Bumble Bee Road Toll (Hymenoptera: Apoidea).

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During a journey from Lincoln to Twizel on 24 November 2009, we became aware that bumble bee queens were being struck by our vehicle, a Hyundai 100 van. Bumble bee queens were often seen flying across the road ahead of the vehicle, appearing as a large (for an insect) compact, rather rotund, fast-moving blob. Sometimes they and the front of the vehicle collided violently, producing a loud, solid thud. Due to the size and shape of bumble bee queens, we thought they could not be confused with other insects, and when impacting with the vehicle no other insect made such a distinct sound.

Four species of bumble bees are present in New Zealand, *Bombus terrestris* (L.), *B. hortorum* (L.), *B. ruderatus* (F.) and *B. subterraneus* (L.), all of which were established in 1885 or 1906 from queens imported from England. The first three species are present and relatively abundant throughout our vehicle route in Canterbury, the Mackenzie Country and through to Central Otago, while the fourth is absent from the Canterbury Plains (Donovan 2007) and recently has been scarce in the Mackenzie Country and Central Otago (Goulson and Hanley 2004, Lye *et al*. 2010). During a round trip from Lincoln to Clyde via the inland route through the Mackenzie Country from 8-10 December 2009, we counted the number of bumble bee queens that collided with our vehicle. We counted only the impacts that we were certain were those of bumble bee queens, and because there were impacts that were doubtful the number of queens impacted was definitely greater than we recorded, perhaps even double.

During a return 1,062 km from Lincoln to Clyde plus a little local running around Clyde, we counted 24 impacts with queen bumble bees. Because the vehicle speed was nearly always close to 100 km/hr (or possibly somewhat over) and the impacts were severe, we assumed that the bumble bees would have been killed. To check whether this was true, we looked for dead queen bumble bees among flowering Russell lupin (*Lupinus polyphyllus* Lindl.) and viper's bugloss (*Echium vulgare* L.) along about 25 m of roadside on both sides of the road several km north of Lake

Pukaki. This stretch of flowers was chosen because bumble bee queens were often seen foraging on flowers of both species of plants and were readily subject to vehicle strike as they flew across the road from one patch of flowers to another. With minimal searching we found 10 dead bumble bee queens within 2 m of the edge of the road seal.

Our death toll of 24 bumble bee queens equates to 12 killed for each one-day, one-way trip of 530 km. To estimate the number of bumble bee queens that might be killed per day along the route we travelled on State Highway 1, Thompsons Track, Regional Highway 72, and State Highways 79 and 8, we calculated the Annual Average Daily Traffic (AADT) from data from 10 traffic monitoring sites along our route that we selected from those maintained by the New Zealand Transport Agency. The AADT for our route for 2009 was 2,736. If each vehicle killed 12 queen bumble bees, nearly 33,000 would have been killed per day. Queens are likely to be most abundant along the route we travelled during October, November and December following emergence from hibernation, feeding prior to nest founding, and for several weeks after nest founding before the emergence of the first workers. So during these three months the death toll on this one route could be more than 3 million.

Our calculated death toll is of course based on very sparse data and from one vehicle size only. The front of our Hyundai was 1.80 m high by 1.42 m wide, for a total of 2.55 square metres, whereas many vehicles have a much smaller frontage and so may kill fewer bumble bees. On the other hand some vehicles are much larger, with the fronts of large tourist buses such as those of InterCity Coachlines measuring about 2.6 m wide and 3.8 m high, which presents a frontage of nearly 10 square metres, so probably these larger vehicles kill more bumble bees. Presumably bumble bees are also killed on all other roads. Our vehicle killed 1 bumble bee for every 44.25 km travelled. The total number of km travelled by vehicles on the 10,909 km of State Highways in New Zealand in 2009 was 19,323 million, so if bumble bees were killed at the same rate as for our vehicle (which is highly unlikely), the total for the 3 months of September, October and November would be an astonishing about 109 million. Then there are all the regional highways and numerous other roads.

Is such a huge road toll possible? Because bumble bees are often quite numerous and are not regarded as being endangered (apart from possibly *B. subterraneus*), they must be propagating very readily despite the road toll. The answer may well lie with the high rate of new queen production per colony. Donovan and Wier (1978) found that

the mean number of new queens produced by 4 naturally-occurring colonies of *B. terrestris* from Christchurch which completed their normal developmental cycle was 125.7, with a maximum of 311, while for 6 colonies of *B. hortorum* the mean was 80.5, and the maximum 148. For colonies formed in nest boxes, one dead *B. terrestris* colony from Lincoln which developed during late 1993 produced 575 new queens, and another from Halswell, which had died out by late February 1998 produced 622 new queens (B. Donovan *pers. obs.*), while for 14 colonies of *B. hortorum* the mean number of new queens was 124.8, and the maximum 202 (Donovan 2001). For *B. ruderatus*, 5 free-foraging colonies which were initiated in field hives near Palmerston North and which were transferred when small to heated observation hives, produced a mean 55 new queens, with a range of 0-228 (calculated from Table 1, Pomeroy 1979) Five colonies formed in nest boxes near Lincoln had a mean of 53.2 new queens, with a range of 2-183 (Donovan and Wier 1978). Dumbleton (1948) found 18 queens in a still-active colony of *B. subterraneus* near Hakataramea, and 6 colonies formed in nest boxes near Twizel produced a mean of 29.5 new queens with a range of 16-49, (Donovan and Wier 1978). So very large numbers of new queens are produced annually.

If the population of bumble bees is to remain relatively constant from year-to-year, then for every colony that produces new queens, in the following year only one of those queens must form a similarly new queen-productive colony: all the other queens must fail to grow colonies that produce new queens. Therefore, because of the large numbers of new queens produced, which is greatly in excess of the number needed for the population to remain stable, the road toll can indeed be enormous, so despite the huge scale of the road toll, bumble bees collectively are probably not threatened with a decline in populations. However, perhaps the roll toll is contributing to the scarcity of *B. subterraneus*?

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