ZooKeys 1: 1-7 (2008)
doi: 10.3897/zookeys.1.11
www.pensoftonline.net/zookeys

EDITORIAL

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

ZooKeys, unlocking Earth's incredible biodiversity and building a sustainable bridge into the public domain: From "print-based" to "web-based" taxonomy, systematics, and natural history

ZooKeys Editorial Opening Paper

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Received 15 May 2008 | Accepted 30 June 2008 | Published 4 July 2008

Citation: Penev L, Erwin T, Thompson FC, Sues H-D, Engel MS, Agosti D, Pyle R, Ivie M, Assmann T, Henry T, Miller J, Ananjeva NB, Casale A, Lourenço W, Golovatch S, Fagerholm H-P, Taiti S, Alonso-Zarazaga M (2008) ZooKeys, unlocking Earth's incredible biodiversity and building a sustainable bridge into the public domain: From "print-based" to "web-based" taxonomy, systematics, and natural history. ZooKeys Editorial Opening Paper. ZooKeys 1: 1-7. doi: 10.3897/zookeys.1.11

Abstract

Publishing taxonomic and systematics studies in the digital era faces major challenges and requires new approaches, many of which are currently stimulating spirited discussions amongst taxonomists and systematists. New amendments to the International Code of Zoological Nomenclature are expected to regulate electronic publishing of new taxa and create a standard form for their registration (ZooBank). Responding to a perceived need, this editorial announces establishment of *ZooKeys* – a new online and print journal in zoological taxonomy and systematics, which aims to quickly respond and adapt to the newest developments in taxonomic publishing. Open Access is accepted as mandatory for *ZooKeys*. The rationale for and concept of *ZooKeys* is discussed in detail.

Keywords

Taxonomy, systematics, online publishing, ZooBank, open access

Introduction

The world around us and the living things that occur in it have always been of critical interest to humankind, both in terms of sustenance for the body and for the mind. Ever since the dawn of written history, or at least as far back as the Greeks more than 2,000 years ago (Aristotle), humans have tried to organize and disseminate knowledge about their surroundings. As humankind spread from its initial roots, more and more biodiversity was discovered, so much so that comprehending it became a significant challenge. This year, we celebrate the 250th anniversary of the 10th edition of *Systema Naturae* (Linnaeus, 1758); the first modern attempt to bring order to our understanding of what we now call biodiversity. Now, here in *ZooKeys*, we build a bridge that will launch knowledge of our rich natural heritage into the future with all the technologies presently available, and continually scoping out those for the future.

With his 10th edition of the *Systema Naturae*, Linnaeus created a method of assigning names (nomenclature) to biological organisms, organized in a structured hierarchy (classification). The result was an effective means for global communication about biodiversity. For each similar group of organisms, what we call today a species-level taxon, he provided a diagnosis. From this system one knew how to identify the taxon and could distinguish it from other taxa, and additionally could locate a summary of what was already known and published elsewhere on its biology, distribution, history of recognition, and the total accumulative body of data documented for the species.

Linnaeus maintained his system for another two editions, but as knowledge about the diversity of life increased, this undertaking became too great for a single person. Hence, the task was divided among his students, such as Fabricius, who wrote *Systema Entomologiae* (1775); but as the rate of knowledge accelerated, these summaries became fewer and more limited in scope. Today, thousands of works are published annually and most cover only a few taxa. For the most part, the means of disseminating these works has changed little from the time of Linnaeus; i.e., printing with ink on paper, with archival sets (or sometimes CD's distributed to a specified number of libraries)! Technologies for data synthesis and information dissemination, however, have changed rapidly in the last half-century, more so in the last decade (even more so in the last year). Thus, the goal of one comprehensive, universal and universally-accessible source of information about life is now achievable. *ZooKeys* sets out to be a holistic bridge that facilitates a transition from the past and even the present to the future of unlocking biodiversity's secrets.

Taxonomy in the digital era

The future of taxonomy in the digital era is widely discussed in several fora and in the literature (e.g., Polaszek, Agosti et al. 2005, Polaszek, Alonso-Zarazaga et al. 2005, Wheeler 2007, 2008). Several recently published papers may be regarded as the first "case studies" of the taxonomy of the future. The first one was published on 1 January 2008 in *Zootaxa* (Pyle et al. 2008), followed by another two in the same journal (Johnson et al. 2008, Deans & Kawada 2008). The fourth, published on 28 May 2008 in *PLoS ONE* (Fisher & Smith 2008), has served as the basis for lively discussion about the need for clearer rules concerning electronic publication of nomenclatural acts as governed by the ICZN Code. All of these papers attempt to set new standards for taxonomic publishing and incorporate some already widely accepted user-friendly features such as embedded hyperlinks, e-referencing, etc. However, at the same time they offer a solution to the problem of universal registration of new taxa within a central repository (ZooBank), links to images of descriptive characters such as morphology (MorphBank) or DNA sequences (GenBank), barcoding of the type specimens and linking to their depositories. Most important, however, seems to be the use of the taxonomic domain specific XML mark up schema (TaxonX) to mark up the content of the publication, which means that XML can be read by machine and imported into other projects, such as plazi.org and through it to GBIF databases (http://data.gbif.org/datasets/provider/241) (D. Agosti, cf. comment from 29 May on *PLoS ONE*).

ZooKeys will begin modestly by utilizing the best of current technologies for the production and dissemination of scientific information. *ZooKeys* will develop and deploy in conjunction with other initiatives (ICZN, TDWG, TaxonX, TaXMLit, DarwinCore and others) common data formats, so information published can be readily integrated into other community activities, such as ZooBank, GenBank, Global Biodiversity Information Facility (GBIF), MorphBank, Tree of Life, Catalogue of Life (Species2000 & ITIS) and the Encyclopaedia of Life (EOL). Eventually, all critical data and general information about animals will be accessible to all through the Internet. This is our vision and herewith we take some important steps toward fulfilling it.

Open Access and its implication in taxonomy – ZooKeys approach

The editorial policy of *ZooKeys* aims to adhere strictly to the principles of Open Access (OA) and free exchange of information, which means a direct, barrier-free, online dissemination of scientific results at no charge to the reader. Pursuing the cutting-edge technologies in the publishing realm, we shall continue to be in constant conformity with the current developmental changes in systematic zoology and in the ICZN, in particular. The editorial policy will pursue the following main objectives:

- High credibility and impact, achieved through an eminent editorial board and rigorous peer-review procedure
- High speed of publication, ranging between 2-3 weeks on average after a manuscript is accepted for publishing
- High-level online publishing technology – digital object identifiers (DOI), search and browse tools, e-citation and cross-referencing (CrossRef), indexing in major repositories worldwide, i.e. Zoological Record, PubMed, ULIDAT, institutional repositories and so on, providing the three most common formats in online publishing (PDF, HTML, XML)
- High visibility of the work – anyone can read your article at no charge, resulting in *higher citation rates* for the author (see The Effect of Open Access, http://opcit.eprints.org/oacitation-biblio.html).
- Greatest possible reduction of Open Access fees and prices for printed copies and reprints.
- Validation of new scientific names under ICZN requirements with "near" simultaneous appearance on the web in e-publications and EOL.

Open Access, in this context, also means that Authors retain the copyright of their articles. According to the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0/) accepted by *ZooKeys*, Open Access papers may be copied, downloaded, and used for text- and data-mining purposes, provided that such uses are fully attributed and undertaken on a non-commercial basis.

Open Access leads to a much higher visibility and citation rate of the published works (Lawrence 2001, Antelman 2004). Eysenbach (2006) found "*strong evidence that, even in a journal that is widely available in research libraries, OA articles are more immediately recognized and cited by peers than non-OA articles published in the same journal.*" The increase of citation counts of Open Access papers was even found to be "dramatic" by some analysts (Harnad & Brody 2004).

As a business model, Open Access is often termed as "author pays but everyone can read at no charge," instead of the traditional "publisher pays but everyone has to pay to read" (Suber 2003, 2007). In fact, the currently used model could in many cases be determined to be even worse – "author pays, readers also pay" – in all cases where subscription-based journals also charge for publishing (in the form of page charges). Naturally, authors are not expected to pay for Open Access out of their pockets but from research grants, foundations, and institutional funds. Several funding agencies in the USA and Europe already include grant money for

Open Access publishing in their budget plans. Such a policy has even filtered to high-level decisions of the Council of the European Union. At the Council Meeting in Brussels on 22-23 November 2007, the Council emphasised "*the strategic importance for Europe's scientific development of current sustainable models for open access to scientific information*". Furthermore, in the same document the Council recognized that "*effective and long-lasting digital preservation of scientific information is fundamental for the current and future development of European research*" and invited the Member States to ensure by 2010 that "*repositories of scientific information are sustainable and interoperable*" (2832nd COMPETITIVENESS – Internal market, Industry and Research). The increasing demand for Open Access especially concerns scientific results obtained from publicly-funded projects. In this way Society avoids "double payment" to obtain scientific information, first when subsidizing scientific work and, then second, when academic and public libraries pay exorbitantly excessive journal subscription rates.

As taxonomy is concerned, Open Access does not seem to be widely accepted, although at least descriptions of taxa should be placed firmly in the public domain (Agosti & Johnson 2006). The low percentage of Open Access papers in taxonomy (less than 5% according to Agosti & Johnson 2006) can perhaps be explained by four main reasons: (1) limited institutional and grant resources in this field of inquiry; (2) even fewer possibilities for funding of privately-working taxonomists, who often produce excellent results but have no institutional bodies backing them to cover the costs of Open Access; (3) unfamiliarity with Open Access philosophy regarding authors rights, and (4) with the revolutionary changes occurring in the transition from the Web to Web2.0, whereby all the publications can be linked to form one virtual entity (rather than thousands of individuals – see Agosti et al. 2007). However, there are and must be several solutions to this problem in order to enhance Open Access to taxonomic publications as much as is possible.

Publication fees in Open Access journals ensure a barrier-free distribution of the contents and include costs involved in processing, formatting, publishing, indexing, and archiving of the published materials. We understand, however, that many zoologists work privately or continue to enjoy their work after retirement. Therefore, if authors do not have funds to pay such fees, they will have an opportunity to ask for a discount or complete waiver. We do not want fees to prevent the publication of worthy work! Discounts and waivers will be offered to private and retired zoologists, as well as to scientists from low income or lower middle income countries (according to the World Bank country classification). Students, especially in the case of exceptionally good manuscripts, may also request discounts/waivers. Discounts/waivers will be also offered to scientists who actively participate in the review and editorial process. With this, we hope to create an opportunity for all taxonomists, independent of their budgetary constraints, to sample the effect of open access on visibility of their work!

Editorial scope and policy

ZooKeys will consider for publication works in taxonomy in the widest sense, i.e., new descriptions of taxa, if they are accomplished with proper diagnoses, keys and/or revision of at least the species-group level; taxonomic revisions of extant (or "recent") and fossil animal groups; checklists and catalogues; phylogenetic and evolutionary analyses; papers in descriptive and/or historical biogeography; methodology papers; data mining and literature surveys; monographs, conspectus, atlases; collections of papers, Festschrift volumes, and conference proceedings.

Papers containing identification keys will be accepted with priority. Extensive manuscripts consisting mostly of keys will be considered for publishing, as well.

Several categories of papers will be considered for publishing – original research articles; reviews – longer articles offering a comprehensive overview, historical analysis and/or future perspectives of a topic; monographs and collections of papers with no limit in size, published as "special issues"; short communications, letters and discussion papers; book reviews.

ISBN numbers will be assigned to large monographic papers (*i.e.*, major revisions of taxa), monographs, collections of papers, Festschrift volumes, atlases, checklists, and conspectus.

The main aim in improving dissemination of the published papers will be ISI (Web of Science) listing and gaining impact factor as quickly as possible, indexing in the world's leading scientific information databases and appropriate repositories.

Today, knowledge is disseminated in various published formats (new taxa descriptions, reviews, revisions, monographs, synopses, etc.). These are nothing more than containers for various kinds of biosystematics information. Each container has a title, authors, abstract, as well as character-state information, occurrence data, images, bibliographic information, etc. Today there are public depositories for much of this information but the containers remain critical as they continue to represent the packages that are counted for purposes of evaluation, merit rewards, tenure decisions, and the like. Recognizing this reality, *ZooKeys* continues the traditional concept of an original source container, with its title, author(s), etc. *ZooKeys* uses the newest and best-practice dissemination model, which includes online PDF, HTML and XML publication, and high-quality printed version. *ZooKeys* incorporates Open Access as mandatory for all contributions. *ZooKeys* is the articulation of a vision that intends to bridge zoological taxonomy with its future. To begin, we will match the best of today (*Zootaxa*), while continually moving forward so as to also become the best for tomorrow.

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ZooKeys 1: 9-22 (2008)
doi: 10.3897/zookeys.1.13
www.pensoftonline.net/zookeys

RESEARCH ARTICLE

A peer-reviewed open-access journal
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The *Carabus* fauna of Israel – updated identification key, faunistics, and habitats (Coleoptera: Carabidae)

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Academic editor: *Terry Erwin* | Received 19 May 2008 | Accepted 1 July 2008 | Published 7 July 2008

Citation: Assmann T, Buse J, Drees C, Friedman A-L-L, Levanony T, Matern A, Timm A, Wrase DW (2008) The *Carabus* fauna of Israel – updated identification key, faunistics, and habitats (Coleoptera: Carabidae). ZooKeys 1: 9-22. doi: 10.3897/zookeys.1.13

Abstract

This key to the *Carabus* species of Israel is an updated identification key with notes on the distribution and habitats of the species. Substantial additions, corrections and taxonomic changes on the *Carabus* fauna of the Middle East generated the need of an update of the knowledge of the genus *Carabus* in Israel. The classification and the identification of sibling taxa of the subgenus *Lamprostus* are still a problem: A zone of sympatry supports the species status of both *C. sidonius* and *C. hemprichi*. The lack of any evidence of sympatry for the taxa in species rank of the *C. syrus* group and their variability of the exoskeleton (mentum tooth, tip of aedeagus) requires further systematic and taxonomic studies.

Keywords

Carabus, *Lamprostus*, identification key, faunistical records, habitat characteristics, Israel

Introduction

Despite the fact that Israel is a small country (about 22,000 km^2), it displays an enormous ecological diversity originating from its peculiar biogeographic location in south-western Asia and its great physical variety (Furth, 1975; Por, 1975; Yom-Tov & Tchernov, 1988): It links the desert Sahara-Arabia belt, the Mediterranean region and the high Asian mountains. The ground beetle genus *Carabus* with its preference for humid habitats reaches its southern distribution limit in Israel, and only some species are distributed there (cf. Bousquet et al., 2003).

The *Carabus* fauna of Israel was first described in a fundamental work by Schweiger (1970). Substantial additions, corrections and taxonomic changes were made by Kleinfeld & Rapuzzi (2004) and Deuve (2004; 2005) in the last years. Additional records of some species demonstrate the need of an update of our knowledge on the genus *Carabus* in Israel. Moreover, the increasing interest in the conservation biology, ecology, evolutionary biology and faunistics of ground beetles in Israel (Bar, 1978; Chikatunov et al., 2006; Chikatunov et al., 1999; 2004; Finkel et al., 2002; Mienis, 1978a; 1978b; 1978c; 1978d; 1988; Pavliček & Nevo, 1996) demands a new identification key and a short synopsis of the present day knowledge of the distribution, faunistics and habitats of Israeli *Carabus* species. The taxonomic confusion in this group prevents us from presenting a final identification key. However, we hope that this short overview stimulates further studies to solve some systematic problems of the *Carabus* fauna of the Middle East.

Material and methods

The *Carabus* collection of The National Collections of Natural History of the Tel Aviv University and material from Upper and Lower Galilee, Carmel Ridge, Samaria (incl. Gilboa Mountains), Judea, Negev, Golan Heights and Mount Hermon collected by Anika Timm (Lüneburg), David W. Wrase (Berlin), Peer Schnitter (Halle) and Thorsten Assmann (Bleckede) were studied (altogether about 800 specimens). The relevant literature on *Carabus* species from Israel and neighbouring countries was evaluated (Alfieri, 1976; Bousquet et al., 2003; Casale & Vigna Taglianti, 1999; Deuve, 2004a; 2005; Kleinfeld & Rapuzzi, 2004; Schweiger, 1970).

Nomenclature of vegetation types for a characterisation of the habitats follows Danin (1988).

Total body length (BL) is measured from the tip of the mandibles to the apex of the elytra as the maximum linear distance.

Line drawings were prepared using a drawing tube attached to a Leica MZ 95 stereobinocular microscope. Dissections were made with standard techniques; genitalia were preserved in euparal or in polyvinylpyrrolidon containing mixture on acetate labels (Lompe, 1989) or without embedding in dried condition.

The aim of this study is not a revision of the subspecific taxa. The classifications given by various authors are strikingly different (e.g. Brežina, 1999; Deuve, 2004b; Kleinfeld & Rapuzzi, 2004). The listed subspecies follow the Palaearctic Catalogue (Bousquet et al., 2003) and Deuve (2004a; 2004b; 2005).

Identification key with notes on distribution and habitats of the species

The members of the genus *Carabus* are easily recognizable by the lack of a typical antennal cleaner, posterior coxae contiguous in midline of body, mandibles not transversally furrowed, and third antennal segment without keel. Moreover, the species living in Israel are characterized by their body size (BL > 15 mm) and entirely black colour (without any spots or markings or metallic luster). For a general characterisation of ground beetles see Trautner & Geigenmüller (1987) and Ball (2001).

1 (15) Pronotum without marginal setiferous pores (Fig. 1a, b, c) 2

2 (3) Labrum divided into three lobes (Fig. 2). Elytra with or without punctuation and granulation, habitus variable. BL: 25-36 mm. An eurytopic species in woodlands (Fig. 15), forests, batha (open and semi-open habitats, Fig. 16), arable land, dunes (Fig. 17), steppe and desert-like, overgrazed, semi-arid habitats of the northern Negev (Fig. 18), up to 1200 m above sea level. In northern and central Israel southwards to the northern Negev south of Be`er Sheva (e.g. Noqdim Plateau).[1] Fig. 1a, 7a and 8.. .... *C.* (*Procrustes*) ***impressus*** Klug, 1832;
in Israel: ssp. *carmelita* Lapouge, 1907
ssp. *palaestinus* Lapouge, 1907
ssp. *hybridus* Ganglbauer, 1887
ssp. *negevensis* Schweiger, 1970

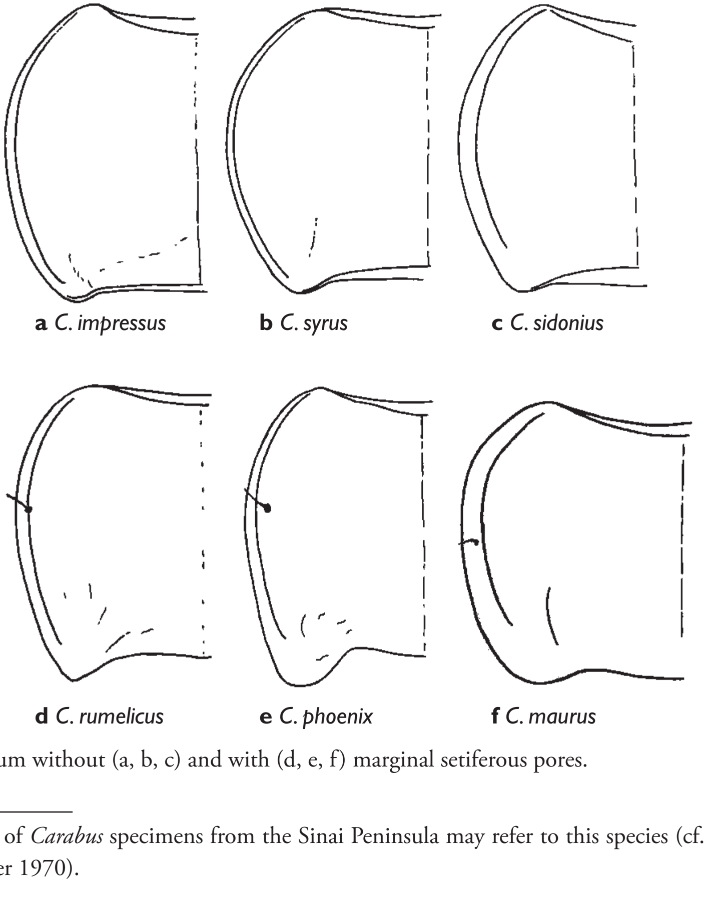

Fig. 1. Pronotum without (a, b, c) and with (d, e, f) marginal setiferous pores.

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[1] All records of *Carabus* specimens from the Sinai Peninsula may refer to this species (cf. Alfieri 1976; cf. Schweiger 1970).

3 (2) Labrum divided into two lobes (Fig. 2)..4

4 (5) Larger in size (BL: 37-44mm). Head and pronotum rugously wrinkled. Protarsus in male not dilated. Last segment of maxillary palpi triangular or axe-shaped. In open and semi-open habitats (up to 1600 m above sea level). Exclusively in the north (Mount Hermon, Golan Heights, Upper Galilee) and very rare. Fig. 7b and 9 .... C. (*Procerus*) **syriacus** Kollar, 1843
in Israel only ssp. *galilaeus* Schweiger, 1970

5 (4) Smaller in size (BL: < 37 mm), if larger then at least head and pronotum smooth, not rugously wrinkled. Three segments of protarsus in male dilated. Last segment of maxillary palpus not triangular or axe-shaped....................6

6 (7) Elytral sculpture with punctures and striae. Slender species. BL: 25-36 mm. In woodlands (Fig. 15), forests, and batha (Fig. 16), not in arable land (~500 to 2000 m above sea level, Fig. 19). In the north (Mount Hermon, Golan Heights, Upper and Lower Galilee). Fig. 7c and 10 ....
.... C. (*Chaetomelas*) ***piochardi*** Géhin, 1884
in Israel: ssp. *labruleriei* Géhin, 1884
ssp. *pinguis* Lapouge, 1914

7 (6) Elytron without punctures or striae, smooth. Wider species.......................8

8 (9) Elytron less rounded in lateral view (Fig. 3). Pronotum wider (Fig. 1b) 11

9 (10) Elytron more rounded in lateral view (Fig. 3). Pronotum slender (Fig. 1c)....
....13

11 (12) Tooth of mentum broad, tip truncate (Fig. 4a). Median lobe of aedeagus rounded at apex (Fig. 7d). BL: 32-39 mm. Mainly in open and semi-open habitats (especially batha, Fig. 16), rarely in woodlands or forests (from 200 m below sea level to 1400 m above sea level, Fig. 15). From Mount Hermon and Golan Heights to Upper Galilee (Mt. Meron, first finding in 2005). Fig. 1b, 2, 3 and 11 .... C. (*Lamprostus*) ***syrus*** Roeschke, 1898
in Israel only ssp. *cheikensis* Deuve, 1992

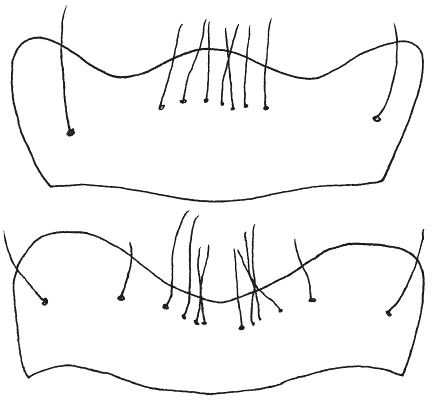

Fig. 2. Labrum divided into three lobes (above: *C. impressus*) and two lobes (below: *C. syrus*).

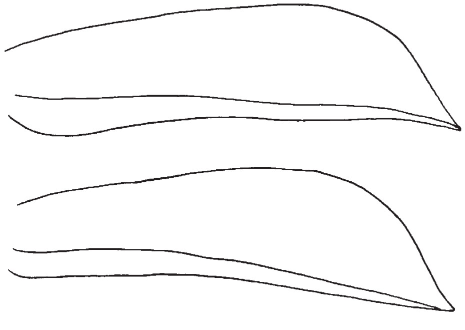

Fig. 3. Elytron in lateral view, less rounded (above: *C. syrus*) and more rounded (below: *C. sidonius*).

12 (11) Tooth of mentum sharpened (Fig. 4b). Median lobe of aedeagus sharpened at apex (Fig. 7e). BL: 32-37 mm. Distribution area still poorly known, described from Lebanon. Listed by Schweiger & Rapuzzi (2004) from north-eastern Israel ....*C.* (*Lamprostus*) ***lecordieri*** Deuve, 1992

Note: *C. lecordieri* was degraded as a subspecies of *C. syrus* by Kleinfeld & Rapuzzi (2004), but the species status was re-established by Deuve (2005). Deuve (2004b) treated the taxon as a subspecies of *C. syrus*. Some specimens from Israel cannot be classified as one of the species due to variability of the mentum tooth and small differences of the aedeagus.

13 (14) Hind angles of pronotum rounded, a little bit more pronounced, very similar to its sister species (*C. hemprichi*). Apical part of aedeagus deflexed, narrow and more distinctly set off (Fig. 7f). BL: 31-35 mm. In woodlands (Fig. 15), forests, and batha (up to 1200 m above sea level, Fig. 16). Northern and central Israel, southwards up to Jerusalem. Fig. 1c, 3, 4c and 12 .... *C.* (*Lamprostus*) ***sidonius*** Lapouge, 1907
in Israel: ssp. *elonensis* Schweiger, 1970
ssp. *cheikhermonensis* Deuve, 1992

14 (13) Hind angles of pronotum rounded, only slightly prolongate. Apical part of aedeagus not distinctly deflexed, wider and not distinctly set off (Fig. 7g). BL: 31-37 mm. In woodlands, batha and arable fields. In north-eastern Israel (Mount Hermon and Golan Heights)..........*C.* (*Lamprostus*) ***hemprichi*** Dejean, 1826
in Israel only *damascenus* Lapouge, 1924

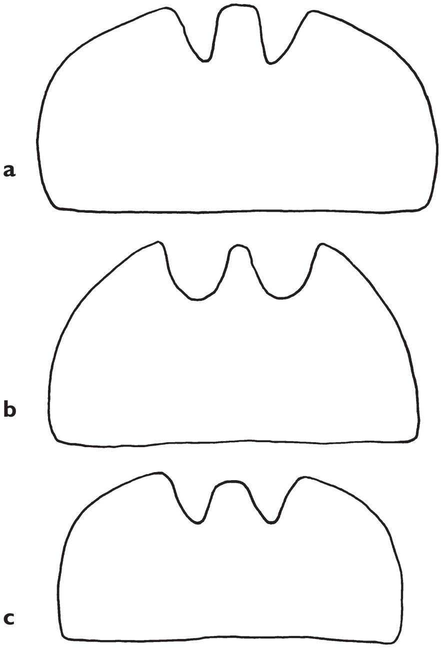

Fig. 4. Mentum of *Lamprostus* species (a: *C. syrus*; b: *C. lacordieri*; c: *C. sidonius*).

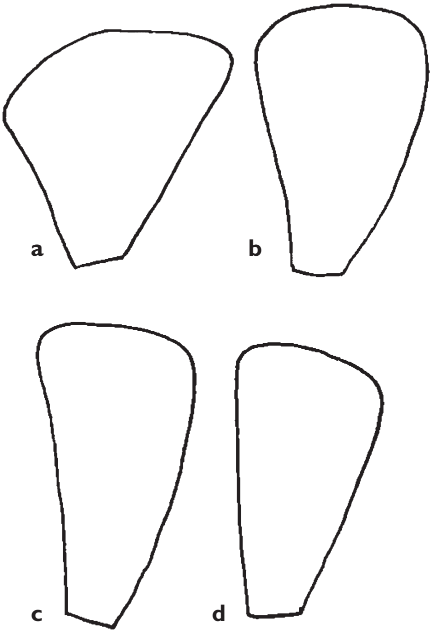

Fig. 5. Last segment of maxillary palpi (a, b: *C. rumelicus*; c, d: *C. maurus*; a, c: male; b, d: female).

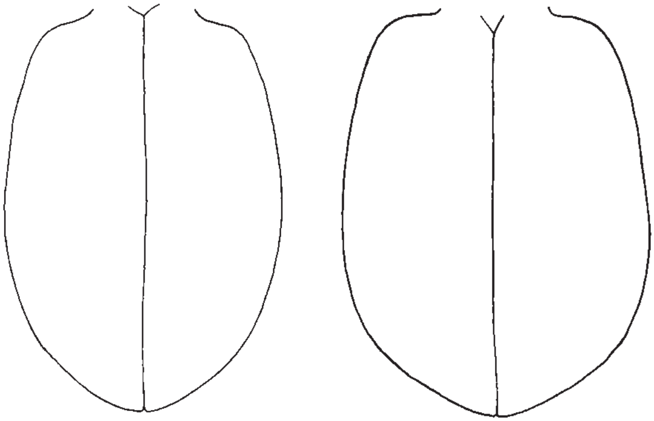

Fig. 6. Shoulder of elytron rounded (left: *C. phoenix*) and angulate (right: *C. maurus*).

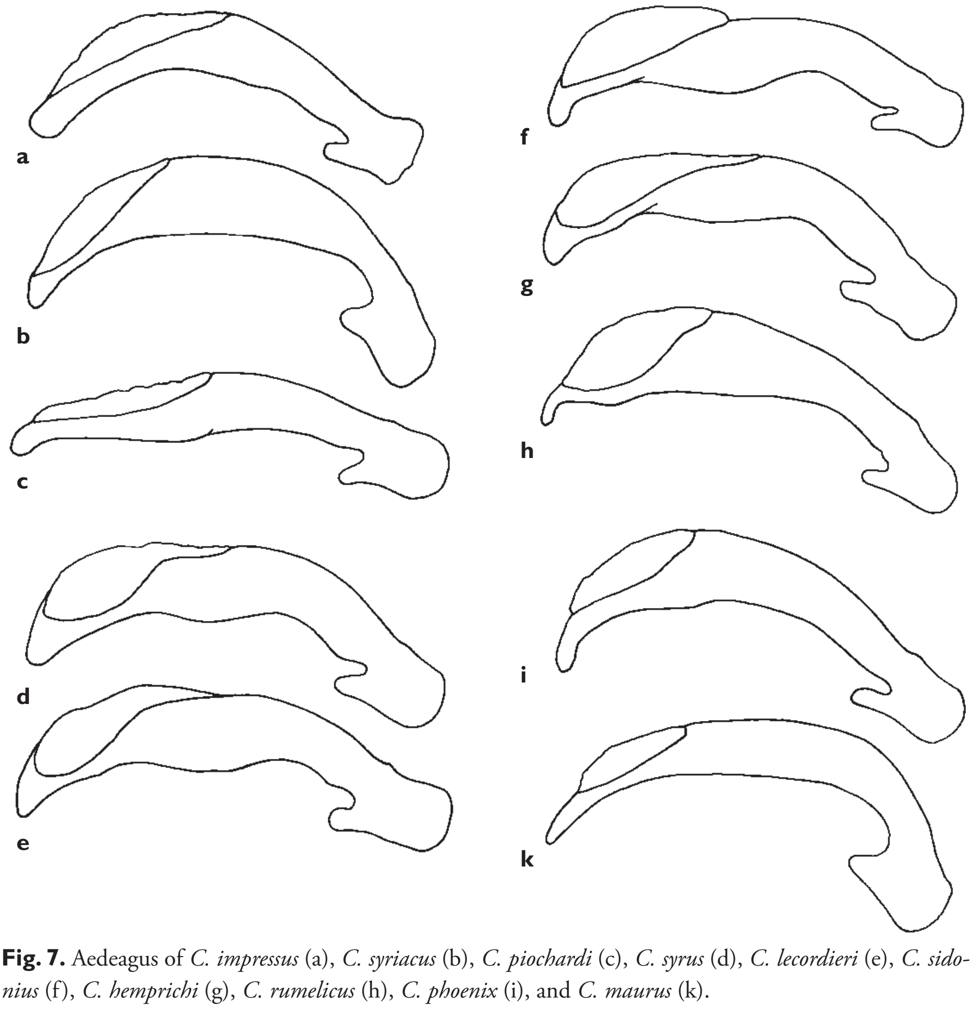

Fig. 7. Aedeagus of *C. impressus* (a), *C. syriacus* (b), *C. piochardi* (c), *C. syrus* (d), *C. lecordieri* (e), *C. sidonius* (f), *C. hemprichi* (g), *C. rumelicus* (h), *C. phoenix* (i), and *C. maurus* (k).

Note: A zone of sympatry between *C. hemprichi* and *C. sidonius* in Lebanon led Deuve (2004) to consider both taxa as valid species. In previous publications these taxa were ranked as subspecies of *C. hemprichi*. The distinction of both species is extremely difficult. Moreover, in the last years two additional sibling species of the subgenus *Lamprostus* were described from Lebanon.

15 (1) Pronotum with marginal setiferous pores (if seta broken, the pupillate insertion is visible) (Fig. 1d, e, f) 16

16 (17) Last segment of maxillary palpus in males triangular or axe-shaped (Fig. 5a). BL: 17-20 mm. In montane and subalpine altitudes of Mount Hermon (semi-open woodlands with *Quercus libani* and tragacanth vegetation, pastures, Fig. 19). Fig. 1d, 5b, 7h and 13 ...... *C.* (*Tomocarabus*) ***rumelicus*** Chaudoir, 1867
in Israel only ssp. *syriensis* Breuning, 1943

17 (16) Last segment of maxillary palpus in males more elongate, slightly dilated (Fig. 5c) 18

18 (19) Submentum thickened. Hind angles of pronotum prolongate (Fig. 1e). Shoulder of elytra rounded (Fig. 6a). BL: 17-25 mm. In Israel exclusively known from Upper Galilee (Mt. Meron), in woodlands (Fig. 15). Fig. 13 ....
.... *C.* (*Archicarabus*) ***phoenix*** Lapouge, 1924

19 (20) Submentum not thickened. Hind angles of pronotum more rounded (Fig. 1f). Shoulder of elytra angulate (Fig. 6b). BL: 15-20 mm. In montane and subalpine altitudes of Mount Hermon (semi-open woodlands with *Quercus libani* and tragacanth vegetation). Fig. 5c, 5 d and 7k ....
.... *C.* (*Mimocarabus*) ***maurus*** Adams, 1817
in Israel only ssp. *hermonensis* Schweiger, 1970

Fig. 8. *Carabus impressus* (Negev).

Fig. 9. *Carabus syriacus* (Mount Meron).

Fig. 10. *Carabus piochardi* (Mount Meron).

Fig. 11. *Carabus syrus* (Mount Meron).

Fig. 12. *Carabus sidonius* (Mount Meron).

Fig. 13. *Carabus rumelicus* (Mount Hermon).

Fig. 14. *Carabus phoenix* (Mount Meron).

Fig. 15. *Quercus calliprinos* dominated woodland (Ya'ar Bar'am). Habitat of *C. impressus*, *C. piochardi*, *C. syrus*, *C. sidonius*, and *C. phoenix*.

Fig. 16. Batha (Mount Meron). Habitat of *C. impressus*, *C. piochardi*, *C. syrus*, and *C. sidonius*.

Fig. 17. Dune habitat (south of Ashdod). Habitat of *C. impressus*.

Fig. 18. Steppe habitat (west of Be'er Sheva). Habitat of *C. impressus*.

Fig. 19. Montane to subalpine pasture (Mount Hermon). Habitat of *C. piochardi* and *C. rumelicus*.

Discussion

Ten species of the genus *Carabus* are known from Israel. The presence of *C. phoenix* in Israel – first records known from the surrounding of Sasa in Upper Galilee (Kleinfeld & Rapuzzi, 2004) – can be confirmed by several records from the Meron area (Upper Galilee, cf. Timm et al., 2008)[2]. At several locations in Galilee (including a site close to the Sea of Galilee, about 200 m below sea level) we detected *Carabus syrus* populations. The previously known distribution area in Israel covers the Golan Heights, parts of the Mount Hermon and the Upper Jordan Valley close to Qiryat Shemona (Schweiger & Rapuzzi, 1970). We believe that larger parts of Galilee (including Lower Galilee), Golan Heights and Judean Foothills are still under-represented in faunistical studies. Therefore it seems most likely that additional populations and perhaps species can be detected. From Jordan and Lebanon new species of the subgenus *Lamprostus* were already described in the last years (*C. pseudopinguis* Heinz, 2000; *C. lecordieri* Deuve, 1992; *C. rostandianus* Deuve, 2005; cf. Deuve, 2005; Heinz & Staven, 2000).

Despite the still incomplete faunistic inventory of Israel, the records of *C. syriacus* seem to decline, especially in the last decades. Coleopterists, also those collecting mainly in the northern parts of Israel, have not found this largest *Carabus* species in the Middle East for many years (e.g. Rittner, personal communication). Urbanization, habitat fragmentation and large-scale changes of land use (especially the transformation of natural and semi-natural habitats, e.g. sclerophyllous woodlands and batha, to pine stands and arable fields) might be a reason for this decline. Species of the subgenus *Procerus* show a remarkable decline not only at the southern limit of their distribution area but also in Europe: *C. gigas* Creutzer, 1799 was once distributed in Styria and Carinthia. At present the species is extinct in Austria (Paill, personal communication), in Slovenia the species is still occurring, but clearly declining (Drovenik, personal communication; Turin et al., 2003). A similar decline seems to occur in some places in Italy (Brandmayr and Casale, personal communication). – If one or several populations are rediscovered, an action plan to conserve the relict populations at the most southern limit of this species (and subgenus) will have to be developed.

A clear problem for identification are the sibling taxa of two *Lamprostus* groups: The characters given in the literature to separate *C. hemprichi* from *C. sidonius* and *C. syrus* from *C. lacordieri* show a remarkable variability within and between populations; this is true for both the mentum tooth and the apex of the median lobe of aedeagus. Sometimes it is impossible to classify some specimens exclusively from the exoskeleton. While a zone of sympatry is known for *C. hemprichi* und *C. sidonius* in Lebanon, any evidence of sympatry is still lacking for the members of the *C. syrus* group (including *C. lacordieri*, *C. pseudopinguis* and *C. rostandianus*).

The results of Pavliček & Nevo (1996) on *C. sidonius* demonstrated a small-scaled genetic differentiation, similar to some other *Carabus* species (Assmann, 2003; Assmann

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[2] Records from Sasa are not considered in the distribution map of *C. phoenix* given by Kleinfeld & Rapuzzi (2004).

& Weber, 1997). The morphological differentiation (from eye inspection) reflects this strong geographic differentiation on another level and should encourage us to study the species complexes morphometrically in order to solve the taxonomic problems (but for this approach still more material is necessary than is available at the moment).

In general one has to keep in mind that differences in the aedeagus, especially those of the apex (and not of the internal sac) of this organ, do not seem to be useful to classify taxa at the species level (see for a detailed discussion: Assmann et al., 2008). The taxa *C. violaceus violaceus* Linné, 1758 and *C. v. purpurascens* Fabricius, 1787 of the subgenus *Megodontus* can be easily distinguished by different forms of the aedeagus tip (and by lack or presence of striae on the elytra). But both taxa form several broad hybrid zones in north-western Central Europe (Assmann & Schnauder, 1998). An excessive gene flow is documented also by molecular techniques (allozymes and mtDNA haplotypes; Eisenacher et al., in prep.). In the light of these results the species rank of some taxa of the *C. syrus* group should be critically reconsidered.

Acknowledgements

We would like to thank Dr Thierry Deuve, Museum National d'Histoire Naturelle (Department de Systématique, Paris), for his help in identification and verification of some of our determinations. We are indebted to the curator of the Coleoptera collection Prof Dr Vladimir Chikatunov, and to the chief curator Dr Amnon Friedberg, who enabled us to study material from The National Collections of Natural History of the Tel Aviv University and to borrow specimens from this collection. Finally, we thank Uta Gebert (Berlin) for the photograph of *Carabus syriacus*.

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ZooKeys 1: 23-58 (2008)
doi: 10.3897/zookeys.1.8
www.pensoftonline.net/zookeys

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Eight new species of *Macvicaria* Gibson and Bray, 1982 (Digenea: Opecoelidae) mainly from endemic temperate marine fishes of Australia

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Academic editor: *David Gibson* | Received 9 June 2008 | Accepted 23 June 2008 | Published 10 July 2008

urn:lsid:zoobank.org:pub:66595057-9C2C-4AEF-AD29-9E2F52BF99FD

Citation: Aken'Ova TO, Cribb TH, Bray RA (2008) Eight new species of *Macvicaria* Gibson and Bray, 1982 (Digenea: Opecoelidae) mainly from endemic temperate marine fishes of Australia. ZooKeys 1: 23-58. doi: 10.3897/zookeys.1.8

Abstract

Nine morphologically distinct species of *Macvicaria* Gibson & Bray, 1982 were recovered from six families, ten genera and twelve species of marine fishes in the waters off the coast of Queensland, Western Australia and South Australia: *M. shotteri* **n. sp.** in *Apogon fasciatus* (type-host), *Sillaginodes punctatus* and *Sillago bassensis* from Moreton Bay (type-locality), off southern Western Australia and off Kangaroo Island, South Australia; *M. mekistomorphe* **n. sp.** in *Sillago maculata* from Moreton Bay; *M. mutovitellina* **n. sp.** in *Dactylophora nigricans* from off southern Western Australia; *M. flexuomeatus* **n. sp.** in *Goniistius gibbosus* (type-host) and *Cheilodactylus rubrolabiatus* from southern Western Australia; *M. vitellocopiosa* **n. sp.** in *Sillaginodes punctatus* from off Kangaroo Island, South Australia; *M. dextrocaula* **n. sp.** in *Notolabrus parilus* (type-host) and *N. fucicola* (Richardson) (Labridae) from off southern Western Australia (type-locality) and Kangaroo Island, South Australia; *M. heronensis* Bray & Cribb, 1989 in *Trachinotus coppingeri* off Stradbroke Island, Queensland; *M. adomeae* **n. sp.** in *Sillaginodes punctatus* off Kangaroo Island, South Australia; *M. kingscotensis* **n. sp.** in *Neoodax balteatus* (type-host) and *Haletta semifasciata* off Kangaroo Island, South Australia. We have used the following characters to distinguish between the species of *Macvicaria*: general body form; length/width ratio; size of cirrus-sac; length of forebody; post-testicular extent of caeca; egg size; and the position of the genital pore. Most of the species of *Macvicaria* showed interspecific differences in all of the characters enumerated, the most dramatic being in the position of the genital pore in one species. All 11 specimens recovered from 2 species of *Notolabrus* were found to have a dextral genital pore. This is the second report of amphitypy in the Opecoelidae. All of the host species, apart from *Apogon fasciatus*, are endemic to Australian or Australian and New Zealand waters. New combinations formed are: *M. dactylopagri* (Manter, 1954); *M. deeghaensis* (Gupta & Gupta, 1988); *M. eleuthoronemae* (Wang, Wang & Zhang, 1992); *M. gerridis* (Fischthal & Thomas 1970); *M. hunghuaensis* (Qiu & Li in Shen & Qiu, 1995); *M. longicirrata* (Manter, 1963); *M. oligolecithosus* (Wang, Wang & Zhang, 1992); *M. synagris* (Yamaguti, 1952).

Keywords
Digenea, Opecoelidae, *Macvicaria*, southern Australia, fishes, endemicity.

Introduction

Macvicaria Gibson & Bray, 1982 is a large genus of marine opecoelids that are widely distributed around the world. The genus was erected by Gibson & Bray (1982) for marine species of *Plagioporus* Stafford, 1904 (*sensu lato*), with a ventro-lateral genital pore and an excretory vesicle reaching at least to the level of the anterior testis. The other main diagnostic features of *Macvicaria* are an unlobed ovary, relatively large eggs and fields of vitelline follicles that extend into the forebody and are confluent dorsally and ventrally in post-testicular area and usually dorsally in the forebody. Three species of *Macvicaria*, *M. macassarensis* (Yamaguti, 1958), *M. heronensis* Bray & Cribb, 1989 and *M. dampieri* Bray, 1990 have been reported from Australian waters by Bray & Cribb (1989) and Bray (1990). Of the three species reported, *M. dampieri* is the only species from temperate waters. It is clear that Australian waters harbour many species, and the exploration of these worms is carried further in this study where nine species are reported, eight new. Cribb (2005) recognized this genus in his key to the Opecoelidae, based on the characters mentioned here. It has become a large genus, with many described species and with many species awaiting description.

This paper reports on the finding of eight new species of *Macvicaria*, almost all records are from endemic perciform hosts in waters off southern Queensland, southern Western Australia and South Australia. One known species is reported from southern Queensland for the first time.

Materials and methods

Opecoelids were collected live from fish as soon as they had died or been anaesthetized. The worms were washed in cold saline then fixed in hot saline and preserved in 5% formalin. Later, they were stained in Mayer's acid haematoxylin, dehydrated in a graded series of ethanol, cleared in methyl salicylate and mounted in Canada balsam. Measurements were taken using a digitizer and recorded in micrometres as ranges followed by their means in parentheses. Figures were prepared with the aid of a drawing tube on an Olympus BH2 microscope. Abbreviations: QM, Queensland Museum, Brisbane, Australia: http://www.qm.qld.gov.au/; BMNH, Natural History Museum, London, UK http://www.nhm.ac.uk/

Results

Family Opecoelidae Ozaki, 1925

Subfamily Plagioporinae Manter, 1947

Genus *Macvicaria* Gibson & Bray, 1982

urn:lsid:zoobank.org:act:1B181DB5-4D60-4744-9520-730FD9B6AAB0
(syn. *Cryptacetabulum* Shalaby & Hassanine, 1997)

Species of *Macvicaria* have been separated into five morphological groups, A to E, based on the distribution of vitelline follicles, the size of the cirrus-sac and the arrangement of the testes. It should be pointed out that it is difficult to assign some species to a particular group, so considerable care should be taken when using these groups. A sixth group, F, comprises worms of unresolved status. All new combinations were originally in *Plagioporus.*

Group A. Species with lateral vitelline fields continuous in the ventral sucker area, oblique to tandem testes and cirrus-sac not normally extending posterior to the ventral sucker: *Macvicaria alacris* (Looss, 1901) Gibson & Bray, 1982; *M. soleae* (Nicoll, 1910) Gibson & Bray, 1982; *M. microtestis* Zdzitowiecki & Cielecka, 1997; *M. oligolecithosus* (Wang, Wang & Zhang, 1992) n. comb.

Comment: Nicoll (1910) figured and described *M. alacris* and *M. soleae* as having oblique testes; Gibson & Bray (1982) figured them with tandem testes.

Group B. Species with lateral vitelline fields continuous in the ventral sucker area, tandem testes and a cirrus-sac usually not extending posterior to the ventral sucker: *Macvicaria aegyptensis* (Shalaby & Hassanine, 1997) Cribb, 2005; *M. crassigula* (Linton, 1910) Bartoli, Bray & Gibson, 1989; *M. cynoglossi* (Madhavi, 1975) Bray, 1990; *M. chrysophrys* (Nagaty & Abdel Aal, 1969) Bray, 1985 (syn: *Plagioporus saoudi* Ramadan, 1985); *M. dactylopagri* (Manter, 1954) n. comb.; *M. dubia* (Stossich, 1905) Bartoli, Bray & Gibson, 1989; *M. eleuthoronemae* (Wang, Wang & Zhang, 1992) n. comb.; *M. longicauda* (Hafeezullah, 1971) Bijukumar, 1997; *M. maillardi* Bartoli, Bray & Gibson, 1989; *M. mormyri* (Stossich, 1885) Bartoli, Gibson & Bray, 1993; *M. obovata* (Molin, 1859) Bartoli, Bray & Gibson, 1989; *M. ophthalmolyci* Zdzitowiecki, 1990; *M. sillagonis* (Yamaguti, 1938) Bray, 1985; *M. taksengi* Bray, 1985; *M. hunghuaensis* (Qiu & Li in Shen & Qiu, 1995) n. comb.

Comments: *M. cynoglossi* has obliquely tandem to tandem testes and can be accommodated in either Group A or B.

Although the cirrus-sac in *M. ophthalmolyci* extends posterior to the ventral sucker, we have not placed it in Group C because its cirrus-sac does not extend appreciably beyond the posterior margin of this sucker, as in the worms in the Group C, and because its general body form is different from the worms in Group C.

Macvicaria cynoglossi, *M. ophthalmolyci*, and *M. dactylopagri* can be distinguished from all the other worms in Group B as follows: *M. cynoglossi* has lobed testes, *M. ophthalmolyci* has the shortest forebody and the largest ventral sucker, and *M. dactylopa-*

gri has the smallest post-testicular space, the largest oral sucker relative to the ventral sucker, and a genital pore which is closest to the anterior end.

Group C. Species with continuous lateral vitelline fields in the ventral sucker area, tandem to oblique or oblique testes and a cirrus-sac extending posterior to the ventral sucker: *Macvicaria jagannathi* (Gupta & Singh, 1985) Bijukumar, 1997; *M. longibursata* Zdzitowiecki & Cielecka, 1997; *M. longisaccus* (Fischthal & Kuntz, 1964) Bray, 1985; *M. deeghaensis* (Gupta & Gupta, 1988) n. comb.; *M. gerridis* (Fischthal & Thomas 1970) n. comb.; *M. longicirrata* (Manter, 1963) n. comb.; *M. skorai* Zdzitowiecki, 1999; *M. synagris* (Yamaguti, 1952) n. comb.

Comments: Gibson & Bray (1982) remarked on the close resemblance of *Plagioporus gerridis* Fischthal & Thomas, 1972 to *Pachycreadium* Manter, 1954. This worm does not appear to conform to Manter's (1954) concept of the genus in relation to the position of the genital pore, which Manter said was median or sub-median, or with Manter's (1940) figure (as *Plagioporus gastrocotylus*) and Yamaguti's (1971) figure of the type-species *Pachycreadium gastrocotylum* Manter, 1940, which showed that the vitelline fields were separate in the forebody, dorsally and ventrally. The definition of *Pachycreadium* in Bartoli, Gibson & Bray (1988) addressed these two points, among others, thereby excluding *Plagioporus gerridis* from *Pachycreadium*. In the light of this development, we propose the new combination *M. gerridis* for *Plagioporus gerridis*, which we have placed in Group C. The paratype of *P. gerridis* (USPC Coll. No. 70680) that we examined did not show the type of vitelline distribution figured and described by Fischthal & Thomas (1972). In the paratype, the vitelline follicles do not extend into the forebody as they do normally in species of *Macvicaria*. However, it is possible that the figure of this species was drawn from the holotype and that the vitelline distribution we observed in the paratype is a variant of the type figured by Fischthal & Thomas. The holotype was not available for study.

Bray (1985) remarked on the similarity of *Plagioporus longicirratus* Manter, 1963 to *Gaevskayatrema* spp. except in its having vitelline follicles which extended posterior to the testes. He suggested that *P. longicirratus* might be congeneric with *P. synagris* Yamaguti, 1952. We have compared the measurements and descriptions of the two worms and found them to be different. *P. longicirratus* is a more elongate worm with a width to length ratio of 1:3.64 versus 1:2.7 in *P. synagris*; it has a smaller ventral sucker with a sucker width ratio of 1:1.18-1.2 versus 1:2.5, a smaller pharynx, with a pharynx to oral sucker width ratio of 1:1.7 versus 1:1.5, a longer forebody of 41.5% versus 29.2% of body-length, a smaller post-testicular space 6.7% versus 16.7% of body-length, longer eggs 72-73 versus 57-66 and a more posteriorly located genital pore 27.4% versus 13.2% of body-length from anterior extremity in *P. synagris*. On the basis of our observations we conclude that these two worms are distinct. The vitelline follicles of *P. longicirratus* extend posterior to the posterior testis, so, it does not fit into *Gaevskayatrema* Gibson & Bray, 1982 (Gibson & Bray, 1982; Cribb, 2005). We have transferred the two species to *Macvicaria* and included them in Group C.

Group D. Species with vitelline follicles interrupted bilaterally in the ventral sucker region, tandem testes and a cirrus-sac not extending posterior to the ventral sucker: *Macvicaria antarctica* (Kovaljova & Gaevskaya, 1974) Zdzitowiecki, 1990; *M.*

georgiana (Kovaljova & Gaevskaja, 1974) Zdzitowiecki, Pisano & Vacchi, 1992; *M. heronensis* Bray & Cribb, 1989; *M. issaitschikowi* (Layman, 1930) Bray, 1985; *M. muraenolepidis* Zdzitowiecki, 1990; *M. selachophidii* Reimer, 1987.

Comments: *Macvicaria selacophidii* was figured and described by Reimer (1987) from a single specimen with no clear indication of the anterior limit of the vitelline follicles. It is not certain if this worm belongs in *Macvicaria*, but we have placed it with other species in Group D because it shares some of their characteristics and also because we have observed variations within a single species of *Macvicaria* that include the absence of vitelline follicles from the forebody. Bray & Cribb (1989) remarked that this worm was probably a species of *Allopodocotyle* Pritchard, 1966 because the vitelline follicles are posterior to the ventral sucker, we share their view, however, any conclusive remarks should await examination of more specimens. No other author appears to have commented on the status of this species.

Group E. Species with vitelline follicles bilaterally interrupted in the ventral sucker area, oblique testes and a cirrus-sac usually not extending posterior to the ventral sucker: *Macvicaria dampieri* Bray, 1990; *M. japonica* (Yamaguti, 1938) Bray & Cribb, 1989; *M. macassarensis* (Yamaguti, 1952) Bray & Cribb, 1989; *M. pennelli* (Leiper & Atkinson 1914) Zdzitowiecki, 1987; *M. branchiostegi* (Yamaguti, 1937) Bray, 1990.

Comments: *M. pennelli* was figured and described as having oblique testes by Gibson (1976) and oblique or tandem testes by Zdzitowiecki (1990) and Zdzitowiecki et al. (1992). Gibson (1976) described the cirrus-sac as reaching posteriorly to a level between middle and posterior margin of the ventral sucker; Zdzitowiecki (1990) made the same observation and mentioned that the cirrus-sac sometimes extended posterior to the posterior margin of the ventral sucker. The distribution of the vitelline follicles in this worm varies; the lateral fields may be continuous, as figured by Gibson (1976), or may be interrupted, as figured by Zdzitowiecki (1990) who observed both conditions in his material.

Yamaguti (1937) described the vitelline follicles in *M. branchiostegi* as surrounding the posterior portion of the oesophagus and entire length of the intestine. There is a slight indication of lateral interruption in the area of the ventral sucker in his figure. For this reason, we have placed this worm in the same group as other species whose lateral vitelline fields are interrupted in the area of the ventral sucker (Group E).

Group F. Species of *Plagioporus* (*sensu lato*) which conform with Gibson & Bray's (1982) definition of *Macvicaria* in every way except in their very tiny eggs; *P. interruptus* Manter, 1954; and in the distribution of vitelline follicles; *P.* (*Plagioporus*) *kyusen* Yamaguti, 1959; and *Plagioporus* sp. of Al-Yamani & Nahhas (1981). Bray (1985) remarked that the latter form resembled Macvicaria but refrained from transferring it to this genus, suggesting that it required further study before a definite decision can be made regarding its status.

Macvicaria shotteri n. sp.

Type-host: *Apogon fasciatus* (White) (Apogonidae).

Other hosts: *Sillaginodes punctatus* (Cuvier) (Sillaginidae), *Sillago bassensis* Cuvier (Sillaginidae).

Type-locality: Moreton Bay, off Tangalooma, Queensland, 27°14'S, 153°19'E.

Other localities: Off Mandurah, 32°31'S, 115°41'E & off Point Peron, Western Australia, 32°18'S, 115°38'E., off American River, South Australia 35°48'S 137°46'E.

Site: Intestine/gut.

Material studied: Ex *Apogon fasciatus:* From Moreton Bay, Queensland: 8 Off Tangalooma, February & December, 1993; Ex *Sillaginodes punctatus*: From Western Australia: 8 Off Point Peron, 1 Off Mandurah Rockwall, December 1994. From South Australia: 12 Off American River, December 1995; Ex *Sillago bassensis*: From Western Australia: 3 Off North Mole, Fremantle, December 1994.

Type-material: Holotype: QM G223130, Paratypes: QM G 223131-223153, G230363-G230375; BMNH 2008.7.5.20-38.

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Description (Figs 1-6)

Based on 16 mature and 4 juvenile unflattened, whole-mount specimens and 1 set each of serial sagittal sections from *Sillaginodes punctatus*. Measurements of worms from *Sillago bassensis* and *Apogon fasciatus* are given in Table 1.

Measurements are of 10 gravid, unflattened, dorso-ventrally mounted worms from *Sillaginodes punctatus*. Body elongate, oval, maximum width usually in area of gonads, sometimes in ventral sucker area, 1,345-2,062 (1,786) × 366-546 (479); width to length ratio 1:3.1-4.2 (3.7). Oral sucker globular, ventrally subterminal, 124-178 (143) × 132-194 (157). Ventral sucker sub-spherical, in anterior third of body, 184-267 (221) × 218-311 (256), sucker width ratio 1:1.5-1.7 (1.6). Forebody short, 371-550 (449) long, 21.8-29.7 (25.3)% of body-length. Prepharynx distinct, short, dorsal to oral sucker. Pharynx subglobular, 65-97 (77) × 78-117 (98); pharynx to oral sucker width ratio 1:1.4-1.7 (1.6). Oesophagus distinct, short. Intestinal bifurcation 48-156 (107) anterior to ventral sucker. Caeca terminate blindly close to posterior extremity.

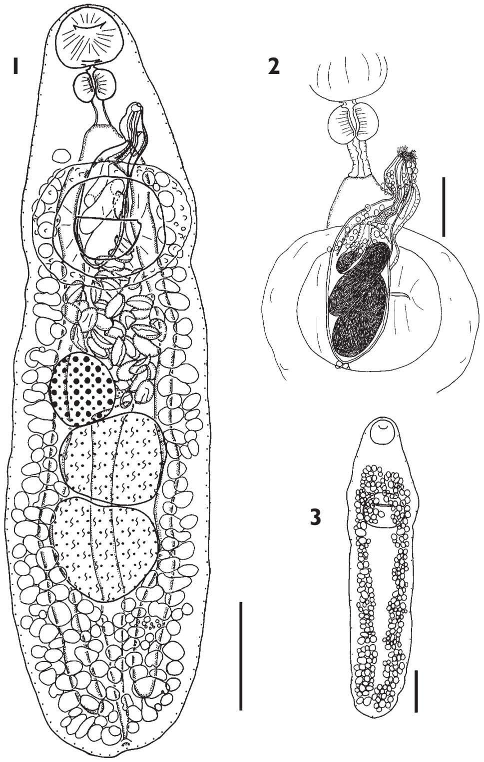
Testes 2, usually contiguous, rarely separate (n=1), tandem, with entire to incised anterior and posterior margins, anterior 137-282 (201) × 155-286 (239), posterior 184-338 (250) × 170-337 (244). Post-testicular region 312-498 (406) long, 19-27.4 (22.9)% body-length. Cirrus-sac clavate, thick walled, overlaps ventral sucker dorsally and extends posteriorly to point anterior to or slightly posterior to posterior margin of ventral sucker, 294-528 (403) × 64-142 (99). Internal seminal vesicle tubular, convoluted, fills most available space in posterior half of cirrus-sac. Pars prostatica distinct, small, surrounded by prostatic cells. Ejaculatory duct long, thick walled. Genital atrium small. Genital pore sinistral to and level with posterior end of oesophagus, anterior to intestinal bifurcation, 200-300 (251) from anterior end, 11.6-18.4 (14.2)% body-length.

Ovary entire, spherical, contiguous with and antero-dextral to anterior testis, 109-208 (145) × 98-194 (144). Mehlis' gland well developed, seen clearly in juvenile worms and sagittal sections, obscured by eggs in gravid whole-mounts, dorsally antero-sinistral and partly anterior to ovary. Canalicular seminal receptacle large, saccular, may be entirely dorsal or sinistral to ovary, overlapping left margin of ovary and anterior margin of anterior testis. Laurer's canal present. Eggs oval, operculate, 54-79 (65) × 29-49 (37). Metraterm distinct, well developed, relatively long. Vitelline follicles extend from 176-282 (229) from anterior extremity, 10.9-15.4 (12.9)% of body-length, to 10-55 (21) from posterior extremity; fields separate ventrally in forebody, confluent dorsally in forebody and post-testicular area; continuous follicle-free zone between ventral sucker and posterior margin of posterior testis, dorsally; follicles lie lateral, ventral and dorsal to caeca; anterior extent usually level with, or slightly anterior to or posterior to posterior margin of pharynx, rarely posterior to posterior limit of oesophagus (n=1).

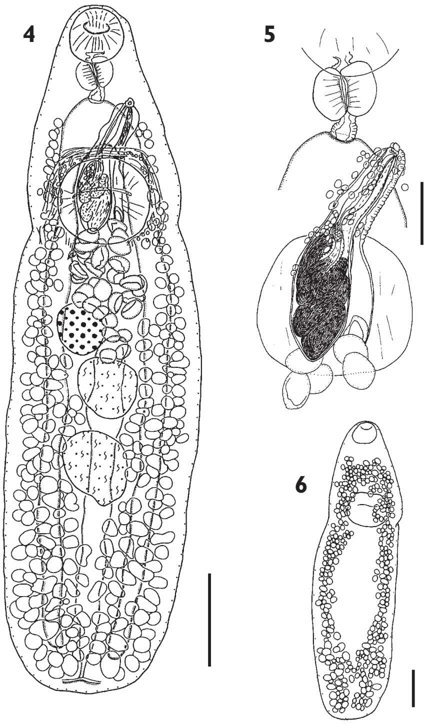
Excretory pore dorsally subterminal. Excretory vesicle I-shaped, narrow posterior end surrounded by gland-cells, widens anteriorly and passes to point antero-dorsal to posterior margin of ovary.

Table 1. Measurements (in µm) of *Macvicaria shotteri* n. sp. from *Sillago bassensis* (n = 2) and *Apogon fasciatus* (n = 8).

Host species	*S. bassensis*			*A. fasciatus*		
	Min.	Max	Mean	Min.	Max.	Mean
Total length	2,204	2,326	2,265	1,393	1,852	1,669
Maximum width	582	712	647	368	448	413
Length/width	3.1	4.0	3.5	3.4	4.3	4.0
Oral sucker length	159	188	174	122	149	132
Oral sucker width (OSW)	177	196	187	135	147	144
Pharynx length	87	101	94	64	83	71
Pharynx width	116	127	122	81	102	92
OSW/pharynx width	1.5	1.5	1.5	1.4	1.7	1.6
Ovary length	201	227	214	117	162	144
Ovary width	171	182	177	117	160	145
Anterior testis length	243	284	264	134	205	173
Anterior testis width	272	292	282	147	230	194
Posterior testis length	339	353	346	147	234	209
Posterior testis width	252	265	259	128	237	190
Forebody-length (FBL)	433	475	454	320	441	385
FBL as % of body-length	18.6	21.6	20.1	20.9	25.8	23.1
Ventral sucker length	251	270	261	203	224	214
Ventral sucker width (VSW)	284	331	308	225	262	244
VSW/OSW	1.6	1.7	1.6	1.6	1.8	1.7
Anterior extremity to genital pore (AEGP)	258	277	268	188	246	223
AEGP as % body-length	11.1	12.6	11.8	12.5	15.8	13.4
Cirrus-sac length	518	518	518	285	415	352
Cirrus-sac width	176	176	176	71	110	90
Intestinal bifurcation to ventral sucker	103	117	110	32	91	64
Post-testicular region (PTR)	501	632	567	333	525	426
PTR as % of body-length	22.7	27.2	25.0	20.4	28.3	25.5
Anterior extremity to vitellarium (AEV)	276	317	297	230	307	263
AEV as % of body-length	11.9	14.4	13.1	13.4	20.7	15.9
Posterior extremity to vitellarium	13	19	16	13	58	25
Eggs	62-76 (69) ×37-48 (42), n=11			58-72 (64) × 32-45 (38), n=66		



Figs 1-3. *Macvicaria shotteri* n. sp. ex *Apogon fasciatus*. 1. Whole-mount ventral view. 2. Terminal genitalia. 3. Dorsal distribution of vitelline follicles. *Scale bars*: 1, 3, 250 µm; 2, 100 µm.



Figs 4-6. *Macvicaria shotteri* n. sp. ex *Sillaginodes punctatus*. 4. Whole-mount ventral view. 5. Terminal genitalia. 6. Dorsal distribution of vitelline follicles. *Scale bars*: 4, 6, 250 µm; 5, 100 µm.

Etymology: This species is named for Professor R. A. Shotter.

Comments: The specimens of *Macvicaria shotteri* from *Sillago bassensis* and *Apogon fasciatus* are similar to those from *Sillaginodes punctatus* except in a few morphological details which we do not consider to be of taxonomic importance, since most of the measurable features are comparable. The largest worms, the two from *Sillago bassensis*, had the largest eggs, whereas the eggs in the worms from *Sillaginodes punctatus* and *Apogon fasciatus* were similar in size. The worms from *Sillaginodes punctatus* had the longest forebody, 21.8-29.7 (25.3) % of the body-length compared with 20.9-25.8 (23.1)% and 18.6-21.6 (20.1)% of the body-length in the worms from *Sillago bassensis* and those from *A. fasciatus* respectively. The testes are usually contiguous in worms from all three hosts except in two worms, one each from *Sillaginodes punctatus* and *A. fasciatus* in which the testes are separate. Bray (1985) observed that larger specimens of *M. taksengi* had larger eggs than the smaller specimens. This may also be the case in *M. shotteri*, since the largest eggs were in the largest worms from *Sillago bassensis*. Although the sharing of this parasite between apogonid and sillaginid hosts is surprising, we can find no morphological basis to interpret these specimens as two different species.

Macvicaria shotteri n. sp. fits into the concept of Group B as outlined above. This species can be distinguished from the other worms in the group as follows:

M. aegyptensis, according to Shalaby & Hassanine (1997), is a less elongate worm with a width to length ratio of 1:2.2-2.8, a longer forebody, (33% of body-length), a larger ventral sucker with sucker-width ratio of (1:2), and a genital pore at about 21% of the body-length from the anterior end.

M. crassigula, according to Bartoli *et al.* (1989), is a less elongate worm with a width to length ratio of 1:2.1 [2.44], it has a longer forebody (32% [40%] of body-length), a longer post-testicular space (27% of body-length), a slightly larger oral sucker with a sucker-width ratio of 1:1.27-1.40 [1.28], and a genital pore which is more posteriorly situated than in *M. shotteri* n. sp., at 26% of body-length from the anterior extremity.

M. chrysophrys, according to Nagaty & Abdel-Aal (1969) and Hassanine & Gibson (2005), is a less elongate species with a width to length ratio of 1:2.3 [2.7-2.9]; it has a longer forebody (39 [31-43]% of the body-length); a shorter post-testicular area (17% of body-length) and larger eggs (80 × 50 [64–78 × 35–48 (71 × 42)].

M. cynoglossi, according to Madhavi (1975), is relatively narrower with a width to length ratio of 1:4.17-4.59, with a longer forebody at 32-33% of the body-length, a generally greater sucker ratio at 1:1.6-2.0, lobed, oblique testes and a subterminal excretory pore (at the level of the caecal ends in the illustration).

M. dactylopagri, according to Manter (1954), is clearly differentiated from *M. shotteri* n. sp. by the anterior extent of the vitellarium which reaches to the oral sucker or pharynx.

M. dubia, according to Bartoli *et al.* (1989), is a less elongate worm with a width to length ratio of 1:2.1, a longer forebody and a shorter post-testicular area of 40% and 14% of the body-length, respectively, it has larger eggs, 71-85 × 33-43 (79 × 39), and a genital pore which is more posteriorly situated, at 29% of the body-length from anterior extremity.

M. eleuthoronemae, according to Wang *et al.* (1992), differs from *M. shotteri* n. sp. in the intestinal bifurcation being in the middle of a long forebody (35% of body-length), a short post-testicular region (14% of body-length) and all the gonads in the final third of the body.

M. hunghuaensis, according to Shen & Qiu (1995), is a squat worm (width to length ratio of 1:2.1-3.0 (1:1.6 in illustration)). The cirrus-sac is confined to the forebody and the vitelline fields are widely separated.

M. longicauda, according to Hafeezullah (1971), is relatively narrower with a width to length ratio of 1:4.2-4.4, a slightly longer forebody at 29-30% of body-length, a long post-testicular region at 33% of body-length and the cirrus-sac does not reach the ventral sucker.

M. maillardi, according to Bartoli *et al.* (1989), has no distinct oesophagus, it has a smaller ventral sucker and a larger oral sucker shown by a sucker ratio of 1:1.06-1.48 (1.22), it has a longer forebody and shorter post-testicular area measuring 40% and 18% of the body-length, respectively, and a more posteriorly situated genital pore at 29% of the body-length from the anterior extremity.

M. mormyri, according to Bartoli *et al.* (1993), is a less elongate species, with a width to length ratio of 1:2.8, a smaller ventral sucker and larger oral sucker with a sucker width ratio of 1:1.16-1.54 (1.35); it has a longer forebody, 35% of the body-length, and a genital pore which is more posteriorly situated at 19% of the body-length from anterior extremity.

M. obovata, according to Bartoli *et al.* (1989), is less elongate with a width to length ratio of 1:2.8, it has a longer forebody (37% of the body-length), and a genital pore which is more posteriorly situated at 23% of the body-length from the anterior extremity.

M. ophthalmolyci, according to Zdzitowiecki (1990, 1997), has a very large ventral sucker (width ratio 1:2.1-2.7), a very short forebody (about 13% of body-length) and the vitellarium reaches the pharynx.

M. taksengi, according to Bray (1985), is very close *M. shotteri* from which it can be distinguished by its smaller size (590-1,110 × 240-480), its less elongate form with a width to length ratio of 1:2.5, by its ovary which is situated dextrally or overlapping the anterior testis and by the distal expansion of the cirrus-sac.

M. sillagonis, according to Yamaguti (1938), is closest to *M. shotteri* from which it can be distinguished by its less elongate form, with a width to length ratio of 1:2.3, a slightly shorter post-testicular area of 20% of the body-length and a slightly smaller pharynx with a pharynx to oral sucker width ratio of 1:2.0.

The seminal vesicle in the new species is distinctive, in that it is thrown into two or more virtually parallel diagonal slings within the cirrus-sac, a feature not observed in *M. sillagonis*. Bray (1985) had commented that the holotype and two specimens of *M. sillagonis* which he examined were so extremely flattened that some of the features of the worms might have been altered; however, we do not think that the alteration will be so much as to unravel the slings of the seminal vesicle, if present in *M. sillagonis*.

Macvicaria mekistomorphe n. sp.

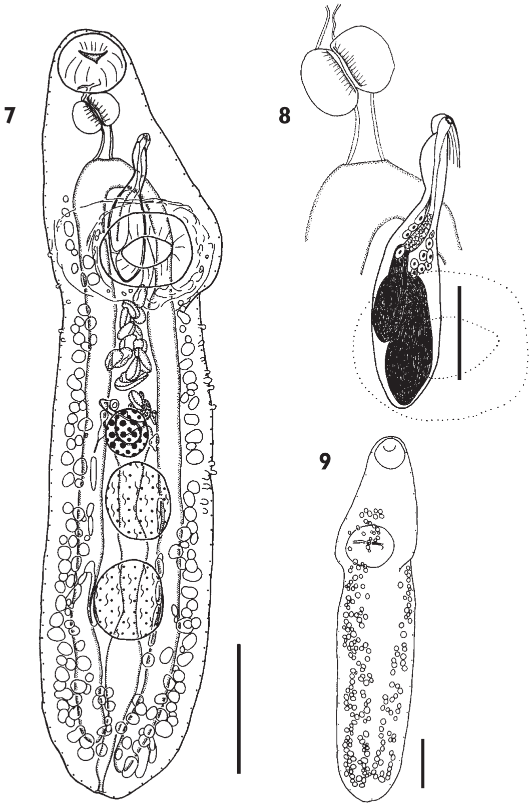
Type-host: *Sillago maculata* Quoy & Gaimard (Sillaginidae).
Type-locality: Off Tangalooma, Moreton Bay, S. E. Queensland. 27°14'S, 153°19'E.
Site: Intestine.
Material studied: 4 from Off Tangalooma, December 1993.
Type-material: Holotype: QM G230376, paratypes: QM G230377-230378, BMNH 2008.7.5.39.
urn:lsid:zoobank.org:act:5D0A5349-4643-4587-B3FB-04CD482451D0
Description (Figs 7-9)

Based on 4 gravid, whole-mount specimens from *Sillago maculata*. Measurements are of 4 gravid, unflattened whole-mount worms.

Body elongate oval; width recorded from area of gonads although greatest in region of the ventral sucker, 1440-1904 (1724) × 287-382 (346); width to length ratio 1:4.7-5.2 (5.0). Tegument with irregularly dispersed papillate structures. Oral sucker ventrally subterminal, sub-spherical, 109-154 (130) × 122-160(141). Ventral sucker larger than oral sucker, transversely oval, borne on slight eminence, in anterior third of body, 160-218 (189) × 192-237 (211); sucker width ratio 1:1.4-

1.6 (1.5). Forebody relatively short, 371-467 (414) long, 24.5-25.8 (24.9)% body-length. Prepharynx, indistinct, short, may be entirely dorsal or posterior to oral sucker. Pharynx well developed, sub-spherical, 77-102 (90) × 83-128 (107); pharynx to oral sucker width ratio 1:1.2-1.5 (1.3). Oesophagus short, thick walled. Intestinal bifurcation 55-104 (81) anterior to ventral sucker. Caeca terminate blindly close to posterior extremity.

Testes 2, entire, usually separate, occasionally contiguous (n=1), tandem, in posterior half of body, anterior 134-173 (154) × 128-154 (141); posterior 154-192 (170) × 125-173 (142). Post-testicular area 339-512 (426) long, 21.0-26.9 (24.5)% body-length. Cirrus-sac well developed, claviform, extends from point sinistral to oesophagus, overlapping ventral sucker dorsally usually to point just anterior to or level with its posterior margin, occasionally to ventral sucker aperture (n=1), 272-305 (294) × 71-78 (75). Internal seminal vesicle tubular; anterior portion narrower than posterior, loops once, occupies most of broad posterior portion of cirrus-sac. Pars prostatica distinct, narrow, surrounded by gland cells. Ejaculatory duct well developed, surrounded by numerous gland cells. Genital atrium distinct, small. Genital pore antero-sinistral to caecal bifurcation, may be level with posterior margin of pharynx, or on outer margin



Figs 7-9. *Macvicaria mekistomorphe* n. sp. ex *Sillago maculata*. 7. Whole-mount ventral view. 8. Terminal genitalia. 9. Dorsal distribution of vitelline follicles. *Scale bars*: 7, 9, 250 µm; 8, 100 µm.

of left caecum and more or less level with posterior limit of oesophagus, 220-298 (251) from anterior end, 13-16 (15)% of body-length.

Ovary entire, sub-spherical, anterior to and usually separated from anterior testis, occasionally contiguous with anterior testis (n=1), 90-134 (111) × 77-128 (101). Mehlis' gland feebly developed, anterior to ovary. Canalicular seminal receptacle large, saccular, elongate, oval, usually overlaps ovary dorsally, occasionally displaced entirely sinistral to ovary (n=1), may extend posteriorly to overlap anterior margin of anterior testis or terminate close to posterior margin of ovary. Laurer's canal present. Uterus coils intercaecally between anterior margin of ovary and posterior margin of ventral sucker, usually overlapping caeca dorsally and leading to genital pore without coiling. Eggs oval, operculate, 58-70 (63) × 26-29 (26). Metraterm indistinct. Vitelline follicles extend from 294-378 (336) from anterior extremity, 15.4-22.2 (19.7)% of body-length, to 38-67 (54) from posterior extremity; follicles feebly developed, particularly in forebody; fields mostly separate in hindbody, more or less confluent in post-testicular area dorsally and ventrally; follicles lie lateral to caeca mostly, with anterior limit at about level of intestinal bifurcation.

Excretory pore ventrally subterminal to terminal. Excretory vesicle I-shaped, anterior limit dorsal to posterior half of ovary, leads to pore through narrow duct.

Etymology: The species name (Gr. *mekistos*, longest; Gr. *morphe*, shape) is derived from the fact that this species is the most elongate worm in its group.

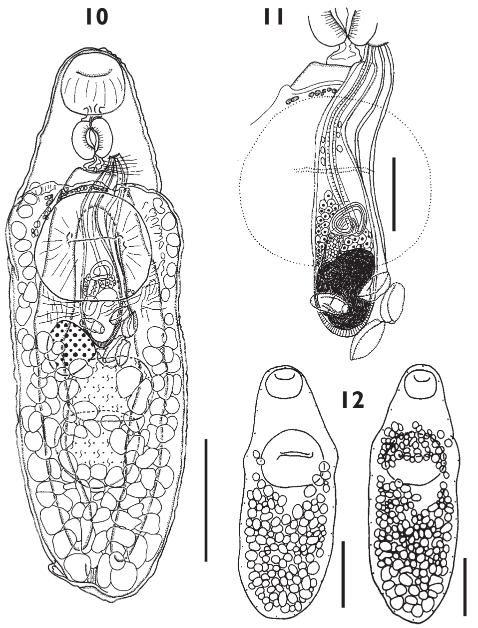
Comments: All the four specimens on which the description of *Macvicaria mekistomorphe* n. sp. was based were covered in irregularly dispersed papillate structures of unknown origin. Some of the structures appeared to contain nuclei, suggesting infection by a unicellular organism, whereas others appeared anucleate, suggesting the occurrence of tegumental papillae which may have been caused by fixation. Aside from the papillate structures, the vitelline follicles in all four specimens of this worm appeared to be poorly developed. It is not certain if the nature of the tegument is in any way related to that of the vitellarium or if the two conditions arose independently. None of the other *Sillago* species examined were infected by this worm, so it was not possible to determine whether or not the two features were characteristic of *M. mekistomorphe* n. sp. or if they were induced by the particular fish from which they were collected.

Macvicaria mekistomorphe fits into the concept of Group B as defined above. It can be distinguished from all the other species of *Macvicaria* in the group by its distinctly more elongate form, with a width to length ratio of 1:4.7-5.2 (5.0). The next most elongate species, *M. ophthalmolyci*, has a width to length ratio of 1:3.3-5.0 (4.1), but it can be distinguished from this and all other species in the group by its short forebody and large ventral sucker. The new species can be distinguished further from the other species by its usually separate testes and the ovary which is usually separated from and is more or less medially anterior to the anterior testis. The seminal vesicle in the new species is also distinctive as it forms a single loop medially. In the last feature, *M. mekistomorphe* resembles *M. taksengi*, which is less elongate, has a width to length ratio of 1:3.1, and has larger eggs (67-80 × 32-53).

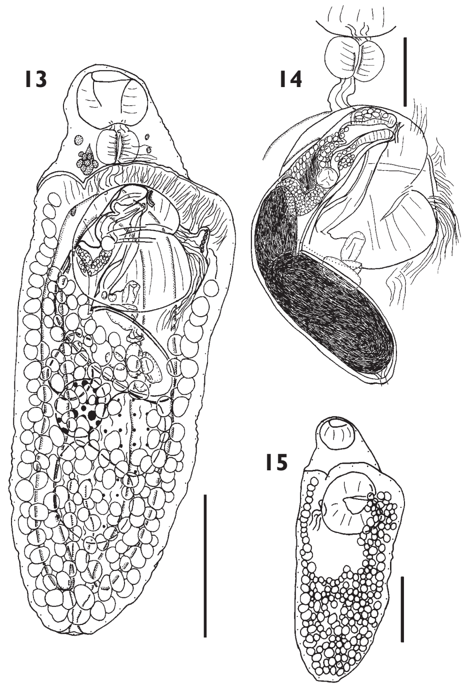
Macvicaria mutovitellina n. sp.
Type-host: *Dactylophora nigricans* (Richardson) (Cheilodactylidae).
Type-locality: Off Point Peron, Western Australia 32°18'S, 115°38'E.
Site: Intestine.
Material studied: 14 Off Point Peron, December 1994.
Type-material: Holotype: QM G230379, paratypes: QM G230380-230389, BMNH 2008.7.5.1-5.
urn:lsid:zoobank.org:act:604CFAD5-C948-4547-846D-47E9F8A10091
Description (Figs 10-15)

Based on 13 gravid, whole-mount specimens and 1 set of serial sagittal sections. Measurements are of 10 gravid, unflattened, whole-mount worms.

Body robust, elongate-oval, sub-cylindrical, tapered at anterior end, rounded at posterior end, lateral margins roughly parallel, 833-1,108 (962) × 296-393 (349); width to length ratio 1:2.5-3.0 (2.8). Oral sucker almost terminal, subglobular, 95-123 (110) × 116-148(131). Ventral sucker larger than oral sucker, transversely oval, 183-228 (203) × 207-261 (228); sucker width ratio 1:1.6-1.9 (1.7). Forebody contains few large and numerous small gland cells, 227-281 (261) long, 25-29 (27)% body-length.



Figs 10-12. *Macvicaria mutovitellina* n. sp. ex *Dactylophora nigricans*. 10. Whole-mount ventral view. 11. Terminal genitalia. 12. Dorsal distribution of vitelline follicles. *Scale bars*: 10, 12, 250 µm; 11, 100 µm.



Figs 13-15. *Macvicaria mutovitellina* n. sp. ex *Dactylophora nigricans*. 13. Whole-mount ventral view. 14. Terminal genitalia. 15. Dorsal distribution of vitelline follicles. *Scale bars*: 13, 15, 250 µm; 14, 100 µm.

Prepharynx distinct, short, partly posterior and partly dorsal to oral sucker. Pharynx large, sub-spherical, 63-80 (71) × 71-99 (81); pharynx to oral sucker width ratio 1:1.5-1.8 (1.6). Oesophagus distinct, short, thick walled. Intestinal bifurcation usually dorsal to anterior half of ventral sucker, 15-29 (21) posterior to anterior margin of ventral sucker, sometimes level with (n=4), and occasionally just anterior to anterior margin ventral sucker (n=1). Caeca terminate blindly close to posterior extremity.

Testes 2, transversely oval, tandem, contiguous, entire, anterior 101-159 (122) × 136-190 (172), posterior 133-167 (148) × 151-188 (174). Post-testicular area 138-246 (180) long, 15-22 (19) % body-length. Cirrus-sac large, clavate, thick walled especially at posterior extremity, extends from about level of posterior margin of pharynx to level of ovary or anterior testis; 306-388 (347) × 78-104 (88). Internal seminal vesicle convoluted, occupies posterior half or third of cirrus-sac. Pars prostatica distinct, well developed, surrounded by numerous gland cells. Ejaculatory duct long, convoluted at posterior end, thick walled, surrounded by few gland cells. Genital atrium small. Genital pore extra-caecal, antero-sinistral to intestinal bifurcation, usually anterior to posterior margin of pharynx, sometimes level with oesophagus (n=3), 169-231 (200) from anterior end, 20-22 (21)% of body-length.

Ovary entire, spherical to sub-spherical, usually contiguous with anterior testis, sometimes separate (n=2), usually antero-dextral to anterior testis, occasionally dextral (n=1), 81-111 (94) × 89-112 (103). Mehlis' gland distinct, sinistral to ovary, anterior to anterior testis. Canalicular seminal receptacle small, saccate, dorsal to anterior testis. Uterine coils usually extend from point just posterior to anterior margin of anterior testis to posterior margin of ventral sucker, overlapping left caecum ventrally and sometimes left side of ovary dorsally, occasionally coils extend to just anterior to posterior margin of anterior testis (n=1) or to posterior margin of posterior testis (n=1). Metraterm distinct, moderately long, well developed, overlaps left caecum to point just anterior to or just posterior to ventral sucker aperture. Eggs relatively large, tanned, usually few, oval, operculate, 54-71 (63) × 26-39 (31). Vitelline follicles extend from 173-314 (215) from anterior extremity, 17-34 (22)% body-length, to 8-19 (14) from posterior extremity; follicles in two separate fields in forebody ventrally, confluent in post-testicular area, covering almost all surface of posterior testis and posterior and or lateral portion of anterior testis and ovary ventrally; dorsal field almost confluent, interrupted in area of posterior half of ventral sucker, particularly in area of male terminal genitalia, sometimes follicles absent dorsally and ventrally (n=1) or feebly developed (n=2) in forebody; fields lie lateral, dorsal and ventral to caeca with unilateral or bilateral follicle-free patches in area of ventral sucker ventrally; anterior extent usually at level of posterior end of oesophagus, or posterior margin of pharynx, rarely at level of ventral sucker aperture (n=1).

Excretory pore terminal. Excretory vesicle I-shaped, with narrow posterior end, broadens and extends anteriorly to point just posterior to anterior margin of anterior testis as seen in sagittal section.

Etymology: The species name *mutovitellina* (L. *muto*, change; *vitellus*, yolk) is derived from the variable patterns of the distribution of vitelline follicles.

Comments: The distribution of vitelline follicles, posterior extent of cirrus-sac and arrangement of testes of *Macvicaria mutovitellina* n. sp. is characteristic of worms in Group C. The following species can be readily distinguished from *M. mutovitellina* and the other members of the group:

M. longicirrata is a more elongate form with the longest forebody, smallest ventral sucker and the smallest post-testicular space (Manter, 1963).

M. longisaccus is also an elongate worm which can be distinguished from *M. mutovitellina* by its larger pharynx with a pharynx to oral sucker width ratio of 1:1.3, its slightly larger ventral sucker with a ventral sucker/oral sucker width ratio of 1:2.1, its longer forebody at 37% of body-length and a shorter post-testicular space at 18.0% of the body-length (Fischthal & Kuntz, 1964)

M. gerridis has a body form similar to that of *M. mutovitellina,* a distinctly bipartite seminal vesicle and a shorter forebody (Fischthal & Thomas, 1970). The only other species of *Macvicaria* which is reported to have a bipartite seminal vesicle is *M. macassarensis* in Group E.

M. synagris is closest to *M. mutovitellina* from which it can be distinguished by its body shape, much longer oesophagus, more conspicuous prepharynx, relatively narrower oral sucker and larger ventral sucker with a sucker width ratio of 1:2.5, caeca which do not reach well beyond the posterior margin of the posterior testis, a more anteriorly situated genital pore and an ovary separated from the anterior testis by the seminal receptacle (Yamaguti, 1952). Furthermore, the vitelline follicles in the new species are more profuse, partly covering the ventral surface of the gonads and just entering the forebody anteriorly, whereas in *M. synagris* the ventral surface of the gonads is free of vitelline follicles which reach anteriorly to a point just posterior to the posterior margin of the pharynx and extend further anteriorly than in the new species.

M. jagannathi is a more elongate worm with a width length ratio of 1:4.7, a shorter forebody of about 20% of body-length, separated gonads, the cirrus-sac just encroaching into the hindbody and a greater distance between the ovary and the ventral sucker (Gupta & Singh, 1985).

M. longibursata has small eggs (42-40 × 26-35), is relatively elongate (width: length ratio 1:4.6-4.7) and the vitellarium reaches to the oral sucker (Zdzitowiecki & Cielecka, 1997).

M. deeghaensis is relatively elongate (width: length ratio 1:4.6-5.0), with a short forebody (about 17% of body-length), with separated gonads and a relatively long ventral sucker to ovary distance into which the cirrus-sac only encroaches slightly (Gupta & Gupta, 1988).

M. skorai is similar to *M. mutovitellina*, but may be slightly more elongate (width: length ratio 1:2.53-4.16), the vitellarium reaches to the pharynx and is confluent in the forebody, the testes are distinctly oblique and the ventral sucker to ovary distance is slightly greater (Zdztowiecki, 1999).

Macvicaria flexuomeatus n. sp.

Type-host: *Goniistius gibbosus* (Richardson) (Cheilodactylidae).
Other host: *Cheilodactylus rubrolabiatus* Allen & Heemstra (Cheilodactylidae).
Type-locality: Off Woodman Point, W. A. 32º08'S 115º45'E

Site: Gut, intestine.

Material studied: Ex *Goniistius gibbosus:* 17 from off Woodman Point, December 1994; Ex *Cheilodactylus rubrolabiatus:* 3 from off Woodman Point, December, 1994.

Type-material: Holotype: QM G230390, paratypes: QM G230391-230403, BMNH 2008.7.5.6-13.

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Description (Figs 16-20)

Based on 15 mature whole-mount specimens and 2 sets of serial sagittal sections from *Goniistius gibbosus.* Measurements of worms from *Cheilodactylus rubrolabiatus* are given in Table 2.

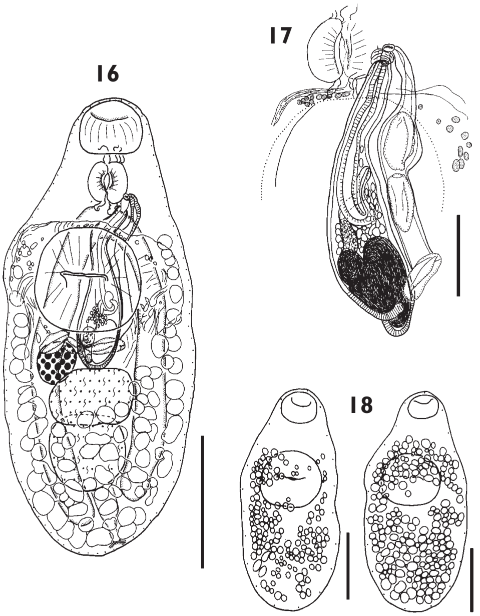
Measurements are of 10 gravid, unflattened whole-mount worms from *Goniistius gibbosus*. Body robust, oval, sub-cylindrical, maximum width in region of gonads, 688-1119 (904) × 316-481 (408); width to length ratio 1:2.1-2.4 (2.2). Oral sucker ventrally subterminal, subglobular, 90-118 (105) × 112-159 (133). Ventral sucker larger

Table 2. Measurements (in µm) of *Macvicaria flexuomeatus* n. sp. (n = 3) from *Cheilodactylus rubrolabiatus.*

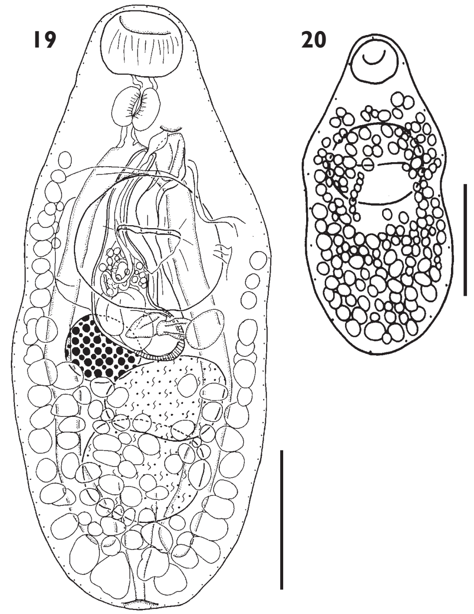
Total length	Min.	Max.	Mean
	675	824	755
Maximum width	305	384	340
Length/width	2.1	2.3	2.2
Oral sucker length	84	103	92
Oral sucker width (OSW)	107	113	109
Pharynx length	53	66	58
Pharynx width	60	68	63
OSW/pharynx width	1.7	1.8	1.8
Ovary width	62	96	84
Anterior testis length	81	134	109
Anterior testis width	119	160	144
Posterior testis length	108	128	119
Posterior testis width	125	156	137
Forebody-length (FBL)	187	220	206
FBL as % of body-length	26.7	27.7	27.3
Ventral sucker length	165	183	176
Ventral sucker width (VSW)	189	212	203
VSW/OSW	1.8	2.0	1.9
Anterior extremity to genital pore (AEGP)	153	166	158
AEGP as % body-length	18.6	23.0	21.1
Cirrus-sac length	256	289	275
Cirrus-sac width	74	83	78
Post-testicular region (PTR)	106	137	121
PTR as % of body-length	15.7	16.6	16.0
Anterior extremity to vitellarium (AEV)	157	178	166
AEV as % of body-length	21.2	23.3	22.0
Posterior extremity to vitellarium	8	16	12
Eggs	57-74 (64) × 25-42 (34), n=12		

than oral sucker, transversely oval, margin of anterior portion bordered by tegumental fold, supplied with numerous prominent muscle fibres, in anterior half of body, 169-234 (205) × 206-256 (232); sucker width ratio 1:1.6-1.9 (1.7). Forebody short, 205-297 (251) long, 26-30 (28)% body-length. Prepharynx distinct, short, almost entirely dorso-posterior to oral sucker. Pharynx well developed, spherical to sub-spherical, 67-86 (76) × 68-99 (83); pharynx to oral sucker width ratio 1:1.5-1.8 (1.6). Oesophagus short, thick walled, surrounded by few gland cells. Intestinal bifurcation usually posterior to anterior margin of ventral sucker, sometimes slightly anterior to (n=2) or level with anterior margin of ventral sucker (n=1). Caeca broad, terminate blindly close to posterior extremity.

Testes 2, rarely one (n=1), spherical to sub-spherical, contiguous, overlapping, usually tandem or oblique, sometimes neither distinctly tandem nor oblique (n=2), in posterior half of body, anterior 88-143 (118) × 125-200 (164), posterior 109-181 (145) × 112-221 (169), overlaps anterior testis dorsally. Post-testicular area small, 89-179 (137) long, 11-18 (15) % body-length. Cirrus-sac large, claviform, thick walled particularly at posterior end, extends from point antero-sinistral to pharynx, reaching past ventral sucker dorsally, usually medially, sometimes laterally, to anterior margin of anterior testis, usually deflecting to left side at level of ovary, sometimes deflecting to right (n=2), or not (n=1); posterior tip may overlap ovary or anterior testis dorsally, depressing anterior margin of anterior testis at point of contact or wedged between ovary and



Figs 16-18. *Macvicaria flexuomeatus* n. sp. ex *Goniistius gibbosus*. 16. Whole-mount ventral view. 17. Terminal genitalia. 18. Dorsal distribution of vitelline follicles. *Scale bars*: 16, 18, 250 µm; 17, 100 µm.



Figs 19-20. *Macvicaria flexuomeatus* n. sp. ex *Cheilodactylus rubrolabiatus*. 19. Whole-mount ventral view. 20. Dorsal distribution of vitelline follicles. *Scale bars*: 19, 20, 250 µm.

anterior testis; 314-404 (351) × 76-101 (91). Internal seminal vesicle, tubular, occupies posterior portion of cirrus-sac. Pars prostatica well developed, thick walled, surrounded by numerous gland cells. Ejaculatory duct long, thick walled, convoluted at posterior end, surrounded by gland cells. Male terminal genitalia absent in one specimen. Genital atrium small, surrounded by few gland cells. Genital pore sinistral, extracaecal, at level of posterior half of pharynx, usually about half way between median and lateral margin, sometimes overlapping left margin of pharynx (n=3); 157-220 (195) from anterior end, 20-23 (22)% of body-length.

Ovary entire, spherical, normally smaller than testes, hypertrophied and about twice size of solitary testis in one worm, contiguous with, and dextral or antero-dextral to anterior testis, occasionally separated from (n=2) or anterior to anterior testis (n=1), 66-110 (88) × 67-114 (89). Mehlis' gland distinct, dorsal to ovary. Canalicular seminal receptacle large, saccate, usually dorsal to anterior testis, overlapping anterior portion of posterior testis, occasionally overlapping ovary and posterior testis dorsally (n=1). Uterine coils mainly intercaecal, between anterior testis and posterior margin of ventral sucker, overlapping ovary, anterior testis and cirrus-sac ventrally and dorsally and, sometimes inner margins of caeca; coils may extend posteriorly to posterior margin of posterior testis (n=1) or anteriorly to posterior portion of ventral sucker (n=2). Metraterm distinct, thick walled, extensive, usually containing eggs, distal extremity surrounded by gland cells. Eggs large, oval, operculate, 50-75 (65) × 25-41 (32). Vitelline follicles extend from 163-247 (208) from anterior extremity, 21-27 (23)% of body-length, to 9-23 (13) from posterior extremity; fields separate ventrally in forebody, confluent in post-testicular area, covering almost all surface of posterior testis and posterior portion of anterior testis ventrally; dorsal field almost confluent throughout length, but interrupted in area of posterior half of ventral sucker, particularly in area of male terminal genitalia, sometimes follicles feebly developed on left or right side of forebody (n=2). Fields lie lateral, dorsal and ventral to caeca with bilateral follicle-free patches in area of ventral sucker ventrally; anterior extent of follicles usually level with posterior end of oesophagus, intestinal bifurcation or sometimes varying between posterior margin of ventral sucker and intestinal bifurcation, rarely to posterior margin of pharynx ventrally (n=1) or dorsally (n=2).

Excretory pore usually dorsally subterminal, sometimes terminal (n=4), or occasionally ventrally subterminal (n=1). Excretory vesicle I-shaped, tubular, posterior end narrow, anterior portion broad, extends anteriorly to terminate just anterior to posterior margin of anterior testis as observed in sagittal section.

Etymology: The species name *flexuomeatus* (L. *flexuosus*, full of bends; L. *meatus*, passage) is derived from the species' characteristic convoluted ejaculatory duct.

Comments: The specimens of *Macvicaria flexuomeatus* n. sp. from *Cheilodactylus rubrolabiatus* are very similar to those from *G. gibbosus*; no significant visible or morpho-metrical differences were observed.

Macvicaria flexuomeatus n. sp. fits the concept of Group C.

M. synagris differs in its general body form (fusiform in *M. synagris*), sucker-ratio (1:2.5), and a more anterior genital pore (13% of body-length from the anterior extremity).

Macvicaria mutovitellina is more elongate with a width to length ratio of 1:2.5-3.0 (2.8) and it has a longer post-testicular space (15-22 (19)% of the body-length). The caeca in *M. flexuomeatus* terminate just beyond the posterior margin of the posterior testis whereas they reach well into the post-testicular space in *M. mutovitellina*.

The other members of Group C differ from *M. flexuomeatus* in the same features as they do *M. mutovillina*.

Macvicaria vitellocopiosa n. sp.
Type-host: *Sillaginodes punctatus* (Cuvier) (Sillaginidae).
Type-locality: Off American River, South Australia 35°48'S, 137°46'E.
Site: Intestine, gut.
Material studied: 8 Off American River, December 1995.
Type-material: Holotype: QM G230404, paratypes: QM G230405-230414, BMNH 2008.7.5.14-19.
urn:lsid:zoobank.org:act:E89B7000-D733-4028-9B49-8314E0337519
Description (Figs 21-23).

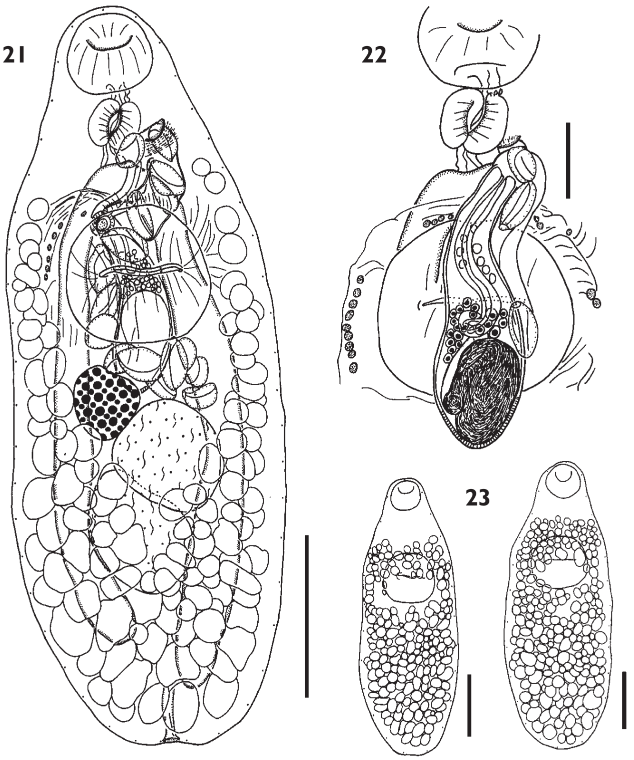
Based on 6 unflattened adult whole-mount specimens and 2 sets of serial sagittal sections and measurements of 5 gravid, unflattened, dorso-ventrally mounted worms.

Body oval, robust, sub-cylindrical, maximum width in region of gonads, 683-1,250 (978) × 254-475 (388); width to length ratio 1:2.4-2.7 (2.5). Oral sucker ventrally subterminal, subglobular, 96-142 (118) × 100-152 (130). Ventral sucker pre-equatorial, larger than oral sucker, transversely oval, 149-233 (192) × 162-267 (220); sucker width ratio 1:1.6-1.8 (1.7). Forebody 209-322 (274) long, 25-31 (28)% body-length. Prepharynx distinct usually entirely dorsal to oral sucker, sometimes posterior to ventral sucker (n=1). Pharynx well developed, large, spherical, 60-86 (76) × 62-93 (76); pharynx to oral sucker width ratio 1:1.6-1.8 (1.7). Oesophagus short, thick walled, surrounded by cluster of gland cells. Intestinal bifurcation almost level with anterior margin of ventral sucker, 3-37 (15) anterior to ventral sucker. Caeca broad, terminate blindly close to posterior extremity.

Testes 2, entire, usually more or less oblique, distinctly oblique in one specimen, contiguous, in posterior half of body, anterior often roughly triangular, 95-176 (147) × 108-212 (167), posterior 100-226 (161) × 131-200 (171). Post-testicular area 106-269 (181) long, 15-21 (18)% body-length. Cirrus-sac elongate, claviform, extends from point sinistral to pharynx, overlapping ventral sucker dorsally, to point posterior to posterior margin of ventral sucker, almost to anterior margin of anterior testis, thick walled, particularly at rounded posterior end, 241-449 (329) × 73-123 (95). Internal seminal vesicle tubular, occupies posterior third of cirrus-sac. Pars prostatica distinct, thick walled, surrounded by numerous gland cells. Ejaculatory duct long, thick walled, loops close to junction with pars prostatica. Genital atrium inconspicuous, small. Genital pore extra-caecal, antero-sinistral to intestinal bifurcation, at level of pharynx, 150-253 (209) from anterior extremity, 18-24 (22)% of body-length.

Ovary entire, subglobular, contiguously antero-dextral or dextral to anterior testis, 79-128 (106) × 70-130 (104). Mehlis' gland indistinct, sinistral to ovary, anterior to anterior testis, just posterior to posterior tip of cirrus-sac, usually obscured by eggs. Canalicular seminal receptacle large, saccular, elongate oval, may be dorsal to ovary, or mostly dorsal to anterior testis overlapping right side of posterior testis dorsally. Uterine coils few, mainly between anterior testis and ventral sucker, overlapping caeca ventrally and anterior testis and left side of ovary dorsally. Eggs large, oval, operculate, 53-83 (71) × 30-52 (40). Metraterm well developed. Vitelline follicles extend from 143-255 (201) from anterior extremity, 18-23 (21)% of body-length, to 18-23 (21) from posterior extremity; in 2 separate fields in forebody ventrally, confluent in post-testicular area and covering almost all surface of posterior testis and sides of anterior testis ventrally; dorsal field almost confluent, interrupted in the area of posterior half of ventral sucker only; lie lateral and dorsal to caeca and, ventral to caeca posterior to ventral sucker; anterior extent between posterior end of oesophagus and level of pharynx ventrally, almost to anterior margin of pharynx dorsally.

Excretory pore terminal. Excretory vesicle I-shaped, narrow posteriorly, widens anteriorly, anterior limit indiscernible in whole-mounts, terminates just posterior to anterior margin of anterior testis in sagittal section.



Figs 21-23. *Macvicaria vitellocopiosa* n. sp. ex *Sillaginodes punctatus*. 21. Whole-mount ventral view. 22. Terminal genitalia. 23. Dorsal distribution of vitelline follicles. *Scale bars*: 21, 23, 250 µm; 22, 100 µm.

Etymology: The species name *vitellocopiosa* (L. *vitellus*, yolk; L. *copiosa*, richly provided with) refers to the abundance of the vitelline follicles in the new species.

Comments: *Macvicaria vitellocopiosa* n. sp. can be accommodated in Group C. It is similar to *M. synagris*, *M. mutovitellina* and *M. flexuomeatus* in many features but can be distinguished from them as follows:

M. synagris is fusiform, it has a larger ventral sucker relative to the oral sucker with a sucker width ratio of 1:2.5; a slightly smaller post-testicular space, a more anteriorly situated genital pore, caeca which do not extend beyond the posterior margin of the posterior testis and it has shorter eggs (51-66 long) (Yamaguti, 1952).

M. flexuomeatus has a slightly less elongate form with a width to length ratio of 1:2.1-2.4 (2.2), a smaller post-testicular space at 11-18 (15)% of body-length and smaller eggs at 50-75 × 25-41 (65 × 32).

M. mutovitellina is a slightly more elongate form with a width to length ratio of 1:2.5-3.0 (2.8), with smaller eggs at 54-71 × 26-39 (63 × 31), a more conspicuous tegumental fold around the ventral sucker and less copious vitelline follicles..

M. skorai is more elongate with a width to length ratio of 1:2.5-4.2 (3.1), a shorter cirrus-sac that does not reach the ovary, short eggs at 43-55 × 23-35 and shorter caeca which terminate, apparently, near to the posterior margin of the posterior testis (Zdzitowiecki, 1999).

The other members of Group C differ from *M. vitellocopiosa* in the same features as they do *M. mutovillina* and *M. flexuomeatus*.

Macvicaria dextrocaula n. sp.

Type-host: *Notolabrus parilus* (Richardson) (Labridae).
Other host: *Notolabrus fucicola* (Richardson) (Labridae).
Type-locality: Off Point Peron, Western Australia 32°18'S, 115°38'E.
Other localities: Off North Mole, Western Australia 32°03'S, 115°43'E.; Off American River, South Australia 35°48'S, 137°46'E.
Site: Intestine.
Material studied: Ex *Notolabrus parilus:* 9 from off Point Peron Western Australia & from off North Mole, December 1994; Ex *Notolabrus fucicola:* 1 from off American River, South Australia, December 1995.
Type-material: Holotype: QM G230415, paratypes: QM G230416-230422, BMNH 2008.7.5.40-43.
urn:lsid:zoobank.org:act:313FE42B-9AFC-4B01-A471-99DAFDE6153F
Description (Figs 24-29)

Based on 11 gravid, unflattened dorso-ventrally and laterally mounted specimens and 1 set of serial sagittal sections from *Notolabrus parilus.* Measurements of worm from *Notolabrus fucicola* are given in Table 3.

Measurements are of 5 gravid, unflattened, dorso-ventrally mounted worms. Body elongate-oval, sub-cylindrical, sharply inflected dorsally in area of ventral sucker in lateral view, with maximum width in region of ventral sucker, 936-1,455 (1,202) × 295-466 (362); width to length ratio 1:3.2-3.6 (3.3). Oral sucker ventrally subterminal, sub-spherical, 129-169 (147) × 141-196 (164). Ventral sucker sub-spherical, close to mid-body, completely surrounded and almost completely enclosed by tegumental fold, 181-234 (212) × 197-276 (237), sucker-width ratio 1:1.4-1.5 (1.4) Forebody moderately long, 307-514 (408) long, 32-35 (34)% body-length. Prepharynx indistinct, short, always entirely dorsal to oral sucker. Pharynx well developed, subglobular, usually partly dorsal to oral sucker, rarely entirely dorsal to oral sucker (n=1); 49-65 (55) × 65-90 (79); pharynx to oral sucker width ratio 1:1.9-2.2 (2.1). Oesophagus short, thick walled. Intestinal bifurcation 96-222 (163) anterior to ventral sucker. Caeca terminate blindly close to posterior extremity.

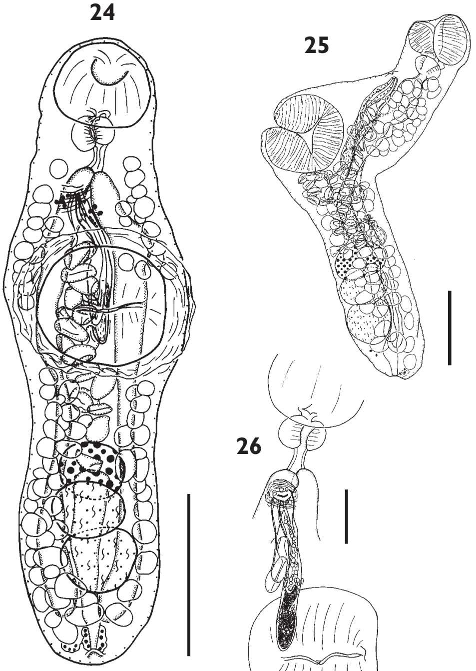
Testes 2, entire, subspherical, tandem, contiguous to overlapping, close to posterior end of body, anterior 63-132 (98) × 112-194 (147); posterior 85-148 (115) × 112-

Table 3. Measurements (in µm) of *Macvicaria dextrocaula* n. sp. (n = 1) from *Notolabrus fucicola*, Off American River, South Australia

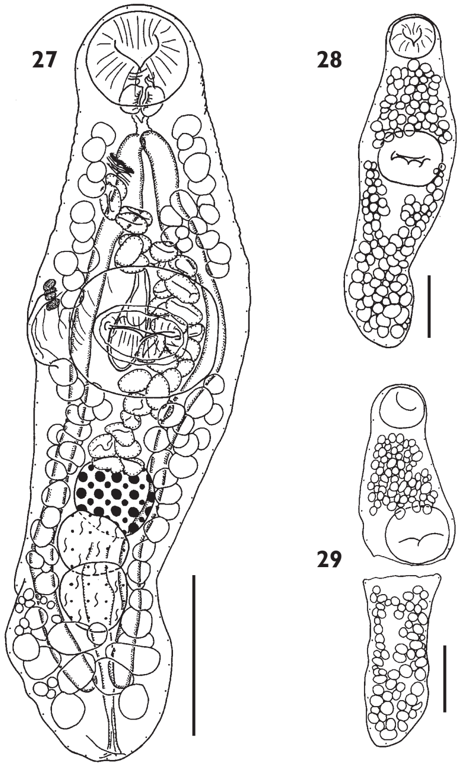
Total length	1,168
Maximum width	326
Length/width	3.6
Oral sucker length	140
Oral sucker width (OSW)	154
Pharynx length	51
Pharynx width	68
OSW/pharynx width	2.3
Ovary length	122
Ovary width	125
Anterior testis length	90
Anterior testis width	105
Posterior testis length	102
Posterior testis width	105
Forebody-length (FBL)	390
FBL as % of body-length	33.4
Ventral sucker length	190
Ventral sucker width (VSW)	219
VSW/OSW	1.4
Anterior extremity to genital pore (AEGP)	231
AEGP as % body-length	19.8
Cirrus-sac length	329
Cirrus-sac width	44
Seminal vesicle length	124
Seminal vesicle width	39
Intestinal bifurcation to ventral sucker	178
Post-testicular region (PTR)	201
PTR as % of body-length	17.2
Anterior extremity to vitellarium (AEV)	145
AEV as % of body-length	12.4
Posterior extremity to vitellarium	27
Eggs	49-56 (52) × 23-37 (31), n=8

196 (150). Post-testicular area short, 105-137 (127) long, 9.4-13(11)% body-length. Cirrus-sac well developed, tubular, long, slender, extends from just posterior to intestinal bifurcation overlapping right caecum to point anterior to or posterior to ventral sucker aperture, 226-366 (297) × 34-60 (43). Internal seminal vesicle, slender, tubular, occupies posterior half of cirrus-sac, posterior portion surrounded by prostatic cells. Pars prostatica small, inconspicuous, surrounded by few gland cells. Ejaculatory duct relatively long, with few prostatic cells in rows along its length. Genital pore dextrally sub-median, caecal to extracaecal, just posterior to intestinal bifurcation, surrounded by gland cells, 209-290 (240) from anterior end, 17 -24 (20)% body-length.

Ovary pretesticular, entire, subspherical, contiguously overlaps anterior testis, 90-139 (104) × 103-152 (127). Mehlis' gland distinct antero-dorsal to ovary. Canalicular seminal receptacle saccular, antero-dorsal to ovary. Uterus coils between anterior testis and posterior margin of ventral sucker, sometimes overlapping caeca; terminal portion usually crammed with eggs. Metraterm distinct, surrounded by gland cells. Eggs oval, operculate, 39-56 (48) × 22-34 (28). Vitelline follicles extend from 130-185 (162) from anterior extremity, 11-18 (14)% of body-length, to 8-24 (15.4) from posterior



Figs 24-26. *Macvicaria dextrocaula* n. sp. ex *Notolabrus parilus*. 24. Whole-mount ventral view. 25. Whole-mount lateral view. 26. Terminal genitalia. *Scale bars*: 24, 25, 250 μm; 26, 100 μm.



Figs 27-29. *Macvicaria dextrocaula* n. sp. ex *Notolabrus fucicola* and *N. parilus*. 27. Whole-mount ventral view. 28. Dorsal distribution of vitelline follicles. 29. Dorsal distribution of vitelline follicles (ex *N. parilus*). *Scale bars*: 27, 28, 29, 250 μm.

extremity; follicles in two separate fields ventrally, confluent dorsally in forebody with interruption in ventral sucker area; fields lie lateral, ventral and dorsal to caeca with anterior limit usually anterior to posterior margin of pharynx, sometimes level with posterior margin (n=2) or up to anterior margin of pharynx (n=1).

Excretory pore usually ventrally subterminal, occasionally dorsally subterminal (n=1). Excretory vesicle I-shaped, posterior end narrow, surrounded by gland cells, wider anterior portion passes anteriorly to overlap posterior third of ovary dorsally.

Etymology: The specific name *dextrocaula* (L. *dextra*, right; L. *caula*, opening) refers to the worm's dextrally located genital pore.

Comments: One of the characteristics of *Macvicaria* species is their sinistral, ventrolateral, caecal or extra-caecal genital pore (Bartoli, Bray & Gibson 1989). Since *M. dextrocaula* does not have a sinistral genital pore, like other members of the genus, the definition of *Macvicaria* is amended with respect to the position of the genital pore, to receive the new species as follows: *genital pore sinistral or dextral, ventro-lateral, caecal or extra-caecal.*

The specimens from *Notolabrus fucicola* are very similar to those from *N. parilus* except in the length of the post-testicular space, which is greater in the single worm from *N. fucicola*, 17.2% of body-length versus a maximum of 13.2% of body-length in the specimens from *N. parilus*. The specimen from *N. fucicola* also had slightly larger eggs than the worms from *N. parilus*. We interpret these slight differences either as induced by fixation or normal intraspecific variation.

Macvicaria dextrocaula can be accommodated in Group D as defined above. The new species can further be distinguished from the other species, apart from *M. georgiana*, by the distribution of the vitelline follicles which always reach further anteriorly, to the level of the pharynx, usually close to its anterior margin and from all other species by its strong dorsal inflection. *Macvicaria dextrocaula* differs from *M. heronensis*, *M. issaitschikowi* and *M. georgiana* by its smaller eggs.

Macvicaria heronensis Bray & Cribb, 1989

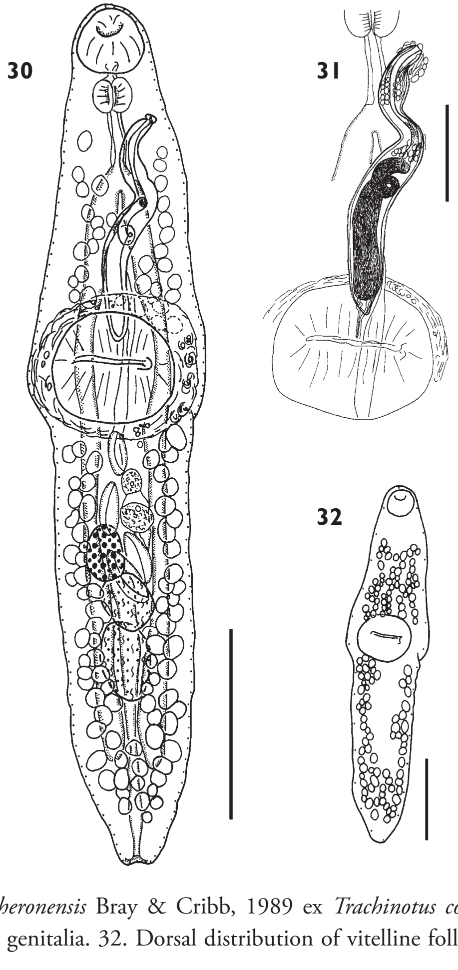
Host: *Trachinotus coppingeri* (Gunther) (Carangidae).
Locality: Off Point Lookout, Stradbroke Island, Queensland. 27°26'S, 153°32'E.
Site: Intestine.
Material studied: 1 from off Point Lookout, Stradbroke Island, Queensland.
Voucher specimen: QM G230423.
Description (Figs 30-32)

Based on 1 gravid unflattened whole-mount specimen. Measurements are of the single gravid, unflattened whole-mount.

Body fusiform, pointed at anterior and posterior ends, maximum width in region of ventral sucker; 1,101 × 243; width to length ratio 1:4.5. Oral sucker ventrally subterminal, sub-spherical, 78 × 88. Ventral sucker larger than oral sucker, transversely oval, protuberant, surrounded by tegumental fold, in posterior part of anterior half of body; 136 × 169, sucker-width ratio 1:9. Forebody moderately long, 389 long, 35.3%

body-length. Prepharynx distinct, short, almost entirely dorsal to oral sucker. Pharynx well developed, subglobular, 45 × 58; pharynx to oral sucker width ratio 1:1.5. Oesophagus distinct, moderately long. Intestinal bifurcation in anterior half of forebody, 156 anterior to ventral sucker. Caeca reach close to posterior extremity, terminate blindly. Excretory pore terminal. Excretory vesicle I-shaped, extends anteriorly to overlap posterior margin of ovary.

Testes 2, entire, sub-spherical, tandem, contiguous, in posterior third of body; anterior 58 × 71; posterior 97 × 65. Post-testicular area 207 long, 18.8% body-length. Cirrus-sac long, narrow, claviform, sigmoid anteriorly, thick walled, 266 × 39; extends from point just posterior to posterior margin of pharynx to overlap anterior margin of ventral sucker dorsally. Internal seminal vesicle tubular, long, narrow, loops anteriorly, occupies more than half of cirrus-sac. Pars prostatica distinct, small, surrounded by gland cells. Ejaculatory duct long, narrow, thick walled. Genital atrium small. Genital pore antero-sinistral to intestinal bifurcation, situated just posterior to posterior mar-



Figs 30-32. *Macvicaria heronensis* Bray & Cribb, 1989 ex *Trachinotus coppingeri*. 30. Whole-mount ventral view. 31. Terminal genitalia. 32. Dorsal distribution of vitelline follicles. *Scale bars*: 30, 32, 250 µm; 31, 100 µm.

gin of pharynx, closer to lateral margin of body than median line, 136 from anterior end, 12.4% of body-length.

Ovary pretesticular, entire, subspherical, contiguously antero-dextral to anterior testis, 65 × 55. Mehlis' gland indistinct. Canalicular seminal receptacle large, saccate, dorsal to ovary. Laurer's canal present. Uterus coils between anterior testis and posterior margin of ventral sucker, passes dorsally to cirrus-sac. Eggs large, oval, operculate, 68-84 (76) × 29-32 (31). Metraterm dorsal to ejaculatory duct. Vitelline follicles extend from 156 from anterior extremity, 14.2% body-length, to 39 from posterior extremity; follicles confluent dorsally in forebody and dorsally and ventrally in post-testicular area, in 2 separate fields ventrally in forebody; dorsal, ventral and lateral fields interrupted in ventral sucker area; fields lie lateral, ventral and dorsal to caeca; anterior extent level with genital pore.

Comments: Bray & Cribb (1989) described *Macvicaria heronensis* from the lethrinids *Lethrinus chrysostomus* and *Gymnocranius audleyi* [= *bitorquatus*] from off Heron Island. Barker *et al.* (1994) subsequently recorded it from the pomacentrid *Parma polylepis*. This is the third report, and for the first time, from a carangid in temperate waters. The worm in this study compares more or less favourably with the one figured as 9B in Bray & Cribb (1989), except that in our specimen the uterus extends posteriorly to overlap the anterior margin of the anterior testis, whereas in Bray & Cribb's specimens, the uterus reaches only to the anterior margin of the anterior testis and they mentioned that in three of their specimens, the uterus overlapped the anterior testis only slightly. The forebody in our worm is also slightly longer than in Bray and Cribb's worms, 35% versus 31-32% of the length of the body. These differences may simply extend the variation of *M. heronensis*, or may link it to *M. issaitschikovi*, whose uterus has been illustrated and described by Layman (1930), Yamaguti (1938) and Manter & Van Cleave (1951) as extending to the posterior edge of the anterior testis. Further comments on points of comparison between our worm and the worms described by Bray & Cribb (1989) should await examination of more specimens from temperate waters to determine whether or not more than one species is involved.

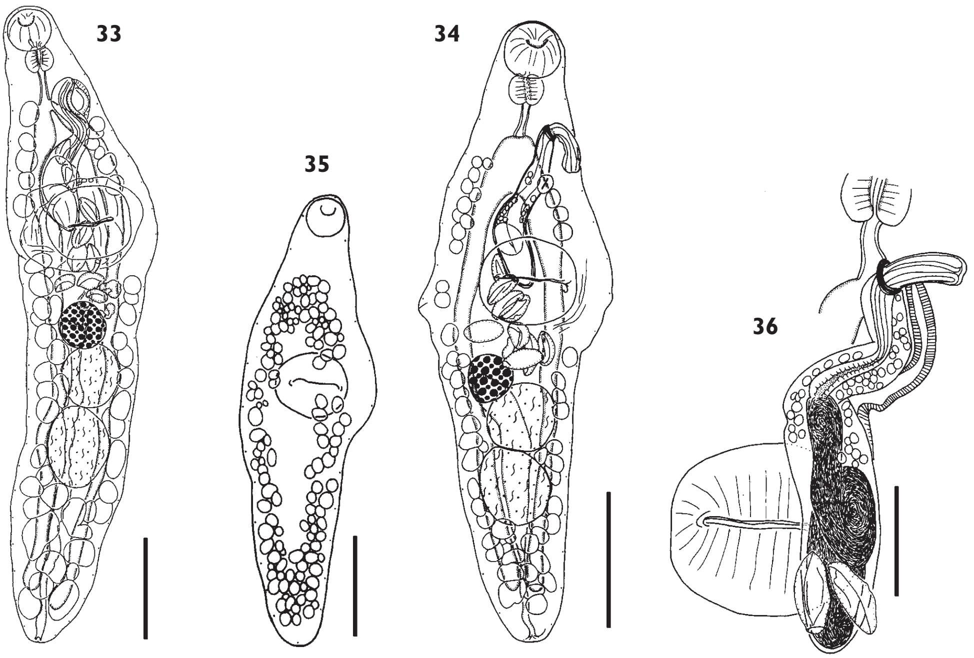
Macvicaria adomeae n. sp.

Type-host: *Sillaginodes punctatus* (Cuvier) (Sillaginidae).
Type-locality: Off American River, South Australia 35°48'S, 137°46'E.
Site: Gut.
Material studied: 9 Off American River, South Australia, December 1995.
Type-material: Holotype: QM G230424, paratypes: QM G230425-230427, BMNH 2008.7.5.44-45.
urn:lsid:zoobank.org:act:EBF2012C-678A-4BEA-8C97-5DE132F6AB60
Description (Figs 33-36)

Based on 8 unflattened, whole-mount specimens and 1 set of serial sagittal sections and measurements of 5 gravid unflattened whole-mount worms.

Body elongate, spindle shaped, maximum width in region of ventral sucker, 1,140-1,578 (1,315) × 302-363 (331); width to length ratio 1:3.4-4.3 (4.0). Oral sucker globular, opening ventrally subterminal, 88-104 (95) × 98-110 (113). Ventral sucker transversely oval, in anterior third of body, 158-179 (167) × 181-213 (101); sucker width ratio 1:1.8-1.9 (1.9). Forebody 358-456 (396) long, 27-35 (30)% of body-length. Prepharynx short, dorsal to oral sucker. Pharynx subglobular, 48-59 (55) × 60-70 (65); pharynx to oral sucker width ratio 1:1.5-1.6 (1.6). Oesophagus distinct, short. Intestinal bifurcation in forebody, 107-166 (134) anterior to ventral sucker. Caeca terminate blindly close to posterior extremity. Excretory pore ventrally subterminal.

Testes 2, oval, entire, contiguous to slightly separated, tandem, in posterior half of body, anterior 115-161 (136) × 121-145 (131), posterior 147-193 (166) × 121-159 (143). Post-testicular area 213-387 (300) long, 19-27 (23)% of body-length. Cirrus-sac elongate, clavate, thick walled, extends from point just posterior to posterior margin of pharynx, overlaps ventral sucker dorsally to its aperture (n=2), sometimes to level of (n=2) or posterior to posterior margin of ventral sucker (n=2), 303-412 (371) × 61-92 (74). Internal seminal vesicle tubular, sinuous, broadest at posterior end, fills broad posterior portion of cirrus-sac, surrounded by gland cells anteriorly. Pars prostatica distinct, thick walled, surrounded by gland cells. Ejaculatory duct long, thick walled. Genital atrium small. Genital pore antero-sinistral to intestinal bifurcation,



Figs 33-36. *Macvicaria adomeae* n. sp. ex *Sillaginodes punctatus*. 33. Whole-mount ventral view. 34. Whole-mount ventral view. 35. Dorsal distribution of vitelline follicles. 36. Terminal genitalia. *Scale bars*: 33, 34, 35, 250 µm; 36, 100 µm.

midway between lateral margin and oesophagus, usually with cirrus protruding, (n=4), 189-209 (199) from anterior end, 13-18 (15)% of body-length.

Ovary entire, spherical, contiguously anterior to or antero-dextral to anterior testis, 73-117 (89) × 78-115 (95). Mehlis' gland indistinct, usually anterior to ovary, occasionally sinistral (n=1) to ovary. Canalicular seminal receptacle saccular, usually dorsal (n=4), sometimes antero-dextral (n=1), or sinistral to ovary, overlapping left side of ovary and anterior portion of anterior testis (n=1). Laurer's canal present, opens dorso-sinistrally to ovary. Uterus coils intercaecally between anterior testis and ventral sucker, sometimes overlaps caeca ventrally, and ovary and testis dorsally, then passes to genital pore without coiling. Metraterm distinct, thick walled, overlaps left caecum. Eggs few, large, operculate, oval, 61-78 (70) × 28-50 (37). Vitelline follicles extend from 182-202 (194) from anterior extremity, 19-27 (23)% of body-length, to 11-38 (26) from posterior extremity; lateral fields may be continuous (n=3) or interrupted in ventral sucker area (n=3), ventral fields separate in forebody, and posteriorly to posterior margin of posterior testis, confluent or almost in post-testicular area; dorsal field confluent in forebody and post-testicular area always with continuous medial and sometimes bilateral or unilateral interruption in ventral sucker, uterine and gonad areas; follicles lie lateral, ventral and dorsal to caeca; anterior limit sometimes level with posterior end of oesophagus (n=3) or more anteriorly to point roughly level with mid-way between anterior and posterior ends of oesophagus (n=3).

Excretory vesicle I-shaped, with narrow posterior end surrounded by few gland cells, passes anteriorly to point dorsal to posterior third of ovary.

Etymology: This species is named for the mother of the first author.

Comments: *Macvicaria adomeae* n. sp. can be accommodated in Group D as outlined above and can be distinguished from other species as follows:

M. antarctica has a smaller pharynx, a shorter forebody at 26% of the body-length, a smaller post-testicular area and distinctly smaller eggs 42-51 × 20-28.

M. georgiana has vitelline fields reaching to the pharynx, a saccular internal seminal vesicle, a shorter forebody (according to the illustrations in Zdzitowiecki, 1997) and small knobs on the anopercular pole of the eggs.

M. issaitschikowi has a shorter forebody at 27% of the body-length, a slightly shorter post-testicular area of 19% of the body-length, a smaller pharynx, a larger ventral sucker, with a sucker width ratio of 1:2.61 versus 1:1.8-1.9 (1.9), smaller eggs 57-63 × 38-40, and its caeca terminate at about the level of the posterior margin of the posterior testis (Yamaguti, 1938) whereas they terminate well beyond the posterior margin of the posterior testis in *M. adomeae.*

M. muraenolepidis has a saccular internal seminal vesicle and smaller eggs (36-50 x 21-32) with small anopercular knobs.

M. heronensis can be distinguished by its slightly longer forebody at 35% of the body-length, a shorter post-testicular area at 19% of the body-length, longer and narrower eggs at 68-84 × 29-32 (76 × 31), the posterior extent of the uterus, the gonads which are situated more posteriorly and a genital pore closer to the anterior end.

Macvicaria kingscotensis n. sp.
Type-host: *Neoodax balteatus* Valenciennes (Odacidae).
Other host: *Haletta semifasciata* (Valenciennes) (Odacidae).
Type-locality: Off Kingscote, South Australia, 35°40'S, 137°39'E.
Other locality: Off American River, South Australia, 35°48'S, 137°46'E.
Site: Intestine.
Material Examined: Ex *Neoodax balteatus:* 6 from off Kingscote; Ex *Haletta semifasciata:* 2 from off American River, S.A, December 1995.
Type-material: Holotype: QM G230428, paratypes: QM G230429-230432, BMNH 2008.7.5.46-48.
urn:lsid:zoobank.org:act:014A738F-826F-4F1A-B425-FEBFF266A8B0
Description (Figs 37-42)

Based on 5 gravid, unflattened whole-mount specimens and 1 set of serial sagittal sections from *Neoodax balteatus*. Measurements of worms from *Haletta semifasciata* are given in Table 4. Measurements are of the 5 gravid, unflattened, whole-mounts from *Neoodax balteatus*.

Body elongate, fusiform, maximum width in area of ventral sucker or gonads, 1,067-1,447 (1,248) × 253-332 (282); width to length ratio 1:3.9-5.0 (4.4). Oral sucker ventrally subterminal, subglobular, 87-113 (97) × 101-118 (107). Ventral sucker larger than oral sucker, pre-equatorial, spherical to sub-spherical, 144-165 (155) × 155-188 (173); sucker width ratio 1:1.4-1.8 (1.6). Forebody contains numerous gland cells, 373-508 (425) long, 31-36 (34)% body-length. Prepharynx distinct, usually antero-dorsal to posterior margin of oral sucker, occasionally partially postero-dorsal. Pharynx large, sub-spherical, 53-65 (59) × 71-87 (77); pharynx to oral sucker width ratio 1:1.3-1.5 (1.4). Oesophagus distinct, well developed. Intestinal bifurcation in forebody, 114-180 (144) anterior to ventral sucker. Caeca terminate blindly close to posterior extremity.

Testes 2, entire, usually sub-spherical, occasionally irregular (n=1), contiguous, flattened at contiguity, tandem, in posterior half of body; anterior 120-165 (137) × 127-153 (144); posterior 159-203 (183) × 125-151 (134). Post-testicular space relatively short, 166-282 (217) long, 16-19 (17)% of body-length. Cirrus-sac clavate, long, thick walled, extends from point antero-sinistral to intestinal bifurcation to point level with or just posterior to ventral sucker aperture, 275-387 (322) × 43-51 (47). Internal seminal vesicle long, tubular; sinuous, looped and narrow at anterior end, broader at posterior end; occupies posterior portion of cirrus-sac. Pars prostatica distinct, narrow, surrounded by gland cells. Ejaculatory duct relatively long, thick walled, surrounded by gland cells. Genital atrium small. Genital pore extra-caecal, antero-sinistral to intestinal bifurcation, 168-222 (194) from anterior end, 15-16 (15.6)% of body-length.

Ovary usually entire, occasionally indistinctly lobed (n=1), sub-spherical, contiguously antero-dextral to anterior testis, flattened at contiguity, 98-108 (104) × 66-104 (84). Mehlis' gland distinct, dorso-sinistral to ovary. Canalicular seminal receptacle large, saccular, dorsal to ovary, overlapping anterior margin of anterior testis. Laurer's canal present. Uterus usually coils between point ventral and posterior to, or ventral to anterior margin of anterior testis and posterior margin of ventral sucker overlapping caeca and lateral and anterior margins of ovary, sometimes overlapping posterior margin of ventral sucker to its aperture (n=2), leads to genital pore without coiling. Metraterm distinct, surrounded by gland cells. Eggs large, oval, operculate, tanned, 59-83 (72) × 29-47 (35). Vitelline follicles extend from 159-216 (191) from anterior extremity, 13-20 (15)% of body-length, to 31-76 (46) from posterior extremity, with bilateral interruption in ventral sucker area; fields confluent dorsally and ventrally in post-testicular area and in forebody dorsally, separate ventrally in forebody; follicles lie lateral, ventral and dorsal to caeca; anterior limit may be just anterior to posterior end of oesophagus or posterior margin of pharynx or occasionally anterior to anterior margin of pharynx (n=1).

Table 4. Measurements (in µm) of *Macvicaria kingscotensis* n. sp. from *Haletta subfasciatus* (n=2).

Total length	Min.	Max.	Mean
	844	971	908
Maximum width	258	283	271
Length/width	3.3	3.4	3.4
Oral sucker length	80	80	80
Oral sucker width (OSW)	92	95	94
Pharynx length	48	53	51
Pharynx width	62	65	64
OSW/pharynx width	1.4	1.5	1.5
Ovary length	80	81	80.5
Ovary width	61	68	65
Anterior testis length	104	107	106
Anterior testis width	109	109	109
Posterior testis length	127	137	132
Posterior testis width	117	119	118
Forebody-length (FBL)	301	301	301
FBL as % of body-length	31.0	35.7	33.3
Ventral sucker length	141	144	143
Ventral sucker width (VSW)	127	148	138
VSW/OSW	1.4	1.6	1.5
Anterior extremity to genital pore (AEGP)	152	153	153
AEGP as % body-length	15.7	18.1	16.9
Cirrus-sac length	237	237	237
Cirrus-sac width	47	47	47
Intestinal bifurcation to ventral sucker	93	93	93
Post-testicular region (PTR)	153	156	155
PTR as % of body-length	15.8	18.5	17.1
Anterior extremity to vitellarium (AEV)	150	163	157
AEV as % of body-length	16.8	17.8	17.3
Posterior extremity to vitellarium	41	43	42
Eggs	71-77 (76) × 32-37 (34), n=5		

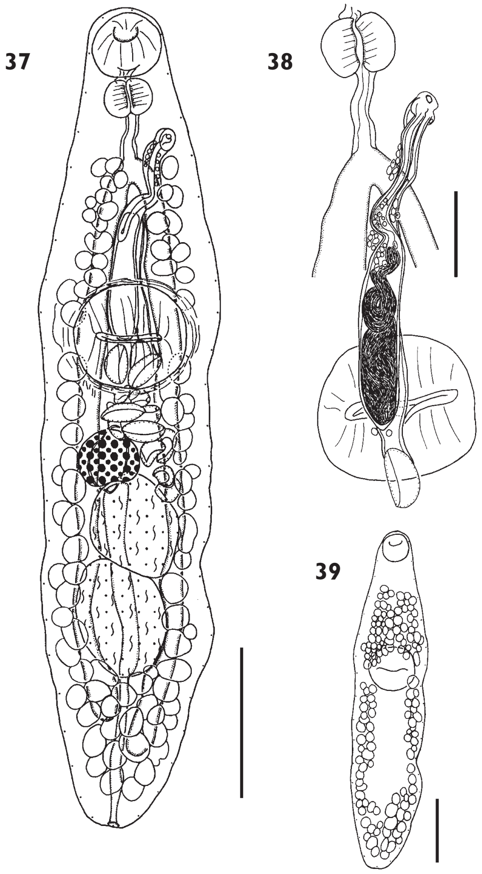
Excretory pore terminal. Excretory vesicle I-shaped; short terminal portion narrow, surrounded by few gland cells; anterior portion widens and passes anteriorly to point just posterior to anterior margin of anterior testis.

Etymology: This species is named after its type locality, Off Kingscote in South Australia.

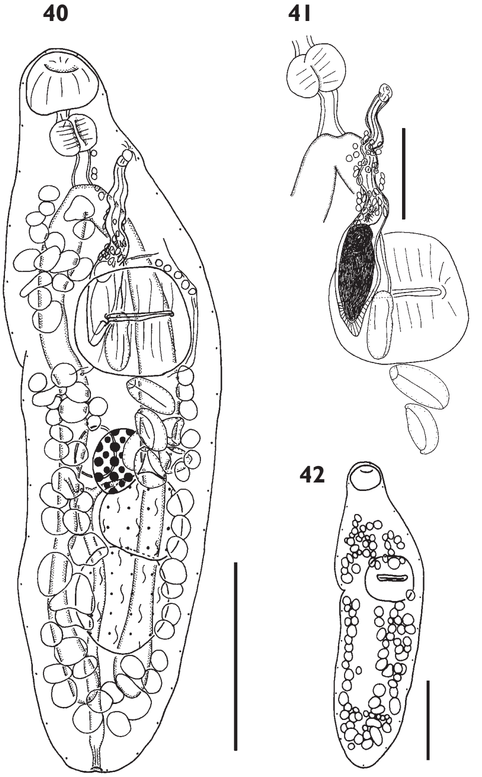
Comments: The worms from *Neoodax balteatus* are metrically very similar to those from *Haletta semifasciata*, but they are longer and more slender, having non-overlapping width to length ratios of 1: 3.9-5.0 (4.4) versus 3.3-3.4 (3.4), respectively. This difference could have been induced by fixation or the host in either case.

Macvicaria kingscotensis n. sp. has the morphological features of the worms in Group D, as outlined above. It can be distinguished from the other worms in Group D as follows:

M. antarctica has a smaller pharynx, its pharynx to oral sucker width ratio being 1:1.8-2.2 (1.92), a shorter forebody measuring 25% of the body-length, smaller eggs measuring 42-51 × 20-28 and a genital pore which is slightly more anteriorly situated.



Figs 37-39. *Macvicaria kingscotensis* n. sp. ex *Neoodax balteatus*. 37. Whole-mount ventral view. 38. Terminal genitalia. 39. Dorsal distribution of vitelline follicles. *Scale bars*: 37, 39, 250 µm; 38, 100 µm.



Figs 40-42. *Macvicaria kingscotensis* n. sp. ex *Haletta semifasciata*. 40. Whole-mount ventral view. 41. Terminal genitalia. 42. Dorsal distribution of vitelline follicles. *Scale bars*: 40, 42, 250 µm; 41, 100 µm.

M. adomeae can be distinguished by its larger ventral sucker which is reflected in a sucker width ratio of 1:1.8-1.9 (1.9) and by its fusiform body-shape.

M. georgiana has vitelline fields reaching the pharynx, a saccular internal seminal vesicle, a shorter forebody (according to the illustrations in Zdzitowiecki, 1997) and small knobs on the anopercular pole of the eggs.

M. heronensis has a larger ventral sucker, with a sucker width ratio of 1:1.9, slightly longer eggs at 68-84 × 29-32 (76 × 31), a genital pore situated slightly more anteriorly (12.4% of the body-length from the anterior extremity) and the ovary is more distant from the ventral sucker.

M. muraenolepidis has a saccular internal seminal vesicle and small eggs (36-50 × 21-32) with small anopercular knobs.

Discussion

All of the hosts reported in this paper are endemic to Australian or Australian and New Zealand waters, apart from *Apogon fasciata*, the type-host of *M. shotteri*, which is widespread in the Indo-West Pacific. The level of marine fish endemicity is high in the waters off southern Australia (about 85% at the species level according to Wilson & Allen, 1987), so it would not be surprising if the parasites are similarly endemic. Manter (1967) estimated 95% species endemicity in southern Australia marine fish digeneans and Bray et al. (1999) estimated that species of the digenean family Lepocreadiidae Odhner, 1905 showed about 83% endemicity in southern Australia, and if those also found in New Zealand are taken into account the level of endemicity rises to about 92%. Our knowledge of the large opecoelid fauna of Australia is rudimentary, but the results presented here indicate similar levels of endemicity in the genus *Macvicaria*, at least. Of the eleven species reported so far from Australian waters only one, *M. macassarensis*, has been reported from elsewhere (off Sulawesi). In this paper we record *M. heronensis* in Australian temperate waters for the first time, but its newly reported host, *Trachinotus coppingeri* is restricted to eastern Australia, including the Great Barrier Reef, the site of the previous findings of this parasite. The host of *M. dampieri*, *Pseudorhombus jenynsi*, is the only non-perciform host reported for *Macvicaria* in Australian waters: it is said to inhabit 'most coasts of Australia' (Froese & Pauly, 2008). *Notolabrus fucicola*, one of the hosts of *M. dextrocaula* n. sp., is found off New Zealand in addition to southern Australia and all other hosts reported for new species in this paper are restricted to southern Australia, including the southern parts of Western Australia, the south-eastern states and Tasmania. Thus of the eleven species so far reported from Australian waters, ten (91%) are likely to be endemic.

Acknowledgements

We thank the Australian and Nigerian governments, Ahmadu Bello University, Zaria, Nigeria and the Australian Biological Resources Study for financial support. We also thank Drs Alistair Dove and Sylvie Pichelin, and Trudy Wright and Scott Burge for assistance in the field. Special thanks are due to Dr Richard Pyle (Bishop Museum, Honolulu) for registration of names, authors and current article in ZooBank.

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ZooKeys 1: 59-66 (2008)
doi: 10.3897/zookeys.1.10
www.pensoftonline.net/zookeys

RESEARCH ARTICLE

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A new candidate for a Gondwanaland distribution in the Zodariidae (Araneae): *Australutica* in Africa

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Academic editor: *Dmitry Logunov* | Received 17 June 2008 | Accepted 1 July 2008 | Published 14 July 2008

urn:lsid:zoobank.org:pub:664C49F1-5384-43C4-8BF1-CE76AC11D32E

Citation: Jocqué R (2008) A new candidate for a Gondwanaland distribution in the Zodariidae (Araneae): *Australutica* in Africa. ZooKeys 1: 59-66. doi: 10.3897/zookeys.1.10

Abstract

Two new species of *Australutica* Jocqué, 1995, a genus formerly only known from Australia, are described from South Africa: *A. africana* **n. sp.** from Soutpansberg and *A. normanlarseni* **n. sp.** from the Cape Peninsula. The taxonomic position of the new species is discussed and a key to the species of *Australutica* is provided.

Keywords

New species, Gondwanaland, Soutpansberg, Araneae

Introduction

The typical Gondwanaland distribution with representatives in three continents, Africa, Australia and South America, often restricted to the southern parts of the continents, is a well known and relatively common phenomenon of vicariance. In the spider family Zodariidae only one example is known. The genus *Cyrioctea* Simon has been found on all three the continents and as expected only in the southern parts (Platnick & Griffin, 1988; Platnick & Jocqué, 1992). Other transcontinental distribution patterns like those of the zodariid genera *Mallinella* Strand and *Asceua* Thorell have a completely different origin and are the result of dispersion (Jocqué, 1993).

The best candidates for a Gondwanaland distribution are ancestral taxa (Jocqué, 1991), which is the case for *Cyrioctea* and the representatives of the subfamily Lachesaninae. A combination of plesiomorphic characters in this subfamily are the chelicerae with dense frontal cover of setae; cheliceral teeth; fangs which are longer than wide at the base; the eyes in two rows; the abdomen with a complex dark pattern and one of the main synapomorphies are the long, cylindrical and retractile anterior lateral spinnerets.

In 1995, Jocqué described the genus *Australutica* for four Australian species characterized by numerous spines on the anterior legs. Recently two species of *Australutica* were found in South Africa, both in areas with a high degree of endemicity. The first species is from the Soutpansberg, the second from the Cape Peninsula. Both these areas can be considered as conservative. The Soutpansberg is one of the oldest formations in southern Africa and it is assumed that this geomorphologic feature was created by faulting that occurred about 150 Ma ago (Haddon & McCarthy, 2005; Ranganai et al., 2002) and that during the last ± 60 Ma, erosion formed the landscape as we see it today (Partridge & Maud 2000). The Soutpansberg species occurs in open woodland with grassy and rocky patches. The Cape Peninsula species was collected from dunes. Dunes and shorelines are among the most conservative biomes on earth because of their unaltered structure, independent from major shifts in vegetation cover occurring in other biomes (Jocqué, 2001). Of all the genera in the two ancestral zodariid subfamilies Cyriocteinae (*Cyrioctea*) and Lachesaninae (*Lachesana*, *Antillorena* Jocqué, *Australutica*, *Lutica* Marx) at least one species in each genus occurs in sandy desert areas or on beaches along the coast. The presence of *Australutica* in the sandy dunes of the Cape Peninsula is therefore a corroboration of this finding.

Material and methods

All measurements are in mm.

Specimens were observed and measured with a Leica M10 stereomicroscope. Photographs were taken with Leica MZ16 and the LAS automontage software.

Abbreviations:

NCA: National Collection of Arachnida, ARC-Plant Protection Research Institute (Pretoria); ALE: anterior lateral eyes; AME: anterior median eyes; AW: anterior width; F: femur; L: length; MRAC: Royal Museum for Central Africa (Tervuren); Mt: metatarsus; P: patella; PLE: posterior lateral eyes; PME: posterior median eyes; PW: posterior width; RTA: retrolateral tibial apophysis; SAM: Iziko South African Museum (Cape Town); t: tarsus; T: tibia.

Taxonomic position

Australutica (urn:lsid:zoobank.org:act:10E438FC-8313-45DA-869C-7EA25BAB0DEE) belongs to the Lachesaninae and was so far believed to be restricted to Australia. The species described in this paper occur in an area with a very high diversity of

Zodariidae, mainly belonging to the subfamily Cydrelinae which has its diversity in southern Africa. A recent phylogenetic analysis of the Zodariidae (Jocqué, in preparation) shows that the *Cydrela* Thorell is at the base of the Cydrelinae but shares a number of characters with the Lachesaninae. Among these are cylindrical and retractable anterior lateral spinnerets and a male palpal cymbium with dispersed thin spines. However, there are numerous characters that separate *Australutica* and *Cydrela* (Table 1).

The inclusion of the new species in *Australutica* is supported by the following diagnostic characters: eye rows slightly procurved; prosoma yellow with darker pattern; abdomen with poorly delimited complex pattern; chelicerae with teeth; length of cheliceral fangs about three times width at base and spiniform scopulae on tarsi. The structure of the male palp differs in the absence of the median apophysis in the Australian species but this is a phenomenon found in several zodariid genera where species with and without this apophysis occur. On the other hand, the apophysis at the base of the embolus is a remarkable synapomorphy of *Australutica* supporting the inclusion of the African taxa in this genus. It should be noted that the similarities concern the type species *A. moreton* Jocqué and not *A. quaerens* Jocqué, one of the other Australian species, which was only tentatively included in the genus (Jocqué, 1995) as it lacks some of the synapomorphies.

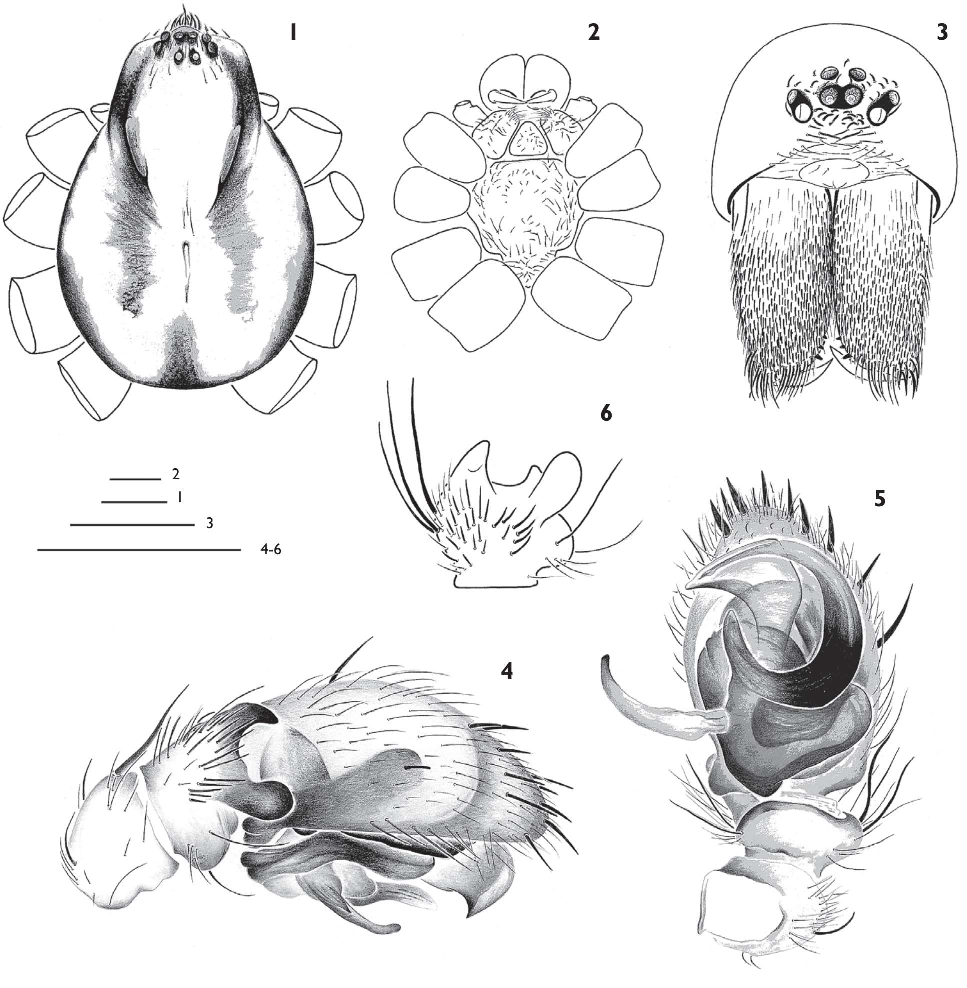
Key to the species of *Australutica*

Note: only the female of one species of *Australutica* is known: *A. xystarches* Jocqué, 1995. Females are thus not considered in this key.

1. Retrolateral tibial apophysis (RTA) with a dorsolateral and a ventrolateral prong (Fig. 6) 2
– RTA with one prong only 3
2. Ventrolateral prong of RTA rounded; median apophysis tapered and smoothly curved .... *A. africana* n. sp.
– Ventrolateral prong of RTA pointed; median apophysis widened medially and strongly curved at tip (Fig. 10) .... *A. normanlarseni* n. sp,
3. RTA strongly bent down at tip; embolus turning clockwise on right palp .... *A. quaerens* Jocqué
– RTA hardly bent; embolus turning anticlockwise on right palp 4
4. RTA with broad base with almost parallel sides; abdomen with a large dark central patch wider in posterior half .... *A. moreton* Jocqué
– RTA gradually tapered from base to tip; abdomen with two rows of small transverse stripes .... *A. manifesta* Jocqué

Table 1. Principal differences between *Australutica* and *Cydrela*

	Australutica	*Cydrela*
Eyes	2 rows	3 rows
Sternum	elongate	Broad
Precoxal sclerites	absent	1 pair
Chelicerae	with teeth on promargin	without teeth on promargin
Cheliceral fang	three times as long as wide at base	twice as long as wide at base
Anterior legs	densely spinated	with few spines
Scopula	dense spiniform scopula	no scopula



Figs 1-6. *Australutica africana* n. sp. male 1. cephalothorax, dorsal view; 2. cephalothorax, ventral view; 3. cephalothorax, frontal view; 4. right male palp, retrolateral view; 5. right male palp, ventral view; 6. right male palpal tibia, dorsal view. (scale bars: 0.5 mm).

Descriptions

Australutica africana n. sp.
urn:lsid:zoobank.org:act:40BD6CA4-1A94-445F-9CDA-BE42EFF39DB6
Figures 1-7

Type material Holotype: male: South Africa, Limpopo Province, Soutpansberg, Lajuma, 23°02'29"S 029°26'45"E, 17.XI.2004, pitfalls in woodland, M. Mafadza (NCA 2006/1002).

Paratypes: 4 ♂: together with holotype (1 ♂ in MRAC 223765).

Other material examined None.

Diagnosis Males of this species are recognized by the slightly swollen tibiae and metatarsi I, with spiniform scopulae on tarsi I and by details of the palp: the inferior prong of the RTA is rounded; the distal tegular apophysis is very large and has an angular prolateral edge; the median apophysis is tapered towards the tip.

Etymology This species is the first representative of the genus on the African continent.

Description Male: total length 5.00 mm; carapace 2.68 mm long, 1.88 mm wide, TI + PI: 1.92.

Colour: carapace yellow, darkened along margin and with two black longitudinal bands and a black spot behind the fovea (Figs 1, 7); fovea orange. Sternum pale yellow, slightly suffused with black along lateral margins. Chelicerae brownish yellow. Legs yellow except femora with broad dark distal rings on all pairs and smaller dark patches at the base of posterior pairs; tibiae with faint darker suffusion on sides. Abdomen pale; dorsum with faint darker pattern delimiting pale chevrons on posterior part. Spinnerets pale yellow.

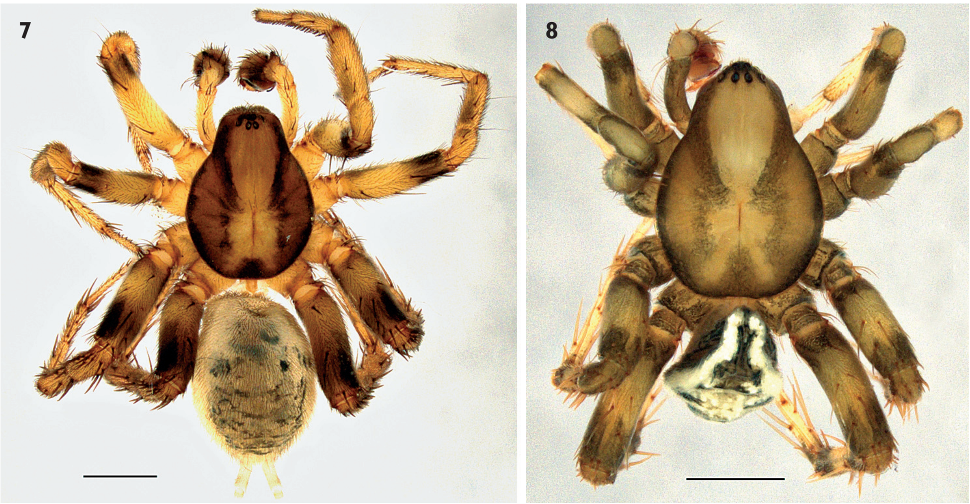
Carapace smooth; in profile slightly elevated in cephalic area; with cluster of short setae in front of anterior eyes and in median ocular area (Fig. 3).

Eyes: AME: 0.08; ALE: 0.10; PME: 0.08; PLE: 0.08; AME-AME: 0.05 AME-ALE: 0.05; PME-PME: 0.05; PME-PLE: 0.10. MOQ: AW = 1.00 PW; AW = 0.87 L; clypeus 0.15 mm high or 1.8 times diameter of ALE. Sternum: 1.12 mm wide, 1.32 mm long (Fig. 2). Chilum single, oval, with a few setae: 0.26 mm wide, 0.08 mm high. Chelicerae with dense cover of setae (Fig. 3), fang three times as long as wide at base, promargin with three teeth.

Legs fairly short. Tarsi all cylindriform, with strong spiniform scopulae sensu Jocqué 1991 (p. 13). Metatarsi I with spiniform setae. Tibiae I and metarsi I slightly swollen. Spines numerous on anterior legs, very numerous and long on posterior ones.

Spination:

	Fe	P	T	Mt	t
I	pl1d1-1-2rl1	–	pl3v1-2-2	pl1rl1v1-2	–
II	d1-1-2rl1	pl1	pl3v1-2-2	pl1rl1v2-1-2	–
III	pl1d1-1-1-2	pl5d4-1rl2	pl1-1-1d1-1-2rl3v1-1-2	10disp dw6	10disp
IV	d1-1-1-1-2	pl5d1-1rl2	pl1-1d1-1-1r13v1-1-2	14disp dw6	12disp



Figs 7-8. 7. *Australutica africana*, male habitus, dorsal view; 8. *Australutica normanlarseni*, male habitus, dorsal view. (scale bars: 0.5 mm).

Palp (Figs 4-6): Cymbium with dispersed thin spines. Tibia with well developed retrolateral apophysis with two short prongs curved towards each other, dorsal one with sharp, inferior one with rounded tip; tegulum broad, sclerotized at base; base of sickle shaped embolus with long prong pointing forward, covering base of terminal distal apophysis which is widened towards tip; median apophysis tapered towards extremity.

Female unknown.

Distribution Only known from type locality.

Australutica normanlarseni n. sp.
urn:lsid:zoobank.org:act:C9D7C09A-90E6-4649-88A6-150443B66C75
Figures 8-10

Type material Holotype: male: South Africa, Western Cape Province, Cape Peninsula, Kommetjie, 34°18'S 18°24'E, 22.XII.1992, on white dune sand on koppie, N. Larsen (SAM C 2593).

Other material examined None.

Diagnosis Males of this species are recognized by the details of the palp: both the prongs of the RTA are sharp, the distal tegular apophysis has a rounded prolateral edge and the median apophysis is fairly broad, somewhat enlarged in the middle and with a short sharp turn at the end.

Etymology Named after Norman Larsen, a dedicated collector of spiders who found the holotype, the only specimen of this species so far known.

Description Male: total length 3.60 mm; carapace 2.36 mm long, 1.72 mm wide, TI + PI: 1.60.

Colour: carapace pale yellow strongly suffused with black on sides leaving a pale central pattern (Fig. 8); fovea orange. Sternum pale yellow, broadly suffused with black along lateral margins. Chelicerae brownish orange. Legs pale yellow, femora and tibiae with distal and proximal black ring, patellae dark on sides; tarsi and metatarsi pale yellow. Abdomen white on dorsum with dark pattern consisting of dark frontal mark followed by two pairs of black spots and dark transverse stripe in front of spinnerets; sides dark; venter brownish orange. Spinnerets pale yellow.

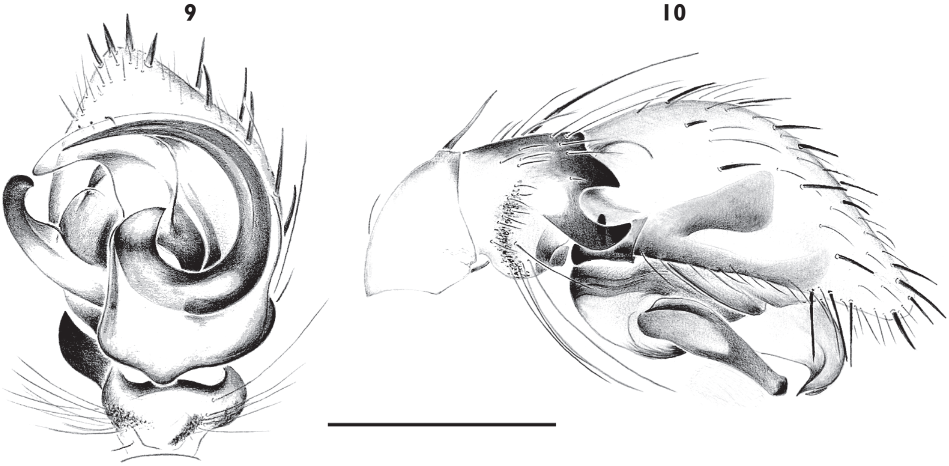
Carapace smooth; in profile slightly elevated in cephalic area; with cluster of short setae in front of anterior eyes.

Eyes: AME: 0.08; ALE: 0.08; PME: 0.08; PLE: 0.08; AME-AME: 0.05 AME-ALE: 0.05; PME-PME: 0.07; PME-PLE: 0.10. MOQ: AW = 0.93 PW; AW = 0.87 L; clypeus 0.18 mm high or 2.2 times diameter of ALE. Sternum: 1.00 mm wide, 1.12 mm long. Chilum single, roughly oval with a few setae: 0.52 mm wide, 0.11 mm high. Chelicerae densely covered with setae, with one tooth on promargin; fang almost three times as long as wide at base.

Legs fairly short. Tarsi all cylindriform, with strong spiniform scopulae sensu Jocqué 1991 (p. 13). Spines numerous on anterior legs, very numerous and long on posterior ones.

Spination:

	Fe	P	T	Mt	t
I	d1-1-1-2rl1	d1	pl1d1-1v2-2-2	pl1rl1v2 group 15 dw4	–
II	d1-1-1-2rl1	pl1	pl1d1-1v1-2-2	pl1d1rl1cv2-2-1 dw4	–
III	pl1d1-2-1-2	pl5d3rl2	pl1-1-1d2-1-1r1-1v2-2-2	12disp dw6	pl5rl1
IV	pl1d1-2-1-1-2	pl5d3rl2	pl1-1-1d2-1r1-1v1-2-2	14disp dw6	pl3rl1



Figs 9-10. *Australutica normanlarseni* n. sp. male 9. right male palp, ventral view; 10. right male palp, retrolateral view. (scale bar: 0.5 mm).

Palp (Figs 9-10): Cymbium with dispersed thin spines. Tibia with well developed lateral apophysis with two short prongs curved towards each other, both with sharp tip; tegulum broad, membranous at base; base of sickle shaped embolus with triangular tip pointing forward, covering base of terminal distal outward curved apophysis; median apophysis fairly broad, somewhat enlarged in the middle and with short sharp turn at extremity.

Female unknown.

Distribution Only known from type locality.

Acknowledgments

I am indebted to Alain Reygel for the marvelous drawings. I thank Ansie Dippenaar-Schoeman (National Collection of Arachnida, Pretoria) and Margie Cochrane (SAM) for the loan of the material. Norman Larsen is thanked for the effort he made to collect dune spiders on the Cape Peninsula and put them at my disposal for study. Stefan Foord provided some information on the geological history of the Soutpansberg. I thank Wouter Fannes for comments on a first draft of the paper.

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ZooKeys 1: 67-71 (2008)
doi: 10.3897/zookeys.1.17
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SHORT COMMUNICATION

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The giant resin bee making its way west: First record in Kansas (Hymenoptera: Megachilidae)

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Academic editor: *Michael S. Engel* | Received 25 July 2008 | Accepted 29 July 2008 | Published 30 July 2008

Citation: Hinojosa-Díaz IA (2008) The giant resin bee making its way west: First record in Kansas (Hymenoptera: Megachilidae). ZooKeys 1: 67-71. doi: 10.3897/zookeys.1.17

Abstract

The invasive giant resin bee (*Megachile sculpturalis* Smith) was first discovered in North America in 1994. A 2005 study provided the first predictive ecological niche model for any bee species and concluded that *M. sculpturalis*, then confined to the eastern United States, would eventually spread as far south as southern Florida, as far north as southern Ontario and Nova Scotia, and as far west as South Dakota, western Kansas, and northwestern Texas. Herein I provide the first record of *M. sculpturalis* from northeastern Kansas, documenting that the species has indeed continued its westward expansion in North America and the new available records entirely correspond to the earlier predictions.

Keywords

Invasive species, bees, Anthophila, Apoidea, potential distribution, ecological modeling

Introduction

The giant resin bee, *Megachile* (*Callomegachile*) *sculpturalis* Smith, a distinctive bee native to eastern Asia (China, Japan, Korea, and Taiwan: Iwata 1933, Wu 2005, and records in the American Museum of Natural History and University of Kansas Natural History Museum), has become adventive in the eastern United States since its presumably accidental introduction sometime in the early 1990's (Batra 1998, Mangum & Brooks 1997). The species was first collected in North Carolina in 1994, and it has since then steadily spread such that by 1999 it had already reached central Ohio (Mangum & Sumner 2003), and by 2000 it was recorded as far west as Athens, Alabama (Kondo et al. 2000). In 2000 records existed as far north as New York State (Ascher 2001) and by 2002 it reached Ontario, Canada (Mangum & Sumner 2003). More recently the northern front of its distribution has reached northern Vermont (Richardson 2005) as well as the Boston area (Rykken 2007), while towards the west records exist from western Indiana (Indiana Cooperative Agricultural Pest Survey 2006). According to pictures and comments posted on the internet, the bee had reached Iowa (undetermined location) by 2007. Herein I newly record *M. sculpturalis* from northeastern Kansas and discuss its continued expansion westward, in accordance with an earlier predictive, ecological niche model for the species (Hinojosa-Díaz et al. 2005).

Material

Megachile* (*Callomegachile*) *sculpturalis Smith
Figure 1

Material Female, Kansas: Douglas County, within Lawrence city limits (adjacent to main University campus), 28 June 2008, I.A. Hinojosa-Díaz (net captured). Deposited in the Snow Entomological Collection, Division of Entomology, University of Kansas Natural History Museum, Lawrence, Kansas, USA.

Comments The specimen was not freshly emerged, exhibiting relatively worn wings along their apices. This indicates that the female was old and had been quite active for some time. This wing wear suggests that either the female had newly dispersed

Fig. 1. Female of *Megachile sculpturalis* Smith captured in northeastern Kansas, USA.

into the area from some distance or, more likely, was part of a newly established population (since no *M. sculpturalis* have been found in previous summers, and such active and robust bees would have otherwise been noticed) and had spent considerable time seeking new, suitable nesting sites and nest materials.

Discussion

On June 28th of 2008, a single female specimen of *M. sculpturalis* (see above) was collected in Lawrence, Kansas, around 7:30 PM, while trying to enter an abandoned wood borrow of a carpenter bee [*Xylocopa virginica* (Linnaeus)] in a backyard very close to the main campus of The University of Kansas. This specimen constitutes the first record for the species in Kansas, as well as the first confirmed individual west of the Mississippi (not counting internet postings). As noted, the specimen is deposited in the Snow Entomological Collection, Division of Entomology, University of Kansas Natural History Museum. Despite the absence of systematic monitoring of the expansion of this species, its spreading pace seems remarkable. Based on an ecological niche model of the native-range of the species projected to North America, Hinojosa-Díaz et al. (2005) predicted that *M. sculpturalis* would potentially inhabit the entire eastern half of the United States as far west as western Kansas and northwestern Texas, and as far north as Nova Scotia, Canada (Fig. 2). The existing records are so far in agreement

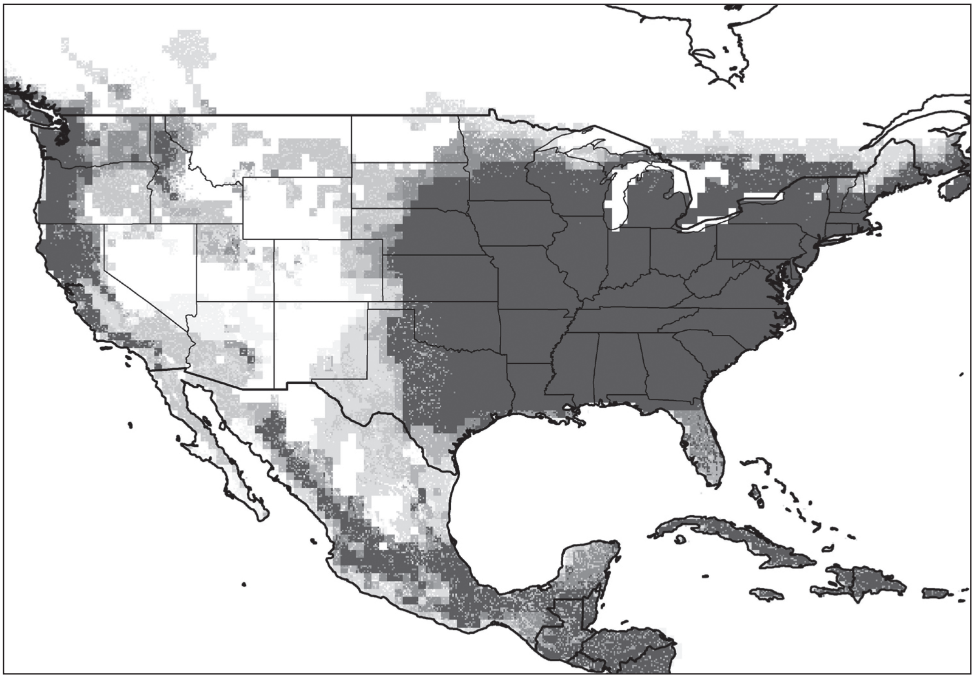

Fig. 2. Potential distribution of *Megachile sculpturalis* Smith in North America based on predictive ecological niche model proposed by Hinojosa-Díaz et al. (2005).

with the proposed model and it is still expected that the giant resin bee will continue on its way westward, filling out the potential distribution as defined by Hinojosa-Díaz et al. (2005). Figure 3 summarizes the available records for *M. sculpturalis* which have data suitable for georeferencing and mapping, and are plotted in accordance with year of collection. This pattern shows some insights on the rate at which *M. sculpturalis* is spreading in North America and, at least up to present, the strong concordance between the earlier predictions and subsequent records for the species. Continuous monitoring may ultimately confirm the accuracy of the potential distribution proposed by Hinojosa-Díaz et al. (2005).

Fig. 3. Observed distribution for *Megachile sculpturalis* Smith in the United States; records of the species mapped by time series according to available data; the star symbol corresponds to the record from Lawrence, Kansas.

Acknowledgements

Special thanks to Charles Linkem for organizing the get together at his place where the bee was collected, as well as to Matt Davis and Raul Diaz for helping in its capture. Yoshinori Nakazawa provided help preparing the maps, and two anonymous reviewers commented on the manuscript. Support was provided by National Science Foundation grant EF-0341724 (to M.S. Engel).

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