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Manduca exiguus (GEHLEN, 1942): a valid species from southern and southeastern Brazil, Uruguay and northeastern Argentina (Lepidoptera: Sphingidae)

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Abstract: *Manduca exiguus* (GEHLEN, 1942) *stat. n.* was first described as a subspecies of *Manduca lucetius* (CRAMER, 1780), but later considered as a junior synonym of *Manduca contracta* (BUTLER, 1875). Here, we compare the two taxa and demonstrate the validity of *M. exiguus* as a species on the basis of a distinctive habitus and differences in the male genitalia, together with corroborating evidence from DNA barcodes. The distribution of *M. exiguus* is detailed.

Keywords: taxonomy, DNA barcoding, geographical distribution.

***Manduca exiguus* (GEHLEN, 1942): espèce valide du sud et sud-est du Brésil, Uruguay et nord-est de l'Argentine (Lepidoptera: Sphingidae)**

Résumé: Le taxon *Manduca exiguus* (GEHLEN, 1942) *stat. n.* a été décrit initialement comme sous-espèce de *Manduca lucetius* (CRAMER, 1780), puis considéré plus récemment comme un synonyme de *Manduca contracta* (BUTLER, 1875). Il est revalidé ici et rehaussé au rang d'espèce. Les différences dans l'habitus et les genitalia sont présentées, ainsi que les résultats congruents de l'analyse des codes-barres ADN. Sa répartition est précisée.

***Manduca exiguus* (GEHLEN, 1942): eine valide Art vom südlichen und südöstlichen Brasilien, von Uruguay und Nordostargentinien (Lepidoptera: Sphingidae)**

Zusammenfassung: *Manduca exiguus* (GEHLEN, 1942) *stat. n.* wurde zuerst als Unterart von *Manduca lucetius* (CRAMER, 1780) beschrieben, dann später als jüngeres Synonym von *Manduca contracta* (BUTLER, 1875) interpretiert. Hier vergleichen wir die Taxa und zeigen die Validität von *M. exiguus* als separate Species auf der Basis eines unterschiedlichen Habitus, Unterschieden im männlichen Genitalapparat sowie unterstützenden Hinweisen aus dem mt-DNA-Barcode. Die bekannte Verbreitung von *M. exiguus* wird klargestellt.

Introduction

Protoparce lucetius exiguus GEHLEN, 1942 was described as a subspecies of *Protoparce lucetius* (CRAMER, 1780) based on a syntypic series of 10 ♂♂ and 1 ♀ from “Uruguay” without further locality information. The description is brief (GEHLEN 1942) and without illustrations, and a comparison was made only with the nominotypical subspecies and *P. lucetius nubila* (ROTHSCHILD & JORDAN, 1903). The taxon was then apparently overlooked for the next 45 years. When D'ABRERA (1987: 20) transferred *lucetius* into *Manduca*, he made no mention of the

subspecies *exiguus*. Indeed, the next reference to *exiguus* appears to be that in CARCASSON & HEPPNER (1996: 50), who treated it as a junior synonym of the nominotypical subspecies, although they gave no reason for so doing, nor did they even flag the synonymy as new. Thus, it is possible that another author prior to 1996 had already published the synonymy, but we have been unable to trace any such taxonomic act. Shortly afterwards, KITCHING & CADIOU (2000: 139–141), while clarifying the nomenclature surrounding *Manduca lucetius* and determining that the correct name for the species was actually *Manduca contracta* (BUTLER, 1875), designated the lectotype of *Protoparce lucetius exiguus*. Having examined the lectotype, they stated that it closely matched specimens of *contracta* in the Natural History Museum, London (NHMUK), and explicitly synonymised *exiguus* with *contracta* (together with three other taxa: *Sphinx panaquire* BERG, 1855, *Protoparce lucetius nubila* and *Protoparce lucetius argentina* CLARK, 1926), being unaware of the earlier treatment by CARCASSON & HEPPNER (1996).

In June 2010, during a visit to the Zoologische Staatssammlung München (ZSM), Munich, Germany, the first author had the opportunity to examine the lectotype of *Protoparce lucetius exiguus* (Fig. 1). Although generally similar to specimens of *Manduca contracta* from south-eastern and southern Brazil (Espírito Santo, São Paulo and Santa Catarina states) and from northeastern Argentina (Misiones department), it was not identical and it struck him that it possibly represented a distinct taxon. In this paper, we reappraise the status of *Manduca lucetius exiguus* using an integrative approach that combines morphology and DNA barcode analysis. Our results demonstrate that *M. exiguus stat. n.* is a valid species that is broadly sympatric with *M. contracta*.

Collection abbreviations

NHMUK The Natural History Museum, London, UK (formerly British Museum (Natural History) = BMNH).
 CJHL Research collection of Jean HAXAIRE, Laplume, France.
 DZUP Collection Padre Jesus S. MOURE, Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Paraná, Brazil.
 IMQC Insectarium de Montréal, Montréal, Québec, Canada.
 ZSM Zoologische Staatssammlung München, Munich, Germany.



Figs. 1–2: Types, approx. natural size, dorsal views. Fig. 1: Lectotype of *Protoparce lucetius exiguus* (ZSM). Fig. 2: Holotype of *Protoparce contracta* (NHMUK). — Figs. 3a–f: Adults: 3a: *Manduca exiguus* ♂, Brazil, Santa Catarina; 3b: *Manduca exiguus* ♂, Brazil, São Paulo; 3c: *Manduca exiguus* ♀, Santa Catarina; 3d: *Manduca contracta* ♂, Bolivia, Chuquisaca; 3e: *Manduca contracta* ♂, Brazil, Santa Catarina; 3f: *Manduca contracta* ♀, Bolivia. — Figs. 4a–b: Lateral view of the abdomen: 4a: *Manduca exiguus*; 4b: *Manduca contracta*. — Fig. 6: *Manduca exiguus*, resting attitude, Argentina, El Bagual, Formosa, 18. iv. 2013, Ezequiel Osvaldo NUÑEZ BUSTOS.

Differential diagnosis of *Manduca contracta* and *M. exiguus* stat. n.

(Figs. 1–5.)

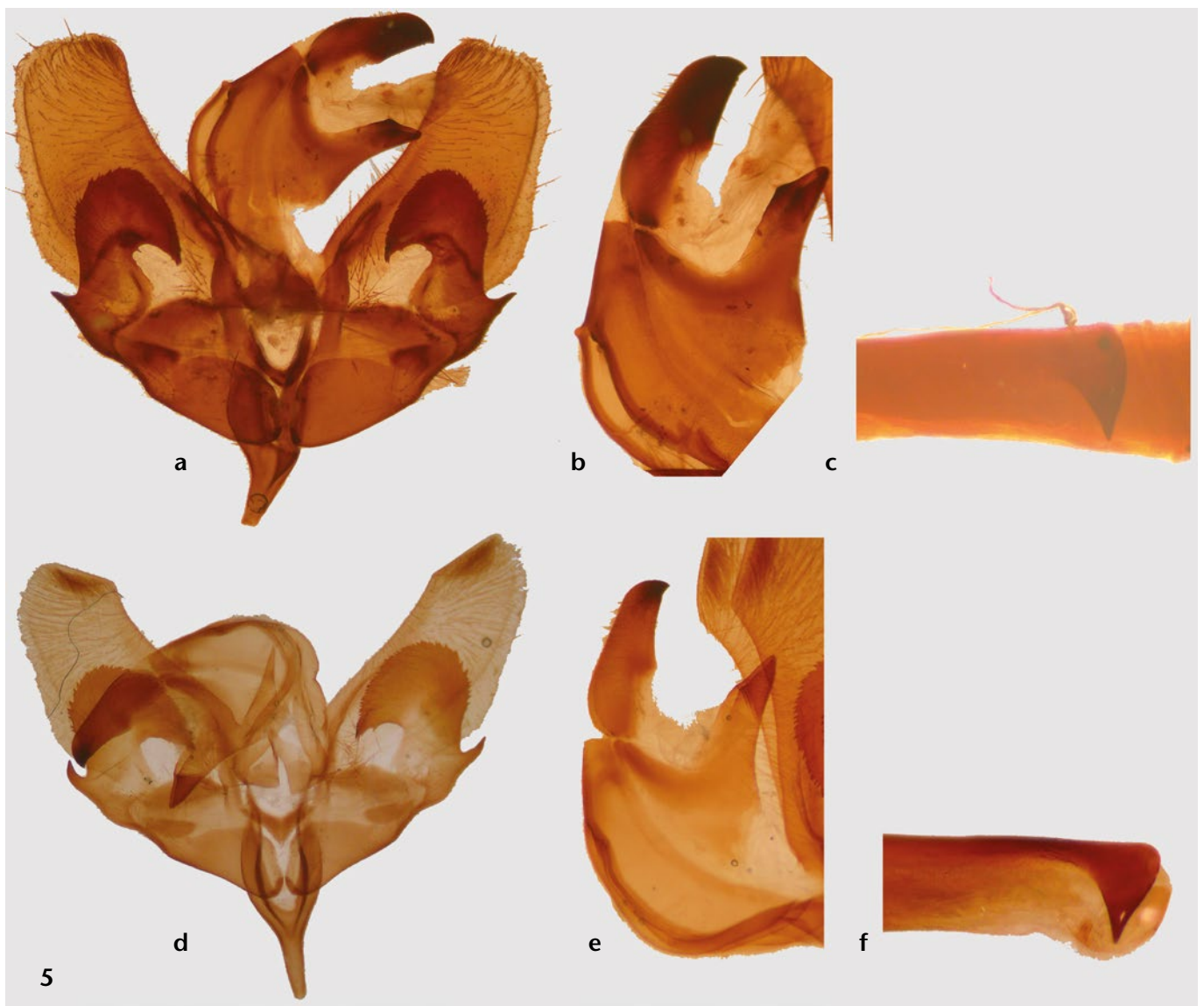
Habitus

M. contracta is a rather variable species. The most conspicuous feature, found in about 95% of the specimens examined, is a strong contrast on the forewing between the shimmering black medial area and the predominantly yellowish-ochre coloration of the rest of the wing (Figs. 3d–f). Thus, in its most common form, *M. contracta* is an easily recognizable “two-tone” insect and it is regrettable that the holotype of *M. contracta* (Fig. 2) represents one of the most extreme individual variations for that species (KITCHING & CADIOU 2000: 139, note 369). Our understanding of the polymorphism in this species, and especially with respect to the form observed in the lectotype, was confirmed by analysis of the DNA barcode for a specimen from Bolivia, Chuquisaca (sample-ID BC-Hax1569, see Fig. 7). This specimen is indeed very similar to the lectotype of *M. contracta* and

its DNA barcode proved to be identical to that of a specimen collected at the same place representing the most common “two-tone” form of this species.

In contrast, the habitus of *M. exiguus* stat. n. is more uniform (Figs. 3a–c), lacking the marked contrast observed on the forewings of *M. contracta* (as such it resembles more the wing patterns observed in *M. diffissa* (BUTLER, 1871) from which it can however be immediately separated by the black and strongly waved post-medial line of the forewings, which is always absent in *M. diffissa*). All the specimens of *M. exiguus* examined (see list below) show little individual variation, with a deep brown and relatively uniform ground colour. They are also all slightly smaller than *M. contracta*, with the mean wingspan of ♂♂ of *M. exiguus* being 92 mm ($n = 20$) versus a mean wingspan of 102 mm ($n = 22$) in ♂♂ of *M. contracta*.

A summary of the diagnostic features of the habitus of *M. exiguus* that permit its separation from *M. contracta* is given below (text within parentheses refers to *M. contracta*):



Figs. 5a–f: Male genitalia, not to the same scale. — Figs. 5a–5c: *Manduca exiguus*, 5a: general view; 5b: uncus and gnathos, lateral view; 5c: detail of phallus. — Figs. 5d–5f: *Manduca contracta*, 5d: general view; 5e: uncus and gnathos, lateral view; 5f: detail of phallus.

- Forewing more elongated and pointed (more rounded).
- Forewing ground colour deep brown, powdered with grey scales (mostly yellowish-ochre).
- Weak contrast between the blackish medial area of the dorsal forewing and the surrounding dorsal, antemedial and postmedial areas (marked contrast).
- Thick black line running inward from the apex of the forewing (line thinner).
- Yellow lateral patches on the abdomen smaller and more distinctly separated from each other by black intersegmental bands (compare Figs. 4a/b).
- Paler dorsal surface of the antennae.

Male genitalia

The members of this species-group (e.g., *M. reducta* (GEHLEN, 1930), *M. duquefi* (HAXAIRE & VAGLIA, 2007)) share a generally similar genital structure, and *M. exiguus* and *M. contracta* are no exception. However, some diagnostic differences in the ♂ genitalia of *M. exiguus* were observed, permitting an unequivocal distinction from *M. contracta*. All the characters listed below are features of *M. exiguus* in comparison to those of *M. contracta*; they are illustrated in Figs. 5a-f:

- Uncus shorter and thicker.
- Gnathos shorter, its apical shovel-shaped section more strongly bent downward, shorter and with a more rounded tip.
- Harpe smaller, distal margin less rounded, its apical point shorter, basally recurved and dorsally flatter. basal tooth shorter and less upcurved.
- Fultura inferior (juxta) rounded (V-shaped in *M. contracta*).
- Saccus shorter and less tapered.
- Apical tooth of phallus with a straighter posterior margin and arising anterior to the phallus apex (in *M. contracta*, the tooth has a more broadly rounded posterior edge and arises apically on the phallus).

Comparison of DNA barcode sequence data

DNA barcodes were generated following standard laboratory procedure at the Canadian Centre for DNA barcoding. Records generated for the global DNA barcoding campaign for Sphingidae were completed with a set of 3 additional records from the Entre Rios province of Argentina, to which we were kindly given access by colleagues from the Museo Argentino de Ciencias Naturales “B. Rivadavia” (see Acknowledgments). In total, 24 DNA barcodes were analysed including 8 records of *M. exiguus* from Argentina (Entre Rios, Chaco, Misiones) and Brazil (Santa Catarina), and 16 records of *M. contracta* from Argentina (Misiones, Tucumán), Brazil (Distrito Federal, Santa Catarina, Mato Grosso, Minas Gerais), Paraguay (Caaguazu), and Bolivia (La Paz, Chuquisaca).

Genetic distances (K2P; pairwise deletion, BOLD alignment) within and between species were calculated in

BOLD (www.boldsystems.org) and are as follows: maximum intraspecific distance of 1.1% and 0.8% within *M. contracta* and *M. exiguus* respectively; minimum distance between the two species of 4.63%. A visual representation of genetic distances between the records analysed, together with the geographical origin of each is given in Fig. 7 in the form of a neighbor joining tree (built in BOLD with standard options, BOLD alignment, K2P distances) clearly illustrating the genetic segregation of *M. exiguus* and *M. contracta* specimens. All records, including images, specimen and sequence data, are publicly available within the dataset EXIGUUS1 ([dx.doi.org/10.5883/DS-EXIGUUS1](https://doi.org/10.5883/DS-EXIGUUS1)) on BOLD and in GenBank with accession numbers HM384221, HM384222, HM384875, HM384876, HQ581522, JN678198 and KM224675 to KM224694.

Geographical distribution

M. contracta occurs in Bolivia (HAXAIRE & HERBIN 1999, KITCHING et al. 2001), Paraguay (DRECHSEL 1994), north-eastern Argentina (MORÉ et al. 2005) and northern to southern Brazil. The two specimens illustrated by MARTIN et al. (2011) as *M. contracta* are correctly determined. The citation of “*Manduca lucetius*” by SIEWERT & SILVA (2010) is probably correctly *M. contracta*.

Manduca exiguus flies in south Brazil, eastern Argentina and Uruguay. The specimens examined for this study are as follows:

Brazil: 3 ♂♂ (including BOLD sample-IDs BC-Hax5000 and BC-Hax5001), 2 ♀♀, Santa Catarina, Urubici, Morro da Igreja, 1250 m, 26.–31. XII. 2008, leg. Carlos MIELKE. 2 ♂♂, same data, but 13.–19. II. 2009. 6 ♂♂, Santa Catarina, Urubici, Morro da Igreja, 1343 m, 24. X. 2011, 28°3′31.88″ S, 49°29′44.75″ W, leg. PAQUIT, HAXAIRE & HERBIN. 1 ♂, Santa Catarina, Rio Vermelho, Piste Rio Natal, 538 m, 23. X. 2011, 26°20′1.28″ S, 49°18′29.12″ W, leg. HAXAIRE, HERBIN & MIELKE. 1 ♀, Espírito Santo, during winter 1980/1981, leg. Laurent SCHWARTZ. 1 ♂, Rio de Janeiro, Itatiaia National Park, 800 m, IX. 1958, leg. L. SCHWARTZ. 1 ♂, Rio de Janeiro, Boracéia, 800 m, IV. 1961, leg. L. SCHWARTZ. 1 ♂, Paraná, 22. X. 2011, Campo do Tenente, leg. PAQUIT, HAXAIRE, HERBIN & MIELKE. – All in CJHL. – 1 ♂, Paraná, Tijucas do Sul, 879 m, in DZUP.

Argentina: 1 ♀, Entre Rios, Liebig, XII. 1996, in CJHL. – 1 ♂ (BOLD sample-ID VAG-279), Entre Rios, Liebig, 6. XII. 2001. 1 ♂ (BOLD sample-ID VAG-280), 1 ♀ (VAG-281), Misiones, San Vicente, 10. X. and 20. XII. 2006, respectively. 1 ♂ (BOLD sample-ID VAG-282), Chaco, Bermejito, Villa Rio, 8. X. 2003. – All in IMQC. – Buenos Aires (Buenos Aires), in Fernando PENCO private collection.

Uruguay: (without locality, the lectotype and paralectotype series in ZSM).

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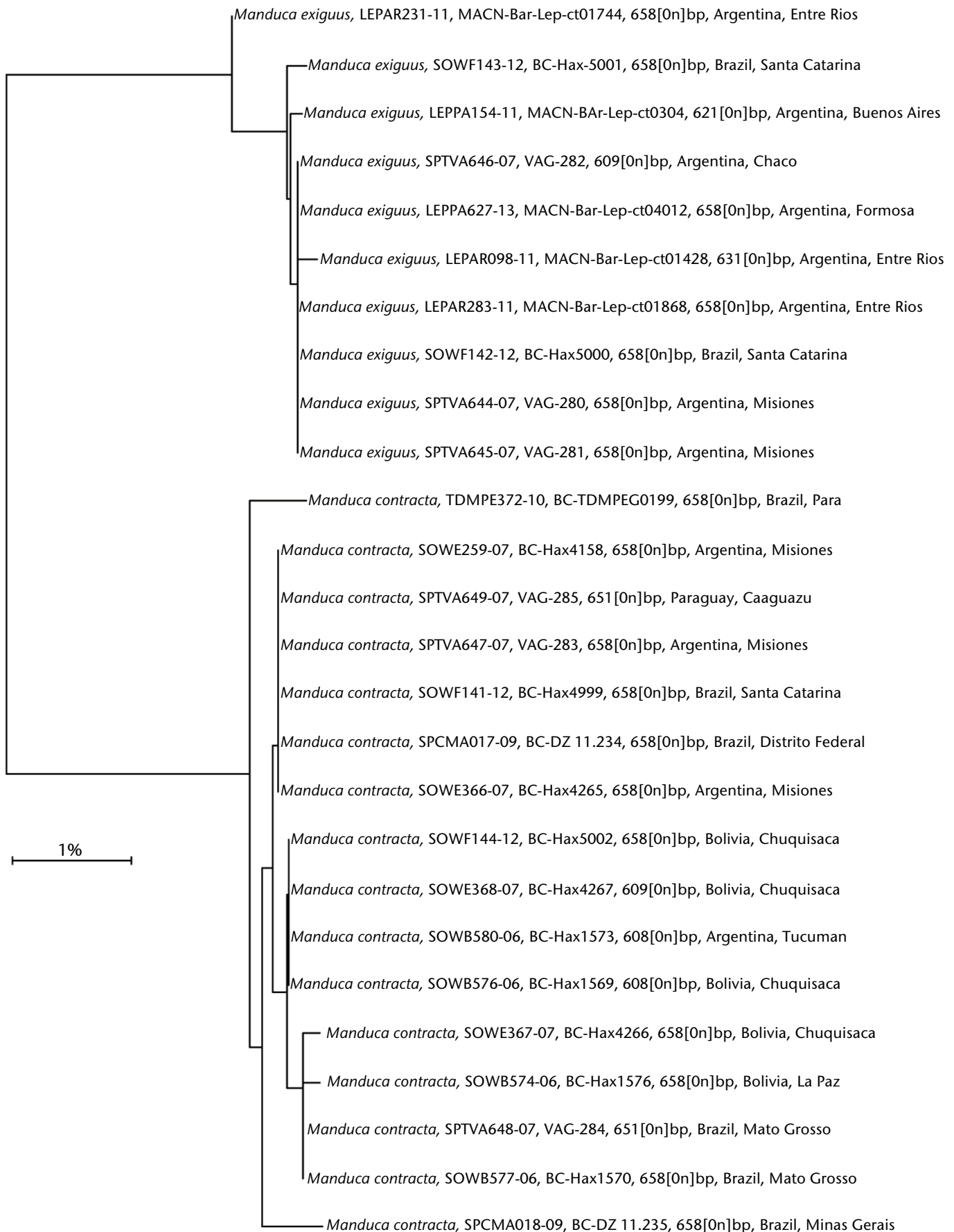


Fig. 7: Neighbor joining tree of the 26 DNA barcode sequences analyzed for *Manduca contracta* and *M. exiguus*. The text for each terminal indicates, from left to right: corrected taxon name, BOLD process-ID, BOLD sample-ID, sequence length (bp = base pairs), and geographical origin (country and province).

data, images and DNA barcodes of their Argentinian records of *M. exiguus*. Thierry VAGLIA and Thibaud DECAËNS also provided samples for DNA barcoding used in this study. Sequencing of DNA barcodes and bioinformatics (BOLD) were supported by funding from the government of Canada through Genome Canada and the Ontario Genomics Institute in support of the International Barcode of Life project (www.iBOL.org), and by the Natural Sciences and Engineering Research Council of Canada (NSERC). The authors are also thankful to the lab team at the Canadian Centre for DNA barcoding (CCDB), University of Guelph, for processing our samples.

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