The Coleopterists Bulletin, 60(01):37–41. 2006.

Deep Interstitial Habitat as a Refuge for *Agabus paludosus* (Fabricius) (Coleoptera: Dytiscidae) During Summer Droughts

Stefano Fenoglio, Tiziano Bo
Department of Environment and Life Sciences
University of Piemonte Orientale, Via Bellini 25
I-15100 Alessandria, ITALY
fenoglio@unipmn.it

AND

G. Bosi
Department of Veterinary Science and Technologies for Food Safety
University of Milan, Via Trentacosta 2
I-20134 Milan, ITALY

Abstract

We report information about the presence of *Agabus* (*Gaurodytes*) *paludosus* (Fabricius, 1801) within the interstitial zone of the streambed of the Po River (NW Italy) during droughts. During August and November 2004, we found adult and larval stages at depths of 70–90 cm below the surface when no water was present in the channel. These findings are discussed in the context of the origin of stygobiont diving beetles.

During the past, the assumption has been made that, generally, aquatic insects do not penetrate much below the stream substratum (Shiosawa and Barnes 1977; Resh and Rosemberg 1984). Recently, some studies have demonstrated that the interstitial zone may act as a refuge for benthic macroinvertebrates, increasing both resistance and resilience of stream communities (Palmer *et al*. 1992; Giller and Malmqvist 1998; Gayraud and Philippe 2003). Moreover, other studies underlined that in unfavorable hydrological conditions stream insects move into deep interstitial zones, escaping from droughts (Cooling and Boulton 1993) or floods (Matthaei *et al*. 1999), especially in gravel-bed habitats.

Droughts have strong effects on density and structure of benthic insect communities and aquatic insects have evolved different mechanisms to survive this particular hydrological condition. Several insect taxa living in intermittent streams have eggs (Boulton 1989) or juvenile stages (Miller and Golladay 1996) that can survive drying, while other taxa escape drought by behavioral mechanisms, mainly habitat selection. In this context, many organisms colonize the interstitial (also called hyporheic) zone, including Plecoptera: Leuctridae and Capniidae (Hynes 1979), Diptera: Chironomidae and other taxa (Boulton 1989).

Agabus (*Gaurodytes*) *paludosus* (Fabricius, 1801) is a central European species that is widely distributed in Italy (Franciscolo 1979; Angelini 1993). The species is subrheophilous, inhabiting low flowing waters, often with dense vegetation (Friday 1988). In Italy *A. paludosus* was found in springs (Gianelli and Osella 1987; Pantini 1993) as well as in alpine marshes (Schizzerotto 1986; Pederzani 1988). Recently, Homes *et al*. (1999) demonstrated that *A. paludosus* prefers gravel bed habitats.

In this paper, we report our observation about the presence of *A. paludosus* in the depths of the riverbed during a protracted drought.

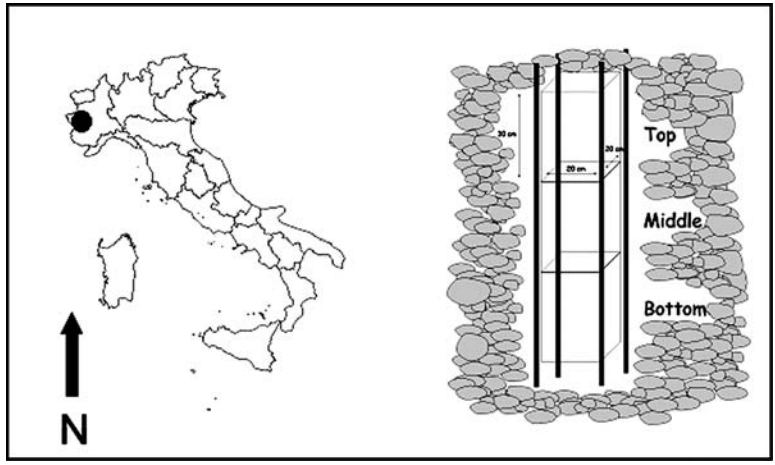

Fig. 1. Po River, NW Italy; circle indicates the sample site (left). The hyporheic trap used to sample interstitial invertebrates (right).

Materials and Methods

This study was conducted in the subalpine reach of the river Po. The Po river in this area is a hyporithral environment, with coarse substratum, an average depth of 50 cm and a streambed width of 10–14 m. No aquatic vegetation is present in this area. This area belongs to the Parco del Po Cuneese (near Saluzzo, CN) and it is characterised by high streambed permeability and summer droughts. The length of the droughts increase along a longitudinal gradient, from Sanfront (water in the streambed for 12 months/year) to Saluzzo (water in the streambed for 2–3 months/year). To investigate the presence and the colonization process of stream macroinvertebrates in the sub-substratum, we constructed and positioned 12 hyporheic traps in the streambed. Each trap consisted in an outer structure containing three inside bags (Fig. 1). The structures were buried in the streambed in June 2004 with a Kubota mini excavator and remain in place to date. The inside bags were filled with clean sterile substrate, similar to the streambed composition, and placed at different depths: the top bag was positioned from 0 to 30 cm, the medium one from 30 to 60 cm and the bottom one from 60 to 90 cm.

On two dates during the 2004 drought (August 17 and November 26) we removed four traps near Martiniana Po. In August, the water level was below our traps (*i.e.,* below 90 cm) and in November moisture was observed in the deepest zone of the traps (*i.e.,* below 50 cm). After extracting the bags, we placed the substratum in large bowls filled with clean water and carefully removed all living invertebrates, placing them in alcohol (70%).

Results and Discussion

Different aquatic taxa were found in the traps (Fenoglio *et al*. 2004), mainly Diptera: Chironomidae, Plecoptera: *Leuctra* sp., Ephemeroptera: *Baetis* sp., Oligochaeta: Lumbricidae and Lumbriculidae. Interestingly, we also found ten *A. paludosus* specimens in the first removal date and three (two adults and one III instar larva) in the

second one. Diving beetles were always found at depths of 70–90 cm below the surface. When beetles were placed in the bowl containing water, they seemed to be numb, with reduced swimming ability and stunned movements.

No other Dytiscidae species were found in the traps, even though *Oreodytes rivalis* (Gyllh, 1827) and *Potamonectes griseostriatus* (De Geer, 1774) were found in the stream before the drought. *Agabus paludosus* is a common species in this area, locally abundant in the stream banks. We hypothesize that *A. paludosus* enter the sub-substratum to escape unfavorable hydrological conditions, remaining confined to the interstitial zone until water reappears. We believe that both larval and adult stages utilize this area as refuge.

Stygobiont Dytiscidae are well known, living exclusively in groundwater (Castro and Delgado 2001; Leys *et al*. 2003). Most belong to the subfamily Hydroporinae (Spangler 1986; Bilton and Fery 1996; Alarie and Wewalka 2001). Recently, Balke *et al*. (2004) found a member of Copelatinae, *Copelatus abditus*, from a 4 m deep bore in central Australia. The adaptation of organisms to groundwater environments has been the subject of many hypotheses (Sbordoni *et al*. 2001). A generally accepted theory (Peck and Finston 1993) states that an epigean species preadapted to underground life (*e.g.,* living under stones in a stream or utilizing interstitial areas during droughts) may survive and adapt to cave or groundwater life when the surface environment becomes unsuitable due to a drastic climate change (*e.g.,* glaciation or aridification). True stygobionts are morphologically highly modified for life in groundwater (Balke *et al*. 2004). Depigmentation, reduction or absence of eyes, and reduced size are among the most frequent adaptations. Also, if *Agabus paludosus* shows no peculiar adaptations to the groundwater environments and no species of Agabinae are known to be stygobionts, we could suppose that a general ability to enter interstitial habitats of riverbeds may be present in many dytiscid subfamilies. In some of these subfamilies (*e.g.,* Hydroporinae and Copelatinae) this ecological plasticity may have evolved into a truly stygobiontic life in some species, and we hypothesize that the use of interstitial/hyporheic zone could be a first step in the invasion of groundwater aquifers.

Our preliminary results also suggest that the interstitial zone represents an important refuge for stream macrobenthos, although it may not be used by all taxa.

Acknowledgments

This work was supported by Parco del Po Cuneese grants. Two anonymous reviewers improved this manuscript.

Literature Cited

Angelini, F. 1993. Coleoptera Adephaga 2 (“Hydroadephaga”) [pp. 1–16]. *In:* Checklist delle specie della fauna italiana, 45 (A. Minelli, S. Ruffo and S. La Posta editors). Calderini, Bologna.

Alarie, Y., and G. Wewalka. 2001. Description of the mature larva of *Glareadessus stocki* Wewalka & Bistrom (Coleoptera: Dytiscidae), a stygobiontic bidessini from the Persian Gulf Region. The Coleopterist Bulletin 55(2):144–151.

Balke, M., C. H. S. Watts, S. J. B. Cooper, W. F. Humphreys, and A. P. Vogler. 2004. A highly modified stygobiont diving beetle of the genus *Copelatus* (Coleoptera, Dytiscidae): taxonomy and cladistic analysis based on mitochondrial DNA sequences. Systematic Entomology 29:59–67.

Bilton, D. T., and H. Fery. 1996. Revisional notes on *Rhithrodytes* Bameul, 1989, with the description of a new subspecies and the introduction of *Rhythrodytes dorsoplagiatus* (Fairmaire) as a valid species (Coleoptera, Dytiscidae). Linzer Biologie Beiträge 28(2): 917–931.

Boulton, A. J. 1989. Over-summering refuges of aquatic macroinvertebrates in two intermittent streams in central Victoria. Transactions of the Royal Society of South Australia 113:23–34.

Castro, A., and J. A. Delgado. 2001. *Iberoporus cermenius*, a new genus and species of subterranean water beetle (Coleoptera: Dytiscidae) from Spain. Aquatic Insects 23(1): 33–43.

Cooling, M. P., and A. J. Boulton. 1993. Aspects of the hyporheic zone below the terminus of a South Australian arid-zone stream. Australian journal of marine and freshwater research 44:411–426.

Fenoglio, S., T. Bo, M. Cucco, and G. Malacarne. 2004. Hyporheic zone as refugium for the macroinvertebrate fauna in the Po river (NW Italy): first data. Abstract book Symposium on World Subterranean Biodiversity - SWSB, Lyon Villeurbanne (France) 7–10 December 04, p. 58.

Franciscolo, M. E. 1979. Fauna d'Italia, Vol. XIV Coleoptera Haliplidae, Hygrobiidae, Gyrinidae, Dytiscidae. Ed. Calderoni, Bologna. 804 pp.

Friday, L. E. 1988. A key to the adults of British water beetles. Field Studies 7. Dorset Press, Dorchester. 151 pp.

Gayraud, S., and M. Philippe. 2003. Influence of bed-sediment features on the interstitial habitat available for macroinvertebrates in 15 French streams. International Review of Hydrobiology 88:77–93.

Gianelli, L., and G. Osella. 1986. La fauna macrobentonica del Fiume Fibbio (Regione Veronese). Bollettino del Museo civico di Storia Naturale di Verona 13:495–528.

Giller, P. S., and B. Malmqvist. 1998. The biology of streams and rivers. Oxford University Press. 296 pp.

Hynes, H. B. N. 1979. The ecology of running waters. Downsview, Ontario. 555 pp.

Homes, V., D. Hering, and M. Reich. 1999. The distribution and macrofauna of ponds in stretches of an alpine floodplain differently impacted by hydrological engineering. Regulated Rivers Management Research 15:405–417.

Leys, R., C. Watts, S. Cooper, and W. F. Humphreys. 2003. Evolution of subterranean diving beetles (Coleoptera Dytiscidae: Hydroporini, Bidessini) in the arid zone of Australia. Evolution 57:2819–2834.

Matthaei, C. D., K. A. Peacock, and C. R. Townsend. 1999. Scour and fill patterns in a New Zealand stream and potential implications for invertebrate refugia. Freshwater Biology 42:41–57.

Miller, A. M., and S. W. Golladay. 1996. Effects of spates and drying on macroinvertebrate assemblages of an intermittent and a perennial prairie stream. Journal of the North American Benthological Society 15:670–689.

Palmer, M. A., A. E. Bely, and K. E. Berg. 1992. Response of invertebrates to lotic disturbance: a test of the hyporheic refuge Hypothesis. Oecologia 89:182–194.

Pantini, P. 1993. I coleotteri idroadefagi dei fontanili Lombardi. Rivista del Museo civico di Scienze Naturali "E. Caffi" di Bergamo 16:231–254.

Peck, S. B., and T. L. Finston. 1993. Galapagos islands troglobites: the question of tropical troglobites, parapatric distributions with eyed-sister-species, and their origin by parapatric speciation. Mémorias Biospéologicas 20:19–37.

Pederzani, F. 1988. Contributo alla conoscenza degli Idroadefagi (Coleoptera: Haliplidae, Dytiscidae) della Valle di Fiemme, in Provincia di Trento. Studi Trentini di Scienze Naturali 64:251–264.

Resh, V. H., and D. Rosemberg. 1984. The ecology of aquatic insects. Praeger Publ., New York. 625 pp.

Sbordoni, V., G. Allegrucci and D. Cesaroni. 2001. Population genetic structure, speciation and evolutionary rates in cave-dwelling organisms [pp. 453–477]. *In:* Ecosystems of the world, Volume 30. Subterranean ecosystems (H. Wilkens, D. Culver and W. F. Humphreys, editors). Elsevier Publ., Amsterdam.

Schizzerotto, A. 1986. Gli Idroadefagi della Torbiera di Vigalzano (Trento). Studi trentini di Scienze Naturali 62:79–85.

Shiosawa, D. K., and J. R. Barnes. 1977. The microdistribution and population trends of larval *Tanypus stellatus* Coquillet and *Chironomus frommeri* Atchley and Martin (Diptera: Chironomidae) in Utah lake. Ecology 58:610–618.

Spangler, P. J. 1986. Insecta: Coleoptera [pp. 622–631]. *In:* Stygofauna mundi. A faunistic, distributional and ecological synthesis of the world fauna inhabiting subterranean waters (L. Botosaneanu, editor). Brill and Backhuys Publishers, Leyden.

(Received 16 May 2005; accepted 11 December 2005. Publication date 30 March 2006.)

The Coleopterists Bulletin, 60(1):41–42. 2006.

SCIENTIFIC NOTE

Stenopelmus rufinasus Gyllenhal 1836 (Coleoptera: Erirhinidae) Naturalized in Spain

Stenopelmus rufinasus Gyllenhal 1836 (Coleoptera: Erirhinidae) has been reported in Europe from Belgium, England, France, Germany, Holland and Italy (Caldara 2004). We recently detected the presence of this species in Spain, within the vicinity of the Parque Nacional de Doñana, Sanlúcar de Barrameda, Bonanza (coordinates 29SQA4078 and 29SQA4077, calculated by the Universal Transversal Mercator System). In May 2003 the weevil was found on mats of the invasive North American water fern *Azolla filiculoides* Lamarck, its main food source. The water fern is spreading into a great number of hot summer wetlands in Spain and Portugal where it is causing ecological problems to the native fauna and flora (Sanz-Elorza *et al*. 2004). Problems are caused by its floating habit and fast growth which enables it to out compete species for light, it can also lead to a reduction in water quality as a result of oxygen depletion. This is the second record of this weevil species in Spain, and is almost concurrent with its discovery by Fernández-Carrillo *et al*. (2005) in a continental area, 235 kms North of our locality. Since the species is host-specific (feeding exclusively on *Azolla* species) it is considered to be a suitable biological control agent and has already proved effective in controlling populations of *A. filiculoides* in England, Reeder and Shaw (in prep.) and S Africa, Hill (1998*a*, 1998*b*); Hill and Cilliers (1999). Currently there is no effective, non-impact method of controlling *Azolla spp*. in Spain. While direct measures to reduce nutrient inputs into wetlands are initiated, the discovery of *S. rufinasus* suggests the possibility of managing populations of the weevil in order to reduce the ecological impact of *A. filiculoides* and offers, the only feasible, long-term solution for the affected wet lands.

It seems reasonable to assume that the current distribution of the species in the Iberian Peninsula could be broader than actually believed. Explorations for other populations and their relationships with local predators are urgently needed.

Acknowledgments

We are grateful for the assistance of Djami Djeddour, Robert Reeder and Richard Shaw (CABI Bioscience, UK) for their help with specimens identification. Thanks are also due to Dr. Alonso-Zarazaga (CSIC, Madrid) for comments and data on the species.

Literature Cited

Caldara, R. 2004. Fauna Europaea: Erirhinidae. *In:* Fauna Europaea: Coleoptera 1 (M. A. Alonso Zarazaga, editor) (2004). Fauna Europaea version 1.1, http://www.faunaeur.org (accessed 2nd June 2005).

Dana, E. D., M. Sanz-Elorza, S. Vivas, and E. Sobrino. 2005. Atlas de Especies Invasoras en Espacios Naturales Protegidos Andaluces. Consejería de Medio Ambiente. Junta de Andalucía. Sevilla.

Fernández Carrillo, J. L., E. Fernández Carrillo, and M. A. Alonso-Zarazaga. 2005. Primera cita de *Stenopelmus rufinasus* Gyllenhal, 1835 en la Península Ibérica (Coleoptera, Erirhinidae). Graellsia 61(1):139–140.

Hill, M. P. 1998*a*. Herbivorous insect fauna associated with *Azolla* species (Pteridophyta: Azollaceae) in Southern Africa. African Entomology 6:370–372.

Hill, M. P. 1998*b*. Life history and laboratory host range of *Stenopelmus rufinasus* Gyllenhal (Coleoptera: Curculionidae), a natural enemy for Azolla filiculoides in South Africa. Biocontrol 43:215–224.

Hill, M. P., and C. J. Cilliers. 1999. *Azolla filiculoides* Lamarck (Pteridophyta: Azollaceae), its status in South Africa and control. Hydrobiologia 415:203–206.

Reeder, R. H., and R. H. Shaw. 2005. Inundative biocontrol of *Azolla filiculoides* using a specialist weevil. EMAPI 8 Conference, University of Silesia, Katowice, Poland (in prep).

Sanz-Elorza, M., E. D. Dana, and E. Sobrino. 2004. Atlas de Especies Invasoras en España. Dirección General de Conservación de la Biodiversidad. Ministerio de Medio Ambiente. Madrid.

Elías D. Dana, and S. Viva, *Dpto. Biología Vegetal & Ecología, Universidad de Almería, Almería E-04120, SPAIN. edana@ual.es and edana@tragsa.es*

(Received 14 September 2005; accepted 30 December 2005. Publication date 30 March 2006.)

The Coleopterists Bulletin, 60(1):42. 2006.

SCIENTIFIC NOTE

Association of Viticiini (Coleoptera: Curculionidae: Cyclominae) with *Ficus* (Moraceae)

Viticiini are curious weevils in that they look like broad-nosed weevils, particularly members of the Ottistirini, but they possess the mouthpart and leg structure of long-nosed weevils. Based on this peculiarity, Morimoto (1983) distinguished Viticiini as a distinct subfamily and placed it as belonging to the long-nosed weevils. Recently, Alonso-Zarazaga and Lyal (1999) classified Viticiini as a tribe of Cyclominae, however, this is at best a temporary treatment since the Cyclominae presently are rather heterogeneous and incompletely defined.

Viticiini contains only the genera *Viticis* Lea and *Tivicis* Morimoto. *Viticis* occurs widely in the Pacific islands and *Tivicis* are restricted in the Ryukyu Islands of Southwest Japan. Species of Viticiini are rare and no biological information is available except for a single record of *V. marquesanus* Zimmerman on *Ficus proxila?* (Zimmerman 1963).

Recently, I noticed that two *Tivicis* species are rarely but consistently beaten from species of *Ficus* L. Subsequent canopy insect surveys using insecticide fogging obtained a number of *Tivicis* adults from several species of fig trees: *Ficus microcarpa* L., *F. superba* Miq. and *F. variegata* Blume. These results suggest that *Ficus* is a likely host plant of *Tivicis* species as well as a good place to look for details on the biology of these odd weevils.

Specimens Examined. Japan: Ryukyus, Iriomote-jima I. 6♂5♀ (*Tivicis aeratus*), Ôtomi, 1. I. 2005 (fogged a portion of lower branches of *Ficus microcarpa*). 1♀ (*T. maculatus*) & 7♂3♀ (*T. aeratus*), Uehara, 30. XII. 2004 (fogged a entire tree of *F. superba*, 10 m in height). 2♀ (*T. maculatus*) & 7♂12♀ (*T. aeratus*), Shirahama, 2. I. 2005 (fogged an entire tree of *F. variegata*, 8 m in height). 2♂1♀ (*T. maculatus*), Uehara, 24–26. XII. 2004 (beaten from several trees of *F. septica* one by one; as one of collecting by usual method other than fogging).

The rarity of Viticiini encountered in the field by usual collecting methods such as sweeping and beating is possibly due to the tarsal structure of Viticiini in which the 3rd tarsal segment is relatively broad and the claw segment is small (*Tivicis*) or lacking (*Viticis*). Such a structure may make it possible for the beetles to cling tightly to leaves and difficult to dislodge.

The author thanks Dr. K. Morimoto for his guidance, and Dr. M. Kinjô, J. Kantô and T. Fukuzawa for their help with fieldwork. This study is supported by the KAKENHI (16770067).

Literature Cited

Alonso-Zarazaga, M. A., and C. H. C. Lyal. 1999. A world catalogue of families and genera of Curculionoidea (Insecta: Coleoptera) (Excepting Scolytidae and Platypodidae). Entomopraxis, Barcelona. 315 pp.

Morimoto, K. 1983. The family Curculionidae of Japan. II. Viticiinae, subfam. nov. Esakia 20: 55–62.

Zimmerman, E. C. 1963. Marquesas island *Viticis* (Coleoptera: Curculionidae, Brachyderinae). Pacific insects 5:899–903.

Hiroaki Kojima, *The Kyushu University Museum, Kyushu University, Fukuoka, 812-8581, JAPAN. kojima@museum.kyushu-.ac.jp*

(Received 28 February 2005; accepted 11 December 2005. Publication date 30 March 2006.)