheme to quantify the risk of entry, spread, establishment and impact on the Irish economy and environment.

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4. Main results:

- About 1450 bumblebee hives are being imported into Ireland p.a. mainly to the East and Southeast.
- Growers disposing of hives correctly increased from 5% to 28% following targeted dissemination.
- Strawberries require 1-5 visits by bumblebees to achieve 100% pollination, increasing fruit yield by 26% and decreasing the incidence of fruit deformity by 47 %.
- Bumblebees, per visit, are 2.5 times more efficient pollinators than honeybees.
- Plant abundance did not effect the number, weight or quality of fruit. One commercial colony should pollinate 5,000 plants in protected crop systems.
- Low plant abundance (120 plants/hive) increased the incidence of drift. Drifting bees were usually larger females seeking out weaker colonies to parasitically lay eggs within. Drift from imported bumblebee colonies poses a significant disease transmission and hybridisation risk.
- In glasshouses, polytunnels and field crop, respectively 28%, 75% and 88% of pollen collected by imported bumblebees was not strawberry pollen indicating unhindered opportunities to interact with native bees. The utility of importing bumblebees for field grown crops is highly questionable.
- Mitochondrial markers reveal that the European subspecies of B. terrestris are still very closely related and statistically cannot be separated using conventional DNA methods.
- The Mitochondrial DNA gene Cytochrome Oxidase I (COI) does contain three diagnostic sites that can reliably differentiate native Irish and British B. t. audax from continental subspecies.
- The fast evolving microsatellite markers reveal that inbreeding can be detected in the majority of B. terrestris populations across Europe. However current population genetic diversity remains high.
- There is significant recent genetic differentiation between European populations of B. terrestris with both commercial stocks tested being genetically distinct from wild populations.
- Microsatellite and novel mitochondrial markers have been successfully developed to identify native, non-native and hybrid B. terrestris.
- Markers confirm that imported bumblebees can be found up to 10 km from the site of importation.
- Imported bumblebees can successfully mate, produce reproductive queens, compete for hibernation sites, hibernate over winter and produce workers in the following season.
- Of the 68 commercially imported bumblebee hives screened, 1.47% contained Apicystis bombi, 32.29% Crithidia bombi, and 60.29% Nosema bombi, and no tracheal mites were detected.
- The incidence of A. bombi and C. bombi was significantly elevated within 2 km of glasshouses, suggesting that diseases are being transmitted to wild populations

5. Opportunity/Benefit:

This is the first study to quantify the economic benefit of bumblebee pollination and to illustrate the impact of plant abundance on drifting behaviour in bees. The plant abundance/bumblebee hive density is relevant to the 56 countries worldwide currently importing commercially reared bumblebees for strawberry pollination, particularly as the cost:benefit ratio for investing in pollination can now be accurately calculated for this crop. Furthermore, the permeability of glasshouses and polytunnels, and the striking lack of time spent on open field crops, suggest a change in management practices regarding containment of pollinators in protected crop systems and questioning the current practice of investing in imported bumblebee pollinators for non-protected crops.

The significance of microparasites in commercially imported colonies and transmission of parasites to wild populations must be highlighted. Although current EU and national legislation focuses exclusively on honeybee pathogens, this is under constant review and the licensing of bumblebee colonies based on the presence/absence of honeybee disease will cease in the near future. Once this occurs, there may be severe restrictions placed on the importation of non-native bumblebees and responsibility for licensing bee importation may devolve to national governments. If this occurs, there will be an immediate negative impact on Irish horticultural production and competitiveness due to lack of suitable pollinators and consequent reduction in yields. Additionally, there may be increased costs involved in state-controlled licensing and independent disease screening of imported hives.

Finally, the development of a novel mitochondrial genetic marker to reliably differentiate between native Irish and non-native B. terrestris will be an invaluable tool. The utility of microsatellite markers in differentiating native, hybrid and non-native genotypes has been proven. Further refinement of these genetic tools would facilitate rapid screening practices of benefit to bumblebee-rearing companies and environmental protection agencies.

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6. Dissemination:

The results of this research were presented in 17 scientific / technical publications or conferences. Key publications are listed below:

Main publications:

Murray, T.E., Kuhlmann, M., Potts, S.G. (2009). Conservation ecology of bees: populations, species and communities. Apidologie 40 211-236.

Murray, T.E., Davis, E.S., Paxton, R.J. (2009). Microsatellite loci for a rare solitary bee, Colletes floralis (Hymenoptera: Apidae), and their variability in other colletid bees. Molecular Ecology Resources 9 1460-1466.

Horgan FG, Murray, T, Kehoe, E (2008) Bumblebee importations into Ireland: growers' understanding of rewards and risks. XXII International Congress of Entomology. 6-12 July 2008, ICC, Durban, South Africa.

Davis, E, Murray, TE, Fitzpatrick, U, Brown, MJF, Paxton, RJ (2008) Conservation ecology and genetics of a rare mining bee, Colletes floralis. Proceedings of III European Congress of Apidology. 7-11 September 2008, QU Belfast. Pg 24-25.

Popular publications:

Murray, T., Horgan, F., Kehoe, E. (2008) Bee-careful: considerate crop pollination in Ireland. Published abstract; Teagasc Soft Fruit Conference and Trade Show. Enniscorthy, Wexford. Pg 14-23.

Horgan FG, Coffey ML & Murray T (2007) Plight of the Bumblebee. T-Research 2: 24-27

Murray T, Horgan F, Kehoe, E (2007) Bee Aware. Today's Farm 18 (6): 10-11.

Horgan, F., Murray, T., Kehoe, E. (2008) The responsible pollinator. In: Irish Soft-fruit Growers Association Newsletter. May 2008

Murray, T.E., Moreira, S., Kehoe, E., Kakouli-Duarte, T., Horgan, F.G. (2009) Bumblebee importation: a question of balancing risks and benefits. T-Research 4(3) 30-31

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