



<http://dx.doi.org/10.11646/zootaxa.3926.4.1>

<http://zoobank.org/urn:lsid:zoobank.org:pub:606759D3-6242-4DC0-9A20-201E2E665F2C>

## The rectal valve in Curculionoidea (Insecta: Coleoptera)

CHRISTOPHER H. C. LYAL & EMELINE A. FAVREAU

*Department of Life Sciences, Natural History Museum, Cromwell Road, London SW7 5BD. E-mail: c.lyal@nhm.ac.uk*

### Abstract

A rectal valve is known from Bostrichiformia (e.g. Dermestidae, Bostrichidae, Ptinidae), Cucujiformia (e.g. Chrysomeloidea, Cleridae, Curculionoidea, Endomychidae, Tenebrionidae) and Buprestidae, associated with the cryptonephridial system for water recovery from fecal matter. The valve is probably homologous in at least the Bostrichiformia and Cucujiformia although the form it takes may not be. It comprises a sclerotized band lying in the wall of the rectum where this meets the perinephric membrane. The valve is plesiomorphically a narrow crimped ring, probably acting as a sphincter to retain fecal matter for water extraction. Apomorphically it extends longitudinally along the rectum and supports the perinephric chamber; this state has probably arisen independently several times. Larval and adult morphology may be similar or different. Within the Curculionoidea different apomorphic forms suggest monophyly of groups within the Anthribidae and Dryophthoridae, and within the curculionid subfamilies Entiminae, Mesoptiliinae, Molytinae and Cossoninae + Scolytinae, although limited weight should be placed on a single character. No support is provided for a relationship between the Platypodinae and Scolytinae. The genera *Cylindrotypetes* Zimmerman 1942 and *Edaphotrypetes* Morimoto 1995 are transferred from Molytinae: Phoenicobatini to Cossoninae: Pentrarthini.

**Key words:** Curculionoidea, Coleoptera, rectal valve, rectal loop, rectal ring, cryptonephridial system, morphology, phylogeny, water retention

### Introduction

Perhaps the only thing that is unequivocal about the rectal valve is that it is near the rectum. Everything else—its structure, function, distribution, possible systematic significance and even name—is unclear, unknown or undiscussed.

The rectal valve is a sclerotized band found in the wall of the hind gut of many weevils (Curculionoidea) (Kuschel 1964; Calder 1989); it has also been reported as occurring in Chrysomelidae, Cerambycidae and Bruchidae (Kuschel 1964) although few detailed descriptions have been published for these groups. The works of Poll (1932) and Saini (1964) suggested that a similar and possibly homologous structure occurs outside the Phytophaga. The detailed distribution of this structure across the Coleoptera is so far unknown.

Discussion of the rectal valve in weevils has focussed on adults. However, weevil larvae also have a ring- or loop- like structure in the posterior part of the rectum, the ‘rectal bracon’ (May 1993; 1994); no association has been made between the larval and adult structures.

The interest of the structure for taxonomy is its variable form. In most weevils it is a more or less simple ring (‘rectal ring’ of Kuschel 1964), in some it is oblique (‘rectal loop’ of Kuschel 1964), or it includes longitudinal struts or plates (Kuschel 1964; Calder 1989). While there are very few morphological descriptions of the rectal valve in Curculionoidea, the distribution of different structures seems in at least some cases to correspond to recognized family-group taxa, such as the loop in Anthribidae, most Petalochilini and most Cossoninae, and a hexagonal form with knobs at the angles in Belidae (Kuschel 1964). Kuschel (1964) and Calder (1989) pointed out that both loop and ring occur in the same taxonomic groups, perhaps limiting the phylogenetic utility of the structure. Nevertheless, the rectal valve features in the character suite of three phylogenetic studies of Curculionoidea higher taxa (Kuschel 1995; Farrell 1998; Marvaldi & Morrone 2000). There have been a number of observations in addition to those of Kuschel and Calder’s papers; these are scattered through the literature and there has been no real attempt at an overview.

plates (Fig. 13). Nevertheless, the rectal valve structure does not support a relationship between the Platypodinae and the Scolytinae (nor does it illuminate any proposed relationship between the Platypodinae and the Dryophthoridae).

## Conclusions

The rectal valve is still very poorly known in Coleoptera. However, there seems no reason to suppose that it was derived more than once, although examination in many more beetle families will be required to test this.

The valve is a sclerotized band lying in the wall of the rectum at the point where the perinephric membrane meets the wall of the rectum posteriorly, thus marking the posterior end of the perinephric chamber. Within the perinephric chamber the Malpighian tubules lie appressed to the rectal wall as a part of the cryptonephridial system, which recovers water from the fecal matter prior to elimination. The plesiomorphic form of the valve is a narrow crimped ring, which probably acts as a sphincter when circular muscles surrounding the rectum are contracted. This sphincter probably causes the rectum to close, trapping fecal matter within the cryptonephridial area of the rectum. The valve may only be closed under tension of the muscles; when the muscles are relaxed it may naturally resume its original shape, opening the rectum and permitting the fecal matter to pass to the posterior of the rectum and be expelled. Several groups of beetles, including several taxa within the Curculionoidea, have apomorphic forms of the valve, in which it extends longitudinally along the rectum, the perinephric chamber being confined to one side of the rectum only. This 'rectal loop' does not appear to have a sphincter function, and any retention of the fecal matter in the perinephric area is presumably managed in a different fashion. Study of stained sections of the rectum may suggest how such retention is managed, if it is. In the Anthribidae and possibly other Curculionoidea a supplementary system to retain fecal matter may exist in the longitudinal tapering plates extending posteriad from the loop, which may cause closure of the rectum if compressed by contracting circular muscles.

The different forms of the loop in various Coleoptera (and taxa within the Curculionoidea) suggest it may assist in providing phylogenetic information to identify monophyletic groups. This is a strong supposition in the Anthribidae, where the sclerotized longitudinal plates are almost unique, being mirrored only by the plates associated with the rectal ring in a few Curculionidae: Entiminae (and possibly much weaker plates elsewhere). Apomorphic forms also exist in the Belidae: Aglycyderini, Dryophthoridae: Litosomini (although the extent of the apomorphic form is not yet known), the Curculionidae: Mesoptiliinae, Entiminae, Eugnomini, Petalochilini, Cossoninae and Scolytinae.

The suggestions made above are preliminary. While many observations have been made in Curculionoidea (see Appendix 2), many more are required to provide sufficient data to adequately test hypotheses of monophyly. In addition many more observations of larvae and adults of the same species are needed to understand better the relationship between the larval and adult valve morphology.

## Acknowledgements

We would like to thank Mike Ivie for pointing out the similarity of the rectal valve in the Curculionoidea and the structures in the Bostrichidae, and raising the possibility of a link to the cryptonephridial system. Rich Leschen made some very helpful comments and suggestions on the manuscript. We would also like to thank Pascoe Harvey, who made some of the observations of the structures in the weevils, and introduced us to the 'weevil rectum cake'. EF was supported by an Entente Cordiale Scholarship and a grant from the Ruby and Will George Trust.

## References

- Agrain, F.A. & Marvaldi, A.E. (2009) Morphology of the first instar larva in the tribe Clytrini, with two new descriptions in the subtribe Megalostomina (Coleoptera: Chrysomelidae: Cryptocephalinae). *Zootaxa*, 2147, 59–68.
- Alonso-Zarazaga, M.A. & Lyal, C.H.C. (1999) *A world catalogue of families and genera of Curculionoidea (Insecta: Coleoptera) (excepting Scolytidae and Platypodidae)*. Entomopraxis, Barcelona, 315 pp.

- Aslam, N.A. (1961) An assessment of some internal characters in the higher classification of Curculionidae s.l. (Coleoptera). *Transactions of the Royal Entomological Society of London*, 113 (14), 417–489.  
<http://dx.doi.org/10.1111/j.1365-2311.1961.tb00799.x>
- Beutel, R.G. & Haas, F. (2000) Phylogenetic relationships of the suborders of Coleoptera (Insecta). *Cladistics*, 16, 103–141.  
<http://dx.doi.org/10.1111/j.1096-0031.2000.tb00350.x>
- Beutel, R.G. & Hornschmeyer, T. (2002) Larval morphology and phylogenetic position of *Micromalthus debilis* LeConte (Coleoptera: Micromalthidae). *Systematic Entomology*, 27, 169–190.  
<http://dx.doi.org/10.1046/j.1365-3113.2002.00172.x>
- Beutel, R.G. (1996) Study of the larva of *Nosodendron fasciculare* (Olivier 1790) Coleoptera: Nosodendridae) with implications for the phylogeny of Bostrichiformia. *Journal of Zoological Systematics and Evolutionary Research*, 34, 121–134.  
<http://dx.doi.org/10.1111/j.1439-0469.1996.tb00818.x>
- Bouchard, P., Bousquet, Y., Davies, A.E., Alonso-Zarazaga, M.A., Lawrence, J.F., Lyal, C.H.C., Newton, A.F., Reid, C.A.M., Schmitt, M., Ślipiński, S.A. & Smith, A.B.T. (2011) Family-group names in Coleoptera (Insecta). *ZooKeys*, 88 (Special Issue), 1–972.
- Calder, A.A. (1989) The alimentary canal and nervous system of Curculionoidea (Coleoptera): gross morphology and systematic significance. *Journal of Natural History*, 23, 1205–1265.  
<http://dx.doi.org/10.1080/00222938900770671>
- Crowson, R.A. (1981) *The biology of the Coleoptera*. Academic Press, London, 802 pp.
- DeMonte, T. (1957) Prima nota sull' apparate plasmatore degli escrementi caratteristica modificazione dell'intestino retto femminile in alcune tribu della sottofamiglia Clytrinae. *Memoire Societa Entomologica Italiano Genoa*, 36, 143–159.
- Ekis, G. & Gupta, A.P. (1971) Digestive system of Cleridae (Coleoptera). *International Journal of Insect Morphology and Embryology*, 1 (1), 51–86.  
[http://dx.doi.org/10.1016/0020-7322\(71\)90008-0](http://dx.doi.org/10.1016/0020-7322(71)90008-0)
- Erber, D. (1968) Bau, Funktion und Bildung der Kotpresse mitteleuropäischer Clytrinen und Cryptocephalinen (Coleoptera, Chrysomelidae). *Zoologische Jahrbücher, Systematik, Ökologie und Geographie der Tiere*, 96, 453–477.
- Farrell, B.D. (1998) “Inordinate fondness” explained: why are there so many beetles? *Science*, 281, 555–559.  
<http://dx.doi.org/10.1126/science.281.5376.555>
- Gillett, C.P.D.T., Crampton-Platt, A., Timmermans, M.J.T.N., Jordal, B.H., Emerson, B.C. & Vogler, A.P. (2014) Bulk de novo mitogenome assembly from pooled total DNA elucidates the phylogeny of weevils (Coleoptera: Curculionoidea). *Molecular Biology and Evolution*, 31, 2223–2237.  
<http://dx.doi.org/10.1093/molbev/msu154>
- Grebennikov, V.V. (2010) First *Alaocybites* weevil (Insecta: Coleoptera: Curculionoidea) from the Eastern Palaearctic: a new microphthalmic species and generic relationships. *Arthropod Systematics and Phylogeny*, 68 (3), 331–365.
- Gullan, P.J. & Cranston, P.S. (2005) *The Insects. An Outline of Entomology*. 3<sup>rd</sup> Edition. Blackwell Publishing Ltd, Malden, Oxford and Victoria, 529 pp.
- Haran, J. & Timmermans, M.J.T.N. & Vogler, A.P. (2013) Mitogenome sequences stabilize the phylogenetics of weevils (Curculionoidea) and establish the monophyly of larval ectophagy. *Molecular Phylogenetics and Evolution*, 67, 15–166.  
<http://dx.doi.org/10.1016/j.ympev.2012.12.022>
- Hunt, T., Bergsten, J., Levkanicova, Z., Papadopoulou, A., John, O.S., Wild, R., Hammond, P.M., Ahrens, D., Balke, M., Caterino, M.S., Gomez-Zurita, J., Ribera, I., Barraclough, T.G., Bocakova, M., Bocak, L. & Vogler, A.P. (2007) A comprehensive phylogeny of beetles reveals the evolutionary origins of a superradiation. *Science*, 318 (5858), 1913–1916.
- Ivie, M.A. (2002) Bostrichidae. In: Arnett, R.H., Thomas, M.C., Skelley, P.E & Frank, J.H. (Eds.), *American beetles. Vol 2. Polyphaga: Scarabaeiodes through Curculionoidea*. CRC Press, Boca Raton, London, New York, Washington D.C., pp. 233–244.
- Jordal, B.H. (2010) Revision of the genus *Phloeoditica* Schedl - with description of two new genera and two new species in Phloeosinini (Coleoptera, Curculionidae, Scolytinae). *Zookeys*, 56, 141–156.  
<http://dx.doi.org/10.3897/zookeys.56.522>
- Jordal, B.H., Sequeira, A.S. & Cognato, A.I. (2011) The age and phylogeny of wood boring weevils and the origin of subsociality. *Molecular Phylogenetics and Evolution*, 59 (3), 708–724.  
<http://dx.doi.org/10.1016/j.ympev.2011.03.016>
- Jordal, B.H., Smith, S.M. & Cognato, A.I. (2014) Classification of weevils as a data-driven science: leaving opinion behind. *ZooKeys*, 439, 1–18.  
<http://dx.doi.org/10.3897/zookeys.439.8391>
- Jordal, B.H. (2010) Revision of the genus *Phloeoditica* Schedl - with description of two new genera and two new species in Phloeosinini (Coleoptera, Curculionidae, Scolytinae). *Zookeys*, 56, 141–156.  
<http://dx.doi.org/10.3897/zookeys.56.522>
- Kiselyova, T. & McHugh, J.V. (2006) A phylogenetic study of Dermestidae (Coleoptera) based on larval morphology. *Systematic Entomology*, 31, 469–450.
- Kojima, H., Morimoto, K. & Horikawa, M. (1998) Two new species of the genus *Ochyromera* (Coleoptera: Curculionidae) from Japan. *Esakia*, 38, 113–122.

- Kuban, V., Majer, K. & Kolibáč, J. (2000) Classification of the tribe Coraebibi Bedel, 1921 (Coleoptera, Buprestidae, Agrilinae). *Acta Musei Moraviae, Scientiae biologicae*, 85, 185–287. [Brno]
- Kuschel, G. (1964) Insects of Campbell Island. Coleoptera: Curculionidae of the subantarctic islands of New Zealand. *Pacific Insects Monograph*, 7, 416–493.
- Kuschel, G. (1995) A phylogenetic classification of Curculionoidea to families and subfamilies. *Memoirs of the Entomological Society of Washington*, 14, 5–33.
- Kuschel, G., Leschen, R.A.B. & Zimmerman, E.C. (2000) Platypodidae under scrutiny. *Invertebrate Taxonomy*, 14, 771–805. <http://dx.doi.org/10.1071/IT00024>
- Lawrence, J.F. & Newton, A.F. (1982) Evolution and classification of beetles. *Annual Review of Ecology and Systematics*, 13, 261–290. <http://dx.doi.org/10.1146/annurev.es.13.110182.001401>
- Lawrence, J.F. & Ślipiński, A. (2010) Dermestidae. In: Leschen, R.A.B., Beutel, R.G. & Lawrence, J.F. (Eds.), *Coleoptera, beetles. Vol. 2. Morphology and systematics (Elateroidea, Bostrichiformia, Cucujiformia partim)*. Walter de Gruyter, Berlin, pp. 198–206.
- Lawrence, J.F., Ślipiński, S.A. & Pakaluk, J. (1995) From Latreille to Crowson: a history of the higher-level classification of beetles. In: Pakaluk, J. & Ślipiński, S.A. (Eds.), *Biology, Phylogeny, and Classification of Coleoptera: Papers Celebrating the 80th Birthday of Roy A. Crowson*. Muzeum i Instytut Zoologii PAN, Warsaw, pp. 87–154.
- Leschen, R.A.B. & Carlton, C.E. (1988) Immature stages of *Endomychus biguttatus* Sat (Coleoptera: Endomychidae) with observations on the alimentary canal. *Journal of the Kansas Entomological Society*, 61 (3), 321–327.
- Leschen, R.A.B. & Ślipiński, S.A. (2010) Chapter 7. Cucujiformia Lameere, 1938. Introduction, Phylogeny. In: Leschen, R.A.B., Beutel, R.G. & Lawrence, J.F. (Eds.), *Handbook of Zoology. Vol. 2*. Walter de Gruyter, Berlin, pp. 227–228.
- Lyal, C.H.C. (1993) Fauna of New Zealand: Cryptorhynchinae (Insecta: Coleoptera: Curculionidae). *Fauna of New Zealand*, 29, 1–308. [Maanaki Whenua Press, Lincoln, New Zealand]
- Lyal, C.H.C. (2014) Molytinae Schoenherr, 1832. In: Leschen, R.A.B. & Beutel, R.G. (Eds.), *Coleoptera, Beetles. Morphology and Systematics. Vol. 3. Handbook of Zoology. Arthropoda: Insecta*. De Gruyter, Berlin and Boston, pp. 529–570.
- Machado, A. (2010) La morfología de *Laparocerus undatus* Wollaston, 1864 y consideraciones sobre la tribu Laparocerini Lacordaire, 1863 (Coleoptera, Curculionidae, Entiminae). *Graellsia*, 66 (2), 233–280. <http://dx.doi.org/10.3989/graellsia.2010.v66.025>
- Marvaldi, A.E. (1997) Higher level phylogeny of Curculionidae (Coleoptera: Curculionoidea) based mainly on larval characters, with special reference to broad-nosed weevils. *Cladistics*, 13, 285–312. <http://dx.doi.org/10.1111/j.1096-0031.1997.tb00321.x>
- Marvaldi, A.E. & Morrone, J.J. (2000) Phylogenetic systematics of weevils (Coleoptera: Curculionoidea): a reappraisal based on larval and adult morphology. *Insect Systematics & Evolution*, 31, 43–58. <http://dx.doi.org/10.1163/187631200X00309>
- Marvaldi, A.E., Oberprieler, R.G., Lyal, C.H.C., Bradbury, T. & Anderson, R.S. (2006) Phylogeny of the Oxycoryninae s.l. (Coleoptera: Belidae) and evolution of host-plant associations. *Invertebrate Systematics*, 20, 447–476. <http://dx.doi.org/10.1071/IS05059>
- May, B.M. (1971) Entomology of the Aucklands and other islands south of New Zealand: Immature stages of Curculionoidea. *Pacific Insects Monograph*, 27, 271–316.
- May, B.M. (1993) *Fauna of New Zealand: Larvae of Curculionoidea (Insecta: Coleoptera): a systematic overview. Fauna of New Zealand. Vol. 28*. Manaaki Whenua Press, Lincoln, Canterbury, 225pp. [New Zealand]
- May, B.M. (1994) An introduction to the immature stages of Australian Curculionoidea. In: Zimmerman, E.C. (Ed.), *Australian weevils (Coleoptera, Curculionoidea). Vol. II. Brentidae, Eurynchidae, Apionidae and a chapter on immature stages by Brenda May*. CSIRO, Canberra, pp. 365–726.
- Morimoto, K. (1995) A new genus and two new species of the edaphic weevils (Coleoptera, Curculionidae) from Japan. *Special Bulletin of the Japanese Society of Coleopterology*, 42 (3–4), 465–473.
- Morimoto, K. & Kojima, H. (2004) Systematic Position of the Tribe Phylloplatypodini, with Remarks on the Definitions of the Families Scolytidae, Platypodidae, Dryophthoridae and Curculionidae (Coleoptera, Curculionoidea). *Esakia*, 44, 153–168.
- Nation, J.L. (2002) *Insect physiology and biochemistry*. CRC Press, Boca Raton/London, 485 pp.
- Opitz, W. (2014) Morphologic studies of the alimentary canal and internal reproductive organs of the Chaetosomatidae and the Cleridae (Coleoptera: Cleroidea) with comparative morphology and taxonomic analyses *Insecta Mundi*, 0342, 1–40.
- Poll, M. (1932) Contribution a l'etude des tubes de Malpighi des Coleopteres. Leur utilite en phylogene. *Recueil de l'Institut Zoologique Torley-Rousseau*, 4, 47–80.
- Reid, C.A.M. & Beatson, M. (2010) Revision of the Australo-Papuan genus *Macrolema* Baly (Coleoptera: Chrysomelidae: Spilopyrinae), with description of a new genus. *Zootaxa*, 2486, 1–60.
- Saini, R.S. (1954) Studies on the anatomy of the genus *Aulacophora*. *Journal of Saugar University*, 1 (4), 111–125.
- Saini, R.S. (1964) Histology and physiology of the cryptonephridial system in insects. *Transactions of the Royal Entomological Society of London*, 116 (14), 347–392. <http://dx.doi.org/10.1111/j.1365-2311.1964.tb02302.x>
- Schmitt, M. (1996) The phylogenetic system of the Chrysomelidae – history of ideas and present state of knowledge. In: Jolivet, P. & Cox, M.L. (Eds.), *Chrysomelidae biology. Vol. 1. The classification, phylogeny and genetics*. SPB,

Amsterdam, pp. 57–96.

- Schoeller, M. (1995) Zur Evolution der *Camptosoma*. *Entomologische Blätter für Biologie und Systematik der Käfer*, 91, 53–61.
- Schoeller, M. (1995a) Arten der Gattung *Cryptocephalus* Geoffroy aus der fauna des südlichen und östlichen Afrika (Coleoptera, Chrysomelidae). *Mitteilung aus dem Zoologischen Museum in Berlin*, 71 (2), 373–385.  
<http://dx.doi.org/10.1002/mmzn.19950710216>
- Schoeller, M. (2008) Comparative morphology of sclerites used by Camptosomatan leaf beetles for formation of the extrachorion (Chrysomelidae: Cryptocephalinae, Camptosomatinae). In: Jolivet, P., Santiago-Blay, J. & Schmitt, M. (Eds.), *Research on Chrysomelidae. Vol. 1*. Brill, Leiden, pp. 87–120.
- Ulmer, B.J., Duncan, R.E., Prena, J. & Pena, J.E. (2007) Life history and larval morphology of *Eurhinus magnificus* Gyllenhal (Coleoptera: Curculionidae), a new weevil to the United States. *Neotropical Entomology*, 36 (3), 383–390.  
<http://dx.doi.org/10.1590/S1519-566X2007000300006>
- Wood, S.L. (2007) *Bark and ambrosia beetles of South America (Coleoptera, Scolytidae)*. Brigham Young University, Provo, Utah, v + 900 pp.
- Zimmerman, E.C. (1942) Curculionidae of Guam. *Bulletin of the Bernice P. Bishop Museum*, 172, 73–146 + pl. 141–147.
- Zimmerman, E.C. (1966) Curculionidae of Marotiri, South-Central Pacific (Coleoptera). *Pacific Insects*, 8, 893–899.
- Zimmerman, E.C. (1968) Rhynchophorinae of southeastern Polynesia (Coleoptera: Curculionidae). *Pacific Insects*, 10, 47–77.
- Zimmerman, E.C. (1974) Studies of Acamptini (Coleoptera: Curculionidae: Cossoninae). *The Coleopterists Bulletin*, 28 (3), 133–142.
- Zimmerman, E.C. (1993) *Australian Weevils (Coleoptera Curculionoidea). Vol. III. Nanophyidae, Rhynchophoridae, Erirhinidae, Curculionidae: Amycterinae, Literature Consulted*. CSIRO, Canberra, x + 854 pp.
- Zimmerman, E.C. (1994) *Australian Weevils (Coleoptera Curculionoidea). Vol. 1. Orthoceri, Anthribidae to Attelabidae, The Primitive Weevils*. CSIRO, Canberra, xxxii + 741 pp.