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An attempt to assess the usefulness of Google Scholar as a data source for entomological review papers on the example of the description of the biology of *Anomala dubia* (Scopoli, 1763) (Coleoptera: Scarabaeidae)

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Abstract. Review papers, especially those with features of meta-analysis, are a valuable part of the scientific literature, both from the point of view of specialists and researchers seeking information in fields new to them. The basis of this type of publication is the proper selection of study sources. The aim of this study was to assess the usefulness of the Google Scholar search engine in the selection of material for review papers in entomology. The analysis was based on a sample assignment involving the characterisation of the beetle species *Anomala dubia*. Problems arising in using the retrieved resource were identified and assigned to selected categories. The search results included almost all relevant records from the SCOPUS and Web of Science databases, plus a number of potentially valuable publications from other sources. The collected material was not sufficient to characterise the studied species in detail, but this could also be due to the lack of digitalised data in the available literature resources.

Keywords: Google Scholar, *Anomala dubia*, scientific publications, bibliographic data

INTRODUCTION

The widespread use of the Internet has changed the accessibility of scientific papers. Many services and repositories have been created where they are collected (e.g. the Polish Repository of Centre for Open Science, repositories of universities, Zenodo), it is also connected with green way of open access. Google Scholar is a free scientific search engine that is widely available, also to scientists from developing countries, covering about half of the world's scientific articles in open access (Singh et al., 2023). For biology and chemistry, it is ranked first in the world (Klopfenstein, Dampier, 2021). It is estimated to include 389 million records (Gusenbauer, Haddaway, 2020). The filters offered, although considered insufficient (What are the advantages ...), allow a certain degree of source ordering, which facilitates initial orientation in the extensive resources. In addition, Google's online translators make it possible to understand texts in numerous rare national languages. The work on the use of Google Scholar in science is mainly concerned with the usefulness of the biblio- and scientometric indicators offered by the search engine (e.g. Pereira, Mugnaini, 2023) and its comparison with database resources and the capabilities of other search engines (e.g. Ungar et al., 2023). Prestigious bibliographic databases such as SCOPUS or Web of Science only include journal articles that meet strict criteria, which, at least in theory, guarantees their high scientific quality. Google Scholar has a significant quantitative advantage over these databases because, in addition to peer-reviewed scientific papers with an international presence, it includes local scientific publications, conference proceedings, research reports, textbooks, book chapters, patents, etc.

However, the diversity of origins of Google Scholar searches can be a source of problems that limit the usefulness of the material so retrieved (What are the advantages...). The aim of this paper is to try to identify such difficulties and their causes. The analysis was carried out using the example of information on the beetle *Anomala dubia*. It is probably the only representative of the genus in Poland (Burakowski et al., 1983), often, even in scientific publications, confused with other representatives of its family (Thomaes et al., 2022; Urban et al., 2020). It is not one of the economically important pests of agricultural crops, but information about it can be useful in agroforestry or energy crop production. It deserves attention due to its affinity with species of greater economic importance that may soon reach Poland (PIORIN, 2016).

MATERIAL AND METHOD

The material for analysis consisted of all records retrieved in March 2023 from Google Scholar in response to the query 'Anomala dubia', with no time limit. The pub-

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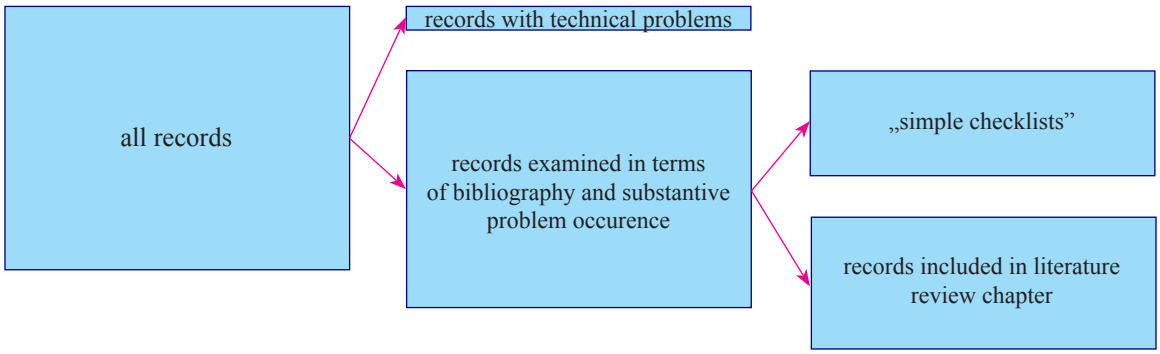

Figure 1. The study scheme.

lications, if it was possible, were searched for the word 'Anomala', as well as 'dubia', to also include the use of the abbreviated species name (A. dubia). The paragraphs contained key words, if it was necessary to understand, were translated independently (Russian, Ukrainian, English, French) or using appropriate Google translators. Problems that arose when using the resource were identified and categorised into one of the distinguished groups: technical, bibliographical or substantive (Fig. 1). Technical problems included difficulties in opening or searching the files (files that cannot be opened, uncopiable or unsearchable files, additional copies). Records under technical problems were excluded from the further study. Bibliographical problems related mainly to the structure of the works and shortcomings in the bibliographic data. Substantive problems referred to the quality of the presented data. In addition, a list of the most important issues in the resource acquired in the manner described is presented. The review of issues and the literature list omit items relating only to the recording of the presence of *A. dubia* in the study area ("simple checklists" in Fig. 1). Similar search ("Anomala dubia", all open access, no time limits, institutional access) was conducted in SCOPUS and Web of Science databases.

RESULTS AND DISCUSSION

Types of publication

The selected collection of records consisted mainly of lists of species found in different areas. These covered a diverse range of organisms: e.g. protected insects, beetles in general or only from the Scarabaeidae family. The search results also included papers published in scientific journals. It should be noted that almost all open-access published articles on the selected topic collected in the prestigious SCOPUS and Web of Science databases were included, but the only item omitted was an important study on the morphology and biology of larvae[1]. Depending on the topic studied and the criteria adopted, the percentage of coverage of results from Google Scholar and the databases compared to it varies, but can reach 100 (Ungar et al., 2023). In addition to this, the resource included master's and doctoral theses, research project reports, conference proceedings, reports from scientific trips and meetings, posters, and book chapters. Such a wide range of included sources is characteristic of Google Scholar (Racki, Drabek, 2013) and is assessed as both a disadvantage and an advantage. With regard to *A. dubia,* it was a source of much interesting information that did not appear in studies dealing directly with the characterisation of this species, for example related to the presence of *A. dubia* in the diet of different bird species. Access to additional literature, including little-known contributory works, can sometimes be inspiring and allows new research directions to be identified. However, at the same time, it forces a critical approach to the data used, as not all sources have been verified through the scientific review process.

Overview of key issues in selected material

The chapter gives the most important issues that are usually discussed when characterising an insect species, as well as additional information. In many publications, reference to *A. dubia* was merely in the nature of citing data from other sources. The records covered the period of 1936–2022.

- TAXONOMY

Audras et al., 1953; Cosandey et al., 2017; Dikmen, Özuluğ, 2018; Greven, 2011; Hielkema, 2022; Kreil, 1993; Kuntze, 1936

- EXTERNAL MORPHOLOGY

Description and photographs: Charrier, 2002; Frantsevich, 2004; Horvath et al., 2014; Petrova et al., 2022

Origin of the Latin name: Forshage, 2000

Body size, weight: Orłowski et al., 2011; Pedersen et al., 2012; Watkins, Mann, 2018a; Wouters, van Oosten, 2013

[1] Micó E., Galante E., 2005. Larval morphology and biology of some European Anomalini (Coleoptera: Scarabaeoidea: Rutelidae: Anomalinae). A phylogenetical approach. Insect Systematics and Evolution, 36: 183-198. It appeared in the results of the search performed in the same way in April 2023.

Table 1. *Anomala dubia* host-plants acc. to literature.

Host-plant (Latin name)	Source
Imago	
Acer campestre	Horvath et al., 2014
Acer negundo	Dumas, 2019
Alnus glutinosa	Petrova et al., 2022
Betula	Gallou, 1985; Olsson, Lemdahl, 2009
Betula pendula	Horvath et al., 2014
Castanea sativa	Chittaro, Sanchez, 2015; Horvath et al., 2014
Cirsium	Teodorescu, Maican, 2014
Corylus	Kuntze, 1936
Crataegus monogyna	Horvath et al., 2014
Euphorbia	Teodorescu, Maican, 2014
Fagus	Bìlokon' et al., 2005
Hippophaë rhamnoides	Reiter, 1986
Malus	Kuntze, 1936
Pinus	Gutowski et al., 2006; Kavka et al., 2022; Kuntze, 1936; Prakhodskiy et al., 2010; Veremeev, 2005
Platanus acerifolia	Horvath et al., 2014
Populus	Georgi, Müller, 2015; Horvath et al., 2014; Radzikowski et al., 2020; Teodorescu, Maican, 2014
Populus alba	Meleshko, 2003
Populus nigra	Horvath et al., 2014
Populus simonii	Meleshko, 2003
Populus tremula	Meleshko, 2003
Prunus avium	Horvath et al., 2014
Prunus persica	Voigt, Tóth, 2004, 2009
Prunus persica var. *nucipersica*	Voigt, Tóth, 2004, 2009
Rhamnus	Teodorescu, Maican, 2014
Rhus typhina	Horvath et al., 2014
Rosa canina	Horvath et al., 2014
Rubus	Kuntze, 1936
Salix	Audras et al., 1953; Delwaide, Thieren, 2010; Gallou, 1985; Georgi, Müller, 2015; Kühne et al., 2000; Marczak, Mroczyński, 2016; Mertlik, 2011; Nicolas, Nicolas, 1965; Olsson, Lemdahl, 2009; Teodorescu, Maican, 2014
Salix daphnoides	Berglind et al., 1999
Salix nigricans	Berglind et al., 1999
Salix triandra	Berglind et al., 1999
Sophora japonica	Horvath et al., 2014
Sorbus aria	Horvath et al., 2014
Sorbus aucuparia	Horvath et al., 2014
Tilia cordata	Horvath et al., 2014
Ulmus campestris	Horvath et al., 2014
Vaccinium corymbosum	Janiuk, Gantner, 2012
Vitis	Audras et al., 1953; Teodorescu, Maican, 2014; Voigt, Tóth, 2004
Larva	
Acacia	Netoiu et al., 2007
Ammophila arenaria (grass)	de Rond, 2016
Beta vulgaris	Spaar et al., 1988
Fagopyrum	Naumkin, Lysenko, 2014
Festuca	Mertlik, Brůha, 2011
Fraxinus	Netoiu et al., 2007
Gleditsia	Netoiu et al., 2007
Pinus	Kozel, 2012
Salix	Netoiu et al., 2007
Solanum tuberosum	Spaar et al., 1987

Table 2. Birds species in which diet *Anomala dubia* was recorded acc. to literature.

Bird (Latin name)	Source
Coracias garrulus	Hebda et al., 2019
Erithacus rubecula	Chaplygina et al., 2016
Ficedula albicollis	Chaplygina et al., 2015, 2022; Leženina et al., 2011
Lanius collurio	Goławski, 2006; Maréchal, 1993; Morelli et al., 2015; Nijssen, Geertsma, 2014; Pedersen et al., 2012; Tryjanowski et al., 2003; van der Kruis, 2008; van Duinen et al., 2004, 2005
Larus cachinnans	Atamas', Loparev, 2015
Motacilla flava	Prokof'eva, 2013
Oenanthe isabellina	de Rond, 2016
Oenanthe oenanthe	van Oosten et al., 2008, 2014
Phoenicurus ochruros	Orłowski et al., 2011
Saxicola rubetra	Prokof'eva, 2013
Saxicola rubicola	van Oosten, van den Burg, 2015
Turdus philomelos	Harčenko et al., 2002
Turdus viscivorus	Prokof'eva, 2003, 2007
Tyto alba	De Pablo, 2000
Upupa epops	Nuhlíčková et al., 2016

variation in body colour: Décobert, 2010; Ostrovskij, 2015; Petrova et al., 2022; Telfer, Eversham, 1995.

Problems of species determination: Schacht, 2022; Thomaes et al., 2016, 2022; Urban et al., 2020

Circular polarization: Horvath et al., 2014.

Morphology and body size of larvae, species determination of *A. dubia* larvae: Laznik, Trdan, 2013; Maksimova, 2008.

• ANATOMY

Bohacz et al., 2020; Frantsevich et al., 2014; Pacheco et al., 2022; Romero-Lopez et al., 2011

• OCCURRENCE AND DISTRIBUTION

Zoogeographic regions, subspecies: Chenchouni et al., 2015; Japoshvili et al., 2022; Smith, 2009; Šohin, 2011

Altitude a.s.l.: Mertlik, 2011; Polat et al., 2018; Szafraniec et al., 2021

Habitats: Aleksandrowicz et al., 2004; Berglind et al., 1999; Borowski et al., 2016; Egorov et al., 2017; Gallou, 1985; Lammerts et al., 2009; Marczak, Mroczyński, 2016; Martikainen, 2016; Mertlik, 2011; Ødegaard et al., 2001; Pedersen et al., 2012; Sažnev, Anikin, 2021; Schacht, 2017; Sörensson, 2020; Telfer, Eversham, 1995; Toth et al., 1994; van Duinen et al., 2004, 2005; Veremeev, 2005; Veremeev et al., 2001; Watkins, Mann, 2018a, 2018b; Wolender, Zych, 2007; Zhukov, 2006, 2007; Zúber, 2011

Anthropogenic habitats: Borowski et al., 2016; Delwaide, Thieren, 2010; Galinovskij et al., 2019; Jäger et al., 2014; Komaromì, 2020; Kubicka, 1981; Kušková, 2014

Types of habitats: Kühne et al., 2000; Nadvorny, 2007; Olsson, 2006; Ostrovskij, 2015

Changes in size and range of population, threat factors: Bayr, Svae Johansen, 2022; Carpaneto et al., 2011; Kavka et al., 2022; Köteles, Bakonyi, 1996; Kubicka, 1981; Leontiev, 2021; Malicky, 1975; Ødegaard et al., 2001; Zúber, 2011

• DEVELOPMENT

Life cycle, imago flying period, egg deposition, factors affecting length of development: de Rond, 2016; Laznik, Trdan, 2013; Mertlik, 2011; Negrobov, 2009; Romero-Lopez et al., 2011; Ruta et al., 2016; Spaar et al., 1987, 1988; van Duinen et al., 2005; Voigt, Tóth, 2009

• HABITS

Non-feeding habitats, role in plant pollination: Bellmann, 2002; Dutto, 2007; Egorov et al., 2017; Jakubska-Busse, Kadej, 2008, 2011; Jakubska, Kadej, 2006; Leontiev, 2021; Radzikowski et al., 2020; Sažnev, Anikin, 2021

Trapping of insects, effect of polarized light: Bayr, Svae Johansen, 2022; Bukejs, 2006; Chenchouni et al., 2015; Horvath et al., 2014; Kofler, 1999; Martikainen, 2016; Radzikowski et al., 2020; Toth et al., 1994, 1997.

Insect motion: Frantsevich, 2004; Mertlik, 2011; Watkins, Mann, 2018b; Zúber, 2011.

Depth of larvae feeding in soil, larval adaptation to unfavourable conditions: Netoiu et al., 2007; van Duinen et al., 2005; Von Niklas, 1964

• FEEDING HABITS, HOST-PLANTS, FEEDING DAMAGE

Feeding habits of imago: Gutowski et al., 2006; Janiuk, Gantner, 2012; Kuntze, 1936; Voigt, Tóth, 2004.

Host-plants: Table 1.

Outbreaks, harmfulness, damage description: Baban, 2006; Georgi, Müller, 2015; Jameson et al., 2003; Kolk, Grodzki, 2011; Kuntze, 1936; Voigt, Tóth, 2004

Feeding on grass (dunes, grasslands), feeding on field crops, feeding in forests: de Rond, 2016; Kulikov, Naumkin, 2004; Laznik, Trdan, 2015; Maleshko, 2003; Netoiu et al., 2007; Radics, Mikóházi, 2010; Spaar et al., 1987, 1988; Voigt, Tóth, 2004

• RELATIONSHIPS WITH OTHER ORGANISMS

Predatory insects, spiders, parasitic insects: Amolin, 2005; Gusenleitner et al., 2008; Heijerman, Turin, 2017; Kavka et al., 2022; Reitze, Nentwig, 1991; Scharfy, 2012; Teppner, 2008; Von Klausnitzer et al., 2013; Von Niklas, 1964

Birds: Table 2

mammals: Lanszkia et al., 2009; Laznik, Trdan, 2014; Mikheyev, 2002

parasitic nematodes: Garcia del Pino, Palomo, 1995; Gradinarov, Petrova, 2011; Gradinarov et al., 2011; Grewal et al., 1996; Han et al., 2012; Jarry, 1964; Nguyen, Smart, 1993; Parra, 2020; Peters, Galarza, 2004; Poinar, Kozodoi, 1988; Quintero Marin, 2003; Uhan, 2005; Wu, 2013

bacteria, protozoa, fungi: Bajc, 2016; Fătu et al., 2016, 2017; Kolasa et al., 2018; Laznik, Trdan, 2015; Lila, 2014; Niklas, 1963; Pandey, 2013; Théodoridès, 1963

• GENETICS, PHYLOGENESIS

Hendrich et al., 2015; Jameson et al., 2007; Ramírez-Ponce, Morón, 2009

• OTHER TOPICS

Content of F, Cl, Br, and I in larval body: Pokarzhevskii, Zhulidov, 1995

PROBLEMS IDENTIFIED IN THE USE OF SEARCH RESULTS

Technical problems

Among the files retrieved, several, despite the pdf extension, could not be opened, were probably corrupted or required non-standard software to view. Records in which the text was presented as an image or is uncopyable also posed a problem, making direct searching and copying into translators impossible. In the case of short documents in known languages, it is possible to search for interesting passages on your own, but in extensive publications this is very time-consuming. There were also duplicate records, which are not protected against by the search algorithm used by Google Scholar (What are the advantages ...). Two publications did not meet the criterion of searching, because words Anomala and dubia occurred only separately and texts concerned to other animals. In the overall collection, the problematic files accounted for a small proportion. In the search carried out, there were no difficulties in accessing the full texts of publications, although according to user feedback, such problems may appear in results derived from Google Scholar (What are the advantages ...).

Bibliographical problems

Bibliographical problems are not due to the substantive quality of the publication, but make it difficult to use and cite. Due to the multitude of non-unified sources and the automatic processing of data, Google Scholar is particularly prone to such errors (Racki, Drabek, 2013; Sauvayre, 2022). Therefore, problems with the quality and transparency of bibliographic data are often reported (Doğan, 2022).

Also in the results of the search carried out, many records lacked the full bibliographic details of the publication. For example, only the title and author were given, while the page range indicated that it was part of a larger whole. It is possible to found missing data in repositories and citations, but this is time-consuming. This problem occurs most often with Russian and Ukrainian publications.

Different spellings of the names of the same authors also lead to citation errors. It may be due to the use of different tables or different ways of transliterating Cyrillic characters, and a similar problem is posed by the prepositions de, von, van before names.

In search results, there were publications in different languages: Bosnian, Croatian, Czech, Danish, Dutch, English, Finnish, French, German, Hungarian, Indonesian, Italian, Korean, Lithuanian, Norwegian, Polish, Portuguese, Romanian, Russian, Slovak, Slovenian, Spanish, Swedish, Ukrainian. English is generally known for scientists, but other languages can be a barrier for texts to be used by foreigners. In such cases, the lack of an English title and abstract makes it impossible to quickly select material for relevance. It is a good practice, relatively uncommon however, to also include English captions for tables and figures.

The lack of a single explanation of the abbreviations and symbols used in the text is also a handicap. Even if they are obvious to the author, readers using other languages may not properly understand them.

The use of, often very arbitrary, common names for animals and plants, different even in articles in the same language, leads to confusion. In the case of living organisms, the Latin nomenclature should be the standard in scientific papers, preferably used throughout the text, not just at the first occurrence of a name.

In the results of the search carried out, several examples can be found of publishing virtually the same content under different titles or with a different author composition. This is sometimes justified by a change of version depending on the target audience or is the result of artificial

over-publication by the author. It wastes the time of the user, who reads texts containing the same information several times.

Substantive problems

Substantive problems may lead to the generation of erroneous or skewed data. Due to the presence in Google Scholar search results of publications that, due to their nature, have not been subjected to a thorough review process, it is particularly important to be critical of the information obtained. An additional risk, independent of the search engine used, are errors resulting from the deliberate falsification of results or the use of artificial intelligence to create publications (Májovský et al., 2023).

Many problems are caused by frequent changes in the systematics of living organisms. Publications from different years differ in nomenclature; for example, it may occur that synonyms are treated as the names of different species. Authors cannot anticipate such changes, so readers must take this risk into account and check the names in the available registers when using the literature.

It is also problematic to refer to publications to which the reader does not have access. This is often the case with old, basic items. Most often such blockages are due to the need to preserve the rights of the author or publisher, but they make it very difficult to verify certain statements, and the suspicion arises that the author is merely quoting a source after earlier publications. Copying information secondarily after other authors without checking it in the original is a reason for perpetuating misrepresentations and errors in interpretation. A certain solution may be to use the resources of libraries and their networks, which also make old collections available electronically. Although the oldest Google Scholar records date back to 1770 (Gusenbauer, Haddaway, 2020), the representativeness of older publications in search results is low (Racki, Drabek, 2013).

A problem in scientific work, which is clearly visible when describing species, is over-generalisation, which manifests itself in attributing to an object the characteristics of the whole group to which it belongs, or treating the result of a single observation as a rule. Lack of precision, i.e. omitting data that are necessary for the correct interpretation of the information presented, also leads to errors.

Anomala dubia, due to its appearance and different colour forms, is easily confused with some other representatives of the family. Such confusion can occur if authors of non-entomological publications, with no experience in beetle species determination, refer to this species in their work. Seeking the opinion of a specialist in this area or including documentary photographs may prevent the uninformed dissemination of misinformation.

Various types of translators, which can even determine the language of the source on their own, are a very big help in using scientific literature. However, they are not perfect and sometimes the translation obtained is illogical or even wrong. Therefore, it is safer to use specialised software and check the interpretation of the text with various examples.

The basis for using the results of other researchers is to understand the capabilities and limitations of the methodology used. Its accurate presentation is usually time-consuming and, if translators have to be used, can be difficult for the reader to interpret, especially if the text deals with complex, novel designs without reference in earlier literature. A good solution, increasingly common in scientific papers, is to supplement the text with photographs, e.g. of the observation site or experimental equipment, which makes it much easier to familiarize oneself with the methodology and scope of the research.

Most publications from the resource analysed are concerned with the occurrence of *A. dubia*, usually for the insect species register of the area. Such lists sometimes include, in addition to the location, the number of individuals observed and the date of observation. Usually it is not possible to infer from them the phenology of the species, so important e.g. in the context of climate change, because these are usually not long-term series of surveys with uniform methodology, but rather random records. They are sufficient for local checklists, but it would be advisable to collect additional information on occasion, e.g. on the location or behaviour of the insect, especially as the tools now widely available make it easier to record and archive data.

SUMMARY

Google Scholar is free, available tool for i.a. literature study. It is a constantly improving search engine, but not yet perfect. Different problems were found also in the tested search. The percentage of records with technical problems, which made the use of papers impossible or difficult, was low. However, many errors in bibliography data were revealed, the correction of which required a great deal of time. Such problems are completely absent in the articles from SCOPUS and Web of Science databases, which are perfectly prepared in this regard. Also, it is commonly believed that substantive inaccuracies and errors are removed from them during detailed editorial review, but it does not exempt readers from critical analysis of information published there.

Substantive errors are a serious problem in scientific communication. There were statements in the publications from the retrieved resource that raised suspicions about their correctness, but their verification would require deeper analysis. Many of the substantive problems may be the result of imperfections in the translators, especially in the case of texts in languages other than English.

The usefulness of Google Scholar as a data source for entomological review papers depends on many factors, including the specificity of the subject matter or its geograph-

ical scope. The results of the sample search, which was the basis of the analysis, included almost all open-access published articles from the SCOPUS and Web of Science databases corresponding to the query used. In addition, the retrieved resource included peer-reviewed scientific papers from outside these databases, which is very valuable **because there are many journals, even English-language journals, which for various reasons do not seek indexation in international prestigious bibliographic databases, but meet all the criteria for high scientific quality**. Google Scholar also lists publications of other origins, including non-peer-reviewed publications. The data from these items need to be verified in other sources, but can be the basis for interesting research topics. The retrieved records lacked much of the information needed for a comprehensive characterisation of the studied species, but this is largely the result of their absence from digitalised resources, not the limited capabilities of the search engine.

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