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Research Article

Incomplete but invaluable: Reassessing the holotype of a singleton madagascan woodlouse (Oniscidea, Armadillidae)

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Abstract

Historical type specimens, even when fragmentary, remain critical for resolving long-standing taxonomic uncertainties—particularly within neglected and underfunded groups such as terrestrial isopods. Many species described during early phases of exploration have never been revisited, leaving them in taxonomic limbo due to incomplete descriptions and the scarcity of new material. This study reexamines the Madagascan species *Armadillo cassida* Budde-Lund, 1908—known only from a single specimen—and finds that its distinctive and atypical morphological features warrant its transfer to a new genus, *Revelosa* gen. nov. Despite the limitations of the available material, key diagnostic traits were recovered that clearly differentiate it from all other genera in the family Armadillidae. This work highlights the enduring value of historical singletons in clarifying biodiversity, reducing taxonomic noise, and improving classification frameworks, even in the absence of fresh specimens. Such revisions are vital steps toward addressing the taxonomic impediment that continues to hinder progress in biodiversity research.

Key words: Afrotropical, Isopoda, new genus, redescription, taxonomic revision, terrestrial isopods

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Introduction

Historical singletons: Challenges and relevance in modern taxonomy

Many historical specimens collected during early phases of taxonomic exploration continue to play a critical role in systematic biology, yet their value is frequently diminished by insufficient descriptions, limited illustrations, and a lack of comparative frameworks available at the time. Furthermore, many species are known only from a single specimen, which are referred to as singleton species. This form of rarity is surprisingly widespread across taxonomic groups, but has often been underappreciated in biodiversity research (Lim et al. 2012). The descriptions of many historical singletons lack key diagnostic features by modern standards and are in dire need of new material and revision. Although obtaining new material is frequently not feasible—especially in neglected and underfunded groups such as terrestrial isopods (Kästle and Regalado Fernandez 2025)—delaying re-examination and taxonomic clarification of such singleton species

in hopes of new material risks indefinite taxonomic stagnation and misrepresentation of biodiversity, which undermines the broader utility of taxonomy and causes cascading errors across ecology, biogeography, and conservation (De Carvalho et al. 2007; Bortolus 2008; Kohlia and Fraser-Jenkins 2011; Ribeiro et al. 2022; Kästle and Regalado Fernandez 2025). Nevertheless, revisions based on imperfect but unique material can still yield meaningful clarification and reduce nomenclatural uncertainty. Recognizing the value of all revisions that enhance our understanding of biodiversity is essential for addressing the taxonomic impediment (De Carvalho et al. 2007; Kästle and Regalado Fernandez 2025), especially those based on type specimens, which serve as name carriers central to biological classification and thus hold enduring relevance, even when fragmentary. Such contributions should not be dismissed simply for lacking modern datasets. Instead, their merit lies in clarifying taxonomic names and distributions that form the foundation for broader biological research. This study illustrates the value of such an approach by reexamining the fragmentary holotype of *Armadillo cassida* Budde-Lund, 1908—a singleton terrestrial isopod species from Madagascar, which has remained unstudied for over a century.

The case of *Armadillo cassida*

The family Armadillidae Brandt, 1831 is the most diverse family of terrestrial isopods and contains almost 700 described species (Boyko et al. 2025). Many taxa that were erected in the 1800s and early 1900s face a multitude of issues such as taxonomic uncertainties, lack of detailed descriptions and figures, as well as damaged or lost material. One author who described many such species was Gustav Budde-Lund (GND: 115775683). Budde-Lund's most notable work (1885) unfortunately lacks illustrations and features only rudimentary descriptions. In his later works he frequently included drawings and revisited some species, however, he usually only provided illustrations of a select few characters per species, leaving many taxa unrecognizable. Although much of Budde-Lund's material is still preserved, the whereabouts of specimens are not always clear as they have been split between different collections. Jeppesen (2000) provided a useful catalog, listing much of the type material of Budde-Lund and the institutions where it is housed with collection numbers, if known. Unfortunately, Jeppesen did not include the Natural History Museum Berlin, where some of Budde-Lund's material is stored. Notably, the holotype of *Armadillo cassida* Budde-Lund, 1908 is located in the Museum für Naturkunde Berlin (ZMB) and, as reported by Jeppesen (2000), some fragments are located in the London Natural History Museum (NHM). The female holotype (Fig. 1) represents the only known individual of the species to date. Discovered in Madagascar by Alfred Voeltzkow (GND: 117449598) in 1904, *Armadillo cassida* was described by Budde-Lund in 1908 and placed in the genus *Armadillo* Latreille, 1803. However, our understanding of the genus *Armadillo* has greatly changed throughout the decades that followed Budde-Lund's publication. *Armadillo cassida* not only deviates far from the morphology displayed by the genus, it is also biogeographically far removed with *Armadillo* sensu stricto being distributed in the Mediterranean and adjacent areas in western Asia (Schmalfuss 1996; Campos-Filho et al. 2023). Apart from its inclusion in the check-list of terrestrial

isopods in Sub-Saharan Africa by Ferrara and Taiti (1979), the world catalog of terrestrial isopods by Schmalfuss (2003), and the aforementioned catalog by Jeppesen (2000), *Armadillo cassida* has not reappeared in the scientific literature and is listed as taxon inquirendum on World Register of Marine Species at present (Boyko et al. 2025). Considering the terrestrial isopod fauna of Madagascar has not seen any taxonomic contributions for the past thirty years, the most recent taxonomic work from Madagascar being Ferrara et al. (1994), the prospects of fresh specimens being available to researchers in the near future are low. Therefore, *Armadillo cassida* is redescribed in as much detail as possible from the available type material and, due to its unique combination of morphological characters—several of which are atypical for the family Armadillidae—it is transferred to a new genus.

Material and methods

Examination and imaging

The holotype specimen of *Armadillo cassida* was examined with non-destructive methods to not further damage the single known specimen.

Images were taken with a Canon EOS 60D and a Canon EF-S 60mm f/2.8 macro lens. Figures were drawn using the application PROCREATE (Version 5.3.15).

Use of person identifiers

To ensure unambiguous attribution, personal names mentioned in the text are, at first mention, accompanied by their corresponding GND (Integrated Authority File) identifier, when possible, available under https://www.dnb.de/EN/Professionell/Standardisierung/GND/gnd_node.htm.

Institutional abbreviations

NHM Natural History Museum (London, England)
ZMB Museum für Naturkunde Berlin (Berlin, Germany)

Systematics

Order: Isopoda Latreille, 1816
Suborder: Oniscidea Latreille, 1802
Family: Armadillidae Brandt, 1833

***Revelosa* gen. nov.**
https://zoobank.org/0B27C056-54E6-4A78-8883-ADCCB3F39B12

Type species. *Armadillo cassida* Budde-Lund, 1908.

Diagnosis. Habitus wide and flattened, typical of clinger eco-morphotype. Frontal shield protruding far above vertex, medially cleft (Figs 1D, 2D–E). Antenna with second article of flagellum three times longer than first. Antennula with three segments. Pereonites 1–2 with small ventral lobe situated at proximal end of epimera and close to posterior margin (Fig. 2B). Epimera of pereonites 3–7 without ventral structures. Telson triangular, longer than wide (Fig. 2G). Uropod protopodite longer than wide. Uropod exopodite moderately sized, inserted medially on the protopodite (Fig. 2F–G). All pleopod exopods with monospiracular covered lungs.

Etymology. The new genus name *Revelosa* gen. nov. (fem.) is derived from Latin *revelo* (to reveal, uncover), referring to the taxonomic rediscovery of the species and the clarification of its long-standing taxonomic uncertainty.

***Revelosa cassida* (Budde-Lund, 1908), gen. et comb. nov.**
Figs 1, 2

Armadillo cassida — Budde-Lund, 1908: 274–275, plate XIII figs. 35–36. — Ferrara and Taiti 1979: 166, 208. — Jeppesen 2000: 235. — Schmalfuss 2003: 47.

Material examined. *Holotype*: MADAGASCAR • female holotype, 9 mm; Sahana or Sakana; Sep. 1904; A. Voeltzkow leg.; ZMB 12302.

Additional material. *Holotype* (Fragments): MADAGASCAR • female holotype (fragments); same data as above; NHM 1921.10.18.1201

Description. Length 9 mm, width 5.5 mm.

Color (in preserved specimen): pale beige color typical for old wet specimens (Fig. 1A).

Dorsum densely granulated (Figs 1A, 2A, M), epimera without granulations (Figs 1A, E, 2B), telson with granulations at base (Fig. 2A, G). Dorsum with small scale setae.

Eyes with 25 ocelli.

Pereonite 1 epimera with acute anterolateral corner, posterolateral corner almost right-angled (Figs 1A, 2A). Pereonites 2–7 epimera rectangular (Fig. 1A, 2A). Pereonite epimera with posterolateral corner extending successively further posteriorly (Fig. 2A; Fig. 1A). Anterolateral corner of epimera successively more rounded, posterolateral corner successively more acute (Figs 1A, 2A).

Pleon epimera 3–5 rectangular with rounded anterolateral corner (Fig. 1F).

Telson, 1.2 times longer than wide with distal portion weakly keeled and proximally half as wide as base, weakly tapering and terminating in rounded tip (Fig. 2G).

Uropod with the protopodite twice as long as wide, weakly curving outwards (Fig. 2F). Posteromedial corner of uropod protopodite acute (Fig. 2F), posterolateral corner strongly rounded; exopodite inserted medially at about half the length of protopodite; endopodite half as long as protopodite (Fig. 2F, G).

Female: Ventral side with developed oostegites (Fig. 1B). Pereopods sparsely populated with large setae. Pleopod 1 exopod almost entirely reduced to tracheal field (Fig. 2H). Pleopod 2–4 exopods triangular with strongly sigmoid posterior margin, about 1.3 times as wide as long (Fig. 2F, I–K). Pleopod 5 exopod triangular, posterior margin straight (Fig. 2F, L). Pleopod 1–2 exopods with

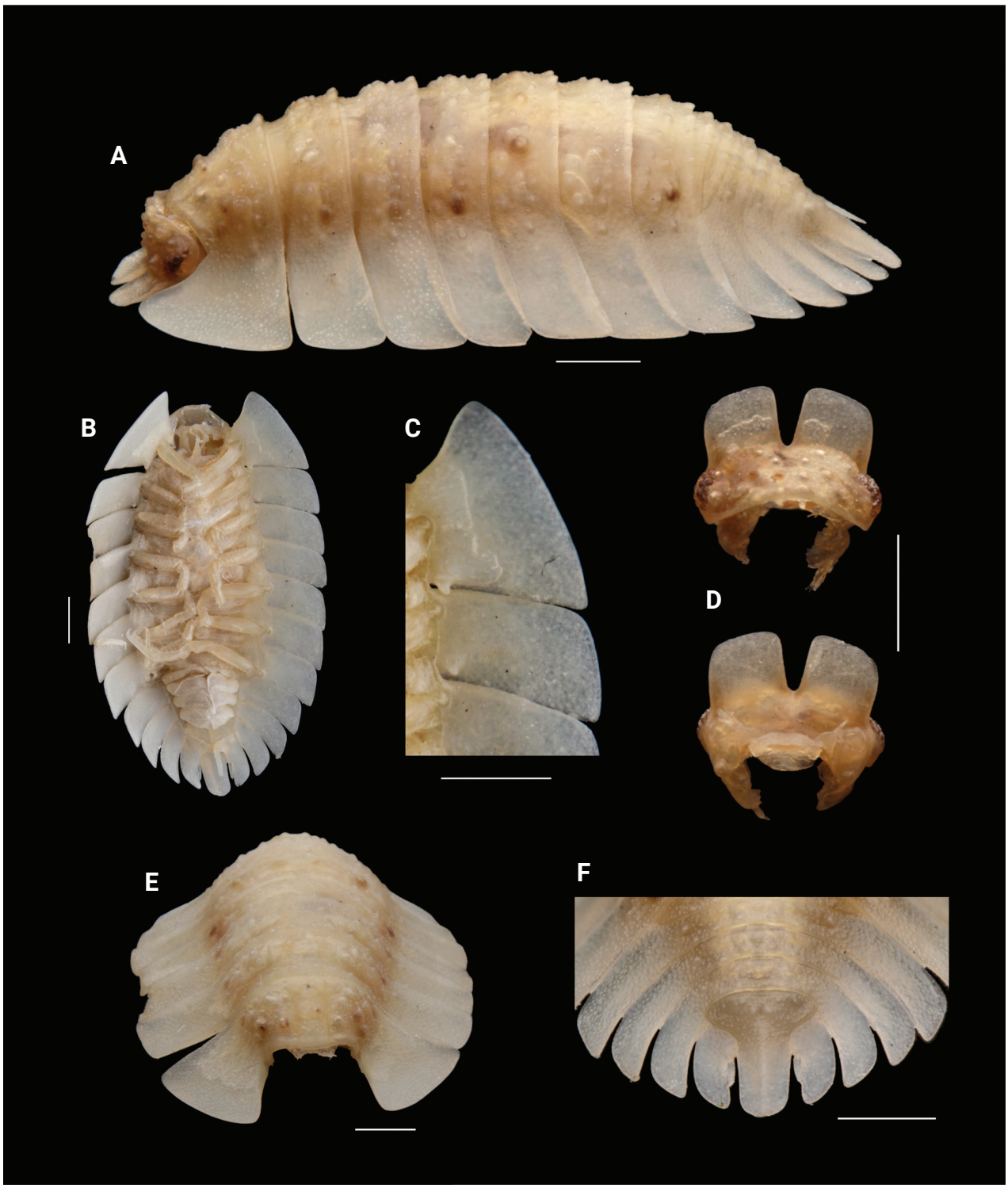

Figure 1. *Revelosa cassida* gen. et comb. nov. Holotype ZMB-12302. **A.** Body with cephalon digitally reattached, lateral view; **B.** Body, ventral view; **C.** Pereonite epimera 1–3, ventral view; **D.** Cephalon, dorsal and ventral view; **E.** Body, anterior view; **F.** Pleon, posterodorsal view. Scale bars: 1 mm.

deep incision at respiratory area (Fig. 2H, I), exopod 3–4 with shallow incision (Fig. 2J, K), exopod 5 without incision (Fig. 2L).

Type locality. Sahana or Sakana.

The locality of *Revelosa cassida* gen. et comb. nov. is stated by Budde-Lund (1908) to be Sakana. However, the specimen labels in both the ZMB and NHM

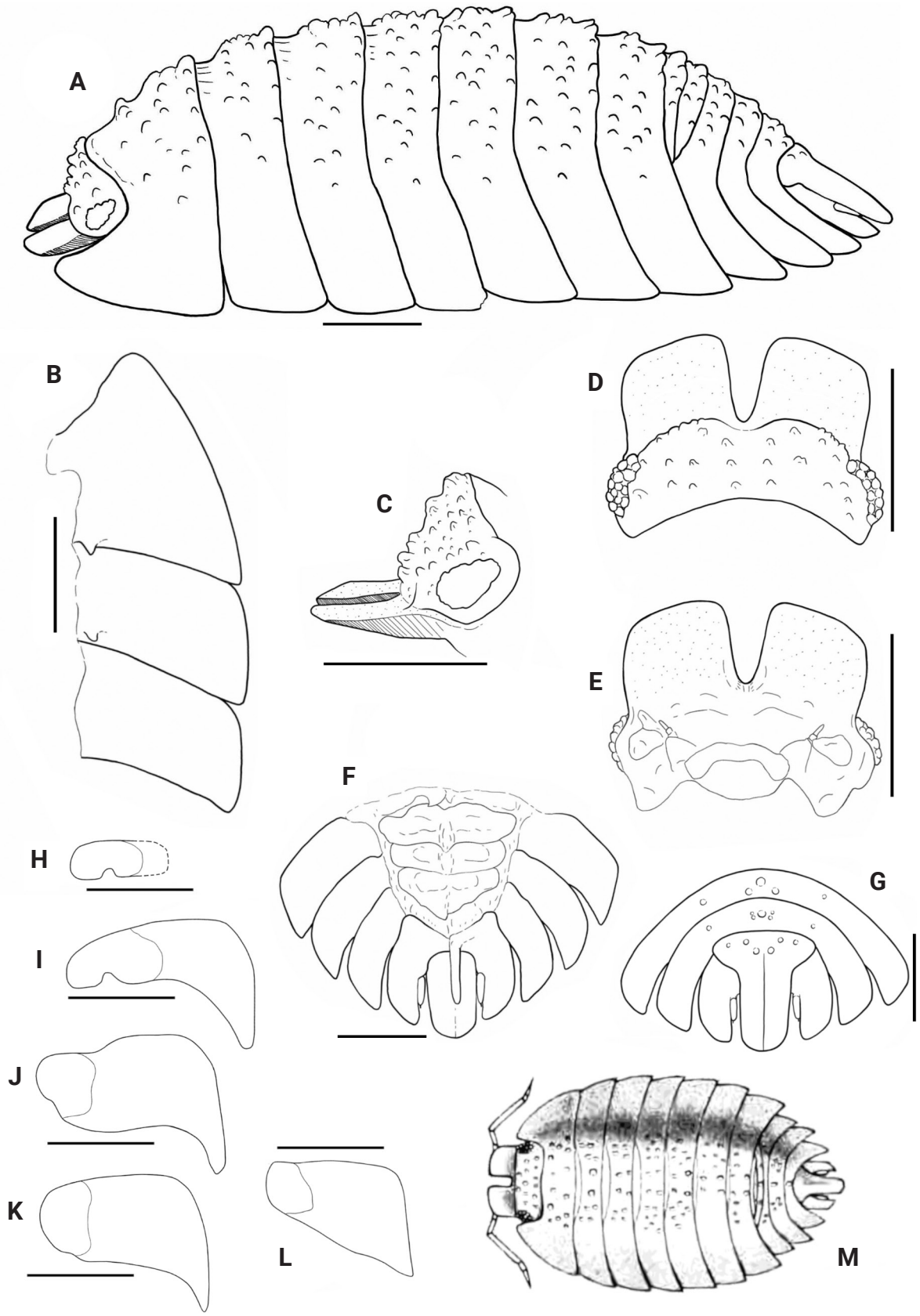

Figure 2. *Revelosa cassida* gen. et comb. nov. illustrated Holotype ZMB-12302. **A.** Habitus, lateral view; **B.** Epimera of pereonites 1–3, ventral view; **C.** Cephalon, lateral view; **D.** Cephalon, lateral view; **E.** Cephalon, lateral view; **F.** Pleon, ventral view; **G.** Pleonites 4–5, telson and uropods, dorsal view; **H–L.** Female pleopod exopods 1–5; **M.** Habitus in dorsal view, reproduced from Budde-Lund (1908, plate XIII figs 35–36). Scale bars: 1 mm (**A–G**); 0.5 mm (**H–L**).

(as indicated by the catalog) state "Sahana" as the locality. Unfortunately, both Sahana (approx. 16°05'05.7"S, 49°38'06.2"E) and Sakana (approx. 17°15'28"S, 49°02'40"E) are localities in the Analanjirofo Region of northern Madagascar, with Sahana located approximately 130 km north of Sakana. While it is unclear which of the two localities represents the true type locality of *Revelosa cassida* gen. et comb. nov., additional research into Alfred Voeltzkow's collections indicates that the majority of specimens recorded from the same expedition list "Sakana" (e.g. Jungers et al. 1995; Wesener and Wägele 2008; Bellati et al. 2018) as their type locality, whereas only very few references cite "Sahana" (e.g. Attems 1914). This could suggest that "Sahana", as written on the specimen labels, might represents a transcription or labeling error.

Discussion

Preservation and availability of type material

The holotype specimen of *Revelosa cassida* comb. nov. in the ZMB is preserved in a damaged state. The head of the specimen is detached from the body and missing all mouthparts as well as both antennae (Fig. 1D). The pereonites are relatively well-preserved, except for some small missing pieces of the right epimeres of pereonites 3–4 (Fig. 1A, B). The pereopods are badly damaged as they are largely missing the more distal segments (Fig. 1B). Right pereopods 1, 3, 4, 6, as well as left pereopods 1–3 have only the basis and ischium preserved. Basis, ischium and merus are present in left pereopod 2 and 5 and right pereopod 4. Left pereopod 6–7 are present with all segments intact, whereas right pereopod 7 is missing entirely. A detached partial leg consisting of propodus and dactylus is present but it was not possible to reconstruct which pereopod this fragment corresponds to. The pleon is relatively well-preserved except for the right uropod missing its endopodite and the absence of right pleopod exopod 1 (Fig. 2G). Budde-Lund (1908) describes color of the specimen as yellow, with small yellowish-red spots; antennae whitish with joints and flagellum reddish. Considering Budde-Lund examined the species four years after its collection, he likely observed colors already altered by the preservation in alcohol.

The fragments listed by Jeppesen (2000)—likely including parts of the mouthparts and/or pereopods—to be in the NHM could not be examined in person nor through images, and thus remained inaccessible. As the specimen in the ZMB is missing most distal segments of the pereopods, as well as the mouthparts and antennae, the fragments in the NHM are likely composed of at least some of these elements. The inaccessibility of this material highlights the challenges that can arise when key specimens are not readily available for study, which can impede progress in taxonomic revisions. Despite these constraints, this study identified several unique morphological characteristics that allowed us to resolve the primary taxonomic issue at hand. However, the lack of access to additional material limited the scope of our findings and the potential for deeper insights into the species' full morphology.

Morphological considerations and phylogenetic relationships

Due to the small ventral lobes and wide, flattened habitus, *Revelosa* gen. nov. corresponds well to a clinger eco-morphotype with likely limited ability to conglobate. The new genus is particularly noteworthy within the family Armadillidae due to its distinct morphology, which deviates far from what is considered the ground pattern for the family (Schmidt 2003). The telson is relatively long and triangular with a rounded posterior margin, clearly differing from the hourglass-shaped telson that characterizes the typical condition in Armadillidae (Taiti et al. 1998; Schmidt 2003). Several spiny genera, such as *Laureola* (Barnard, 1960) and *Calmanesia* (Collinge, 1922), also possess a triangular telson, as well as members of the "*Synarmadillo*-group", although the placement of *Synarmadillo* Dollfus, 1892 within Armadillidae remains tentative (Ferrara and Schmalfuss 1976). In addition, the uropod exopodites are inserted on the medial edge of the uropod protopodite, setting this genus apart from all other genera in the family, where the uropod exopodites are inserted dorsally on the uropod protopodite (Taiti et al. 1998; Schmidt 2003). These characters, paired with the deeply cleft frontal shield, which is otherwise known only in the Australasian genus *Merulana* Budde-Lund, 1913, make the new genus highly distinctive within the family Armadillidae.

Although the cleft frontal shield is a curious similarity to the Australasian genus *Merulana*, the cleft is of much smaller extent in *Merulana*. *Merulana translucida* Budde-Lund, 1885—one of the most notable *Merulana* species—possesses a similarly large frontal shield with a deep, but very narrow, cleft. Given the significant biogeographic separation and otherwise distinct morphology, this resemblance is best interpreted as homoplasic. The functional or adaptive significance of a cleft frontal shield, as seen in *Merulana* and *Revelosa* gen. nov., remains unknown.

Furthermore, *Revelosa* gen. nov. is similar to the afrotropical members of *Pyrgoniscus* Kinahan, 1859 in the wide habitus, geographic proximity, and, most notably, the shape and position of the ventral lobes. However, it differs significantly in the aforementioned key features—the frontal shield being cleft, the triangular shape of the telson, and the medial insertion of the uropod exopodites—indicating that this resemblance does not reflect a close relationship of the two genera.

It should be noted that the genera *Pyrgoniscus* and *Merulana* face taxonomic debate. *Pyrgoniscus cinctutus* Kinahan, 1859, the type species of what is typically considered an Afrotropical genus, originates from Australasia and may be a senior synonym of *Merulana translucida* (Budde-Lund, 1885). As a result, several authors have proposed that *Merulana* is a junior synonym of *Pyrgoniscus* (Monod 1935; Ferrara 1977; Taiti et al. 1998), however, no formal synonymization or subsequent revision has been undertaken.

Additionally, the holotype fragments of *Revelosa cassida* gen. et comb. nov. in the NHM are cataloged under the unavailable name "*Bethalus cassida*". This name likely represents a renewed identification, possibly by Budde-Lund himself, though it was never formally published. However, there is no morphological justification for assigning the species to the genus *Bethalus* (Budde-Lund, 1909), as *Bethalus* differs substantially in several diagnostic characters, most notably by having a typical, non-cleft frontal shield and an hourglass-shaped telson.

The value of deteriorated and fragmentary type specimens

Reexamining historical type specimens, despite their often fragmentary or incomplete condition, can offer significant value to taxonomic research, as these specimens serve as the foundational references for species names and classifications. Revisiting them can clarify longstanding ambiguities, correct historical misplacements, and stabilize taxonomy. Even when preservation is poor, reevaluation and redescription within the limits of the available material can reveal diagnostic characters, allowing for meaningful reassessments. In many cases, especially when fresh material is unavailable or unlikely to be collected, these specimens represent the only tangible link to taxa. Their reassessment not only improves our understanding of individual species but also contributes to broader efforts in documenting biodiversity and ensuring that biological records remain accurate and usable for future research, as allowing taxonomic inaccuracies to persist delays progress in fields dependent on reliable classifications, such as conservation, ecology, and biogeography.

While the limitations of fragmentary material may preclude an exhaustive redescription, publishing new findings based on such specimens remains critical. As outlined by Kästle and Regalado Fernández (2025), even partial revisions make important contributions by opening new research avenues, reducing taxonomic noise, and contributing to more coherent classification systems. Incremental improvements, such as the one presented here, are vital for addressing the taxonomic impediment in groups like terrestrial isopods, where many taxa remain poorly defined due to incomplete historical descriptions.

This is particularly pressing in Armadillidae, which are considered among the most difficult Oniscidea to identify (Schmidt 2003), with the family urgently requiring a thorough revision to enable meaningful diagnoses, monophyletic generic definitions, and informed hypotheses on phylogenetic relationships. As also noted by Taiti, Paoli and Ferrara (1998), the taxonomy of Armadillidae remains highly confused and can only be clarified gradually, given the vast number of included genera and species. This underlines the need for ongoing research to prevent the persistence and further propagation of outdated or inaccurate information, and the case of *Revelosa cassida* gen. et comb. nov. exemplifies this challenge.

Conclusion

The revised species *Revelosa cassida* gen. et comb. nov. nicely illustrates the challenges and opportunities imposed by historical and neglected material: the species was insufficiently described, erroneously assigned to a genus, and remained unstudied for over a century. Though fragments of the holotype remained inaccessible, we were nevertheless able to identify distinct morphological characters—including one that deviates from the character state observed in all other known members of the family—that justify the establishment of a new and highly recognizable genus. This correction not only resolves a long-standing taxonomic error but also enhances our understanding of the morphological diversity within Armadillidae and contributes to a more accurate representation of Madagascar's oniscidean fauna.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Conceptualization: BK. Investigation: BK, OD. Project administration: BK. Visualization: OD. Writing – original draft: BK. Writing – review and editing: BK, OD.

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Data availability

All of the data that support the findings of this study are available in the main text.

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