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Is the exotic bumblebee *Bombus terrestris* really invading Tasmanian native vegetation?

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Abstract

There has been a great deal of disagreement surrounding the capacity of *Bombus terrestris* to invade Tasmanian native vegetation. This paper reviews the conflicting findings of previous surveys of the invasion of Tasmania by *B. terrestris*, and presents new data from the 2004–2005 austral summer. From this, it is clear that *B. terrestris* has extensively invaded Tasmanian native vegetation. The new data provide strong evidence that *B. terrestris* is breeding in native vegetation in every region of Tasmania. More than 10 bumblebees were seen in one day at 153 locations in native vegetation, including 42 locations within 10 National Parks and 38 locations within the Tasmanian Wilderness World Heritage Area. Nests of *B. terrestris* were also found within two National Parks. These findings suggest that *B. terrestris* would also invade native vegetation in non-arid temperate regions of the Australian mainland, if it is introduced there.

Introduction

The effectiveness of the European large earth bumblebee, *Bombus terrestris* (L.) (Apidae), as a pollinator of greenhouse tomatoes has resulted in its importation to numerous countries (Hingston et al. 2002). Although an application to import *B. terrestris* to the Australian mainland in 1997 (Goodwin and Steiner 1997) was rejected, another horticultural organization has recently begun the process of reapplying (Carruthers 2004). However, some introduced species become invasive and harmful, and this could be the case with introduced bumblebees (Hingston et al. 2002).

Cunningham et al. (2002) regarded the capacity for an imported pollinator to become established beyond the agricultural areas where the target crop is grown as the most important factor influencing the severity of its ecological impact. An indication of the extent to which *B. terrestris* could invade native vegetation on the Australian mainland can be gained by observations of the feral population established on the Australian island of Tasmania, although the level of uncertainty in such predictions is exacerbated by the inbred nature of the Tasmanian population (Hingston 2005a). However, studies into the capacity of *B. terrestris* to invade Tasmanian native vegetation have produced conflicting results, and much disagreement among people who have done this research (Hingston and McQuillan 1998; Stout and Goulson 2000; Goulson et al. 2002; Hergstrom et al. 2002; Hingston et al. 2002). There has also been an absence of consensus among other authors who have interpreted these studies (Carruthers 2003; Inari et al. 2005; cf. Kreyer et al. 2004; Matsumara et al. 2004; Ings et al. 2005).

This paper reviews the conflicting results of previous studies of the extent of the invasion of Tasmanian native vegetation by *B. terrestris*, and assesses the validity of conclusions drawn in the most recently published paper on this subject (Goulson et al. 2002). The results of a new survey of the distribution of *B. terrestris* in Tasmanian native vegetation are also presented, to hopefully resolve the disagreement that exists in the literature.

Conflicting results of previous surveys

During the austral summer of 1996–1997, Hingston and McQuillan (1998) found large numbers of *B. terrestris* in a wide variety of native vegetation types within 3 km of the suburbs of Hobart where the species was first recorded in Tasmania. This led them to conclude that *B. terrestris* would probably invade native vegetation across much of Tasmania, and non-arid temperate regions of the Australian mainland if introduced there.

That conclusion was not supported by a survey conducted in January 1999 (Stout and Goulson 2000), which found that the distribution of *B. terrestris* was expanding from Hobart in all directions where human settlements occurred, but not southwest into the Tasmanian Wilderness World Heritage Area (WHA) [compare distributions of *B. terrestris* according to Stout and Goulson (2000) and Semmens (1995) in Figure 1]. Stout and Goulson (2000) concluded that *B. terrestris* was restricted largely to gardens, urban parks and pastures, and that high altitudes and the paucity of European plant species in the WHA may prevent *B. terrestris* from invading that part of Tasmania.

The findings of Stout and Goulson (2000) were disputed by Hingston et al. (2002) following their survey of the distribution of *B. terrestris* up to autumn 2001. Hingston et al. found evidence of *B. terrestris* breeding across approximately half of Tasmania, including within six National Parks and the most remote parts of the WHA (Figure 1), and in all of Tasmania's major types of native vegetation. Indeed, they reported that *B. terrestris* had been locally abundant in the WHA as early as 1995–1996 (Hingston et al. 2002).

The conclusion drawn by Hingston et al. (2002) was subsequently questioned by Goulson et al. (2002) for several reasons that are detailed below. These factors, together with their own survey between 15 November and 10 December 1999 that found *B. terrestris* had a similar distribution to that reported by Stout and Goulson (2000), led Goulson et al. (2002) to conclude that 'The western limits of the distribution corresponded closely with the edge of human settlement.....there were no resident bumblebee populations within the Tasmanian Wilderness World Heritage Area' and 'bumblebees remain far more abundant in gardens, cultivated areas, and where there are substantial numbers of introduced plants, compared to areas of native vegetation'. The latter conclusion was also reached by Hergstrom et al. (2002), despite finding evidence of *B. terrestris* breeding in the WHA and National Parks and making no comments on the studies of Stout and Goulson (2000), Hingston et al. (2002) or Goulson et al. (2002).

Assessment of the concerns raised by Goulson et al.

Goulson et al. (2002) questioned the conclusion of Hingston et al. (2002) because the latter 'accept a single sighting of a pollen-collecting bee, or two sightings of (perhaps the same) bees as evidence of breeding populations'. It is certainly possible that a single bee, that had dispersed into native vegetation from an urban or agricultural area, was seen twice by a person in one day. However, it is unlikely that one person would see the same bee more than 10 times in one day, a situation that occurred at 22 of the 51 locations where Hingston et al. (2002) found evidence of breeding in native vegetation (Figure 1). These 22 locations encompassed the most remote areas from human settlement, including eight locations within National Parks and six within the WHA (Figure 1). Even the more stringent conditions for evidence of colony establishment used in a report commissioned by the horticulture industry, of sighting more than one bumblebee per minute (Hergstrom and Buttermore 1999), were met at numerous locations outside the distribution described by Stout and Goulson (2000) and Goulson et al. (2002) including at several sites within the WHA and National Parks (Hergstrom et al. 2002; Carruthers 2003).

Goulson et al. (2002) also raised doubts about the validity of the findings of Hingston et al. (2002) because the data presented by the latter

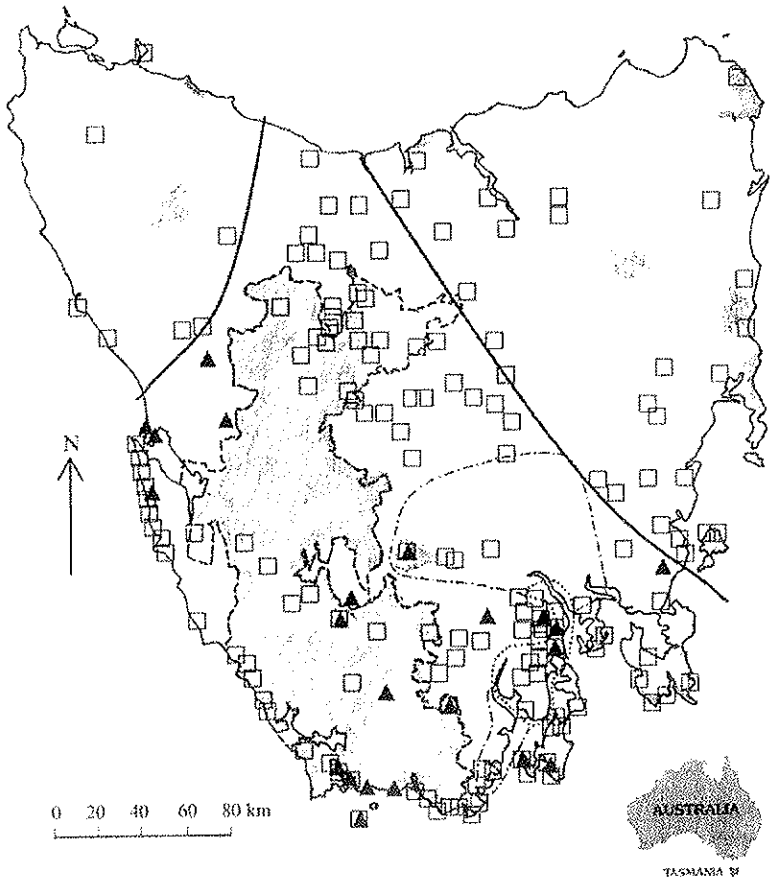

Figure 1. Tasmania, showing the distributions of *Bombus terrestris*, the World Heritage Area (WHA) boundary (---), and National Parks (▫). Symbols indicate locations of native vegetation where more than 10 individuals of *B. terrestris* were observed by one person in one day: ▲, before mid-2001 (Hingston et al. 2002); □, between spring 2004 and autumn 2005. The limits to the distribution of *B. terrestris* according to Semmens (1995) (.....), Stout and Goulson (2000) (-.-), and Hingston et al. (2002) based on observations of more than one bumblebee in one day or of one bee carrying pollen in its corbiculae (—) are also shown.

were 'gathered by a large number of amateur recorders'. However, the observations of more than 10 bumblebees in one day presented by Hingston et al. (2002) were made by individuals connected with universities and land management agencies, rather than amateur recorders, at 18 of the 22 locations. Regardless of this, there is no reason for Goulson et al. (2002) to question observations of bumblebees made by amateurs because in their original study they included observations made by amateurs that they regarded as 'reliable because there are no insects in Tasmania which look similar to *B. terrestris* and so there was little chance of misidentification' (Stout and Goulson 2000).

Goulson et al. (2002) also questioned the conclusion of Hingston et al. (2002) because 'With many recorders working over many years, it is perhaps not surprising that they have accumulated records of these large, mobile organisms from throughout Tasmania'. However, a survey of the distribution of *B. terrestris* in Tasmanian native vegetation during the 2004–2005 austral summer, using the same methods as Hingston et al. (2002), shows that it does not require many years of observations to accumulate numerous records of *B. terrestris* in Tasmanian native vegetation (Figure 1).

I agree with Goulson et al. (2002) that the difference between their findings and those of

Hingston et al. (2002) 'probably reflects recorder effort, and the greater number of sites that they (Hingston et al.) surveyed'. The absence of observations of *B. terrestris* in the WHA by Stout and Goulson (2000) and Goulson et al. (2002) can be attributed to the fact that their surveys of the WHA were limited to between five and 30 min at each of only a handful of sites.

Results of a more recent survey

Between spring 2004 and autumn 2005, I contacted other scientists, land managers, and amateur naturalists, asking them to report observations of more than 10 bumblebees in one day during this period in Tasmanian native vegetation. I collated these, along with my own, observations and mapped them to determine the current distribution of *B. terrestris* in Tasmanian native vegetation. When considering these observations, it is important to note that the people that I contacted are unlikely to have visited every area of native vegetation in Tasmania during the survey period. For this reason, an absence of observations in an area does not necessarily reflect an absence of *B. terrestris*.

This survey indicates that *B. terrestris* is breeding in native vegetation in all regions of Tasmania, and suggests that it has become more widespread and abundant since the last surveys were done (Figure 1). More than 10 bumblebees were seen by one person in one day at 153 locations in Tasmanian native vegetation (Figure 1) between mid-September 2004 and mid-May 2005. Of these locations, 104 involved the observations of individuals connected with universities and land management agencies rather than those of amateur recorders. The 153 locations encompassed the most remote areas from human settlement, including 42 locations within 10 National Parks and 38 locations within the WHA (Figure 1). In addition, active nests of *B. terrestris* were found in Cradle Mountain – Lake St Clair National Park in the northern end of the WHA, and in Maria Island National Park off Tasmania's east coast (Hingston et al. ~~in press~~ 2006). Such widespread invasion of Tasmanian native vegetation by *B. terrestris* can be attributed to the polylectic foraging behaviour of this bee that enables it to use a wide variety of native plants as food sources (Hingston and McQuillan 1998; Hingston et al. 2002; Hingston 2005b; Hingston et al. ~~in press~~ 2006) and its broad climatic tolerance (Hingston et al. 2002).

Conclusions

Despite some reports to the contrary (Stout and Goulson 2000; Goulson et al. 2002; Hergstrom et al. 2002; Carruthers 2003; Inari et al. 2005), *Bombus terrestris* is clearly highly invasive in Tasmanian native vegetation having established in all regions of the island within 13 years of the discovery of a feral population in suburban Hobart. It is, therefore, likely that this species will also invade native vegetation in temperate non-arid regions of the Australian mainland if it is introduced there.

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