Preface Bern meeting ................................................................. I
List of participants Bern meeting ........................................... III

Preface Cardiff meeting ............................................................. V
List of participants Cardiff meeting .......................................... VII

Contents Bern meeting 2007 ......................................................... IX
Contents Cardiff meeting 2010 ..................................................... XI

Contents Bern meeting 2007

The slug *Arion lusitanicus* Mabille in Norway. 1. Testing control methods in private gardens

*Arild Andersen* .............................................................................. 1-2

Abstract: Different methods to reduce the population of *Arion lusitanicus* are being tested in private gardens already infested naturally with the slug, as well as and in arenas in the laboratory. After the first 2 years out of a 4 year project the following preliminary trends has been observed: Untreated gardens had the highest populations. Gardens with owners trapping and killing slugs had the lowest populations. Gardens that were rearranged to become drier had intermediate populations. In arenas in the laboratory, slugs avoided cocoa chips mulch and alginate.

 Slug control in no-till agriculture and slug population monitoring

*Markus Bieri, Evelyne Joliat, Andreas Chervet & Wolfgang G. Sturny* ....................... 3-8

Abstract: In the long-term field trial “Oberacker” of the Soil Protection Service, the slug populations were monitored and the effects of slug control treatments with Metaldehyde slug pellets were investigated. It was found that in the “no-till” plots the slug population recovers very fast and reaches within a summer the same level as in spring. In “no-till” agro ecosystems the slug populations are constantly on a high level and have to be monitored all year round to undertake slug control measures at the right time.

Can scavenging suppress application success of pathogenic nematodes?

*Pavel Foltan & Vladimir Puza* .......................................................... 9-12

Abstract: Two-choice trials were used to assess prey choice of the generalist predator/ scavenger *Pterostichus melanarius* (Coleoptera: Carabidae) between *Deroceras reticulatum* (Mollusca: Agriolimacidae) slugs or wax moth *Galleria mellonella* (Lepidoptera: Pyralidae) larvae killed by infection of *P. hermaphroditida* /Steinernema affine and control killed by freezing. We demonstrate that the presence of either of the two nematodes tested deters the beetles from consuming infected cadavers. This mechanism enables the nematodes to survive extreme scavenging pressure during their development inside cadavers.
Efficacy of pesticide seed treatment of oilseed rape to control slug damage

Hilferd F. Huiting & Albert Ester

Abstract: Slugs are an important pest of oilseed rape. The most susceptible plant stages are from the start of germination until the second leaf has been formed. Damage results in open spots in the field which can cause yield loss, weed problems and variation in ripening. Baited molluscicide pellets are predominantly used to control slugs often resulting in inadequate control. One laboratory experiment and two field experiments were carried out to test the efficacy of film-coating oilseed rape seeds to protect the crop against slug damage. Treatments were compared with an untreated control as well as a reference treatment in the field experiments consisting of broadcast applications of metaldehyde slug pellets at a rate of 448g a.i./hectare. In conclusion, metaldehyde showed sufficient protection of the crop against slug damage at rates from 80g a.i./kg seed upwards and thiacloprid protected the oilseed rape from rates of 38.4g a.i./kg seed upwards. Results of imidacloprid were variable showing good protection in 2006/2007 only. The remaining pesticides failed to protect the oilseed rape. Results are discussed with particular focus on the variation in results between metaldehyde and imidacloprid and thiacloprid.

Recent advances in the taxonomy of the NW European slugs of the genus Arion (Mollusca, Gastropoda, Pulmonata)

Kurt Jordaens, Anton de Winter, Karin Breugelmans, Jan Pinceel, Sofie Geenen, Hilde Vrijders & Thierry Backeljau

Abstract: Many NW European slug species are serious pests in agriculture and horticulture. A sound knowledge of the slug’s life cycle is essential in order to successfully control slug numbers. However, for many slug species, knowledge of their biology is scarce and insufficient because they prove difficult to identify. Many slugs are now considered complexes of sibling species whereas several species also show a high intraspecific variation in external and genital morphology. Here, we provide an overview on the current knowledge on the morphological, anatomical and molecular characterisation of the NW European species of the land slug genus Arion (family Arionidae).

Biodiversity of terrestrial molluscs in urbophytocoenoses of Vilnius, capital of Lithuania

Viktorija Kuznecova & Grita Skujienė

Abstract: A total of 6941 terrestrial molluscs of 50 species, belonging to 16 families were found during 2006 May-October in three urbophytocoenoses of parks of Vilnius and 27 species of 12 families are known as the most important pest Gastropods according to D. Godan (1983). Two species were new for the Lithuanian fauna – Oxychilus draparnaudi (Beck, 1837) and Oxychilus alliarius (Miller, 1822) – and these species are known in Europe as pest Gastropods, too. The most abundant (eudominant) species were: Vallonia costata (O. F. Müller, 1774), Succinea putris (Linnaeus, 1758), Vitrina pellucida (O. F. Müller, 1774), Nesovitrea hammonis (Ström, 1765), Xerolenta obvia (Menke, 1828), Trichia hispida (Linnaeus, 1758), Arianta arbustorum (Linnaeus, 1758), Lacinaria plicata (Draparnaud, 1801). Diversity of molluscs in parks of the biggest city of Lithuania is the same as the number of species in Natural National park in Latvia – 50-51 species. Ability of Clausiliidae (8 species), Vertiginidae (6 sp.) and Pupillidae (1 sp.) shows that environment conditions are quite tolerable for the diversity of land molluscs community.

Spatial distribution and activity of Microxeromagna armillata in an Australian citrus orchard – implications for pest management

Angela Lush, Michael Keller, and Geoff Baker

Abstract: Microxeromagna armillata is a small, cryptic, introduced snail which inhabits both terrestrial and arboreal environments in Australian citrus orchards. This species has caused significant problems for the citrus industry as a contaminant on exported produce to the United States of America. Snails have been found sheltering in the navel of export oranges, and costly quarantine measures have been established when interceptions occur on produce. As the USA is a key export market for Australian Navel oranges, M. armillata poses a serious problem for the
industry. A key factor impeding development of a targeted control strategy is the lack of understanding of *M. armillata*’s spatial distribution and activity in the tree canopy.

In this paper, the activity patterns of *M. armillata* during fruit harvest and post harvest are reported. *Microxeromagna armillata* was active in all areas sampled within the orchard, although snails were not equally active in all areas or on all sampling dates. Snail activity levels decreased with increasing height above ground during both the harvest and post harvest periods, with activity on all surfaces higher during the latter.

These findings suggest that late harvested citrus varieties may be more susceptible to contamination by *M. armillata*, reinforce the recommendation to skirt trees, and highlight the need to keep fruit-picking bins off the orchard floor.

**Manipulation of slug spatial behaviour by the rhabditid nematode**  
*Phasmarhabditis hermaphrodita*  
*Hana Pechova & Pavel Foltan* .......................................................... 59-62  
**Abstract:** Post-mortem location of slugs killed by six different treatments (three types of molluscicides, simulation of unsuccessful predation and two *P. hermaphrodita* nematode treatments) were compared. In comparison to other pathogenic states, significantly more slugs killed by the nematodes died within the soil. We assume that this is an outcome of behavioural manipulation, which prevents the parasites from being predated or scavenged together with their host until the nematodes complete development inside the host cadaver.

**Impact of molluscicidal formulations of earthworm surfacing behaviour: a novel use of security cameras**  
*Emma M. Shaw & A. Mark Langan* .......................................................... 63-68  
**Abstract:** Earthworms are of paramount importance in many soil systems, often comprising the dominant fraction of the soil macrofauna. Their activities have positive influences on soil functioning, recycling nutrients and promoting plant root growth for example. Pelleted methiocarb and, more recently iron phosphate, molluscicides can impact on earthworm populations. The Daniel funnel test was used to determine the impacts of an iron phosphate and metaldehyde molluscicide on nocturnal surfacing behaviour and feeding of *Lumbricus terrestris*. This technique monitors the removal of pellets and food (leaf portions) from the soil surface, but lacks detailed information regarding the level of direct interaction between pellets and earthworms. Therefore, night vision security cameras were mounted above a number of burrows and, with the help of motion detection software, earthworm activity was filmed. This allowed earthworm surfacing patterns and the frequency and duration of pellet contact to be documented for the first time. Metaldehyde was found to have no significant impact on earthworm behaviour whilst iron phosphate significantly reduced surfacing behaviour and feeding frequency.

**Contents Cardiff meeting 2010**

**Molecular identification of interaction pathways between carabid beetles and slugs in alfalfa**  
*Mark K. Adams, Eric G. Chapman & James D. Harwood* ............................................. 71-74  
**Abstract:** Global trade facilitates the intercontinental movement of cargo and thus increases the potential introduction of exotic gastropods to new areas of the world. Hence, there is a growing need to understand ecological interactions of newly introduced species with the native fauna. Furthermore, exotic slugs are of particular concern because yield losses to commodities planted throughout much of the continental United States are high and states such as Kentucky, whose humid climate typically supports a high density of these species, have significant acreage of farmland planted to crops at risk of damage including alfalfa, soybean, wheat and corn. Given these concerns, and the high density of endemic natural enemies inhabiting these agroecosystems, it is essential to examine the mechanisms of predation, decipher the strength of interaction...
pathways and evaluate the role of predators in biological control. In 2008, over 1,000 specimens of three species of ground beetles (Carabidae) were collected from alfalfa and screened by polymerase chain reaction using species-specific primers to identify the presence of DNA of the exotic slug *Deroceras reticulatum*. Feeding trials indicated that slug DNA was detectable in predator guts for approximately 12 h and, significantly, during the month of June, 5% of *Harpalus pensylvanicus*, 25% of *Scarites quadripect* and 5% of *S. subterraneus* specimens screened positive for *D. reticulatum* DNA. Drought conditions thereafter likely caused slug predation rates to decrease as their availability to epigeal predators declined. This research has enhanced our understanding of complex and emerging slug-carabid interactions in North America and provides a valuable framework for future efforts in conservation biological control.

Natural mollusc repellents and molluscicides based on Somali oleoresins

*Ahmed Y. Ali, Catherine J. Whaley, Jon B. Court & Ifor D. Bowen* .......................... 75-79

**Abstract:** The Somali oleoresins, commonly known as frankincense (*Boswellia carteri*), myrrh (*Commiphora molmol*) and opoponax (*Commiphora guidotti*), were evaluated for their potential as natural slug control agents. Split substrate assays were used to compare the effect of various varnish paint formulations, containing Somali oleoresins and a chemical component, on *Deroceras reticulatum* slugs. Paints containing frankincense or a chemical component from opoponax (CDF1) demonstrated high incidences of slug death or paralysis. In contrast, varnish paint containing opoponax oleoresin showed no molluscicidal or sub-lethal activity but displayed significant slug repellence properties. Myrrh, formulated as a topical foliar spray, was applied at various application rates to a field planted with a crop of pansy flowers. The optimum application (20ml/L), significantly reduced the feeding activities of *Deroceras* spp. and *Arion* spp. slugs. The spray also significantly reduced plant damage to levels comparable to those observed with commercial Metaldehyde based pellets. After fourteen days, no signs of phytotoxicity and negligible levels of slug mortality were observed. This study validates the use of Somali oleoresins as an alternative means of controlling slugs both in home and garden and field situations.

Reducing numbers or populations of the Iberian slug (*Arion lusitanicus*) in private gardens in Norway

*Arild Andersen* ...................................................................................... 81-83

**Abstract:** Sixteen gardens in South-eastern Norway were divided into 4 groups of 4 gardens. In treatment 1 (untreated control) nothing was done to reduce slug numbers. In treatment 2 (‘killing’) the owners were encouraged to collect and kill as many slugs as possible. In treatment 3 (habitat manipulation) owners were encouraged to change their garden so that an area of about 20cm close to the ground was kept as open and dry as possible. Treatment 4 (extended habitat manipulation) included treatment 3 but also by removing of potential overwintering sites such as open compost, heap of stones etc. A reduction in the number of slugs was observed in all the years and in all treatments from June to September, probably due to natural mortality. The mean number of slugs was always lowest in treatment 2, in the third year showing a significant reduction of more than 80% from the control. In treatment 4 the mean reduction of slugs (not significant) was almost 40% during the third year. In treatment 3 the mean reduction (not significant) was about 55% during the third year. In conclusion, creating a garden not favourable to the Iberian slug can reduce the population without using molluscicides.

The effect of slugs on seedling recruitment and community composition in upland hay meadow plant communities

*Sarah Barlow, Roy Sanderson & Gordon Port* .................................................... 85-89

**Abstract:** Restoration of species-rich upland hay meadows is a target of the EC Habitats Directive and the UK Biodiversity Action Plan for Upland Hay Meadows. Previous restoration research has predominantly focused on the optimum farming management regime, and interactions between the above ground vegetation and the soil microbial community, with little attention being paid to the role of grazing invertebrates. Slugs have the potential to affect
seedling recruitment and community composition through the selective removal of favoured species at the seedling stage. A mesocosm experiment was designed to test this hypothesis over a three year period. Results showed a significant effect of slug grazing on community composition one year after sowing, with evidence of selective grazing on *Rhinanthus minor* L. (Hay rattle) (Orobanchaceae) seedlings. The selective removal of *R. minor*, a hemi-parasite and keystone species, by slugs, is of critical interest to the restoration process as *R. minor* is used as a management tool to reduce the dominance of competitive grass species in species-poor meadows that are targeted for restoration.

**Slug control using Metaldehyde under modern ecotechnological aspects**
*Rolf Barten & Jaeger,* C. .......................................................... 91-92
**Abstract:** For many years Metaldehyde based products have been successfully used for the control of slugs and snails throughout Europe and beyond. Metaldehyde is particularly suited for integrated mollusc control programs and has therefore gained widespread usage in arable and horticultural crop situations. As with any pesticides, the form of delivery of the active ingredient in the product formulation can become the decisive factor not only for the potential of biological control but also for any unwanted side effects. For example, recent findings of Metaldehyde residues in raw water sources in the United Kingdom have raised concerns about the future of this active substance. Leading bait manufacturer frunol delicia has developed new bait formulas using a novel manufacturing process allowing to significantly reduce the concentration of Metaldehyde in the bait formula and the application rate per hectare. Following ten years of field experience, the eco-balance, in terms of reduction of both the active ingredient consumed and the carbon dioxide produced, confirms a viable way of how solutions in bait manufacturing can help to maintain Metaldehyde as an integrative active ingredient for reliable and eco-friendly slug control even in future years.

**Observations of field slug activities in Switzerland in relation to weather conditions**
*Markus Bieri, Florian Burkhalter, Andreas Chervet, Wolfgang G. Sturny & Susanne Appoloni* .......................................................... 93-97
**Abstract:** Over the last years the slug activity-density (method: Glen et al. 2003) was monitored from early spring to midsummer (growing season) in a no-tillage plot and a plot with conventional plough tillage in the “Oberacker” long-term field trial of the Office of Soil Protection at the Inforama Ruetti in Zollikofen (Switzerland). In a first evaluation the numbers of observed animals were compared with the weather conditions over these years. In this study the parameters of the over-wintering conditions for slugs are investigated. The main factors influencing the over-wintering populations are also found to be soil temperature and soil matrix potential. Soil temperatures lower than +3°C of water saturated soils reduce the surviving chance of slugs and snails in winter. In periods with favourable weather conditions for slugs the slug activity density reacts faster and reaches higher values in the no till plots.

**Application of *Phasmarhabditis hermaphrodita* (Nemaslug®) to commercial broad acre crops**
*Andrew P. Brown, Anthony Barker, Anthony Hopkins & David Nelson* .......... 99-104
**Abstract:** The mollusc specific parasitic nematode *Phasmarhabditis hermaphrodita* (Nematoda: Rhabditida) has been shown to infect and kill a number of economically important pest slug and snail species. This beneficial nematode is available commercially under the trade name Nemaslug® (Becker Underwood Ltd., Littlehampton, UK). Use of this biological control agent by large commercial growers is increasing. This increase in use also includes expanding from its traditional markets in higher value salads, to broad acre vegetables such as potatoes. Use of *P. hermaphrodita* has increased in recent years on outdoor crops due to a number of factors. Firstly additional products are often needed to compliment the available chemicals (e.g. Methiocarb, Metaldehyde and Ferric phosphate) in sub-terranian environments where they are often not as effective. Secondly there is a drive for more environmentally sensitive farming
practices of which biological control, as part of an integrated pest management program, is an important component.

This expansion into new markets, such as potatoes, has presented a number of challenges in applying these microscopic worms. Application of these soft bodied nematodes now needs to be carried out to large areas over long periods of time. To enable a grower to be able to do this, nematode specific application equipment has been developed. The Wroot water Nemaslug Xtra applicator is an injection unit which, whilst being able to inject nematodes into irrigation water for a boom or gun, can keep the nematode solution constantly agitated and supplied with oxygen. This system has been shown to be able to keep the nematodes alive and mixed in suspension for over 24 hours. This equipment allows a grower the increased flexibility of no longer having to wait for rain to apply and reduced application labour costs by not having to spend time spraying *P. hermaphrodita* onto the crop with a tractor mounted boom.

The Wroot water Nemaslug Xtra applicator is the first ever piece of nematode specific application equipment developed. This equipment has been designed, built and made available for commercial growers, specifically for use of applying the biocontrol agent *P. hermaphrodita* (*Nemaslug®* Xtra) to broad acre vegetable crops.

The molecular detection of slow worm (*Anguis fragilis*) predation on slugs

David S. Brown & William O. C. Symondson ...................................................... 105-112

Abstract: Slow worm (*Anguis fragilis*) numbers are in decline due to habitat loss, modification and fragmentation through agricultural intensification and urban development. While it is known that slugs are a significant component of slow worm diet, slug species, and patterns of predation on them, have not been studied before due to inherent difficulties of determining slug identity through traditional methods of dietary analysis. In this study, a non-invasive molecular approach was taken to detect slow worm predation on *Deroceras reticulatum* and *Arion* species, major pests of agriculture, allotments and gardens. Slug DNA was detected in slow worm faeces collected each month between April-September over two years from sites in Dorset and South Glamorgan. Relationships between the consumption of slugs and slow worm sex, maturity stage, snout-vent length and weight along with month, site, rainfall and temperature were assessed by generalized linear models (GLM). Predation on slugs was high, with 45% of slow worms (*N* = 400) found to have eaten them (22% *D. reticulatum* and 30% *Arion*). Predation on both *D. reticulatum* and *Arion* was significantly affected by month, probably following changes in the abundance / availability of slugs, with *D. reticulatum* predation also found to be positively correlated with rainfall. In addition, predation on both *D. reticulatum* and *Arion* was positively correlated with air temperature, when there is a greater abundance of slugs and when slow worms are more active. Furthermore, a sex bias was found in predation on *Arion*, with female slow worms more likely to have consumed them in April, May and September. This may reflect different nutritional requirements of males and females. On a domestic scale, slow worms could be encouraged to help suppress slug numbers on allotments and in gardens by the provision of areas of rough grass and refugia (large stones / sheets of tin / carpet).

Assessment of slug populations in grassland with permanent refuge traps

Maria Cordoba, Javier Iglesias, Jose Castillejo & Paula Ribadulla ....................... 113-120

Abstract: Surface refuge traps are recommended by researchers, consultants and manufacturers of molluscicides to monitor slug density-activity in arable crops, but pastureland differs from arable land with respect to many characteristics which play a major role in the slugs’ biology. Here we report on the performance of non baited mat refuge traps permanently placed at the same position over more than two years in established pasture, for the assessment of slug numbers and biomass, in comparison with soil sampling and flooding over three days. Despite the availability of alternative shelters provided by the vegetation, a great many slugs and slugs’ eggs were registered in the traps over the year and over a wide range of temperatures under the traps. Overall, traps showed the same trends as in arable land: traps showed a bias towards the larger individuals and underestimated the numbers of the smallest slugs of each species (*Deroceras*
Control of the water snail *Lymnaea stagnalis* in ponds

**Albert Ester & Klaas Van Rozen** .......................................................... 121-126

**Abstract:** In The Netherlands several plant growers, specialists on the production of water plants such as *Nymphaea alba* and *Nuphar lutea* for the nurseries and home market, have problems with the great pond snail *Lymnaea stagnalis* (Gastropoda; Lymnaeidae). Generally, these plants are imported from outside Europe without any snails. During the production season of seedlings into a more advanced stage plants are damaged by *L. stagnalis*, which is an increasing problem. The damage consists of leaf damage or destroying the plants completely. Consequently, plants are often no longer marketable. Normally damage appears in late spring until mid summer.

Plant growers using water from canals or other open surface water have serious problems, as this water is contaminated with this species of snail and eggs. Growers using tap water do not have snail problems. Nurseries do not accept plants with damage or any contamination with snails or eggs. The consumers buy infected plants and their ponds have an ideal habitat for multiplication of the snails.

Research is focused on the reduction of the water snail population without any impact on the environment of the water organisms. Additionally, the products may not be phytotoxic to the water plants.

Birch tar oil is an effective mollusc repellent: field and laboratory experiments

**Marleena Hagner, Lindqvist, I., Lindqvist, B., Tiilikala, K., Penttinen, O.-P., Pasanen, T., & Setälä, H.** ................................................................. 127-130

**Abstract:** Populations of two molluscs, the land snail *Arianta arbustorum* (Gastropoda: Helicidae) and the Iberian slug *Arion lusitanicus* (Gastropoda: Arionidae), have increased substantially in many places in the northern Fennoscandia in recent years. In this study birch tar oil (BTO), a new biological plant protection product, was tested against these molluscs. We examined whether 2 types of BTO, used either alone, mixed together, or mixed with Vaseline®, could be applied as a repellent against 1) snails when painted on a Perspex® fence, and 2) slugs when smeared on pots containing *Brassica pekinensis* seedlings. Both the fences and the pots with seedlings were placed in each field with a high population of the target organism. The BTO – barriers were effective in repelling both snails and slugs. However, the repellent effect of BTO alone against the molluscs was short-term. Repeated treatments were required to keep the slugs away from the plants and we found that the interval between treatments should not exceed two weeks. Most noticeably, the BTO+Vaseline® mixture prevented the land snails from passing over the treated fences for up to several months. The results of these experiments provide evidence that BTO, especially when mixed with Vaseline®, serves as an excellent long-term repellent against molluscs.

Conservation tillage, field crops, and slugs in North America

**Ronald B. Hammond** ................................................................. 131-133

**Abstract:** Slugs are often problems in field crops grown using conservation tillage practices in the eastern United States, as well as certain locations in the Midwest and the southern USA, as well as in Canada. Although most concern has been on corn and soybean, reports of problems from dry beans, cotton, oil-seed rape, sunflowers, winter wheat, and fall planted alfalfa are often received. Although most problems are in fields located in the original forested areas of eastern and southern USA, reports are also being received from the Great Plains’ grass lands of slug issues in irrigated no-till fields. Overall, slug problems have increased in geographical area as growers in the USA and Canada have adopted conservation tillage practices. As in other areas of the world, determining new methods of slug control is of utmost importance in order to allow...
growers to continue using conservation tillage practices. In areas that are new to slugs, a primary concern is educating growers on IPM approaches to slug management.

Perennial ryegrass seed treatment to control slug damage

*Hilfred Huiting & Albert Ester* .......................................................................................... 135-145

**Abstract:** Slugs are an important pest of grass seed production on marine loam soils. Significant damage occurs from the start of germination until tillering, the main slug attack occurring at emergence and shortly after. Slug attack causes plant loss resulting in open spots in the field which in severe cases may cause significant yield loss. Predominantly baited molluscicide pellets are used to control slugs in Dutch grass seed production however occasionally being applied untimely resulting in repeated application or even unsatisfactory control. Four field trials in three subsequent years and one semi field trial were carried out to test the efficacy of grass seed treatments to protect the crop against slug damage. In the field trials treatments were compared with both an untreated control and a reference treatment consisting of broadcast applications of metaldehyde slug pellets at a rate of 448g a.i. per hectare. A field trial starting in autumn 2003 together with a field trial in 2004/2005 and an additional semi field trial in 2004 resulted in two field trials testing metaldehyde at three application rates and thiacloprid at one rate, in 2005/2006. Tested on heavy marine loam soils both metaldehyde at 360g and thiacloprid at 154g a.i. per kg seed resulted in excellent crop protection, reduced application rates however showing efficacy as well. Plant numbers as well as crop development figures were equal to or significantly higher than the results of two applications of metaldehyde baited pellets. Results are discussed with particular focus on the variation in results and possible variation in mode of action between metaldehyde and thiacloprid.

Is the mollusc *Ena montana* (Draparnaud, 1801) invasive or relict species in Lithuania?

*Viktorija Kuznecova & Grita Skujienė* .............................................................................. 147-154

**Abstract:** Usually invasive molluscs represent some of the world’s most important ecological and economic pests which quickly and abundantly colonize habitats not typical for their provenance. In this sense *E. montana* is local in the mountains of Alps, Carpathians, Sudeten under 2800 m but in Lithuania it was found in the Northern Lithuanian Lowland. The first finding of *E. montana* in Lithuania was made in 1958 by P. Šivickis and our data show that this species is abundant in Biržai forest (maximum 314 individuals in one square meter). Conversely we can assert that *E. montana* is post-glacial relict species of the Holocene because its distribution in Lithuania have the most striking feature – it was found only in one location – in one of the oldest woodland of Lithuania – Biržai forest. Regrettably we don’t have fossil data from this part of Lithuania and the implication above was made only after intensive molluscs search in 238 localities of Lithuania during the Woodland Key Habitat Inventory in 2001-2005. The differences in gleysols between other woodland sites in Lithuania are fractionally except for twice bigger Mg$^{2+}$ ions (30 mg/kg) and high humidity in Biržai forest. During the past few decades Biržai forest was intensively exploited and melioration took place since 1960 till 2004. Since all known places for *E. montana* are in the most humid central part of Biržai forest, what prognosis can we make – will *E. montana* spread or decrease? The other question is, can we associate this population with one from Latvia Gauja National park which is known for the Devonian sandstone cliffs, in some places reaching 90 meters, along the banks of the Gauja river, or mountains of Poland, where the nearest populations of *E. montana* can be found? All these questions are under discussions.

Testing the efficacy of different substances with a potential molluscicidal effect under laboratory conditions

*Žiga Laznik, Matej Vidrih & Stanislav Trdan* ................................................................. 155-160

**Abstract:** We studied in 2008 and 2009 under laboratory conditions a molluscicide activity of 26 substances in 89 different treatments. Experiments, in which slugs (*Arion* spp.) were comprised,
took place in two series, namely with injection of active substance in slug intestine and application of pellets. After conducting the injection we observed 100% mortality of slugs in treatments with bacteria *Bacillus thuringiensis* var. *kurstaki* (0.25ml in 10% concentration/individual), caffeine (0.25ml in 10% concentration/individual), sodium dodecyl sulphate (0.25ml in 10% concentration/individual, 0.125ml in 10% concentration/individual, 0.125ml in 5% concentration/individual, 0.0625ml in 10% concentration/individual) and pirimicarb (0.25ml in 10% concentration/individual, 0.125ml in 10% concentration/individual, 0.125ml in 5% concentration/individual, 0.0625ml in 10% concentration/individual). Meanwhile application of pellets gave the highest (100%) slug mortality when sodium dodecyl sulphate in 0.5% concentration with caraway as a supplement was used.

**Snails, slime and sciomyzid flies – prey location in a malacophagous Diptera**

Rory J. McDonnell, Collette J. Mulkeen & Mike J. Gormally ........................................ 161-165

**Abstract:** The family Sciomyzidae is unique amongst insects in that almost all species are exclusively malacophagous. Globally, this feeding behaviour has made the family a target for the selection and assessment of biological control agents of snail intermediate hosts of trematode diseases and of gastropod pests of agriculture and horticulture. Although a wide range of information has been published on the life history of these flies, relatively little is known about prey location mechanisms. In this study, the ability of neonate and third instar larvae of the aquatic sciomyzid, *Sepedon spinipes*, to follow fresh and aged (45 minutes) snail mucus trails was assessed using filter paper Y-mazes. When fresh mucus trails were used, all of the neonates and third instar larvae displayed a positive response and followed the mucus trail into the experimental arm. The stimulatory substance(s), however, appeared to become inactive with time and after 45 minutes none of the tested larvae reached the trail end. These results suggest that trail-following behaviour in Sciomyzidae is an innate response and that aquatic species may also have the potential to forage for snails on shoreline and semi-aquatic areas.

**Energy balance of lettuce fed Arion ater/rufus (Biscay, Northern Spain) throughout development**

M. Mercedes Ortega-Hidalgo, Hugo Alejandro Núñez-García & Jesús M. Txurruka ........................................................................................................ 167-172

**Abstract:** In temperate areas, the big terrestrial slug *Arion ater* reaches a considerable size within a limited growing season (7 to 14 months) exhibiting remarkable growing rates. In this work, energy balance of different size specimens of *Arion ater* sampled at distinct moments chosen to portray the various developmental stages along its life cycle has been determined in the laboratory through short-term experiments using lyophilized lettuce (*Lactuca sativa*) as foodstuff. In addition allometric relationships of the various components of energy balance (ingestion, absorption and, metabolic rates) have been established. Whereas mass exponent for oxygen consumption is 1 within each developmental stage (metabolic expenditure scales proportionally to body size provided animals belong to a similar growth phase) physiological descriptors related to energy intake (ingestion and absorption rates) share a common correlation coefficient of 0.610 (± 0.130) the combination of both results explaining increased reduction of growth rates from immature young phases to active growing males (IGR = 0.035 to 0.020mg/mg/d on dry weight basis). Assimilation Efficiency has remained constant along the study being 60% of organic uptake. Lettuce appears as a suitable food for *Arion* and SFG determined in the laboratory has resulted in positive values for every developmental stage, including egg-lying females: 313 J/d for young slugs, 934 J/d for males and 1646 J/d to 1452 J/d for October and November females respectively. Integrated Mean Gross Conversion Efficiency (SFG/Ingestion) is 44.6% (±3.8). As a conclusion, cumulative ingestion of a given slug from an initial size of ~3.5g live weight to a full-grown female of ~23g would require about 600g of fresh lettuce.
Hibernation and latitude in Helix (Cornu) aspersa: an attempt to integrate environmental restrictions to active life, length of stasis endurance and metabolic costs
Abstract: Original data from a Mid-Atlantic population (43°19’) of Helix aspersa is discussed in relation to literature and compared with the overlapping species Helix pomatia. An asymptotic relationship relating length of hibernation period and latitude within temperate areas is described. This simple model predicts maximal hibernation periods of 7.5 months and no hibernation below~35ºN ($r^2 = 0.89$) for Helix aspersa. While lack or severe reduction of hibernation-linked dormancy is usually accompanied by increased inactivity due to aestivation, maximal length of hibernation in non-or scarcely aestivating populations would probably represent a fixed trait in terms of supporting metabolic arrest that would be restricting the ability to inhabit colder areas for this species.

Vertical and horizontal movement by slugs
Gordon Port & Alain D. Craig ................................................................. 179-182
Abstract: Following treatment with molluscicides, slugs can recolonize a site very quickly, but what proportion of the colonizing slugs move from adjacent areas (horizontal movement) and what proportion from within the soil (vertical movement)? On a grassland site barriers were used to trap and exclude slugs to estimate horizontal and vertical movement over a period of 32 months. For the first 15 months vertical movement made a significant contribution to the slugs recolonizing the area. The ecological mechanisms and the implications for control of slugs are discussed.

Predation and scavenging by the generalist predator Pterostichus melanarius
Adam Powell, David Bohan, Alison Haughton, William O. C. Symondson & Jean-Francois Testut ................................................................. 183-187
Abstract: Pterostichus melanarius is a generalist predator that may be a significant predator of slugs in arable ecosystems and therefore potentially part of an integrated pest management programme against this pest taxon. A suite of field and laboratory experiments were conducted to investigate feeding behaviour in this beetle, and its ability to reduce slug population size. Experimental results suggest: (1) at the semi-field scale, P. melanarius did not reduce slug density despite beetles being in a state of hunger. (2) The feeding activity of P. melanarius changed according to the vital status of prey. (3) Conditioning of P. melanarius to specific food types had little effect on subsequent feeding behaviour. Dietary conditioning only affected their subsequent propensity to feed on seeds.

Does paternity influence slug growth rate?
Lisa Redford, Kirsten Wolff & Gordon Port .................................................. 189-191
Abstract: Slugs from the same batch of eggs may exhibit very different growth rates. Initial egg size and food availability do not seem to be the cause. We investigated slugs from the same egg batch using microsatellites to look for differences in the paternity of eggs within a single batch. There was no evidence to suggest that differing paternity was the reason for the different growth rates of embryos from the same mother.

Neu 1184: A new bait to control the Golden Apple Snail (Pomacea canaliculata) in rice cultivation
Reinhard Arndt & Andreas Prokop ............................................................. 193-197
Abstract: The tropical sweet water snail Pomacea canaliculata (Golden Apple Snail) from South America was introduced to Asia as a potent protein source. Unfortunately this snail failed as a food source but was released into the environment and has become a serious pest in rice cultivation. An economical relevant damage occurs through the feeding of the snails on the young leaf tips of rice plants within the first 14 days after transplanting or emergence of the seedlings. Besides mechanical protection methods various chemical products, most of them
without an official registration, are currently used to control the Golden Apple Snail. Moreover, baits with the molluscicidal active metaldehyde are applied. The company Neudorff manufactures and sells slug baits (Ferramol, Sluxx) with the active iron phosphate for the control of land slugs and snails. In order to evaluate if the active iron phosphate has also a potential to control the Golden Apple Snail a rearing system for this aquatic snail was established and different tests system were developed. The formulation of the current bait was optimized for the control of aquatic snails. The new bait is stable in water and thereby suitable to control aquatic snails like the Golden Apple Snail. Own tests have shown that the new bait is as efficacious as currently sold metaldehyde baits. At present comprehensive field tests are under way in Asia to assess the efficacy of the environmentally friendly iron phosphate bait in rice cultivation.

**Food consumption and activity in Deroceras reticulatum and Cantareus aspersus**

*Paula Ribadulla, Javier Iglesias, Jose Castillejo & Maria Cordoba* .......................... 199-205

**Abstract:** Activity and food consumption were simultaneously monitored in populations of known density (20 or 40 animals m⁻²) and biomass of adult slugs *Deroceras reticulatum* (Müller, 1774) and adult snails *Cantareus aspersus* (Müller, 1774), kept in mini-plots under semi-natural conditions. Food consumption of turnip roots was monitored daily in terms of dry weight. The activity of the populations was monitored using time-lapse video techniques to record the movements of the animals. To obtain a comprehensive measure of the activity over the time course, the numbers of active and feeding animals registered at 30 min intervals were integrated over time using the formula for the calculation of the “area under the disease progress curve” (AUDPC), thus allowing expressing the intensity of activity and the intensity of feeding activity of the populations by single values over each 24-hours period. Daily food consumption per gram of biomass was independent of population density for both species, and it was nearly 3 times larger in the slug than in the snail; however, food consumption per plot was nearly 10 times larger in the snail because of their bigger size. On average, the activity level over the year was higher and less variable in *D. reticulatum* populations than in *C. aspersus* populations. The daily intensity of activity and daily intensity of feeding activity showed significant correlations between them and with food consumption (g d.w./g biomass/day), but activity explained only a limited amount of the variability in food consumption.

**Seasonal changes in feeding rates and respiratory metabolism in two cohorts of Helix aspersa (Müller) across an extreme heat wave:**

*laboratory and field studies*

*Iker Rodriguez-Zaldua, Jesus M. Txurruka & Mercedes M. Ortega-Hidalgo* ........... 207-211

**Abstract:** Seasonal evolutions of organic growth rates, metabolic rates and organic assimilation rates of two actively growing age classes of brown garden snail (*Helix aspersa*) from a wild population have been studied during 2003-2004. Organic growth rate was calculated for each age class as differences between samplings divided by time elapsed. Maximal rates were observed throughout the spring season once snails had aroused from hibernation (~50 to 100J d⁻¹). An extreme heat wave induced an aestivation period associated to weight loss (in September minimal growth rates are recorded: ~ -15.7 to -24.7J d⁻¹) degrowth increasing in smaller animals. Positive net growth was recovered in autumn before the hibernation period, activity being resumed in the next spring. Continuous increase of metabolic rate observed during the spring, due mainly to individual weight gain (effects of temperature increase being exclusive to the month of June) allows higher activity levels and subsequent higher ingestion and assimilation rates. Maximal assimilation rates occur in July: 225J d⁻¹ for young immature snails and 360J d⁻¹ for adult reproductive specimens. Minimal and maximal routine metabolic rates of active snails recorded in this study oscillate between 25 to 60J d⁻¹ in April (for non-reproducing and mature snails respectively) to 175 to 275J d⁻¹ in August. Although oxygen consumption of hibernating snails was not recorded, values registered at the peak of negative organic growth rate in mature snails could be taken as an approaching value: 25.8J d⁻¹ animal⁻¹. Since 114.7J d⁻¹ animal⁻¹ can be taken as winter active metabolic rate acute metabolic depression would represent 22.5% of that of active snails at the onset of hibernation. A 3 month period of hibernation seems to occur
repeatedly (2005, 2006), whereas the recorded aestivation period was unexpected, being attributed to the singular weather conditions during the summer of 2003, indicating that \textit{Helix aspersa} dwelling in this locality would behave as facultative aestivators.

**Detecting introduced species in the slug fauna of the British Isles**  
\textit{Ben Rowson & William O. C. Symondson} .......................................................... 213-218  
**Abstract:** The problems of discriminating native from introduced slug species in Britain and Ireland, and of knowing the existing fauna so that future introductions are detected, are discussed. To help resolve these, we suggest the slug fauna should be taxonomically clarified, genetically screened for known pest lineages, and the public profile of slugs, raised to promote vigilance.

**Slugs from the Nearctic: what we need to learn from the Western Palearctic**  
\textit{Anna K. Thomas, Rory J. McDonnell & James D. Harwood} .............................. 219-222  
**Abstract:** The increase in slug biological control research over the last twenty-five years has been prolific throughout much of the Western Palearctic region, leading to a literature replete with examples of pest management recommendations. In contrast, the Nearctic region suffers from a limited knowledge of the ecology, biology, distribution, and impact of slugs throughout the entire ecozone, despite the area supporting a rich exotic fauna and several genera endemic to the region. Consequently, management options are limited, new invasive species are often unreported, and agricultural productivity is regularly impacted due to limited control options and the lack of robust guidelines for growers. This has been exacerbated by increases in global trade and movement of produce and horticultural materials within North America, facilitating the dispersal of exotic molluscs to new areas. In this paper, we will provide a brief overview of the status of exotic and native molluscs in North America, paying particular attention to the diversity of crops throughout the Nearctic and identifying those areas with greatest probability for experiencing slug damage at economically significant levels. Detailed information on the source location of exotic slugs invading the Nearctic from the western Palearctic is also presented using \textit{Arion subfuscus} as a case study. To conclude, we refer to the literature from the Western Palearctic to aide us in considering options for biological control and prioritizing malacophagous natural enemies for future research efforts in the Nearctic.

**Molluscs in defense: Cellular and sub-cellular mechanisms in snails and slugs to cope with stress**  
\textit{Rita Triebskorn & Alexandra Scheil} ................................................................. 223-226  
**Abstract:** The paper reviews cellular and subcellular mechanisms which are – among possible others – responsible for the relative robustness of molluscs under stressful environmental conditions (e.g. chemical or mechanical stress, extremely high and low temperature, drought, or changes in the pH). It provides several explanations why representatives of this animal group are capable to survive even under severely polluted conditions, and why others are capable to tolerate or neglect impacts of possible molluscicides.

**Influence of life cycle and food quality on polysaccharide and total carbohydrate content of the body wall and genitalia of \textit{Arion ater} L. (Gastropoda: Pulmonata)**  
\textit{Jesus M. Txurruka & Mercedes M. Ortega-Hidalgo} ............................................ 227-233  
**Abstract:** Carbohydrate and polysaccharide contents in \textit{Arion ater} are highly dependent on stage of the life cycle (male (August) or female (November)), type of carbohydrate in the food (starchy or non-starchy foods) and tissue (body wall (BW) or genitalia (G)). Carbohydrates accounted for nearly a 37.3\% of the dry weight (DW) of body walls of male slugs fed in the lab for 10 days on starchy foods, whereas that content lowered to 21.5\% of DW of BW of female slugs. When slugs were fed for the same period on foods lacking starch, carbohydrate content (CC) of BW lowered to 13.6\% of DW in male slugs and dropped to 6.9\% of DW in females. Regarding genitalia, CC of reproductive tissues in female slugs was 42.0\% of DW when slugs were fed on starchy foods, and a mere 27.8\% of DW when fed on or non-starchy foods. Most of the carbohydrates seem to
be polymerized, because polysaccharides stand for \(\approx 57\%\) of the carbohydrates in BW of both male and female slugs fed on starchy foods. When slugs were fed on non-starchy foods, polysaccharide percentage reduced to 42.3\% of the carbohydrates in males and, as it could be expected, diminished more in females, where polysaccharides represented only a 30.6\% of the carbohydrates. In genitalia of female slugs the carbohydrates were primarily in their polymerized form, but their percentages did not depend on the amount or on the type of carbohydrate present in food.

**Slug damage in potatoes in The Netherlands**

*Klaas van Rozen & Albert Ester* ...................................................................... 233-240

**Abstract:** At times, slugs are reported causing severe damage in potato tubers on loess soils. Tubers show relatively small holes and larger cavities inside. Slime and occasionally slugs are observed. Damaged tubers are not saleable and severe affected lots of potatoes are rejected from the market. The moment when farmers observe damage is rather late and control actions are limited. In contrast to the British situation, studies on slug species responsible for potato damage in The Netherlands have been underexposed. Neither control strategies nor factors influencing slug population densities have been investigated regarding the specific species. In 2009 a preliminary study was started aiming at finding the slug species responsible and make an inventory of factors with a possible relation to slug population dynamics. Farmers facing problems with slugs have been visited and were exposed to an extensive questionnaire. Fields where damaged potatoes were harvested were compared to fields lacking any slug damage. Subsequently farmers suffering no slug damage in potatoes at all have been exposed to the same questionnaire. Both target growers were questioned on experiences with slugs, control methods and crop production management. The results with ‘soft’ conclusions are discussed.