TWO NOTES ON THE INVASIVE IBERIAN SLUG, *ARION LUSITANICUS* MABILLE, 1868

Invasive organisms may have a huge environmental impact in the area where they have been introduced. The recent introduction of the Iberian slug *Arion lusitanicus* (Mabille, 1868) to Northern Europe is one such example. The species has a high rate of reproduction and few known predators, Koslowski et al 1998[2], Keller *et al.* (1999[3]) makes this species a rapidly spreading agricultural pest (e.g. von Proschwitz *et al.* 1994[4], Proschwitz 1997[5]). The recent discovery that *A. lusitanicus* produces fertile hybrides with *Arion ater* (Linné, 1758) (Hagnell et al 2003[6]) allowing rapid accommodation to a temperate-boreal climate has increased the need for finding means to control the species, and several research projects with this aim have been launched. We here report two observations that relates to this goal.

The sticky mucus of *A. lusitanicus* constitutes a good defence against predators (pers obs). Hedgehogs and birds do feed on the domestic black forest slug (*Arion ater*) but not on *A. lusitanicus*. There are a few previously published observations on blackbird (*Turdus merula,* Linné, 1758) feeding on slugs (Falkner 1984[7], Pitchford 1969[8]). During two days in July 2003 one individual of *T. merula* was observed feeding on abundant *A. lusitanicus* outside the village of Fiskebäckskil in Southwest Sweden. The bird was observed collecting several slugs and bringing them from the place of capture to a gravel path. Here the bird held the slug in a firm grip whilst pecking a whole just posterior of the mantle. During the process, the bird repeatedly cleaned its beak on the surrounding gravel. Through the hole, the bird then devoured out the slug's internal organs. External parts were left uneaten.

This tactic is most likely a novel invention by a single individual. Earlier observations suggest that this strategy can be learned by other individuals (Falkner 1984[7], Pitchford 1969[8]). *Arion lusitanicus* is a newcomer to Sweden, and is now extremely abundant, partly due to lack of predators. If the behaviour could spread within the blackbird population, in a way similar to the behaviour of gulls that have learned forage on earth worms in newly plowed fields (Tomlin et al 1988[9]) it would be highly advantageous since it would not share this source of food with any other predators. It would also be a welcome aid to both professional and amateur crop cultivators.

Other birds can be less successful in their

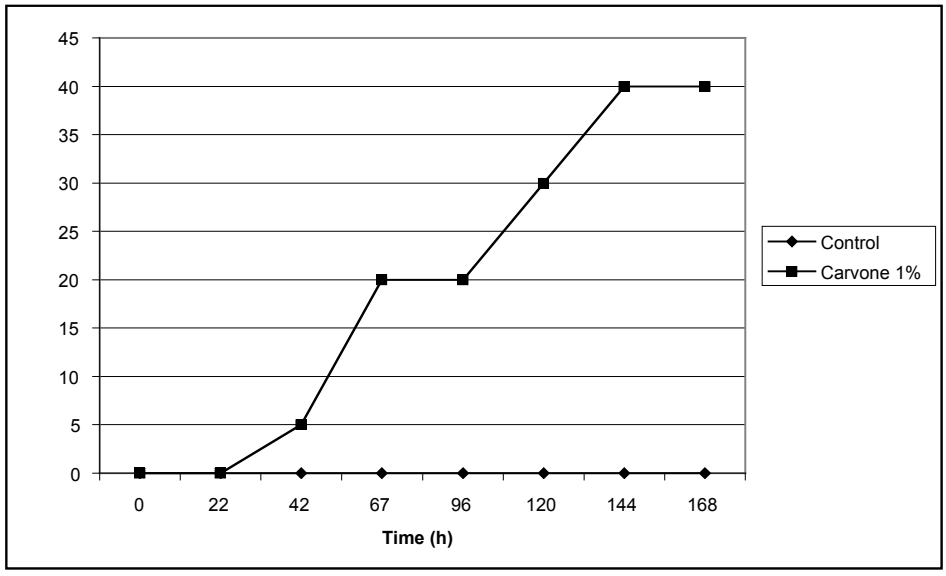

Figure 1 The effect of Carvone. 20 slugs in a sealed container were fed with special food treated with carvone. 25 slugs in an other container were used as control and fed only with the special food. The former slugs were noted to move as far away as possible from the contaminated food.

Table 1 Recipe for slug food, approx 0,5l:

60g	cat or kitten dry food pellets
13g	casein
1g	sorbic acid
0,5g	methylparaben
7,5g	agar
400ml	water

Crush the cat food (preferably in a kitchen blender) and add all ingredients except agar and water. Heat the water to boiling temperature and add agar while whipping thoroughly. Leave to cool only just until the mix starts to coagulate. Pour it into the dry mix and mix everything thoroughly. Pour into one or several containers of suitable size. Close with lid and place in refrigerator.

attempt to make the slugs part of their diet. A jay, *Garrulus glandarius* (Linné, 1758) was observed through binoculars in August 1997 sitting on a spruce branch in Fengersfors (province of Dalsland, W. Sweden). The bird held an almost adult *A. ater* in its beak, making several unsuccessful attempts to open the slug with the beak by pressing it to the branch. It also tried to swallow the prey whole. After trying for several minutes, the jay let go of the slug, which fell to the ground. The bird then, for more than five minutes, in different ways forcefully tried to clean its beak from the slug slime. The sides of the beak were pressed against the stem, rubbing both sideways and back and forth. The jay also shook its head intensively opening and closing its beak alternatively with the rubbing movements. Also swallowing movements were observed, most likely in attempt to get rid of slime in the mouth.

Another mean of protecting crops is by using chemical or physical barriers, as well as poison (eg. Speiser *et al.* 2002[10], Schüder *et al.* 2003[11]). The ketone Carvone (5-isopropenyl-2-methylcyclohex-2-en-1-one; ISO 1750) is a highly volatile substance in caraway seeds (*Carum carvi* Linné, 1753) with a smell often associated with bread in which the seeds often are an ingredient. Carvone is classified as a fungicide and as a plant growth regulator. Frank et al. (2002[12]) showed that carvone has feeding deterrent properties on the Nettled Slug, *Deroceras reticulatum* (O. F. Müller, 1774), we therefore conducted two small scale experiments to see if this apllied also to *A. lusitanicus*.

Specimens of *A. lusitanicus* were placed in closed but ventilated containers and fed with a special food-mixture based on cat-food pellets (Table 1). In some containers 1% Carvone were added to the food. The slugs reacted rapidly by

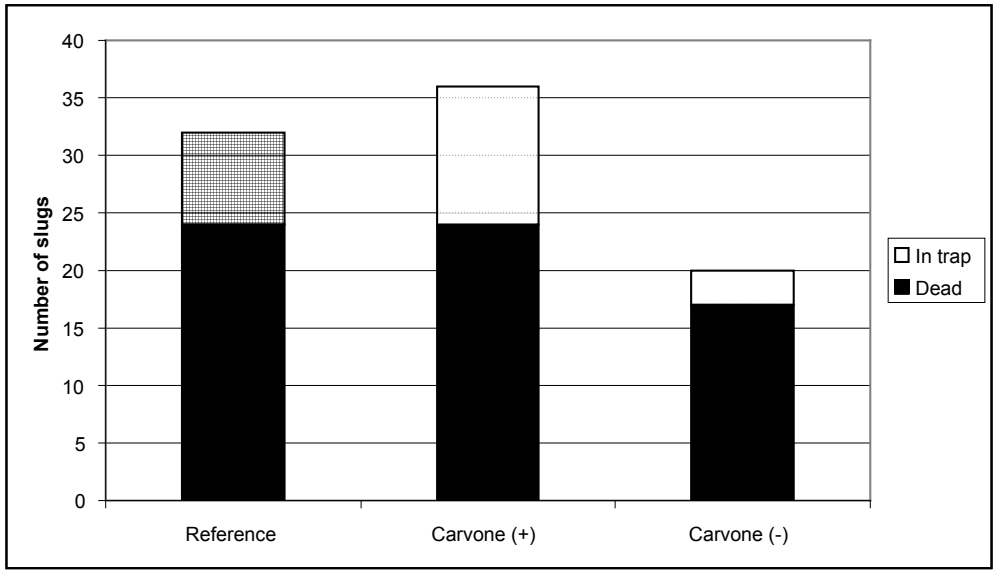

Figure 2 Effect of Carvone in field traps. The Slug Traps™ were placed on three different locations in the garden and moved between the these locations to avoid interference from local population variations. The carvone was applied to Oasis™ which was jinxed in the opening of two of the traps. The "in trap"-groups represent the slugs attracted to the traps' bait but hadn't crawled down into and drowned in the beer in the bottom of the traps.

withdrawing from the carvone baited food, as far as possible. The mortality rate in the containers with carvone baited was also significantly higher (t=0) than in the controls (Figure 1). Frank et al. (2002[12]) showed that slugs can die after having crawled over mulch containing Carvone. Our test makes it seem likely that the vapour itself is enough to harm the slugs. It is therefore not necessary for the slugs to eat or even to be in direct physical contact with the Cavone in order to cause increased mortality.

The high volatility of carvone seams to be a disadvantage when applied as a barrier in the field. In field-test, 3 traps (Slug-Trap™, Bröderna Nelson, Sweden) were set up according to the manufacturers instructions. Small pieces of Oasis™ (Smithers-Oasis, Denmark) (a porous material used for planting flowers) were treated with the + and – carvone isomeres and placed in the opening of two traps respectively. The third trap was used as control. Pieces of Oasis™ treated with a repellant has previously been shown to be effective against the common deer *Capreolus capreolus* (Linné, 1758) (http://www.nrm.se/jourhavande_biolog/). The positions of the traps were changed daily so that different local population concentrations of slugs wouldn't affect the test. The test was run for 12 consecutive days. As shown (Figure 2), + Carvone seems to have no deterring effect on the slugs. The - Carvone seems to have better effect but we could not find any statistically significant difference between the traps treated with carvone and the control.

We conclude that Carvone has high potential as slug pesticide but the forms for its distribution must be investigated further.

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