

Two Introduced Pest Slugs: *Tandonia budapestensis* New to the Americas, and *Deroceras panormitanum* New to the Eastern USA

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Abstract. This paper reports new findings in North America of two pest slugs from Europe. *Tandonia budapestensis*, previously unknown from America, was found in Washington DC and near Philadelphia. *Deroceras panormitanum*, unreported from the Eastern United States and from Eastern North America outside of greenhouses, was found in Washington DC. We describe how to recognize these species and briefly summarize knowledge of their distribution and ecology.

INTRODUCTION

Since the classic monograph of Pilsbry (1939–1948), a number of papers have dealt further with introduced terrestrial mollusks in North America (e.g., Hanna, 1966; Chichester & Getz, 1969; Dundee, 1974, 1977; Rollo & Wellington, 1975; Roth & Pearce, 1984; Forsyth, 1999). However, in the last twenty years rather little has been published on this topic. This is surprising as the introduced species tend to dominate the malacofauna in disturbed habitats, and consequently are economically the most important pests. They are often also significant pests in their countries of origin (Godan, 1979, 1983). Without knowing the present distribution of an introduced species, or even if it is present in North America, the US Department of Agriculture's Animal and Plant Health Inspection Service's Plant Protection and Quarantine division (USDA APHIS PPQ) lacks the basis to determine whether a mollusk species intercepted on an imported commodity represents a potential novel agricultural or environmental threat.

In Europe the spread of some recent introductions has been followed in detail (e.g., De Wilde et al., 1986; von Proschwitz, 1996; Reise et al., 2000). In contrast, in North America the density of recording of terrestrial mollusks has been much lower. Consequently with novel records there must often be uncertainty about how long ago the introduction had occurred. Nevertheless such initial

reports are important in providing a baseline for later studies that follow up the subsequent survival and spread. Introductions of some species started long ago and have occurred repeatedly (e.g., *Arion subfuscus* (Draparnaud, 1805); Chichester & Getz, 1969; probably also *Arion silvaticus* Lohmander, 1937; Geenen et al., 2003). However, other species might well have been introduced only very recently, as seems very probable with *Boettgerilla pallens* Simroth, 1912, since it has spread from the Caucasus through Europe only within the last few decades (Reise et al., 2000). Species currently unknown in North America are frequently reported on incoming cargo (Robinson, 1999).

Species not yet reported for North America are liable to be overlooked because of the difficulties of identification when the North American literature does not deal with them. The problem is worse for slugs, because the lack of shell deprives them of many more obvious identification characters. For unfamiliar species often the clearest characters require dissection, which is always necessary for some species. To further complicate the matter, ongoing research among malacologists in Europe has shown that several of the Palearctic taxa actually represent complexes of closely related or superficially similar species: e.g., *Arion hortensis* Férussac, 1819 s.l. (Davies, 1979; Backeljau, 1987); *A. subfuscus* s.l. (Pinceel et al., 2004); *Arion fasciatus* (Nilsson, 1823) s.l. (Backeljau

et al., 1987; but see Jordaens et al., 2000). More anatomical evidence, perhaps coupled with molecular data, needs to be used to determine which members of these species complexes are present on the North American continent.

This paper reports occurrences that considerably extend the range of two pest slugs from Europe: *Tandonia budapestensis* (Hazay, 1881), previously unreported from America, and *Deroceras panormitanum* (Lessona & Polonera, 1882), unreported from the Eastern United States and from Eastern North America outside of greenhouses. Because of its greater novelty, we give more details on identification and ecology of *T. budapestensis* than of *D. panormitanum*.

COLLECTION DETAILS

H.R. and J.M.C.H. found three juvenile specimens of *T. budapestensis* on 28 July 1998 along Rock Creek in Washington DC (38°54.48'N, 77°03.24'W). The habitat was broad-leaved woodland along the slope above the creek, without much ground flora, but with garbage and flood debris. The specimens were raised in the laboratory for differing periods and then dissected to confirm identification. Two specimens are stored in the collection of the State Museum of Natural History Görlitz, Germany (p13048 and p13049).

Two adult specimens of *T. budapestensis* were collected on 29 May 1999 by Richard Horowitz (of the Academy of Natural Sciences, Philadelphia) from under a decaying log in Carroll Park, north bank of Cobbs Creek, south of Old Manor Road, Havertown, a suburban parkland area in Delaware County, just west of Philadelphia, Pennsylvania (39°58.78'N, 75°16.95'W). One specimen has been deposited in the collection of the Academy of Natural Sciences, Philadelphia (ANSP A 19999), the other in the USDA National Mollusk Collection (USDA 10294). In addition to the anatomical evidence, the identity of the latter specimen was confirmed by matching DNA sequencing data from conspecific specimens from the United Kingdom and Belgium, by Douglas Prasher of the USDA APHIS PPQ Center for Plant Health, Science and Technology.

H.R. and J.M.C.H. found two specimens of *D. panormitanum* on 29 July 1998 outside the National Museum of Natural History on Constitution Avenue, Washington DC (38°53.50'N, 77°01.57'W). They were collected in litter under rhododendron bushes, surrounded by a sparse lawn; this was shaded by the museum building, and periodically watered. Determination was based on genital anatomy. They are stored in the State Museum of Natural History Görlitz, Germany (p13050).

TANDONIA BUDAPESTENSIS

Taxonomy and Appearance

Tandonia budapestensis (the Budapest slug) is a member of the Milacidae, a family of less than 50 species,

with a center of distribution in the Balkans (Wiktor, 1981). Until Wiktor's taxonomic review of 1981, *T. budapestensis* was usually included in the other genus of the family, *Milax*. *Milax gracilis* (Leydig, 1876) is a synonym. In Britain it was not distinguished from *Tandonia sowerbyi* (Férussac, 1823) until Phillips & Watson's paper of 1930.

Like other milacids, *T. budapestensis* has a prominent keel running from the tail to the rear of the mantle, the pneumostome is at the rear half of the mantle, and a horseshoe-shaped groove runs around the central part of the mantle. *T. sowerbyi*, *Milax gagates* (Draparnaud, 1801), and *Milax nigricans* (Philippi, 1836) are the other widespread synanthropic Milacidae in Western Europe (and *M. gagates* is known from North America), but *T. budapestensis* is slenderer and when resting often curls round into a C shape (Figure 1a), whereas these others hunch up into a bilaterally symmetrical dome (Kerney & Cameron, 1979). *Boettgerilla pallens* is another species known from North America with a long keel, but it is much paler, smaller, and wormlike (Reise et al., 2000). In color *T. budapestensis* is somewhat polymorphic, but usually of a dark dirty appearance due to dense dark speckling on a dull cream or orange background (Figure 1b); the keel stands out owing to its lighter olive or dull orange color. However, in alcohol it is only the black pigment that remains prominent. The length when crawling is 50–70 mm. For other characters, including anatomy, see Phillips & Watson (1930), Wiktor (1987) and Barker (1999).

Ecology and Distribution

The original range of this European species is probably the southern Alps and northern Balkans (Wiktor, 1987). However, it is now known from Turkey to northernmost Great Britain and Iceland, and in much of this range is clearly a still-spreading introduction, as it is in New Zealand (Waldén, 1966; Wiktor, 1987; Barker, 1999; Kerney, 1999). Waldén's collection from Iceland was not restricted to greenhouses (*contra* Kerney & Cameron, 1979; T. von Proschwitz, personal communication). Previous reports from America seem unreliable. Godan (1979:63) refers to occurrences in America, Hawaii and Australia, but this must have been a misprint (these localities are listed for *M. gagates* earlier in the book; we can find no such records for *T. budapestensis* before or since). She elsewhere refers to interceptions of *T. budapestensis* on shipments to the USA based on the "Lists of intercepted plant pests" of the "Plant Protection and Quarantine Programs, Animal and Plant Health Inspection Service, US Department of Agriculture." These lists record incidents of pests being discovered, at which point the plants would be fumigated, incinerated or returned to the country of origin, so they are not cases of introductions. Moreover, D.G.R.'s redetermination of a sample of such records of a variety

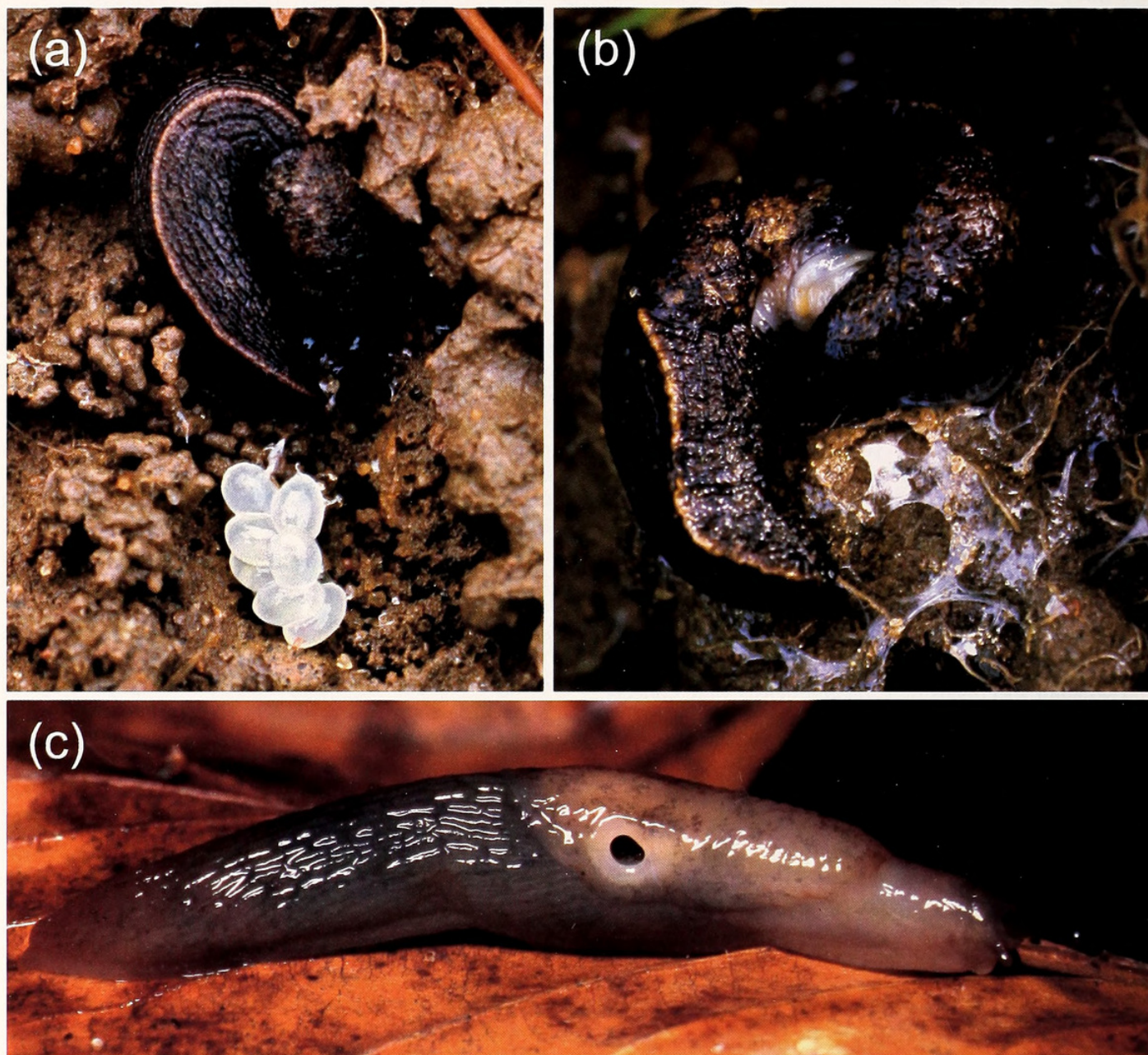


Figure 1. (a) *Tandonia budapestensis* in its typical C-shape resting position within a soil cavity that was topped by a board. The eggs could well be from this specimen. (b) A pair of mating *T. budapestensis*, as the species is commonly encountered because of its prolonged copulation (typically from evening to midday: Quick, 1960). Both pictures from Nork Park allotments, Banstead, Surrey, England. (c) *Deroceras panormitanum*, from England.

of species has shown that the lists prior to 1993 are frequently based on faulty identification. Based on later records, Robinson (1999) reported *T. budapestensis* as occurring in <0.1% of interceptions, but this was based on a single juvenile specimen tentatively identified as this species, whereas other intercepted *Tandonia* from the same country of origin have all been *T. sowerbyi*. Thus, despite the enormous volumes of imported commodities from Europe over the years, *T. budapestensis* has not been definitively identified among the many slug specimens intercepted by the USDA.

Tandonia budapestensis is the commonest milacid in Britain, where its habitat includes gardens, ploughed fields, waste ground and woods that have been subject to some disturbance (Kerney, 1999). In Central Europe it has been observed to be associated with lowland plains rather than hilly areas (Dvořák et al., 2003). It occurs amongst litter, and is often easiest to find under wood and stones, but it also burrows up to 37 cm underground (Stephenson, 1966) and over summer the entire population in potato fields can temporarily disappear deeper than 15 cm (Wareing & Bailey, 1989). In Western Europe it can be

a serious pest on arable land, particularly of potatoes and other root crops, and some ornamental flowers (Van den Bruel & Moens, 1958; Godan, 1979, 1983; South, 1992), and in captivity at least it also eats grain seeds and seedlings (Duthoit, 1964). Its underground habits make it less susceptible to control both by poison bait and cultivation (Symondson, 1997), but it is not so consistently a problem as some other slug pests (South, 1992).

In England the eggs hatch in spring and summer. The rate of development of both eggs and young is strongly dependent on temperature, being very slow at 5°C (Hunter, 1966a; Stephenson, 1966). Adults mature and mate in late autumn and winter, but this is usually their second winter, and they die off by August (Bett, 1960; Hunter, 1966a). However, in the more continental climate of the Czech Republic and Slovakia, mating slugs are found mostly in summer (Hudec, 1963).

For other aspects of its biology see Hunter (1966b) and literature cited in South (1992) and Symondson (1997).

DEROCERAS PANORMITANUM

This species has formerly been referred to as *D. caruanae* (Pollonera, 1991), which is now generally considered as a synonym (Wiktor, 2000). It is believed to originate from the Mediterranean, where there are several similar forms whose taxonomic status is still controversial (Wiktor, 2000).

In appearance it has a watery thin transparent skin (Figure 1c). Individuals vary from light grayish brown to chocolate brown, to almost black, and this is fairly uniform over the body; the fine dark spotting usually present is only obvious under magnification. In North America it is most readily confused with *Deroceras laeve* (O. F. Müller, 1774), some morphs of which resemble *D. panormitanum* much more closely, especially in size, than do specimens from Europe. In fact at the same site in Washington DC where we collected the two *D. panormitanum* we collected 12 other specimens which we considered to be conspecific, but which upon dissection turned out to be aphyallic or hemiphallic and thus were presumably *D. laeve*. Barker (1999) gives the pale rim to the pneumostome of *D. panormitanum* as a character distinguishing these species, but our examination of European and North American material has shown that it is sometimes not pale in *D. panormitanum* and it is often pale in *D. laeve*. A considerably more reliable character, although not clear in all specimens, is the shape of the tail (de Winter, 1988): seen in profile, the tail of *D. panormitanum* rises up from the sole vertically, or even curves backwards, whereas in *D. laeve* it slopes forward. The difference may exist because in *D. panormitanum* a flattening and enlargement of the tail accompanies its use in courtship (H.R., personal observation; Barker, 1999), but the character is still visible in non-courting individuals, especially if gently irritated. The difference is also usually apparent in alco-

hol-preserved specimens. In Europe there are other externally very similar species such as *Deroceras sturanyi* (Simroth, 1894).

Deroceras panormitanum has colonized large areas of Europe away from the Mediterranean and is still spreading (e.g., only recently reported for Poland (Wiktor, 2001)). It occurs mainly in disturbed sites but in Britain, for instance, is also found in wilder habitats such as woods and sea cliffs (Kerney & Cameron, 1979; Kerney, 1999). In Fennoscandia it occurs only in greenhouses (Waldén, 1966; von Proschwitz, 1993). It has also been introduced to the Canary Islands, South Africa, Colombia, Australia, New Zealand, Tristan da Cunha and even Marion Island 47°S (Smith, 1992; Barker, 1999; Preece, 2001; Hausdorf, 2002). The first report in North America is from California where it was already widespread in the Bay Area by 1940 (Pilsbry, 1939–1948). The next report was from two greenhouses in Quebec (Chichester & Getz, 1969), and it is now widespread in synanthropic habitats in the Pacific Northwest, both in the USA and Canada (Rollo & Wellington, 1975; H.R. & J.M.C.H., personal observation). But we know of no outdoor records from the East, nor any records from the Eastern United States. This is surprising as the USDA regularly intercepts the species on a wide variety of commodities, particularly on cut flowers and fresh fruits and vegetables from Colombia, Panamá, the Netherlands, and New Zealand (D.G.R., personal observation). Earlier records of interceptions into the USA cited by Godan (1979, 1983) and Dundee (1974) suffer from the same unreliability of the USDA lists as discussed above for *T. budapestensis*.

Deroceras panormitanum can be important as a pest in pastures, nurseries, greenhouses, gardens and commercial crops such as asparagus and lettuce (Castillejo et al., 1996; Barker, 1999), but seems not to be mentioned as a significant pest of cereals or root crops. In a 1988 survey of 372 gardens in Manchester, England, it was found in 258 of them, more than any other slug (North & Bailey, 1989).

It may be helpful to note that Quick (1960) rightly questioned Gregg's (1944) interpretation of the life cycle of *D. panormitanum* in California: probably the study population was mixed with *D. laeve*.

CONCLUSION

As mentioned above, the sparse recording of introduced slugs in North America makes it likely that *T. budapestensis* and *D. panormitanum* are already more widely distributed there than these three new records indicate. In an effort to collect slug data from throughout the United States and Canada, and map the distributions of all introduced species, the USDA APHIS PPQ initiated in 1998 the North American Slug Project (NASP), encouraging any interested malacological workers to collect and submit slug specimens for identification. Most submitted

slugs have been dissected to confirm identity, and samples have been DNA sequenced to add to the national database. A number of individual State Departments of Agriculture have also participated in NASP over the last five years, and slug surveys have been conducted in a number of states under the Cooperative Agriculture Pest Survey (CAPS) program, producing vast amounts of data that is still being collated and analyzed. Although our understanding of the distribution of a large number of Palearctic species is now far better than before, NASP has not turned up additional records of *T. budapestensis* or *D. panormitanum* other than the latter from regions where it was already known.

However, since the original submission of this manuscript, one of us (J.M.C.H.) spent one week in summer 2004 surveying synanthropic habitats in the Denver region of Colorado. *D. panormitanum* was widespread and common in garden centers, often together with externally very similar *D. laeve*, but it also turned up in a park-like habitat along the unkempt grassy bank of a drainage ditch. This confirms our suspicion that it might occur more widely east of the Rocky Mountains.

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