References - *Bubas bison*

The biology of *Bubas bison* (L.) (Coleoptera: Scarabaeidae) in southern France and its potential for recycling dung in Australia, A. A. Kirk, 2009

Abstract

The biology of *Bubas bison* (L.) was studied in southern France. It was active from September to the end of May. Adult emergence lasted from September to January; 8 % of the female population was parous and laying eggs in September, and 100% were parous from February to the end of June. Females exhibited extraovariolar egg resorption, which may have been a response to adverse conditions. Eggs laid in October, November, February and March hatched synchronously in May. Adults resulting from eggs laid in March emerged in early September. The rate of oviposition varied from 0–03 egg/day in January to 0·5 in March. Females stopped laying eggs for three weeks in January. The structure of the nests formed from buried dung brood-masses was studied. Each brood-mass contained two eggs, one at each pole. About 12 brood-masses were formed under each dung pad in October 1981. The mean length of each mass was 96 mm and the dry weight 10–5 g. The mean number of masses in a nest was 24, with a mean number of 4–9 nests under each dung pad. The dry weight of dung buried under a pad in October 1981 was 1239 g, 66–6%, of the mean dry weight of an experimental dung pad. *B. bison* has the potential for recycling large amounts of dung in climatic areas of Australia equivalent to southern France.

An insect ecosystem engineer alleviates drought stress in plants without increasing plant susceptibility to an above-ground herbivore

S. N. Johnson, G. Lopaticki, K. Barnett, S. L. Facey, J. R. Powell, S. E. Hartley, 2015

Summary

Climate change models predict more extreme rainfall patterns, ranging from droughts to deluges, which will inevitably affect primary productivity in many terrestrial ecosystems. Insects within the ecosystem, living above- and below-ground, may modify plant responses to water stress. For example, some functional groups improve soil conditions via resource provision, potentially alleviating water stress. Enhanced resource provision may, however, render plants more susceptible to herbivores and negate beneficial effects.

Using a model system, we tested how plants (*Brassica oleracea*) responded to drought, ambient and increased precipitation scenarios when interacting with both a soil conditioning ecosystem engineer (dung beetles; *Bubas bison*) and an above-ground herbivore, the major crop pest diamondback moth (*Plutella xylostella*).

Dung beetles enhanced soil water retention by 10% and promoted growth in plants subjected to drought by 280%, relieving the impacts of water stress on plants. Under drought conditions, plants grown with dung beetles had c. 30% more leaves and were over twice as tall as those without dung beetles. Dung beetles produced a 2·7-fold increase in nitrogen content and more than a threefold increase in carbon content of the shoots, though shoot concentrations of nitrogen and carbon were unchanged. Carbon concentrations in roots, however, were increased by dung beetles under both ambient and increased precipitation regimes.

Increased precipitation reduced root and shoot nitrogen concentrations by 16% and 30%, relative to plants under ambient regimes, respectively, most likely due to dilution effects of increased plant growth under increased precipitation. Soil carbon and nitrogen concentrations were largely unaffected.

While dung beetles enhanced plant growth and nitrogen content in plants experiencing drought, the anticipated increase in plant suitability to herbivores did not arise, possibly because shoot nitrogen concentrations and C:N ratio were unaffected.

To our knowledge, this is the first report of an insect ecosystem engineer alleviating the effects of predicted drought events on plants via physical manipulation of the soil matrix. Moreover, their effects did not change plant suitability to an above-ground herbivore, pointing to potential beneficial role for insect ecosystem engineers in climate change adaptation and crop protection.

Nest construction and larval behaviour of *Bubas bison* (L.) and *Bubas bubalus* (01.) (Coleoptera, Scarabaeidae), H. G. Klemperer, 1981

Abstract

Female beetles working alone or in cooperation with a male excavated vertical, tunnel-shaped brood chambers. Each chamber was filled with dung to form a cylindrical brood mass which contained two eggs, one near each pole.

To examine the possible relationship with other Onitini (which lay either one or several eggs per brood mass) factors that influence the two-egg programme were studied. Brood masses with only a single egg were formed if excavation was resumed prematurely. Conversely, when excavation was suppressed several oviposition programmes fused to produce a multi-egg brood mass.

The larvae repaired their chambers in the typical Scarabaeine manner by building a self-supporting wall formed from their own excrement. This behaviour also prevented direct contact and fighting between adjacent larvae in the same brood mass, and it allowed the larvae to survive inside artificial brood balls. Similar behaviour was observed in larvae of *Onthophagus taurus* and *Onthophagus vacca* (which develop in one-egg brood masses). The evolution of nesting habits that involve multi-egg brood masses or free-standing brood balls may depend on the pre-existence of this larval repair behaviour.

Effect of dung burial by the dung beetle *Bubas bison* on numbers and viability of *Cryptosporidium* oocysts in cattle dung

U. Ryan, R. Yang, C. Gordon, B. Doube

Abstract

Cryptosporidium oocysts were inoculated into fresh dung (~1.2 × 104 oocysts per gram wet weight) and fed to dung beetles to assess the effect of dung burial by the dung beetle *Bubas bison* on the distribution of the oocysts in small cores of soil in the laboratory. The experiment consisted of five replicates of each of two treatments; controls (dung but no dung beetles) and the experimental treatment (inoculated dung and seven pairs of dung beetles). After 5 days, when approximately 90% of the dung was buried, the surface and buried dung was recovered and subsampled. The oocysts in the subsamples were recovered and enumerated using qPCR. Oocyst viability was evaluated using an assay based on the exclusion or inclusion of two fluorogenic vital dyes, 4',6-diamidino-2-phenylindole (DAPI) and propidium iodide (PI). Results revealed that overall 13.7% of oocysts remained on the surface and 86.3% of oocysts were buried. The viability of oocysts in buried dung was only 10% compared to oocysts the surface dung (58%). Therefore, widespread dung burial by B. bison during the winter months could substantially reduce the numbers of *Cryptosporidium* oocysts available to be washed into waterways following winter rains.