

# Land slugs (Gastropoda: Pulmonata) on birds demonstrate dispersal potential

**Timothy A. Pearce**

Carnegie Museum of Natural History  
Section of Mollusks  
4400 Forbes Ave.  
Pittsburgh, PA 15213 USA

**Robert S. Mulvihill<sup>1</sup>**

Powdermill Nature Reserve  
Carnegie Museum of Natural History  
1847 Route 381,  
Rector, PA 15677 USA

**Katherine A. Porter**

Carnegie Museum of Natural History  
Section of Mollusks  
4400 Forbes Ave.  
Pittsburgh, PA 15213 USA

## ABSTRACT

We describe the discovery of two slugs, *Arion subfuscus* and *Deroceras reticulatum*, on living adult birds captured for banding at Powdermill Nature Reserve, Rector, Pennsylvania. The presence of slugs on birds suggests that bird transport might play a role in slug dispersal.

*Additional keywords:* Gray fieldslug, *Deroceras reticulatum*, dusky arion slug, *Arion subfuscus*, common yellowthroat, *Geothlypis trichas*, northern saw-whet owl, *Aegolius acadicus*.

## INTRODUCTION

Although land snails and slugs are quintessentially slow-moving creatures, their ability to colonize new areas indicates that they do, in fact, disperse. Some terrestrial gastropod species have evidently dispersed considerable distances, including across inhospitable bodies of salt water (Rees, 1965; Vagvolgyi, 1975; Wesselingh et al., 1999). Other than direct locomotion or transport by humans (including as eggs), possible agents of dispersal include water (Smith and Djajasmita, 1988), wind (Kirchner et al., 1997), and other organisms such as birds (Dundee et al., 1967; Purchon, 1977: 383; Wesselingh et al., 1999; Wada et al., 2011).

Direct evidence for these dispersal mechanisms remains limited, and we are not aware of any published evidence for slug dispersal via wind or water. Most evidence for gastropod dispersal via other organisms pertains to shelled snails. We are aware of only two previous reports of slugs being carried by non-human animals: one report of a slug in the fur of a house cat (McMillan, 1989) and one report of slugs being caught and subsequently dropped by bats (Johnston, 1992). This paper presents the first known report of slugs on living adult birds.

## MATERIALS AND METHODS

In 2003 and 2004, two land slugs were found on birds trapped in mist nets at Powdermill Nature Reserve (Rector, PA; 40.1636° N, 79.2668° W). The birds were trapped by R.M. as part of the Powdermill Nature Reserve (PNR) bird banding program. The nets were located in a wet shrub-scrub habitat dominated by willows. cursory examination of all birds for ectoparasites is a routine part of the banding procedure, as is documentation of molt, and, during examination, the slugs were discovered on two species of birds. The two birds upon which the slugs were found were a common yellowthroat (*Geothlypis trichas* (Linnaeus, 1766)) and a northern saw-whet owl (*Aegolius acadicus* (Gmelin, 1789)). The common yellowthroat was captured on September 14, 2003, and the northern saw-whet owl was captured on November 11, 2004 at night. The slugs were sent for identification and deposited in the collection at the Section of Mollusks, Carnegie Museum of Natural History (CM).

## RESULTS

The two birds upon which the slugs were found were a common yellowthroat and a northern saw-whet owl. The slug on the common yellowthroat was *Deroceras reticulatum* (Müller, 1774) (CM 66603) and was found among the bird's body feathers. This slug was a juvenile, 7.4 mm long (in alcohol), and was identified as *D. reticulatum* by its paler tan color, reticulated markings, and presence of a pale pneumostome border (mucus color was not noted before preservation). The slug on the northern saw-whet owl was *Arion subfuscus* (Draparnaud, 1805) (CM103313), and it also was found among the bird's body feathers. This slug was also a juvenile, 10.4 mm long (in alcohol), and was identified as *A. subfuscus* by the pale sole and presence of 15 rows of tubercles between the lateral bands (mucus color was not noted before preservation). The common yellowthroat was high in the net when it was captured; the owl

<sup>1</sup> Current address: National Aviary, Allegheny Commons West, 700 Arch Street, Pittsburgh, PA 15212 USA

was in the lower shelf of the net and in contact with the ground.

## DISCUSSION

The presence of the slugs within the plumage of the birds suggests that these migrants might have been actively transporting the slugs when they were caught. We acknowledge the possibility that the slugs crawled onto the birds after they were trapped in the mist net; however, two factors suggest that this is unlikely. First, during R.M.'s 25+ years of mist-net banding at PNR, he has never observed a slug or snail on a mist net. Second, one of the birds, the common yellowthroat, was caught high in the net, about 1.5 m off the ground.

While both slug species were already known in the vicinity of PNR, the possibility of transport by migratory birds has implications for distribution and gene flow of slugs, as it has for other gastropods (Miura et al. 2011). The fact that this is the first report of slugs being found on living adult birds suggests that if dispersal by birds does occur, it is rare (or rarely documented). Kew (1893: 175), in a chapter on dispersal of slugs, speculated that slug dispersal by birds, if it occurred, would be rare, but did not cite any actual examples of such dispersal. However, given the wide ecological and migratory ranges of many bird species, even very occasional transport by birds could allow some slugs to spread over much greater distances than would otherwise be possible.

The ranges and habitats overlap for the slugs and the birds. In addition, both slug species ascend trees or vegetation during moist weather (Jennings and Barkham, 1975; pers. obs.), which might increase chances of an encounter with a bird. *Deroceras reticulatum*, originally native to Europe, is now introduced in most temperate and subtropical regions throughout the world (Roth and Sadeghian, 2003; Forsyth, 2004). It occurs in open and modified environments including agricultural land, roadsides, hedges, and grasslands, avoiding woodlands (Kerney and Cameron, 1979; Wiktor, 2000; Barker, 2002: 422; Forsyth, 2004). The common yellowthroat extends throughout North and Central America and it inhabits thick, tangled vegetation (particularly in wet areas) (Guzy and Ritchison, 1999; GBIF, 2011).

The ranges of *Arion subfuscus* and the northern saw-whet owl also overlap (Rasmussen et al., 2008; NatureServe, 2011), as do their habitats. *Arion subfuscus*, native to Europe where it mainly inhabits deciduous and coniferous forests and sometimes pastures (Wiktor, 1983), is introduced in northeast and northwest North America. Although it is not commonly associated with humans in most of Europe, in western Britain and in North America, in addition to occurring in deciduous and coniferous forests, it is frequently found in gardens and on roadsides near human settlements (Chichester and Getz, 1973; Kerney and Cameron, 1979; Kerney, 1999; Forsyth, 2004). Saw-whet owls are found in a variety of wood-

lands and forested habitats, with densities highest in coniferous forests, especially along riparian corridors (Johnson and Anderson, 2003; Rasmussen et al., 2008).

Because the geographical ranges and habitats of the slugs and birds overlap, the current distribution of these slugs in North America might be partially the result of bird dispersal. Dispersal of the slugs by birds might be especially relevant to their distribution given that they are not native to North America and have been present on the continent for relatively short periods of time (160–170 years (Pilsbry, 1948)).

Two other examples of interactions between slugs and birds, while not involving dispersal, indicate that contact occurs between birds and slugs, demonstrating the plausibility of slugs attaching to feathers of living birds. Livezey et al. (2008) reported a barred owl capturing and eating slugs. Biasioli (2009) suggested that an arionid slug, possibly *Arion subfuscus*, was eating a living nestling black-throated blue warbler while the female bird continued to attend to the nest. During these interactions, other slugs, had they been present, might have become entangled in the feathers of the birds.

The two slugs reported here were alive when they were discovered. However, it is unclear how long the slugs had been on the birds prior to their discovery. The increased humidity inside a bird's feathers, coupled with the ability of many slugs to survive significant desiccation (e.g., up to 50% of their body weight (Runham and Hunter, 1970: 72)), might allow slugs to survive on birds far longer than otherwise expected. On the other hand, birds might be expected to remove slugs through preening.

Relatively little is known about the distribution and transport of gastropods (especially slugs) by other animals. It is likely that transport by birds is infrequent, given the lack of any prior observations of slugs on living adult birds. For example, R.M. has banded hundreds of thousands of birds (including >2,500 common yellowthroats and >100 northern saw-whet owls). Each bird is examined for ectoparasites, as well as signs of active molt, but these are the first times slugs have been noticed. The presence of small slugs deep within the plumage of other birds handled at Powdermill, however, cannot be ruled out, because the examinations may not be detailed enough (especially on busy banding days) to detect slugs deep in the feathers or otherwise obscured (indeed, the soft, feather-covered blobs removed from the birds were not initially recognized as slugs until they started to move). It seems reasonable that species of bird such as the common yellowthroat and northern saw-whet owl, which forage (or attack prey) in dense, often damp vegetation on and near the ground, might come into direct contact with slugs that then become attached to the bird's plumage. Especially in the case of birds that are actively migrating, it is conceivable that the urge to migrate when conditions are favorable might supersede maintenance behavior activities, such as preening. We know that at least some of the northern saw-whet owls captured at Powdermill at night were, in fact, actively

migrating when they were netted (Powdermill Nature Reserve, 2007).

Range expansion via bird transport has been reported for snails (Wesselingh et al., 1999). Our observations of slugs on living adult birds suggest that this dispersal mechanism might also be important to the establishment and expansion of at least some slug populations, which, like many snails, are hermaphroditic and many can self-fertilize. Further investigation into the prevalence of slug transport by birds could be useful in predicting the possible spread of invasive slug species.

#### ACKNOWLEDGMENTS

We thank Bob Leberman at Powdermill for his role in establishing and overseeing the bird-banding program for more than 40 years, beginning in 1961, and also Marilyn Niedermeier at CM for her assistance in accessing Powdermill's computerized banding data. Comments from two anonymous reviewers improved the paper.

#### LITERATURE CITED

- Chichester, L.F. and L.L. Getz. 1973. The terrestrial slugs of northeastern North America. *Sterkiana* (51): 11–42.
- Biasioli, T.G. 2009. Depredation of black-throated blue warbler nestlings by an introduced slug (Arionidae). *Wilson Journal of Ornithology* 121: 422–423.
- Barker, G.M. 2002. Molluscs as Crop Pests. CABI Publishing, New York. i–xii+1–468 pp.
- Dundee, D.S., P.H. Phillips, and J.D. Newsom. 1967. Snails on migratory birds. *The Nautilus* 80: 89–91.
- Forsyth, R.G. 2004. Land Snails of British Columbia. Royal BC Museum, Victoria. 188 pp.
- GBIF (Global Biodiversity Information Facility). 2011. *Geothlypis trichas* (Linnaeus, 1766). <http://data.gbif.org/>. [accessed 13 November 2011].
- Guzy, M.J. and G. Ritchison. 1999. Common Yellowthroat (*Geothlypis trichas*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/448> [accessed 13 November 2011].
- Jennings, T.J. and J.P. Barkham. 1975. Food of slugs in mixed deciduous woodlands. *Oikos* 26: 211–221.
- Johnson, A.S. and S.H. Anderson. 2003. Conservation Assessment for the Northern Saw-whet Owl in the Black Hills National Forest, South Dakota and Wyoming. United States Department of Agriculture, Black Hills National Forest, Custer, South Dakota. 27p. [http://www.fs.usda.gov/Internet/FSE\\_DOCUMENTS/fsm9\\_012447.pdf](http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_012447.pdf) [accessed 13 November 2011].
- Johnston, D. 1992. Indiscriminate prey-capture in an opportunistic gleaner, the pallid bat *Antrozous pallidus*. *Bat Research News* 33: 60–61.
- Kerney, M.P. and R.A.D. Cameron. 1979. A field guide to the land snails of Britain and North-west Europe. Collins, London, 288 pp.
- Kerney, M. 1999. Atlas of the Land and Freshwater Molluscs of Britain and Ireland. Harley Books, Colchester. 261 pp.
- Kew, H.W. 1893. The dispersal of shells: an inquiry into the means of dispersal possessed by fresh-water and land Mollusca. Kegan Paul, Trench, Trübner and Co., Ltd., London, xiv + 291 pp.
- Kirchner, Ch., R. Krätzner, and F.W. Welter-Schultes. 1997. Flying snails – how far can *Truncatellina* (Pulmonata: Vertiginidae) be blown over the sea? *Journal of Molluscan Studies* 63: 479–487.
- Livezey, K.B., M.F. Elderkin, P.A. Cott, J. Hobbs, and J.P. Hudson. 2008. Barred owls eating worms and slugs: the advantage in not being picky eaters. *Northwestern Naturalist* 89: 185–190.
- McMillan, N.F. 1989. Cat carrying a slug. *Conchologist's Newsletter* (111): 245–246.
- Miura, O., M.E. Torchin, E. Bermingham, D.K. Jacobs, and R.F. Hechinger. 2011. Flying shells: historical dispersal of marine snails across Central America. *Proceedings of the Royal Society B*, published online 14 September 2011, doi: 10.1098/rspb.2011.1599.
- NatureServe. 2011. *Arion subfuscus*. <http://www.natureserve.org/explorer>. [accessed 13 November 2011].
- Pilsbry, H.A. 1948. Land Mollusca of North America (North of Mexico). Academy of Natural Sciences of Philadelphia, Monograph 3, volume II, part 2. i–xlvii, 521–1113.
- Powdermill Nature Reserve. 2007. Pictorial highlights, late fall 2007. <http://www.powdermillarc.org/highlights/2007/november.aspx> [accessed 13 November 2011].
- Purchon, R.D. 1977. *The Biology of the Mollusca*, 2nd edition. Pergamon Press, Oxford, xxv + 560 pp.
- Rasmussen, J.L., S.G. Sealy, and R.J. Cannings. 2008. Northern saw-whet owl (*Aegolius acadicus*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/042> [accessed 13 November 2011].
- Rees, W.J. 1965. The aerial dispersal of Mollusca. Presidential address. *Proceedings of the Malacological Society of London* 36: 269–282.
- Roth, B. and P.S. Sadeghian. 2003. Checklist of the land snails and slugs of California. Santa Barbara Museum of Natural History Contributions in Science 3: 1–81.
- Runham, N.W. and P.J. Hunter. 1970. Terrestrial slugs. Hutchinson University Library, London. 184 pp.
- Smith, B.J. and M. Djajasasmita. 1988. The land molluscs of the Krakatau Islands, Indonesia. *Philosophical Transactions of the Royal Society of London, Series B* 323: 379–400.
- Vagvolgyi, J. 1975. Body size, aerial dispersal, and origin of the Pacific land snail fauna. *Systematic Zoology* 24: 465–488.
- Wada, S., K. Kawakami, and S. Chiba. 2011. Snails can survive passage through a bird's digestive system. *Journal of Biogeography*. doi: 10.1111/j.1365-2699.2011.02559.x, 5 pp.
- Wesselingh, F.P., G.C. Cadée, and W. Renema. 1999. Flying high: on the airborne dispersal of aquatic organisms as illustrated by the distribution histories of the gastropod genera *Tryonia* and *Planorbarius*. *Geologie en Mijnbouw* 78: 165–174.
- Wiktor, A. 1983. The slugs of Bulgaria (Arionidae, Milacidae, Limacidae, Agriolimacidae – Gastropoda Stylommatophora). *Annales Zoologici* 37: 71–206.
- Wiktor, A. 2000. Agriolimacidae (Gastropoda: Pulmonata) – a systematic monograph. *Annales Zoologici* 49: 347–590.