Even smaller radar tags on insects

SIR — Movement behaviour is fundamental to the understanding of insect population dynamics[1]. Unlike researchers working on vertebrate species, insect ecologists have not had the benefit of such technology as radio-collaring for tracking animal movements. Walking beetles have been fitted with 'tags' that reflect harmonic radar[2]; these tags have now been reduced in size so that bees can carry them and be detected using powerful radar signals[3]. To ensure that the tag attached to the insects does not itself alter their normal movement, its size and weight must be extremely small. Here we report extreme miniaturization of such a tag to an order of magnitude smaller than that previously used[3], and describe its use with portable radar equipment in the field on a variety of insect species (Fig. 1).

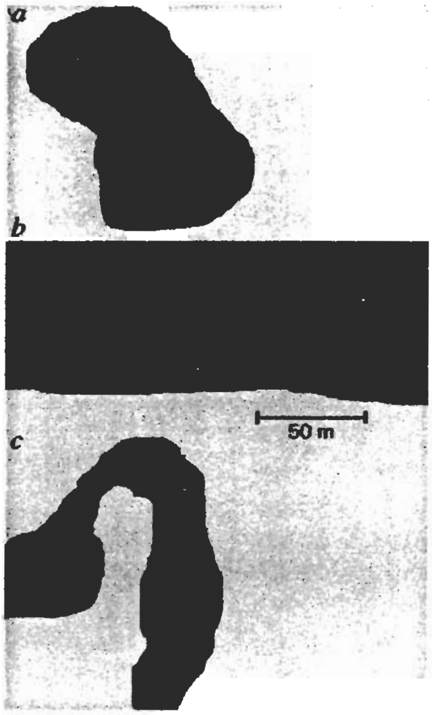

FIG. 1 Relocations and trajectories from a release point for: *a*, a single *Patelloa pachypyga* fly over a 3-h period; *b*, *c*, forest tent caterpillar moths over 48 h, all within forest stands of trembling aspen (shaded) adjacent to clearings (unshaded).

The tag (Fig. 2) is glued to the insect thorax or abdomen with rubber cement, and the near-invisible dipole simply trails behind the insect. This configuration is two orders of magnitude lighter than that used for tracking ground beetles[2], and an order of magnitude lighter than that used for tracking bees[3]. Our transmitter–receiver (RECCO Rescue Systems, Lidingö, Sweden) is carried in a portable backpack, weighs 8 kg and transmits a 1.7-W continuous microwave frequency of 917 MHz from a hand-held Yagi antenna. The tag on the target insect reflects this energy at a frequency of 1,834 MHz, which is detected by the same hand-held antenna. The use of a longer frequency than that used for tracking bees[3] reduces the attenuation of the signal by water in intervening vegetation. The current configuration of transmitter–receiver and dipole permits detection at up to 50 m. Tagged insects are relocated at intervals by systematic searching and triangulation on the reflected signal.

We have successfully fitted tags to five species of flying insects with a range of body weights: the small Apollo butterfly *Parnassius sminthius* (350 mg), the common alpine butterfly *Erebia epipsodea* (150 mg), both the larvae and moths of the forest tent caterpillar *Malacosoma disstria* (200 mg; Fig. 2*a*), and the parasitic tachinid fly *Patelloa pachypyga* (45–60 mg; Fig. 2*b*) and sarcophagid fly *Arachnidomyia aldrichi* (55–75 mg), both of which attack the tent caterpillar. The tag increases the weight of these insects by only 0.1–0.9%. Tagged insects can be used to examine the effect of habitat structure on insect movement. Over a period of 3 hours, we repeatedly located tagged parasitic flies moving within a forest stand (Fig. 1*a*); after 48 hours, the moth stage of their tent caterpillar hosts was relocated up to 100 m from the point of release (Fig. 1*b*). In a mark–recapture study of the Apollo butterfly, we repeatedly recaptured 10 individuals fitted with tags, together with untagged butterflies, over a period of 2 weeks. Butterflies did not seem to be affected by the 0.4-mg tags.

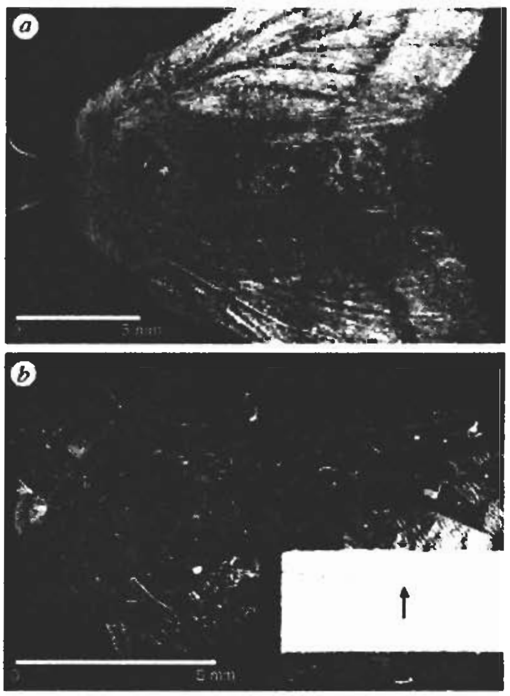

FIG. 2 Forest tent caterpillar moth (*a*) and tachinid fly *Patelloa pachypyga* (*b*) fitted with tags made from a Schottky low-barrier diode (Hewlett-Packard, HP 5082-2837) mounted in the centre of an 8-cm dipole antenna of extremely fine aluminium bonding wire (arrows). Total weight of this configuration is 0.4 mg.

Movement data can be collected by one or more researchers, each carrying a transmitter–receiver. Use of tags small enough so as not to alter insect movement, in combination with more powerful transmitters, may provide a tool for studying movement, the 'missing element' of insect population dynamics.

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Reducing antibiotic resistance

SIR — A reduction in the use of antibiotics has recently been proposed as a measure to forestall, and ideally reverse, the growing public-health problem of antibiotic-resistant bacteria[1–3]. This recommendation implicitly assumes that resistance to antibiotics reduces the fitness of bacteria in the absence of antibiotic-mediated selection, thereby allowing sensitive bacteria to replace resistant strains in drug-free environments. We now show that, although mutations to antibiotic resistance in bacteria may initially impose a considerable fitness burden, natural selection can result in the rapid fixation of second-site, compensatory mutations which substantially reduce this cost by restoring physiological functions impaired by resistance mutations without altering the level of bacterial resistance.

Some point mutations in the *rpsL* gene in the bacterium *Escherichia coli* confer resistance to high concentrations of streptomycin, but reduce the darwinian fitness of bacteria by decreasing peptide chain elongation rates[4,5]. We considered two spontaneous streptomycin-resistant (Str^r), *rpsL* mutants of *E. coli* CAB281 (see table). One mutant had a 14% per generation disadvantage relative to the Str^s parental strain, and the other had a 19%