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ARTICLE

Updated checklist, dubious and erroneous records of *Trichogramma* species (Hymenoptera: Trichogrammatidae) in South America

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Abstract. Taxonomic studies of the genus *Trichogramma* have advanced since the 1970s, mainly due to the use of reliable morphological characters, based on male genital capsule, for species identification. Here, we discus the *Trichogramma* species that actually occur in South America, and also the dubious or erroneous records of species, which should not be considered present in the South American countries. We found that 70 species are recorded in South America, of which 46 correspond to correctly identified species and 24 are dubious or erroneous species records. Most of the species (44) belong to the subgenus *Trichogramma,* and only two species to the subgenus *Vanlisus.* In the first part, we listed the 46 species of *Trichogramma,* focusing on taxonomic information, including type material, type locality, insect hosts, and geographical distribution, based on bibliographic references, to confirm if the species was correctly identified. Thus, we gathered information scattered throughout the literature on taxonomic studies, including descriptions, identification keys, checklists, morphological, morphometric and molecular studies. In the second part, we discussed dubious and erroneous records of 24 species of *Trichogramma* in South America based on extensive literature review, taking into account that the identification of *Trichogramma* species was clarified in the 1970s. There are no voucher specimens available to verify the identification of the introduced species in South America. Nevertheless, based on extensive literature review, it was possible to reliably confirm whether a species was misidentified or not established in a South American country. Although these records of *Trichogramma* species are clearly dubious or erroneous, they have been cataloged and discussed in several publications. To avoid incorrect records, an introduced species should be considered present in a country only after releases and field recoveries. Among the introduced species in South America, only *T. pintoi* Voegelé was established in Peru.

Keywords. Egg parasitoids; Hosts; Distribution; Records; Taxonomy.

INTRODUCTION

Although the genus *Trichogramma* was created in the 19th century (Westwood, 1833), taxonomic studies of the genus only advanced from the 1970s onwards, with the use mostly of the morphological characters of the male genital capsule for species identification (Nagarkatti & Nagaraja, 1971). Therefore, many species recorded in South America, prior to 1970, correspond to dubious or erroneous identifications because they were not based on reliable characters. For instance, until the 1960s, *T. minutum* Riley was the sole name employed for egg parasitoids associated with various agricultural pests in Brazil (Silva *et al.,* 1968). Similarly, in Peru, *T. minutum* was regarded as the only species utilized in biological control programs (Ruiz & Korytkowski, 1979). However, as taxonomic studies progressed, other species were identified in Peru (Whu & Valdivieso, 1999), but at that time, many species were misidentified. The first taxonomic studies of the genus *Trichogramma* in South America emerged toward the end of the 1970s and continued into the 1980s (Ruiz & Korytkowski, 1979; Voegelé & Pointel, 1980; Brun *et al.,* 1984; Whu, 1985; Zucchi, 1988).

The use of *Trichogramma* species names without appropriate taxonomic procedures has resulted in errors in species identification in various South American countries. Moreover, even when taxonomic procedures were conducted, reliable morphological characters for species recognition were not well established until the late 1970s,

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leading to misidentifications. Additionally, due to the significant economic importance of *Trichogramma* in biological pest control, several introductions were conducted in South America without confirming whether the species became successfully established. Nevertheless, despite this uncertainty, a species was considered present (recorded) in the country. Once the occurrence of the species was documented in the country where it was introduced, this information was disseminated through various publications, without confirmation of the species identity or preservation of voucher specimens. In some cases, the record was based exclusively on reports of host eggs parasitized by *Trichogramma* sent to some South American countries (CIBC, 1976). Therefore, along with the taxonomic issues, the lack of knowledge regarding native species may have influenced assessments of the efficiency of these parasitoids.

The *Trichogramma* catalogues for South America listed species records based on taxonomic studies, but also on information from biological control studies (*e.g.,* De Santis, 1979). However, in many cases, applied studies tended to overlook taxonomic studies, leading to unreliable information and confusion in the records of *Trichogramma* in various countries. Despite this, all studies related to *Trichogramma* were included in several catalogs, without verifying whether taxonomic procedures had been adopted to identify the species. Anyway, the mention of a species in any type of publication (*e.g.,* reports, conference proceedings, etc.) was sufficient to register it in a South American country. Subsequently, this record was reproduced in several publications, releasing erroneous information on the distribution of the species until today. Our analysis clearly revealed that introduced species into a South American country were studied primarily in laboratories, rarely released, and virtually never recovered in the field.

Before 1970, numerous species of *Trichogramma* were used in biological control programs despite not being accurately identified. This led to the failure of several programs (Danks, 1988) and contributed to misinformation regarding the geographic distribution of the species. Additionally, numerous inaccurate records on identification and distribution of *Trichogramma* were cataloged and widely used without verification on this information.

Confirmation of the species being reared is a crucial step in any biological control program and requires verification by a taxonomist throughout the program, followed by deposition of voucher specimens in a public collection. When this protocol is neglected, the hosts and distribution of *Trichogramma* species utilized in applied research are often inaccurately documented in a country, leading to the inappropriate use of species names. Pinto (1999), reflecting on this issue, noted that *"One of the mysteries of* Trichogramma *taxonomy is how certain common New World species became misidentified as they did and how these misidentifications became well-established in the literature".* Unfortunately, the absence of voucher specimens and surveys on the establishment of introduced species difficult the clarification of species identity in a certain country. However, it is possible to safely recognize dubious and erroneous records of *Trichogramma* species in South America countries through careful analysis of information on species identifications published by taxonomists.

In this study, we examined records for 70 species of *Trichogramma* in South America. Our analysis confirmed the accuracy of records for 46 species (Table 1) and dubious or erroneous records for 24 species, most of them introduced (Table 2).

Table 1. Distribution of *Trichogramma* species in South American countries.

Species	Countries										
	ARG	BOL	BRA	CHL	COL	ECU	GUY	PAY	PER	URU	VEN
T. acacioi			X								
T. acuminatum			X								
T. alloeovirilia			X								
T. atopovirilia	X		X		X						X
T. atropos			X								X
T. bellaunionensis										X	
T. bennetti					X		X				X
T. bertii			X								
T. bruni	X	X	X	X							X
T. cacoeciae									X		
T. clotho			X								
T. colombiensis	X				X					X	X
T. demoraesi			X								
T. diazi											X
T. dissimilis			X								
T. disctinctum			X							X	
T. erebus					X						
T. esalqueanum			X								
T. exiguum	X		X	X	X		X		X	X	X
T. fasciatum						X					X
T. foersteri			X								
T. fuentesi	X								X		
T. galloi	X	X	X		X			X	X	X	
T. iracildae			X								
T. jalmirezi			X								
T. koehleri	X										
T. lasallei		X	X						X	X	X
T. lopezandinensis					X						
T. manicobai			X								
T. marandobai			X						X		
T. maxacalii			X								
T. nerudai				X							
T. nomlaki				X							
T. obscurum											X
T. parrai			X								
T. pintoi									X		
T. piracicabensis			X								
T. pratissolii			X								
T. pretiosum	X	X	X	X	X	X		X	X	X	X
T. pusillum			X								
T. rojasi	X		X	X					X		
T. stampae					X						
T. terani											X
T. tupiensis			X								
T. valmiri			X								
T. zucchii			X								

Table 2. Dubious or erroneous records of *Trichogramma* species in South American countries.

Species	Comments	References
ARGENTINA		
T. achaeae	Not recovered after introduction	Aquino & Querino (2023)
T. agrotidis	Not recovered after introduction	Aquino & Querino (2023)
T. australicum	Prior to 1982, name improperly applied	Pinto *et al.* (1982)
T. brassicae	Homonym (name preoccupied by *T. buesi*)	Voegelé (1985)
T. buesi	Not recovered after introduction	Aquino & Querino (2023)
T. cacoeciae	Not recovered after introduction	Aquino & Querino (2023)
T. evanescens	Species not adequately characterized	Noyes *et al.* (2000, 2001)
T. euproctidis	No record of establishment	De Santis (1998)
T. fuentesi	No record of establishment	De Santis & Fidalgo (1994)
T. maidis	Junior synonym of *T. brassicae* Bezdenko	Pinto (1999)
T. minutum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
T. nerudai	Not recovered after introduction	Aquino & Querino (2023)
T. oleae	Not recovered after introduction	Aquino & Querino (2023)
T. perkinsi	No record of establishment	De Santis & Fidalgo (1994)
T. pintoi	Laboratory rearing, without release	De Santis (1998)
T. semifusca [sic]	*Nomen nudum*	Zerova & Fursov (1989)
BOLIVIA		
T. semifumatum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
BRAZIL		
T. australicum	Prior to 1982, name improperly applied	Pinto *et al.* (1982)
T. bennetti	Does not occur in Brazil	Querino & Zucchi (2007)
T. brasiliensis	*Trichogrammatoidea* (not *Trichogramma*)	Pinto (1997)
T. chilotraeae	No record of establishment	CIBC (1976) (consignment)
T. fasciatum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
T. japonicum	No record of establishment	CIBC (1976) (consignment)
T. minutum	Does not occur in Brazil	Querino & Zucchi (2007)
COLOMBIA		
T. australicum	No record of establishment	CIBC (1976) (consignment)
T. chilotraeae	No record of establishment	CIBC (1976) (consignment)
T. japonicum	No record of establishment	CIBC (1976) (consignment)
CHILE		
T. achaeae	No information after introduction	Pintureau *et al.* (1999)
T. brasiliensis	*Trichogrammatoidea* (not *Trichogramma*)	Prado (1991)
T. cacoeciae	Lab rearing; no additional information	Velásquez & Gerding, 2006
T. evanescens	Lab rearing; no additional information	Velásquez & Gerding, 2006
T. fasciatum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
T. maidis	Lab rearing; no additional information	Velásquez & Gerding, 2006
T. minutum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
T. perkinsi	Probable misidentification of *T. exiguum*	Pinto (1999)
PERU		
T. australicum	Prior to 1982, name improperly applied	Pinto *et al.* (1982)
T. atopovirilia	No record of establishment	Whu & Valdivieso (1999)
T. brasiliense	*Trichogrammatoidea* (not *Trichogramma*)	Whu & Valdivieso (1999)
PERU		
T. chilotraeae	No record of establishment	Whu & Valdivieso (1999)
T. evanescens	Species not adequately characterized	Noyes *et al.* (2000, 2001)
T. dendrolimi	Not recovered after introduction	Whu & Valdivieso (1999)
T. embryophagum	Not recovered after introduction	Whu & Valdivieso (1999)
T. fasciatum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
T. japonicum	Not collected after introduction	Whu & Valdivieso (1999)
T. minutum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
T. perkinsi	Probable misidentification of *T. exiguum*	Pinto (1999)
T. semifumatum	Prior to 1978, name improperly applied	Pinto *et al.* (1978)
VENEZUELA		
T. chilotraeae	No record of establishment	De Santis & Fidalgo (1994)
T. japonicum	No record of establishment	De Santis & Fidalgo (1994)

Therefore, we have compiled an updated checklist of *Trichogramma* species that occur in South American countries. Additionally, based on a literature review, we listed dubious or erroneous records of *Trichogramma* species in South America, such as misidentification or lack of information on species establishment.

MATERIAL AND METHODS

Updated checklist of *Trichogramma* in South America

We compiled information on *Trichogramma* species exclusively from taxonomic papers, where the identification was uncontested by other taxonomists. Cases of contested identification are discussed in the "Comments" section for the respective species. We traced the history of identification for all 46 species and their records in South America, which were correctly identified and published in taxonomic papers. Records published in applied studies without a taxonomic basis were excluded. For each species, we provide information on type material, hosts (insects and plant associates), distribution in South American countries (Table 1), and bibliographical references. The specific epithet, particularly those relating to localities or countries (-ensis), follows Universal Chalcidoidea Database (UCD, 2023). Names of host plants are in accordance with the standards of the World Flora Online (WFO, 2024).

Trichogramma species erroneously recorded in South America

In this second part, we discuss cases of *Trichogramma* species in South American countries that correspond to dubious or erroneous records due to incorrect identification or lack of information about the establishment of the species in the country. The checking of dubius and/or erroneous records was based on the taxonomic literature (scientific journals, symposium proceedings, reports, and newsletters) and considering the year of introduction or record of *Trichogramma* species in South American countries. The year of introduction is important information, as most identifications prior to 1978 are dubious or erroneous because they were not based on reliable morphological characters. After that year, by cross-referencing information from several publications, we discussed and justified the species erroneously recorded in South American countries.

Acronyms used for the depositories: BPBM = Bernice Pauahi Bishop Museum, Honolulu, Hawai'i, USA; **CELM** = National Taxonomic Collection "Luis Ma. Murillo", Colombia; **CEURG** = Colección Entomológica Universidad Rómulo Gallegos. San Juan de los Morros, Estado Guárico, Venezuela; **CIBC** = Commonwealth Institute of Biological Control, Bangalore, India; **CNC** = Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Canada; **ICB** = Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Belo Horizonte,

Minas Gerais, Brazil; **INIA** = Instituto de Investigaciones Agropecuarias, Subestación Experimental La Cruz, Chile; **INRA** = Institut National de la Recherche Agronomique, Station de Zoologie et de Lutte Biologique, Antibes, France; **INTA** = Instituto Nacional de Tecnología Agropecuaria, Instituto de Patología Vegetal, Argentina; **MELQ** = Museu de Entomologia Luiz de Queiroz, Piracicaba, São Paulo, Brazil; **MHNS** = Museo de Historia Natural de Santiago, Chile; **MIZA** = Museo del Instituto de Zoología Agrícola "Francisco Fernandez Yépez", Facultad de Agronomia de la Universidad Central de Venezuela, Maracay, Venezuela [formerly Museu de Zoologia, Escola de Agronomía, Universidade Central, Venezuela]; **MNHN** = Muséum national d'Histoire naturelle, Paris, France; **NHM** = Natural History Museum, London, UK [formerly British Museum (Natural History)]; **UCR** = University of California Riverside, California, USA; **UFPR** = Universidade Federal do Paraná, Departamento de Zoologia, Curitiba, Paraná, Brazil; **USNM** = National Museum of Natural History, Smithsonian Institution, Washington, DC, USA [formerly United States National Museum].

South American countries: ARG = Argentina; **BOL** = Bolivia; **BRA** = Brazil; **CHL** = Chile; **COL** = Colombia; **ECU** = Ecuador; **GUY** = Guyana; **PER** = Peru; **PRY** = Paraguay; **URY** = Uruguay; **VEN** = Venezuela.

RESULTS

Trichogramma species in South America

According to our literature review and detailed analysis of taxonomic papers, 46 species of *Trichogramma* are recorded in South America, with 44 belonging to the subgenus *Trichogramma* and two to the subgenus *Vanlisus*. Brazil has the largest number of recorded species (30), followed by Venezuela (12), Argentina (9), Colombia (8), and Peru (8). These numbers primarily reflect the level of research conducted on *Trichogramma* in these countries rather than natural variations in *Trichogramma* diversity. Indeed, the prevalence of records in these countries corelates with the extent of research on agricultural pests and biological control programs. Consequently, most records correspond to *Trichogramma* species collected in agricultural environments. Relatively few collections have been carried out in undisturbed habitats, leaving the diversity in these areas largely unexplored. Notably, there are no records of *Trichogramma* in French Guyana and Suriname.

Genus *Trichogramma* in South America

Trichogramma Westwood, 1833: 444.

Trichogramma Westwood, 1833: 444; Type species, *Trichogramma evanescens* Westwood, 1833 (by monotypy).

Calleptiles Haliday, 1833: 340; Type species, *Calleptiles latipennis* Haliday (by monotypy).

Pentarthron Packard, 1872: 104; Type species *Pentarthron minutum* Riley (by monotypy).

Aprobosca Westwood, 1878: 592 (as subgenus); Type species, *Trichogramma* (*Aprobosca*) *erosicornis* Westwood (by monotypy).

Oophthora Aurivillius, 1897: 250; Type species, *Oophthora semblidis* Aurivillius (by monotypy).

Pentarthrum: Dalla Torre, 1898: 2, incorrect subsequent spelling of *Pentarthron*.

Xanthoatomus Ashmead, 1904b: 360; Type species, *Xanthoatomus albipes* Ashmead (by monotypy).

Neotrichogramma Girault, 1911a: 38; Type species, *Neotrichogramma acutiventre* Girault (by original designation).

Trichogrammatana Girault, 1932: 1 (as subgenus). Type species, *Trichogramma* (*Trichogrammatana*) *singularis* Girault (by monotypy).

Nuniella Kostadinov, 1988: 49; Type species, *Nuniella bistrae* Kostadinov (by monotypy).

Comments: Synonymies of the genus based on Pinto (1999, 2006). The original description of *T. evanescens* is quite short, illustrated by a female antenna and a tarsus. A single slide-mounted female is the only remaining type material (Noyes *et al.,* 2000). According to Triapitsyn (2015), the female should be considered a syntype, since lectotype was never designated, and *T. evanescens* should be considered as a *nomen dubium* and the name should be used only for the original syntype female, however, the species name *T. evanescens* Westwood should be retained as a valid taxon. As type material is a female, it is impossible to establish the identity of *T. evanescens,* as the classical taxonomy of *Trichogramma* is based on the morphological characters of the male. In addition, there is disagreement between taxonomists regarding the identity of the species, and at least two species have been identified as *T. evanescens* (see Noyes *et al.,* 2000, 2001). To clarify the identity of *T. evanescens,* morphological and molecular techniques were used to identify *Trichogramma* reared from suitable lepidopteran eggs on various plants from Chelsea, London (type locality), and compared with other known European species (Noyes *et al.,* 2001). However, there is no further information on this study. The history of the taxonomy of the genus *Trichogramma* in Brazil was reviewed by Zucchi & Querino (2024).

Subgenus *Trichogramma* Westwood, 1833 (nominotypical)

T. acacioi Brun, Moraes & Soares, 1984: 809 (fig. 4, antenna and genital capsule of the male, female external genitalia and posterior tibia). **Type material:** Holotype (male), allotype (ICB) (both apparently lost). **Type locality:** Brazil, Minas Gerais, Jaboticatubas. **Hosts:** *Psorocampa denticulata* (Lep., Notodontidae) on *Eucalyptus grandis* (Myrtaceae) and six other lepidopteran species in agricultural and forestry environments, including *Anticarsia gemmatalis* (Lep., Erebidae) on *Glycine max, Dione juno juno* (Lep., Nymphalidae) on *Passiflora* sp. (Passiflorace-

ae), and *Euselasia* sp. (Lep., Riodinidae) on eucalyptus. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2003a) (host, morphological characters); Querino & Zucchi (2005) (key, Brazil); Zucchi *et al.* (2010) (hosts, distribution); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

T. acuminatum Querino & Zucchi, 2003b: 2 (figs. 1a, 2a, male genital capsule). **Type material:** Holotype (male); paratype (1 male) (MELQ). One paratype (male) with same data as holotype (UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Tupi forest reserve), suction trap. **Host:** Unknown. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comments: Only the type material is known. This name was used by Ashmead (1888) when he described *T. acuminatum*. However, according to Girault (1911a, b), this species was erroneously described in *Trichogramma* by Ashmead, since it belongs to the genus *Abbella* Girault. Therefore, *Trichogramma acuminatum* Ashmead, 1888 (not *T. acuminatum* Querino & Zucchi) is a junior synonym of *Abbella acuminata* (Ashmead, 1888).

T. alloeovirilia Querino & Zucchi, 2003b: 5 (figs. 2a, 2b, male genital capsule). **Type material:** Holotype (male), 3 paratypes (males) (MELQ), 1 paratype (male) with same data as holotype (UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Tupi forest reserve), suction trap. **Host:** Unknown. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. atopovirilia Oatman & Platner, 1983: 710 (fig. 1, forewing, hind wing, male antenna, mesoscutellum, male genital capsule). **Type material:** Holotype (male), allotype (USNM). **Type locality:** Guatemala, near Solola. **Hosts:** several lepidopteran pests, including *Alabama argillacea* (Lep., Erebidae), *Anticarsia gemmatalis* (Lep., Erebidae), *Diatraea considerata, D. grandiosella, D. saccharalis* (Lep., Crambidae), *Erinnyis ello* (Lep., Sphingidae), *Helicoverpa zea* (Lep., Noctuidae), and *Spodoptera frugiperda* (Lep., Noctuidae). **Distribution:** Northern Mexico south to El Salvador, Argentina, Brazil, Colombia, Venezuela (UCD, 2023). **Refs.:** Isas *et al.* (2016) (host); Pinto (1999) (description, hosts); Querino & Zucchi (2003a) (host, morphological characters); Querino & Zucchi (2005) (key, Brazil); Zucchi *et al.* (2010) (hosts, distribution); UCD (2023) (database, distribution); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (distribution, hosts, database); Querino (2024) (catalog).

Comment: *Trichogramma caiaposi* Brun, Moraes & Soares, 1984 is a junior synonym of *T. atopovirilia* (see Zucchi & Monteiro, 1977).

T. bellaunionensis Basso & Pintureau, 2001: 14 (fig. 1, forewing, male antenna and genital capsule). **Type material:** Holotype (male), allotype, 30 paratypes (3 males, 3 females) (MNHN); 6 males, 6 females (NMNH); 12 (males (MFA). **Type locality:** Uruguay, Bella Unión region. **Host:** *Diatraea saccharalis* (Lep., Crambidae) on *Oryza sativa* (Poaceae). **Distribution:** Uruguay. **Refs.:** Querino & Zucchi, 2019 (checklist, key, South America); Zucchi *et al.* (2010) (host, distribution); Querino *et al.* (2021) (database).

Comment: It is closely related morphologically to *T. lasallei* Pinto (see Querino & Zucchi, 2019).

T. bennetti Nagaraja & Nagarkatti, 1973: 290 (figs. 1, forewing, 2, male antenna, 3, male genital capsule, 4, aedeagus, 5, volsella, 6, intervolsellar process, 7, relative lengths of aedeagus, hind tibia and ovipositor). **Type material:** Holotype (male), allotype, paratypes (number not specified) (USNM, CIBC). **Type locality:** "Trinidad". **Hosts:** *Hypsipyla ferrealis* (Lep., Pyralidae) on *Carapa procera* (Meliaceae), *Anomis* sp. (Lep., Noctuidae) on *Malva* sp. (Malvaceae), and undetermined lepidopteran on *Spiracantha cornifolia* (Asteraceae). **Distribution:** Colombia, Guyana, Trinidad & Tobago, Venezuela. **Refs.:** UCD (2023) (database, distribution), Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (distribution, hosts, database); Velásquez de Ríos & Terán (1995) (hosts in Venezuela); Zucchi *et al.* (2010) (hosts, distribution).

Comment: *Trichogramma guariquensis* Velásquez de Ríos & Terán, 1995 is a junior synonym of *T. bennetti* (see Velásquez de Ríos & Teran, 2003).

T. bertii Zucchi & Querino, 2003, *in* Querino & Zucchi (2003c): 2 (figs. 1a, 2a, male genital capsule). **Type material:** Holotype (male), 1 paratype (male) (MELQ), 1 paratype (male) (UCR). Zucchi (1985) (*nomen nudum;* in a thesis). **Type locality:** Brazil, São Paulo, Altinópolis, Chamflora farm (holotype), Sorocaba (paratypes). **Hosts:** *Glena* sp. (Lep., Geometridae) and *Melanolophia* sp. (Lep., Geometridae) on eucalyptus (Myrtaceae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (distribution, hosts, database); Zucchi *et al.* (2010) (hosts, distribution); Querino (2024) (catalog).

Comment: Only the type material is known.

T. bruni Nagaraja, 1983: 38 (figs. 4, male antenna, 6, forewing, 10, male genital capsule, and aedeagus, 10a, volsella, paramer and intervolsellar process, 14, aedeagus, hind tibia and ovipositor). **Type material:** Holotype (male), allotype, 16 paratypes (8 males, 8 females) (NHM, ICB). **Type locality:** Brazil, Minas Gerais (no locality). **Hosts:** It parasitizes about 10 species, including *Anticarsia gemamatalis* (Lep., Erebidae) and *Bonagota cranaodes* (Lep., Tortricidae) (Querino *et al.,* 2021). **Distribution:** Ar-

gentina, Bolivia, Brazil, Chile, Costa Rica, Mexico, Trinidad and Tobago, Venezuela. **Refs.:** Pinto (1999) (description, distribution); Querino & Zucchi (2002) (intraspecific variation, hosts); Querino & Zucchi (2005) (key, Brazil); Querino *et al.* (2017) (host); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (distribution, hosts, database); Valverde *et al.* (2009) (host); Zucchi *et al.* (2010) (hosts, distribution); Querino (2024) (catalog).

Comment: *Trichogramma castrensis* Velásquez de Ríos & Terán, 1995 is a junior synonym of *T. bruni* (see Velásquez de Ríos & Terán, 2003).

T. cacoeciae Marchal, 1927: 490 (no figures). **Type material:** Females (apparently lost). **Type locality:** Antony (nr. Paris), France. **Hosts:** *Archips rosana* (Lep., Tortricidae) and *Cydia pomonella* (Lep., Tortricidae) on apple (Rosaceae). **Distribution:** Europe, the Pacific Northwest in North America, and Peru. **Refs.:** Pinto (1999) (description, host, distribution); Almeida & Stouthamer (2003) (Peru, molecular identification).

Comments: The definition of *T. cacoeciae* is controversial, because the type material may not exist. In addition, it is a thelytokous species that cannot be converted to arrhenetoky with antibiotics or high temperature treatments; however, a few males are occasionally produced (Pinto, 1999). The specific epithet has been written as *cacoeciae* (*e.g.,* Pinto, 1999) or cacaeciae (*e.g.,* UCD, 2023). However, it should be *cacoeciae,* as the epithet alludes to the name of the host, a moth of the genus Cacoecia, a junior synonym of *Archips* (Tortricid.net: http://tortricidae.com/default.asp). In Pinto (1999: 120), *Archips* is referred to as the associated plant, as follows, "Types. – Type females. France. Antony (nr. Paris): on *Cacoecia rosana* (Tortricidae) eggs collected on *Archips rosana* L.; apparently lost". By comparision with ITS2 sequences from the GenBank, Almeida & Stouthamer (2015) identified *T. cacoeciae* collected in *Cydia pomonella* (Lep., Tortricidae) eggs from Huarochiri, Peru.

T. clotho Pinto, 1992: 627 (figs. 2, funicle, 6, maxillary palp, 9, thoracic microsculpturing, 13, male genital capsule). **Type material:** Holotype (male) (USNM). **Type locality:** Costa Rica, Puntarenas, Golfo Dulce, 13 km S Rincon, Malaise trap. **Host:** *Parrhasius polibetes* (Lep., Lycaenidade) on *Didymopanax vinosus* (as *Schefflera vinosa*) (Araliaceae) and *Pyrostegia venusta* (Bignoniaceae). **Distribution:** Brazil, Costa Rica. **Refs.:** Pinto (1999); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (hosts, distribution, database); Querino (2024) (catalog).

T. colombiensis Velásquez de Ríos & Téran, 1995: 42 (fig. 1c, male genital capsule, aedeagus, hind tibia and antenna). **Type material:** Holotype (male), allotype, paratypes (males, females and paratypes; number not informed) (MIZA). **Type locality:** Colombia, Buga. **Hosts:** *Spodoptera frugiperda* (Lep., Noctuidae) on *Zea mays, Erinnyis ello* (Lep., Sphingidae) on *Manihot esculenta* (Euphorbiaceae) and undetermined noctuid on *Olea eurpaea* (Oleaceae). **Distribution:** Argentina, Colombia, Uruguay, Venezuela. **Refs.:** Botto *et al.* (2002) (Argentina); Grille *et al.* (2009) (host, Uruguay); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (hosts, distribution, database); Velásquez de Ríos & Terán (2003) (distribution, hosts).

Comment: Holotype and allotype collected in Colombia and all paratypes in Venezuela. The year of publication of this species is 1995, when it was formally published, and not 1994, when the description was published in a M.Sc. dissertation (Velásquez de Ríos, 1994), which is not considered a publication by the International Code of Zoological Nomenclature for the purposes of describing a new species. In fact, the name published in 1994 is a *nomen nudum* (Querino & Zucchi, 2019).

T. demoraesi Nagaraja, 1983: 37 (figs. 2, male antenna, 11, male genital capsule, and aedeagus, 11a, volsella, paramer and intervolsellar process, 15, aedeagus, hind tibia, ovipositor). **Type material:** Holotype (male), allotype, paratypes (9 males, 7 females) (NHM, ICB). **Type locality:** Brazil, Minas Gerais, Felixlândia. **Host:** *Glena bipennaria* (Lep., Geometridae) on *Eucalyptus grandis* (Myrtaceae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (distribution, host, database); Vieira *et al.* (2014) (identity; *E. ello* as non-host); Zucchi *et al.* (2010) (hosts); Querino (2024) (catalog).

Comment: Examination of the paratype of *T. demoraesi* revealed that this species was misidentified as *T. marandobai,* which parasitizes *Erinnyis ello* (Lep., Sphingidae) eggs. Therefore, *T. demoraesi* does not parasitize *E. ello* in Brazil, and all records from that host prior to 2014 are misidentifications of *T. marandobai* (see Vieira *et al.,* 2014).

T. diazi Velásquez de Ríos & Téran, 2003: 141 (figs. 16 and 17, male genital capsule). **Type material:** Holotype (male) (CEURG). **Type locality:** Venezuela, Estado Guárico, Las Lajas. **Host:** unknown (undetermined noctuid) on *Malachra* sp. (Malvaceae). **Distribution:** Venezuela. **Ref.:** Querino & Zucchi (2019) (checklist, key, South America).

Comment: Only the holotype is known.

T. dissimilis Zucchi, 1988: 135 (fig. 1, male genital capsule). **Type material:** Holotype (male), 3 paratypes (males) (MELQ). Zucchi (1985) (*nomen nudum;* in a thesis). **Type locality:** Brazil, São Paulo, Iracemápolis, Santa Filomena farm. **Host:** *Diatraea saccharalis* (Lep., Crambidae) on *Saccharum officinarum* (Poaceae). **Distribution:** Brazil **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. distinctum Zucchi, 1988: 136 (fig. 2, male genital capsule). Zucchi (1985) (*nomen nudum;* in a thesis). **Type material:** Holotype (male), 13 paratypes (males) (MELQ). **Type locality:** Brazil, Pernambuco, Carpina (rearing laboratory). **Host:** *Diatraea saccharalis* (Lep., Crambidae) on *Saccharum officinarum* (Poaceae). **Distribution:** Brazil, Uruguay (Basso & Pintureau, 2004). **Refs.:** Parra *et al.* (1991) (biology); Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: This species is closely related to *T. galloi* morphologically (Basso & Pintureau, 2001; Querino & Zucchi, 2019). Only the type material is known.

T. erebus Pinto, 1999: 249 (figs. 20, forewing, 104, 184a, b, male genital capsule). **Type material:** Holotype (male), allotype (USNM), 6 paratypes (males) (UCR, NHM, CNC). **Type locality:** USA, Florida, Miles City. **Host:** *Urbanus proteus* (Lep., Hesperiidae) on *Desmodium* sp. (Fabaceae). **Distribution:** Bahamas, Colombia, Costa Rica, Guatemala, Mexico, USA. **Refs.:** UCD (2023) (database, distribution); Querino & Zucchi (2019) (checklist, key).

T. esalqueanum Querino & Zucchi, 2003c: 3 (figs. 1b, 3d, e, male genital capsule; 3a, b, c, basiconic sensilla; f, mesoscutum, scutellum). **Type material:** Holotype (male), 27 paratypes (males) (MELQ), 2 paratypes (males) (UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Luiz de Queiroz campus). **Hosts:** *Mechanitis lysimnia* (Lep., Nymphalidae) on *Passiflora* sp. (Passifloraceae) and *Heliconius erato phyllis* (Lep., Nymphalidae). **Distribution:** Brazil. **Refs.:** Almeida & Stouthamer (2015) (molecular analysis); Querino & Zucchi (2005) (key, Brazil); Querino *et al.* (2017) (distribution); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. exiguum Pinto & Platner, 1978: 177 *in* Pinto *et al.* (1978) (fig. 3, male antenna, 16, male genital capsule). **Type material:** Holotype (male), from culture material originating from Selma. **Type locality:** USA, Alabama, Selma (USNM). **Hosts:** Several species of Lepidoptera, most of economic importance. **Distribution:** Argentina, Brazil, Canada, Chile, Colombia, Guyana, Peru, Uruguay, USA, Venezuela. **Refs.:** Basso *et al.* (1999) (Uruguay); Pinto (1999) (variation, crosses); Querino & Zucchi (2003a) (host, morphological characters); UCD (2023) (database, distribution); Querino & Zucchi (2019) (checklist, key, South America); Zucchi *et al.* (2010) (hosts, distribution); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comments: *Trichogramma exiguum* can be confused with *T. fuentesi* Torre and *T. minutum* Riley. However, identification of these species was clarified by Pinto *et al.* (1983). These authors also discussed the characters to separate *T. exiguum* and *T. fasciatum* (Perkins) and found that *T. exiguum* had been wrongly identified as *T. perkinsi* Girault by several authors.

T. fasciatum (Perkins, 1912) (as *Pentarthron fasciatum* Perkins, 1912: 19). **Type material:** Lectotype (male) (BPBM). **Type locality:** Mexico, Vera Cruz, Orizaba. **Hosts:** *Diatraea saccharalis* (Lep., Crambidae) on sugarcane, *Hypsipyla grandella* on *Cedrela tonduzii* (Meliaceae), *Acleris gloverana* (Lep., Tortricidae) on unknown plant, *Peridroma saucia* (Lep., Noctuidae) on *Agave sisalana* (Asparagaceae), and an unidentified noctuid (Lepidoptera) on maize. **Distribution:** Canada, Costa Rica, Ecuador, Mexico, Venezuela. **Refs.:** Benzing (1998) (hosts); UCD (2023); Pinto (1999) (taxonomy); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (database); Velásquez de Ríos & Terán (2003) (Venezuela).

Comments: Originally described in the genus *Pentarthron* Packard (junior synonym of *Trichogramma*). Lectotype designated by Pinto *et al.* (1978). According to Pinto *et al.* (1983), several publications before 1978 mistakenly used the name *T. fasciatum* (see *T. fuentesi*). Therefore, many distribution records listed in the UCD (2023) probably do not actually refer to *T. fasciatum*. Records of *T. fasciatum* in Peru (Ruiz & Korytkowski, 1979) are misidentifications of *T. fuentesi* or *T. exiguum* (Querino & Zucchi, 2003a). According to Pinto (1999), *Trichogramma beckeri* Nagarkatti, 1973 is a junior synonym of *T. fasciatum*.

T. foersteri Takahashi, 2021: 3 *in* Takahashi *et al.,* 2021 (figs. 1a, b, antenna and forewing and hind wing of the male, 2, male genital capsule, 3a, mesoscutum and scutellum, b-d, male genital capsule, e, basiconic sensillum). **Type material:** Holotype (male), paratypes (3 males, 3 females) (UFPR). **Type locality:** Brazil, Paraná, São José dos Pinhais. **Host:** *Anticarsia gemmatalis* (Lep., Erebidae) on *Glycine max* (Fabaceae), *Palpita forficifera* (Lep., Crambidae) on *Olea europaea* (Oleaceae). **Distribution:** Brazil. **Refs.:** Takahashi *et al.* (2021) (molecular identification); Villalba *et al.* (2023) (host); Querino *et al.* (2021) (database); Querino (2024) (catalog).

T. fuentesi Torre, 1980: 12 (figs. 4, 5, male genital capsule). **Type material:** not designated. **Type locality:** Cuba, La Habana Province, San José de las Lajas. **Host:** *Diatraea saccharalis* (Lep., Crambidae) on *Saccharum officinarum* (Poaceae), *Helicoverpa zea* on maize, *Chloridea virescens* (Lep., Noctuidae) on cotton (Malvaceae) and *Anomis texana* (Lep., Erebidae) on cotton. **Distribution:** Argentina, Cuba, Dominican Republic, Mexico, USA (UCD, 2023), and Peru (Whu & Valdivieso, 1999). **Refs.:** Pinto (1999) (description); Querino & Zucchi (2003a) (host, morphological characters); Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key); Zucchi *et al.* (2010) (hosts, distribution); Querino *et al.* (2021) (distribution, hosts, database); Querino (2024) (catalog).

Comments: Torre (1980) described the male and female of *T. fuentesi* but did not designate types. He recorded La Habana Province as the type locality; however, this province was divided, and San José de Lajas is now in Mayabeque Province. Until the 1970s, several authors

misidentified *T. fasciatum* as it corresponded to *T. fuentesi* (see Pinto *et al.,* 1978, 1983).

T. galloi Zucchi, 1988: 136 (fig. 3, male genital capsule). **Type material:** Holotype (male), 13 paratypes (males) (MELQ). Zucchi (1985) (*nomen nudum;* in a thesis). **Type locality:** Brazil, São Paulo, Araras. **Host:** *Diatraea saccharalis* (Lep., Crambidae) on *Saccharum officinarum* (Poaceae). **Distribution:** Argentina, Bolivia, Brazil, Colombia, Paraguay, Peru, Uruguay. **Refs.:** Basso & Pintureau (2004) (distribution); Querino & Zucchi (2005) (key, Brazil); Isas *et al.* (2016) (host, Argentina); Querino & Zucchi (2003a) (host, morphological characters); Querino & Zucchi (2019) (checklist, key, South America); Zucchi *et al.* (2010) (hosts, distribution); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: This species is associated exclusively with *Diatraea* spp. in sugarcane, in all South American countries where it has been recorded.

T. iracildae Querino & Zucchi, 2003c: 6 (figs. 1c, 2b, male genital capsule). **Type material:** Holotype (male), 17 paratypes (males) (MELQ), 2 paratypes (males) (UCR). **Type locality:** Brazil, Alagoas, Maceió. **Host:** *Calpodes ethlius* (Lep., Heperiidae) on *Canna* sp. (Cannaceae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. jalmirezi Zucchi, 1988: 137 (fig. 4, male genital capsule). **Type material:** Holotype (male), 2 paratypes (males) (MELQ). Zucchi (1985) (*nomen nudum;* in a thesis). **Type locality:** Brazil, Rio de Janeiro, Campos (Jacarandá farm). **Host:** *Diatraea saccharalis* (Lep., Crambidae) on *Saccharum officinarum* (Poaceae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Zucchi *et al.* (2010) (host, distribution); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. koehleri Blanchard, 1927: 600 (fig. 2, wing, antenna). **Type material:** Holotype (female) (type repository not mentioned). **Type locality:** Argentina, Buenos Aires. **Hosts:** *Ecpantheria indecisa* Walker [sic] and *C. venata* [sic] (Blanchard, 1927). **Distribution:** Argentina. **Refs.:** De Santis, 1967 (catalog); Querino & Zucchi, 2019 (checklist).

Comments: Querino & Zucchi (2019) considered *T. koehleri* as *species inquirenda.* Guagliumi (1973) reported *Spodoptera frugiperda* (Lep., Noctuidae) on sugarcane as the host in northeastern Brazil, definitely an erroneous record. It is not possible to recognize *T. koehleri,* as it was described based on females. It was not cataloged by De Santis & Fidalgo (1994). The holotype is apparently lost (De Santis, 1998).

T. lasallei Pinto, 1999: 153 (figs. 107, 187, male genital capsule). **Type material:** Holotype (male). **Type locality:** British Virgin Islands, Tortola, Sage Mountain National Park (USNM). **Hosts:** Unknown (in the original description); *Anticarsia gemmatalis* (Lep., Noctuidae) on *Glycine max* (Fabaceae), *Mocis latipes* (Lep., Erebidae) on *Megathyrsus maximus* (Poaceae) (as *T. rojasi*). **Distribution:** Bolivia, Brazil, British Virgin Islands, Costa Rica, Mexico, Peru, USA, Uruguay, Venezuela. **Refs.:** Ciociola Jr. *et al.* (2001) (molecular key); Pinto (1999) (hosts); Querino & Zucchi (2003a) (diagnosis, distribution); Zucchi *et al.* (2010) (hosts, distribution); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comments: *Trichogramma lasallei* morphologically resembles *T. rojasi,* and these species have been confused with each other. Therefore, specimens identified as *T. rojasi* before 1998 may actually belong to *T. lasallei,* as observed by Pinto (1999) regarding Cuban specimens identified by Galán & Rodrigues (1991). In Brazil, *T. lasallei* was also misidentified as *T. rojasi* (Querino & Zucchi, 2003a). Likewise, a sample from Peru, which had been identified as *T. rojasi* by S. Nagarkatti (M. Whu, pers. inf.), belonged to *T. lasallei* (RBQ, not published).

T. lopezandinensis Sarmiento, 1993: 3 (fig. 1, a, male genital capsule, and aedeagus. b, male antenna. c, male wing. d, female genitalia, hind tibia). **Type material:** Holotype (male) (CELM), paratypes (31 males; 10 females) (CELM, NHM). **Type locality:** Colombia, Cundinamarca, Chipaque. **Hosts:** *Colias dimeras* (Lep., Pieridae) on *Trifolium repens,* and *Copitarsia consueta* (Lep., Noctuidae) on *Solanum tuberosum* (Solanaceae). **Distribution:** Colombia. **Refs.:** Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (hosts); Zucchi *et al.* (2010) (host, distribution).

Comment: Only the type material is known.

T. manicobai Brun, Moraes & Soares, 1984: 809 (figs. 2a, male antenna. 2b, aedeagus and male genital capsule, 2c, ventral ridge, 2d, intervolsellar process, volsellae, 2d, female external genitalia). **Type material:** Holotype (male), allotype (ICB). **Type locality:** Brazil, Minas Gerais, Felixlândia. **Host:** *Erinnyis ello* (Lep., Sphingidae) on *Manihot esculenta* (as *M. utilissima*) (Euphorbiaceae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino *et al.* (2017) (intraspecific variations, hosts); Querino & Zucchi (2019) (checklist, key, South America); Zucchi *et al.* (2010) (host, distribution); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comments: This species was redescribed by Querino *et al.* (2017). The specific epithet *manicobai* is an emendation of *maniçobai* used in the original description (Zucchi, 1985).

T. marandobai Brun, Moraes & Soares, 1984: 1245 (figs. 1a, male antenna, 1b, forewing. 1c, aedeagus and

male genital capsule, 1d, apical part of the male genitalia, 1e, female external genitalia, hind tibia). **Type material:** Holotype (male), 8 paratypes (males) (ICB) (apparently lost). **Type locality:** Brazil, Minas Gerais, Felixlândia. **Host:** *Erinnyis ello* (Lep., Sphingidae) on *Manihot esculenta* (as *M. utilissima*) (Euphorbiaceae). **Distribution:** Brazil, Peru. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America; Vieira *et al.* (2014, 2015) (key; integrative taxonomy); Zucchi *et al.* (2010) (host, distribution); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comments: An integrative taxonomic study revealed that variations in the male genitalia of *T. marandobai* are intraspecific (Vieira *et al.,* 2015), and specimens from eggs of *Erinnyis ello* previously identified as *T. demoraesi* are, in fact, *T. marandobai*.

T. maxacalii Voegelé & Pointel, 1980: 600 (figs. 1a, female external genitalia, 1b, hind leg of male, 1c, female antenna, 1d, male genital capsule, 1e, male antenna). **Type material:** Holotype (male), allotype (MNHN), paratypes (5 males, 5 females) (INRA). **Type locality:** Brazil, Minas Gerais, site between the Jequitinhonha and Mucuri rivers in an area inhabited by the Maxacali indigenous people. **Host:** *Euselasia euploea eucerus* [sic] (in the original description), *Euselasia* spp. (Lep., Riodinidae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Zucchi *et al.* (2010) (host, distribution); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (host); Querino (2024) (catalog).

Comments: Only the type material is known. *Trichogramma soaresi* Nagaraja, 1983 is a junior synonym of *T. maxacalii* (see Zucchi & Monteiro, 1997).

T. nerudai Pintureau & Gerling, 1999: 56 *in* Pintureau *et al.* (1999) (figs. 1a, male genital capsule. 1b, aedeagus. 1c, male antenna). **Type material:** Holotype (male), allotype (MNHN), 5 paratypes (1 female, 1 male) (MHNS; 3 males (Pintureau collection). **Type locality:** Chile, Angol. **Hosts:** *Rhyacionia buoliana* (Lep., Tortricidae) on *Pinus radiata* (Pinaceae) (Pintureau *et al.,* 1999), *Cydia pomonella* (L.) (Lep., Tortricidae) on *Malus domestica* (Malvaceae), *Tuta absoluta* (Lep.: Gelechiidae) on *Lycopersicon esculentum* (Solanaceae). **Distribution:** Chile. **Refs.:** Pintureau *et al.* (1999) (host); Botto *et al.* (2009) (hosts); Zucchi *et al.* (2010) (hosts, distribution); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (host); Aquino & Querino (2023).

Comment: *Trichogramma nerudai* was originally described from Chile (Angol region).

T. nomlaki Pinto & Oatman, 1985: 180 (figs. 3a, male genital capsule, 3b, aedeagus). **Type material:** Holotype (male) (NMNH). **Type locality:** USA, California, Glenn Co., Stony Creek, 5 mi. (approximately 8 km), N. Elk Creek. **Host:** Hemerobiid (Neuroptera), not identified. **Distribution:** Canada, Chile, USA. **Refs.:** Pinto (1999) (description, records); Zucchi *et al.* (2010) (host, distribution); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (host).

Comments: According to Pinto (1999), most of the records are from wooded areas, and he considered that *T. nomlaki* is probably a Holarctic species. However, specimens from Chile (unknown host on pine and beech) are deposited in the UCR collection, Riverside (Zucchi & Monteiro, 1977) but were not mentioned by Pinto (1999).

T. obscurum Pinto, 1999: 97 (fig. 139, male genital capsule, a, dorsal, b, ventral). **Type material:** Holotype (male) (CNC). **Type locality:** Mexico, Quintana Roo. **Host:** *Dione juno juno* (Cramer) (Lep., Nymphalidae) on *Passiflora edulis* (Passifloraceae). **Distribution:** Costa Rica, Guatemala, Mexico, Venezuela. **Refs.:** Velásquez de Ríos & Terán (2003) (Venezuela, host); Zucchi *et al.* (2010) (host, distribution); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (host).

T. parrai Querino & Zucchi, 2003b: 6 (figs. 1c, 2c, male genital capsule). **Type material:** Holotype (male), 2 paratypes (males) (MELQ), 1 paratype (male) (UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Tupi forest reserve), suction trap. **Host:** Unknown. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. pintoi Voegelé, 1982: 165 (figs. 1b, 1, flagellum, 2, pedicel, male genital capsule, 4, posterior extension of dorsal lamina). **Type material:** Holotype and allotype (INRA), 5 paratypes (sex not mentioned) (MNHN). **Type locality:** not clearly specified (rearing laboratory at INRA). **Host:** *Icaria acmon* (Lep., Lycanidae) on *Eriogonum effusum* (Polygonaceae); *Lycaeides melissa* (Lep., Lycaenidae) on *Glycyrrhiza lepidota* (Fabaceae); *Actebia fennica* (Lep., Noctuidae) on unspecified plant; *Vanessa* sp. (Lep., Nymphalidae) on *Malva* sp. (Malvaceae); *Platyptilia caduidactyla* (Lep., Pterophoridae) on *Cirsium vulgare* (Asteraceae). **Distribution:** Holartic, USA, Peru. **Refs.:** Pinto (1999) (distribution, hosts); Whu & Valdivieso (1999) (naturalized species, hosts).

Comments: The original description was based on specimens reared in *Corcyra cephalonica* (Lep.) eggs, from Berkely USA, but originating from India and reared at the Zoolgy Station (Voegelé, 1982. *Trichogramma pintoi* from Africa was introduced into Peru in 1972 and, among eight exotic species, was the only one recovered and considered as naturalized in the field from eggs of several pests (Whu & Valdivieso, 1999). By comparison with ITS2 sequences from the GenBank, Almeida & Stouthamer (2015) identified *T. pintoi* collected in Chincha, Peru. In Brazil, a single specimen very similar to *T. pintoi* has been collected (Querino & Zucchi, 2004); however, more specimens are needed to confirm the species identification.

T. piracicabensis Querino & Zucchi, 2017: 138 (figs. 1, antenna, 2, wings, 3, 4, male genital capsule). **Type material:** Holotype (male), 2 paratypes (males) (MELQ). **Type locality:** Brazil, São Paulo, Piracicaba (Luiz de Queiroz campus). **Host:** *Heraclides astyalus* (Lep., Papilionidae) on *Citrus* sp. (Rutaceae) **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (hosts); Querino (2024) (catalog).

Comment: Only the type material is known.

T. pratissolii Querino & Zucchi, 2003c: 8 (fig. 1d, 4b, male genital capsule; 4a, basiconic sensillum). **Type material:** Holotype (male), 10 paratypes (males) (MELQ), 2 paratypes (males) (UCR). **Type locality:** Brazil, Espírito Santo, Conceição do Castelo (district of Indaiá). **Host:** Unknown. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino (2024) (catalog).

Comments: Only the type material is known. Collected in traps containing eggs of *Ephestia kuehniella,* hung on avocado trees.

T. pretiosum Riley, 1879: 161. **Type material:** Lost. From eggs of *Alabama argillacea* (Lep., Erebidae), from near Selma, Alabama, USA (Pinto *et al.,* 1978). Neotype (male) (USNM) (fig. 1, male antenna, 8, hindwing, 13, male genital capsule. **Type locality:** USA, Alabama, near Selma. **Hosts:** Several lepidopteran species, mostly of agricultural importance. **Distribution:** Throughout the New World from southern Canada to Argentina. **Refs.:** Pinto *et al.* (1978) (synonymies, description); Pinto (1999) (description, distribution); Querino *et al.* (2002) (morphometry); Querino & Zucchi (2005) (key, Brazil); Isas *et al.* (2016) (Argentina, host); Querino & Zucchi (2019) (checklist, key); Zucchi *et al.* (2010) (hosts, distribution); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comments: Neotype designated by Pinto *et al.* (1978), from rearing laboratory originating near Selma, Alabama, USA, from eggs of *Helicoverpa zea* (as *Heliothis zea*) (Lep., Noctuidae). Rodríguez *et al.* (1996) considered *T. sudhae* Torre, 1980 as *incertae sedis* or a junior synonym of *T. pretiosum.* Pinto (1999) listed the species misidentified as *T. pretiosum,* and hosts in North America. For hosts in South America, see Querino *et al.* (2021).

T. pusillum Querino & Zucchi, 2003b: 7 (figs. 1d, 2d, male genital capsule). **Type material:** Holotype (male), 1 paratype (male) (UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Tupi forest reserve), suction trap. **Host:** Unknown. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. rojasi Nagaraja & Nagarkatti, 1973: 296 (figs. 22, forewing, 23, male antenna, 24, male genital capsule, 25, aedeagus, 26, paramere and volsella, 27, intervolsellar process, 28, relative length of aedeagus, hind tibia and ovipositor). **Type material:** Holotype (male), allotype (USNM), paratypes (NHM, INIA). **Type locality:** Chile, La Cruz. **Host:** *Tatochila* sp. (Lep., Pieridae) on *Trifolium* sp. (Fabaceae). **Distribution:** Argentina, Brazil, Chile, Peru. **Refs.:** Ciociola Jr. *et al.* (2001) (molecular key); Querino & Zucchi (2003a) (distribution, host, morphological characters); Querino & Zucchi (2019) (checklist, key); Whu & Valdivieso (1999) (Peru); Zucchi *et al.* (2010) (host, distribution); Querino *et al.* (2021) (database); Querino (2024) (catalog).

T. stampae Vincent, 1986: 498 *in* Vicent & Goodpasture, 1986 (figs. 14, male antenna. 17, male genital capsule. 18, aedeagus, 15, female antenna. 16, female antennal club. 19, female hindwing). **Type material:** Holotype (male), 76 paratypes (17 males, 59 females) (NMNH). **Type locality:** USA, Virginia, Warren Co., Front Royal. **Hosts:** *Euphydryas phaeton* (Drury) egg (Lep., Nymphalidae) on *Chelone glabra* L. (Plantaginaceae); *Chlosyne janais* (Drury) egg (Lep., Nymphalidae) on *Anisacanthus quadrifidus* var. *quadrifidus* (as *Anisacanthus wrightii*) (Acanthaceae); *Chlosyne eherenbergii* egg on *Buddleja sessiliflora* (Scrophulariaceae) (Vicent & Goodpasture, 1986). **Distribution:** Colombia, Mexico, USA. **Refs.:** Pinto (1999) (distribution, hosts); Zucchi *et al.* (2010) (hosts, distribution); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (host).

T. terani Velásquez de Ríos & Terán, 2003: 141 (figs. 12 and 13, male genital capsule). **Type material:** Holotype (male) (CEURG). **Type locality:** Venezuela, Estado Guárico, Las Lajas. **Host:** unknown (undetermined noctuid) on *Sida* sp. (Malvaceae). **Distribution:** Venezuela. **Ref.:** Querino & Zucchi (2019) (checklist, key, South America).

Comment: Only the holotype is known.

T. tupiensis Querino & Zucchi, 2003b: 8 (figs. 1e, 2e, male genital capsule). **Type material:** Holotype (male), 6 paratypes (males) (MELQ), 1 paratype (male) (UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Tupi forest reserve), suction trap. **Host:** Unknown; forest habitat. **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2019) (checklist, key, South America). Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: Only the type material is known.

T. valmiri Querino & Zucchi, 2017: 139 *in* Querino *et al.* (2017) (figs. 5, antenna, 6, forewing, 7, hind wing, 8, male genital capsule). **Type material:** Holotype (male), 3 paratypes (males) (MELQ). **Type locality:** Brazil, São Paulo, Jundiaí. **Host:** *Urbanus esta* (Lep., Hesperiidae) on *Desmodium uncinatum* (Fabaceae). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2019) (checklist, key, South America); Querino *et al.* (2021) (host); Querino (2024) (catalog).

Comments: Only the type material is known. This species was collected in a suction trap installed by RQB in a *Eucalyptus* sp. tree in a forest reserve.

T. zucchii Querino, 2003: 9 *in* Querino & Zucchi (2003b) (figs. 1f, 2f, male external capsule). **Type material:** Holotype (male), 2 paratypes (male) (MELQ, UCR). **Type locality:** Brazil, São Paulo, Piracicaba (Tupi forest reserve), suction trap. **Host:** *Melanolophia* sp. (Lep., Geometridae) (São Paulo, Sorocaba, Itavuvu forest reserve). **Distribution:** Brazil. **Refs.:** Querino & Zucchi (2005) (key, Brazil); Querino & Zucchi (2004) (distribution); Querino *et al.* (2017) (host); Querino & Zucchi (2019) (checklist, key, South America). Querino *et al.* (2021) (database); Querino (2024) (catalog).

Comment: In addition to the type locality, *T. zucchii* was also collected in another location in the state of São Paulo (Sorocaba city).

Subgenus *Vanlisus* Pinto, 1999

Trichogramma (*Vanlisus*) Pinto, 1992: 621; Type species, *Trichogramma lachesis* Pinto (original designation).

T. atropos Pinto, 1992: 628 (figs. 3, funicle, 8, thoracic microsculpturing, 14, male genital capsule). **Type material:** Holotype (male) (USNM). **Type locality:** Venezuela, Mérida, La Montaña Station, Malaise trap. **Host:** Unknown. **Distribution:** Brazil, Venezuela. **Refs.:** Pinto (1999) (distribution); Querino & Zucchi (2019) (checklist, key).

T. clotho Pinto, 1992: 627 (figs. 2, funicle, 6, maxillary palp, 9, thoracic microsculpturing, 13, male genital capsule). **Type material:** Holotype (male) (USNM). **Type locality:** Costa Rica, Puntarenas, Golfo Dulce, 13 km S Rincon, Malaise trap. **Host:** *Parrhasius polibetes* (Lep., Lycaenidade) on *Didymopanax vinosus* (Araliaceae) and *Pyrostegia venusta* (Bignoniaceae). **Distribution:** Brazil, Costa Rica. **Refs.:** Pinto (1999) (distribution); Querino *et al.* (2017) (hosts); Querino & Zucchi (2019) (checklist, key); Querino *et al.* (2021) (database).

Dubious or erroneous records of *Trichogramma* species in South America

Trichogramma is the best-known genus in the family, because several species have been used in the biological control of agricultural pests worldwide. *Trichogramma* species parasitize primarily lepidopteran eggs. Consequently, exotic species of *Trichogramma* have been introduced into various South American countries for biological control of pest lepidopterans.

Most introductions of *Trichogramma* were neither preceded by surveys of native species in the region nor followed by studies to determine whether the exotic species had become established. This oversight in applied studies of *Trichogramma* has led to dubious or erroneous records in several countries. Frequently, the introduced parasitoid did not establish itself, or the biological control program was discontinued, yet the exotic species is still considered to occur in the country. Nevertheless, erroneous or dubious records of *Trichogramma* species have been published in several journals, catalogs (*e.g.,* De Santis, 1979; UCD, 2023) and book chapters (*e.g.,* Jalali *et al.,* 2016) providing misleading information about the occurrence and distribution of *Trichogramma* in South America. Additionally, catalogs for *Trichogramma* species in South America often have a confusing layout, prioritizing applied work (bionomy and usage) over detailed taxonomic information about the species (*e.g.,* De Santis, 1979).

Many introductions were conducted in several South American countries (Table 2), as part of biological control research. However, except for *T. pintoi* Voegelé in Peru, there is no information on whether other introduced species have been established in South America, therefore, the other exotic species should not be considered present in a given South American country, as has often been done so far. Pinto *et al.* (1978, 1983) clarified the identification of several introduced species in South America, such as *T. fasciatum, T. perkinsi* and *T. semifumatum,* which actually correspond to *T. fuentesi* Torre, 1980; *T. exiguum* Pinto & Platner, 1978; and *T. pretiosum* Riley, 1879, respectively.

Some *Trichogramma* species were introduced into at least two South American countries (Table 2). The species with the most introductions were sent to four countries: *T. australicum* Girault, 1912a (ARG, BRA, COL, PER), *T. chilotraeae* Nagaraja & Nagarkatti, 1969 (BRA, COL, PER, VEN), *T. japonicum* Ashmead, 1904a (BRA, COL, PER, VEN) and *T. minutum* (ARG, BRA, CHI, PER). Three species were introduced into three countries: *T. fasciatum* (BRA, CHI, PER), and *T. perkinsi* (ARG, CHI, PER). Three other species were introduced into two countries: *T. achaeae* Nagaraja & Nagarkatti, 1969 (ARG, CHI), *T. evanescens* Westwood, 1833 (ARG, PER), and *T. semifumatum* (BOL, PER). For the reasons discussed for each South American country (see below), some records of *Trichogramma* are dubious or erroneous, and therefore, none of the listed species should be considered present where they were introduced (Table 2). In addition to the exotic species mentioned above, there are three other species with identification problems in South America: *T. brasiliensis* recorded in Brazil, Chile and Peru (see item Brazil), *T. minutum* (several countries) and *T. semifusca* Blanchard (see item Argentina).

Based on literature review, we found that 24 records of *Trichogramma* species are dubious or erroneous in South America. *Trichogramma* species incorrectly recorded in South American countries are discussed below.

Argentina

The number of native and exotic species of *Trichogramma* is imprecise and somewhat contradictory. Some species have been included or excluded from catalogs with no apparent reason, as there are no detailed taxonomic references for each species, *e.g.,* the catalogs

of De Santis (1979, 1981, 1989) and De Santis & Fidalgo (1994). These catalogs list numerous references related to bionomic studies and the use of *Trichogramma*. De Santis (1998) mentioned 21 species of *Trichogramma* in Argentina, of which 16 were introduced. However, according to Aquino & Querino (2023), only 10 species are considered present in the country (Table 1). Fourteen species were introduced, but information on exotic species is apparently limited only to the introduction record. Therefore, without post-introduction information and without data on the current situations (Aquino & Querino, 2023), the introduced species listed below cannot be considered to have become established in Argentina. Therefore, until these species are recovered in the field, they should be considered not present in Argentina.

T. achaeae Nagaraja & Nagarkatti, 1969. The original description was based on specimens from India, published in 1969 (not 1970, as commonly used by some authors). Specimens from the rearing colony of the INRA Agricultural Zoology Station, imported from Poland, were kept for study at the Institute of Plant Pathology of INTA (De Santis & Fidalgo, 1994). There is no other information about this species in Argentina. The record in the UCD (2023) was probably based on De Santis & Fidalgo, 1994 catalog, so, it was not well founded.

T. agrotidis Voegelé & Pintureau, 1982. Introduction under the control of INTA of live specimens sent by the INRA Agricultural Zoology Station (De Santis & Fidalgo, 1994). Based on this information, *T. agrotidis* was recorded in Argentina (UCD, 2023), however, Aquino & Querino (2023) did not place *T. agrotidis* among *Trichogramma* species with precise record in Argentina.

T. australicum Girault, 1912a. It was cataloged among the introduced species into Argentina, with no additional information about the introduction (De Santis, 1998). According to Pinto *et al.* (1982), most previous references to *T. australicum* are assignable to *T. chilonis* Ishii. *Trichogramma australicum* was not listed in Argentina (UCD, 2023).

T. brassicae Voegelé, 1982. It was listed by Aquino & Querino (2023) as an introduced species into Argentina; however, the name given by Voegelé (1982) was preoccupied by *T. brassicae* Bezdenko, 1968. Voegelé (1985) discovered the homonymy and renamed *T. brassicae* Voegelé as *T. buesi* Voegelé (new name). The live specimens received by INTA came from the rearing colony at INRA, where Voegelé worked. Therefore, they should be referred to as *T. buesi* Voegelé, the new name proposed by Voegelé, not as *T. brassicae* Voegelé (nec *T. brassicae* Bedezko). Live specimens were kept for study at the Institute of Plant Pathology at INTA (De Santis & Fidalgo, 1994), but there is no further information. However, Triapitsyn (2015) traced the history of the description of *T. brassicae* Bezdenko, and discussed the validity of the species, concluding that it should be considered as *nomen dubium* and no longer used.

T. buesi Voegelé, 1985. Live specimens were kept for study at the Institute of Plant Pathology at INTA (De Santis & Fidalgo, 1994), but no additional information is known. The record in the UCD (2023) was based exclusively on De Santis & Fidalgo (1994). See comment on *T. brassicae* Voegelé, 1982 (above).

T. cacoeciae Marchal, 1927. This is a thelytokous species (males are rare). Arrhenotoky is not induced by antibiotics or high temperatures. It was another introduced species into Argentina, resulting from the rearing colony at INRA. De Santis & Fidalgo (1994) listed dozens of references, but none from Argentina. The definition of *T. cacoeciae* is not clear, as the types are apparently lost. Pinto (1999) commented on the difficulties in identifying *T. cacoeciae* and discussed the species related to it.

T. evanescens Westwood, 1833. This is the type species of the genus, described based on a female. It is not possible to determine which of several closely related Palearctic species corresponds to *T. evanescens* Westwood, as the identification of *Trichogramma* species is based on males (Pinto, 1999). Consequently, which species was introduced into Argentina under the name *T. evanescens* remains unknown (see Comments under genus *Trichogramma* – Part 1).

T. euproctidis (Girault, 1911b). It was cataloged in Argentina, with no additional information about the introduction (De Santis, 1979). Later, De Santis (1981) noted that according to Pinto *et al.* (1978), the identification of Nagarkatti & Nagaraja (1971) and other subsequent authors did not correspond to *T. euproctidis.* De Santis' information is the only reference, in the UCD (2023) for the distribution of *T. euproctidis* in Argentina.

T. fuentesi Torre, 1980. Originally described from Cuba. According to De Santis (1989), INTA sent him specimens of laboratory-reared *T. fuentesi* from Peru, but until that date, no releases had been carried out.

T. maidis Pintureau & Voegelé, 1980. This species was recorded in Argentina without additional information (De Santis & Fidalgo, 1994). Anyway, it is a junior synonym of *T. brassicae* Bezdenko (not *T. brassicae* Voegelé) (Pinto, 1999; UCD, 2023). However, the identity of *T. brassicae* Bezdenko was not clarified (Triapitsyn, 1915) (see *T. brassicae* Voegelé, above). Consequently, the introduced species in Argentina remains unknow, so *T. maidis* should not be registered in Argentina.

T. minutum Riley, 1879. *T. minutum* was considered the only species of *Trichogramma* occurring in some South American countries, therefore, it could be easily identified. For example, Jaynes (1933) reported that "the familiar egg parasite *T. minutum* was present in both Argentina and Peru." A few decades later, De Santis & Esquivel (1967) listed several host species of *T. minutum* in Argentina. However, *T. minutum* could only be correctly identified, when Pinto *et al.* (1978) redescribed the species and designated the neotype (male). Consequently, all identi-

fications prior to the article by Pinto *et al.* (1978) should be disregarded, as they were not based on reliable taxonomic characters (see item Brazil).

T. nerudai Pintureau & Gerding, 1999. Specimens from Chile were taken to Argentina to control *Rhyacionia buoliana* (Lep., Tortricidae) in pine, *Cydia pomonella* (as *Carpocapsa pomonella*) (Lep., Tortricidae) in apple, and *Phthorimaea absoluta* (as *Tuta absoluta*) (Lep., Gelechiidae) in tomato (Botto *et al.,* 2009). However, Aquino & Querino (2023) mentioned that the establishment of *T. nerudai* in Argentina has not been confirmed, based on the latest surveys carried out in that country.

T. oleae Voegelé & Pointel, 1979. It is a thelytomous species, which can be converted to arrhenotoky with antibiotics and high temperatures. However, separation of males of *T. oleae* and *T. pretiosum* is difficult (Pinto, 1999), and this latter species occurs in Argentina. *Trichogramma oleae* was introduced into Argentina by INTA, through living material from INRA (De Santis & Fidalgo, 1994), without any additional information. The record of *T. oleae* in Argentina (UCD, 2023) was based exclusively on De Santis & Fidalgo (1994).

T. perkinsi Girault, 1912b., De Santis & Fidalgo (1994) commented, in their catalog, that they received specimens of *T. perkinsi* reared in Santa Cruz, Bolivia, and later, they received specimens collected in Tucumán but did not provide additional information. Apparently, this is the only record in Argentina, as later this species was not mentioned among the introduced species in Argentina (De Santis, 1998). *Trichogramma perkinsi* is known only from Mount Olympus, Oahu Island, Hawaii. According to Pinto *et al.* (1978) and Oatman *et al.* (1982), the redescription of *T. perkinsi* by Nagarkatti & Nagaraja (1971) corresponds to *T. exiguum*. Therefore, the registration of *T. perkinsi* in Argentina and other South American countries in the UCD (2023) is unsubstantiated information.

T. pintoi Voegelé, 1982. Specimens from Peru were reared at INTA, but no field releases were carried out (De Santis, 1989), however, De Santis & Fidalgo (1994) reported that this species was released at the "Estación Experimental del Alto Valle del Río Negro", and Pinto (1999) commented on an unpublished record of the introduction of *T. pintoi* into Argentina. No further information has appeared regarding *T. pintoi* in Argentina. Anyway, it is not listed among the *Trichogramma* species with accurate records in the country (Aquino & Querino, 2023). Hence, the record in the UCD (2023) should not be considered.

T. semifusca [sic] Blanchard MS *in* De Santis & Esquivel, 1967: 47. This species was considered *nomen nudum* by Zerova & Fursov (1989).

Bolivia

T. semifumatum (Perkins, 1910) (as *Pentarthron semifumatum* Perkins). De Santis & Fidalgo (1994) cataloged this species for Bolivia, without clearly indicating the reference consulted. Most references to *T. semifumatum* are misidentifications, as they were made without knowledge of the characteristics of the type material, collected in the island of Oahu, Hawai'i. In addition, the original description was based on two females, therefore, adequate identification of this species depends on discovering the males (Pinto *et al.,* 1978). Undoubtedly, the record of *T. semifumatum* in Bolivia does not correspond to this species.

Brazil

Six exotic species have been recorded in Brazil. Three species are mentioned in a CIBC report (1976) concerning a shipment of *T. australicum, T. chilotraeae,* and *T. japonicum* to the state of Amapá, without additional information. The other three species represent instances of misidentifications (*T. bennetti, T. fasciatum,* and *T. minutum*). In both cases, these exotic species have not been collected since 1980s in Brazil. The reasons for considering these records dubious or erroneous in Brazil are discussed below.

T. australicum Girault, 1912a. The only record of this species in Brazil is in a CIBC report (1976), which states that 200 eggs from a host (species not specified) parasitized by *T. australicum* were sent to a sugarcane mill established in the state of Amapá. However, most previous references to *T. australicum* are instead attributed to *T. chilonis* (see Pinto *et al.,* 1982). Therefore, the species mentioned in the CIBC report (1976) may not be *T. australicum* and the specimens submitted were not reared.

T. bennetti Nagaraja & Nagarkatti, 1973. The record of this species in Brazil (*e.g.,* De Santis, 1980) is probably an erroneous reference to *Trichogrammatoidea bennetti* Nagaraja, originally described from Brazil. *Trichogramma bennetti,* originally described from Trinidad and Tobago, does not occur in Brazil (Querino & Zucchi, 2007).

T. brasiliensis (Ashmead, 1904b). This species was originally described in *Pentarthron* Riley, a synonym of *Trichogramma*. The original description was based on a single female collected on cotton in Bahia, Brazil. Thus, the definition of *Trichogramma brasiliensis* was not clarified (Pinto & Stouthamer, 1994), because the identification of *Trichogramma* species depends mostly on male traits. However, the examination of the type revealed, based on wing and antenna traits, that it belongs to the genus *Trichogrammatoidea* Girault (see Pinto, 1997). Despite frequent citations, including in recent literature, *Trichogramma brasiliensis* is an inappropriate designation for species that have been misidentified. According to Pinto (1997), *Trichogramma brasiliensis* is a *nomen dubium, i.e.,* a name not certainly applicable to any known taxon.

T. chilotraeae Nagaraja & Nagarkatti, 1969. Another record from the CIBC report (1976) indicates that 200

eggs from a host (species not specified) parasitized by *T. chilotraeae* were sent to a sugarcane mill in Amapá. This is the only record of this species in Brazil. The parasitoid was probably not reared at the sugarcane mill that was being established.

T. fasciatum (Perkins, 1912). It was originally described in the genus *Pentarthron* Packard. The identification of this species was clarified by Pinto *et al.* (1978), based on type material. Consequently, information on *T. fasciatum* prior to the late 1970s does not belong to this species. In recent decades, during surveys of *Trichogramma* species conducted in Brazil, *T. fasciatum* has never been collected.

T. japonicum Ashmead, 1904a. Another species from the CIBC report (1976), which states that 200 eggs from a host (species not specified) parasitized by *T. japonicum* were sent to the sugarcane mill in Amapá. This is the only record of *T. japonicum* in Brazil. The parasitoid was probably not reared in the sugarcane mill that was being established. The record of *T. japonicum* in the UCD (2023) is baseless.

T. minutum Riley, 1879. The only species of *Trichogramma* cited in Brazil until the 1960s was noted as a parasitoid of eggs of several lepidopteran species (Silva *et al.,* 1968, Zucchi & Querino, 2024). However, this citation was due primarily to the name available in North American literature, without taxonomic studies or the deposit of voucher specimens in collections. Conversely, *T. minutum* could be accurately recognized only after its redescription and designation of the neotype (male) (Pinto *et al.,* 1978). As of 2006, *T. minutum* had not been collected in Brazil (Querino & Zucchi, 2007), nor has it appeared in more recent surveys.

Colombia

The following records are extracted from the CIBC report (1976) regarding the shipment of three species of *Trichogramma* to a private enterprise for the control of *Diatraea.* A total of 200 individuals of each species were provided.

T. australicum Girault, 1912a. According to the CIBC report (1976), this species was provided to the Rio Paila Estate in Colombia. This record is documented in the database by UCD (2023), despite the absence of recent reports on the presence of this parasitoid in Colombia (Querino *et al.,* 2021).

T. chilotraeae Nagaraja & Nagarkatti, 1969. The record of *T. chilotraeae* in Colombia is also present in the CIBC report (1976), with same details provided for *T. australicum*. This report stands as the only reference to the occurrence of *T. chilotraeae* in Colombia.

T. japonicum Ashmead, 1904a. The information in the CIBC report (1976) corresponds exactly to the information for the preceding two species. In the UCD (2023), this record is sourced from CIBC (1976) and De Santis & Fidalgo (1994), but those latter authors do not give further information on the record in Colombia.

Chile

Several species of *Trichogramma* were introduced into Chile apparently without any taxonomic support or additional information about the introduction.

T. achaeae Nagaraja & Nagarkatti, 1969. According to De Santis (1989), it was introduced into Chile in 1969. However, Pintureau *et al.* (1999) did not include *T. achaeae* in the list of *Trichogramma* species from Chile.

T. brasiliensis (Ashmead, 1904b). Species listed by Prado (1991); however, it is a member of the genus *Trichogrammatoidea* (see item Brazil).

T. cacoeciae Marchal, 1927. Rearing laboratory at Instituto de Investigaciones Agropecuarias (INIA), in Quilamapu. No additional information (origin, year of introduction, voucher specimens) (Velásquez & Gerding, 2006).

T. evanescens Westwood, 1833. Rearing laboratory at Instituto de Investigaciones Agropecuarias (INIA), in Quilamapu. No additional information (origin, year of introduction, voucher specimens) (Velásquez & Gerding, 2006).

T. fasciatum (Perkins, 1912). Imported from Peru in 1968 (Rojas, 2005). Records of this species prior to the 1970s are incorrect (Pinto *et al.,* 1978) (see item Brazil).

T. maidis Pintureau & Voegelé, 1980. Rearing laboratory at Instituto de Investigaciones Agropecuarias (INIA), in Quilamapu, Chillán. No additional information (origin, year of introduction, voucher specimens) (Velásquez & Gerding, 2006).

T. minutum Riley, 1879. Imported from Peru in 1965 (Rojas, 2005). Identifications made before the 1970s lack clarity regarding the species to which they refer, as the identity of *T. minutum* was not clarified until that decade (Pinto *et al.,* 1978) (see item Brazil).

T. perkinsi Girault, 1912b. In 1972, this species was brought from Tacna, Peru, by Rojas (2005), without any other information. According to Pinto *et al.* (1983), most references to this species prior to the 1970s correspond to *T. exiguum* (see Pinto *et al.,* 1978; Oatman *et al.,* 1982), which occurs in Chile (Querino & Zucchi, 2019) (see item Argentina).

Peru

In the first taxonomic study of *Trichogramma* in Peru, Ruiz & Korytkowski (1979) identified and illustrated eight exotic species (*T. australicum, T. brasiliensis, T. chilotraeae, T. euprocitids, T. fasciatum, T. japonicum, T. perkinsi* and

T. semifumatum), apparently based on work carried out in India (*e.g.,* Nagarkatti & Nagaraja, 1971), but all these species were wrongly recorded in Peru (see below). Whu & Valdivieso (1999) analyzed data from 25 years of *Trichogramma* collections and identifications across 11 agroecological zones in Peru. From their study, four native species (*T. fuentesi, T. exiguum, T. pretiosum,* and *T. rojasi* Nagaraja & Nagarkatti, 1973 – see Part 1) were identified, alongside only one exotic species, *T. pintoi* Voegelé, 1982, among the nine species of *Trichogramma* introduced between 1970 and 1996 into Peru. Pollack (1975) examined the biology of three exotic species (*T. fasciatum, T. perkinsi,* and *T. semifumatum*) without providing information about the origin of the parasitoids. However, these three records are misidentifications of native species to Peru.

T. atopovirilia Oatman & Platner, 1983. Introduced from Colombia to Peru in 1995, it was recovered by Whu & Valdivieso (1999). Subsequently, there is no other record of this species in Peru. Anyway, Peru was not listed in the distribution of *A. atopovirilia* by Querino & Zucchi (2019) nor in the UCD (2023).

T. australicum Girault, 1912a. It was introduced in Peru in 1975 (Whu & Valdivieso, 1999), possibly by CIBC (1976). The report from that institution mentions sending 600 parasitized eggs to Peru but lacks details about the host and the specific location in Peru. Pinto *et al.* (1982) verified that the name *T. australicum* was improperly applied to *T. chilonis,* one of the most common Australasian species of *Trichogramma.* Therefore, the definition of *T. australicum* prior to the 1980s is uncertain.

T. brasiliensis (Ashmead, 1904b). Whu & Valdivieso (1999) mentioned that this species had been transferred to the genus *Trichogrammatoidea.* However, those authors erroneously considered the species as a member of the genus *Trichogramma.* Thus, it remains uncertain which species was introduced into Peru under the name *Trichogramma brasiliensis* (see item Brazil).

T. chilotraeae Nagaraja & Nagarkatti, 1969. This species was originally from India. It was introduced into Peru in 1975, although it has not been recovered (Whu & Valdivieso, 1999). According to a report from CIBC (1976), 600 eggs from a parasitized host (species unspecified) were sent to Peru, but details about location and targeted pest are missing. Not recorded in Peru (Querino *et al.,* 2021) and UCD (2023).

T. dendrolimi Matsumura, 1925. Introduced from Germany in 1996, but not recovered (Whu & Valdivieso, 1999). *Trichogramma dendrolimi* was not cataloged in Peru (Querino *et al.,* 2021; UCD, 2023).

T. embryophagum (Hartig, 1838). Introduced from Germany in 1996, but not recovered (Whu & Valdivieso, 1999). This species was not cataloged in Peru (Querino *et al.,* 2021; UCD, 2023).

T. euproctidis (Girault, 1911b). Probably, Peruvian record was based on Nagarkatti & Nagaraja (1971), who misidentified this species (Pinto *et al.,* 1978).

T. evanescens Westwood, 1833. Introduced from Germany in 1996 (Whu & Valdivieso, 1999). Since the original description is based on the female, it cannot be determined which of the closely related Palearctic species actually corresponds to *T. evanescens* (see item Argentina). Not recorded in Peru (Querino *et al.,* 2021; UCD, 2023).

T. fasciatum (Perkins, 1912). It is likely that the record of this species in Peru (De Santis, 1979; UCD, 2023) was only due to applied studies, such as that of Pollack (1975). *Trichogramma fasciatum* was not listed by Whu & Valdivieso (1999). This species has been misidentified as *T. exiguum* or *T. fuentesi* (see Querino & Zucchi, 2003a, 2019, respectively) in South America (see item Brazil).

T. japonicum Ashmead, 1904a. Introduced into Peru in 1975 (Whu & Valdivieso, 1999). This parasitoid may correspond to the shipment of 600 parasitized eggs from a host (species not specified) (CIBC, 1976). The destination of the parasitoid shipment was not disclosed. Although cataloged in Peru (De Santis & Fidalgo, 1994; UCD, 2023), *T. japonicum* has not been recovered in that country (Whu & Valdivieso, 1999).

T. minutum Riley, 1879. For decades, this species was considered the only parasitoid used in biological control programs in Peru (Ruiz & Korytkowski, 1979). Therefore, the record of *T. minutum* in Peru follows the pattern observed for Argentina and Brazil (see above). However, only from 1965, other species were recorded (Whu, 1985), although they were misidentified as discussed in the item. Anyway, there is no record of *T. minutum* in Peru.

T. perkinsi Girault, 1912b. The species was reared and released by Pollack (1975) in Venezuela, with no information on its origin. *Trichogramma perkinsi* is known only from Mount Olympus, Oahu Island, Hawaii (Oatman *et al.,* 1982). According to Pinto *et al.* (1978), material identified as *T. perkinsi* by Nagarkatti & Nagaraja (1971) corresponds to *T. exiguum.* Thus, *T. perkinsi* should not be considered present in Peru (see item Argentina).

T. semifumatum (Perkins, 1910). The species was reared and released by Pollack (1975) with no information on its origin. Anyway, most references to *T. semifumatum* prior to the paper of Pinto *et al.* (1978) are misidentifications. In fact, *T. semifumatum* should not be recorded in Peru (see item Bolivia).

Venezuela

T. chilotraeae Nagaraja & Nagarkatti, 1969. It was cataloged by De Santis & Fidalgo (1994) in Venezuela, but without additional data. This record possibly originated from an account of the activities of the CIBC in Latin

America (Bennett & Street, 1984). This species is not recorded in Venezuela (UCD, 2023).

T. japonicum Ashmead, 1904a. De Santis & Fidalgo (1994) cataloged this species in Venezuela, without any additional information. This single record in Venezuela is the only entry for this species in the UCD (2023), since in the other two references by De Santis (1979, 1981 not 1983), mentioned in this database, *T. japonicum* was not listed.

DISCUSSION

The use of *Trichogramma* in biological pest control across South America experienced an increase between the 1970s and 1990s. Consequently, numerous introductions of *Trichogramma* species occurred during a period when regulations for shipping and introducing natural enemies among countries were nonexistent. Thus, various introductions of *Trichogramma* species occurred worldwide. However, currently, protocols and regulations with procedures for classical biological control have been adopted by several countries (Shimbori *et al.,* 2023).

Prior to the establishment of reliable taxonomic criteria for identifying *Trichogramma* species, numerous introductions of these egg parasitoids were conducted around the world. Consequently, there was uncertainty regarding the precise species being reared and subsequently introduced, as well as the potential for contamination with native species during laboratory rearings. Only in the 1970s, *Trichogramma* species were accurately identified by the male genital capsule (Nagarkatti & Nagaraja, 1971).

Taxonomic studies pose significant challenges, particularly for species as minute as those in the genus *Trichogramma* (around 0.7 mm in length). In biological control programs, it is imperative to ensure that the species being reared over several generations aligns with the initial species. There is also the need to verify the efficacy of the species released in the field (Zucchi, 2021). Consequently, taxonomy plays a pivotal role in addressing these fundamental issues in biological control programs (*e.g.,* Bin *et al.,* 2012). While classical taxonomy forms the foundation for *Trichogramma* species identification, other studies, encompassing biological, morphological, and molecular approaches, aim for an integrative taxonomy to improve species recognition.

In addition to the problems in identifying the species, these introductions were poorly documented, with reports only that certain *Trichogramma* species from abroad, often without specifying the country of origin, were reared in laboratories in a South American country, usually alongside native specices. The names assigned to these species were routinely used but were never confirmed, nor voucher specimens were preserved. Despite this, records and/or information on these species have persisted in the literature, being erroneously recorded in a given country and cited in various publications.

We analyzed data from *Trichogramma* species recorded in South America based on an extensive and detailed literature review rooted in taxonomic research. This process allowed us to identify dubious or erroneous records of several species, most of them introduced without the proper taxonomic procedures, especially after being introduced. Although there are no voucher specimens for the introduced species into South America, the bibliographic references provided sufficient evidence to identify inaccuracies in the species records, since the taxonomy of *Trichogramma* on a reliable basis was established in the 1970s. Therefore, records prior to that date do not know which species they refer to.

We determined that 46 *Trichogramma* species are correctly recorded in South America, and another 24 species correspond to dubious or erroneous records, due to misidentifications or non-establishment after introduction into a country. We strongly recommend that species with dubious or erroneous records not be listed, mentioned or discussed in scientific publications until their establishment has been duly confirmed by a taxonomist and voucher specimens be deposited in public collections. Anyway, without post-introduction information and without data on current status, introduced species should not be considered to have become established in a specific country until they are recovered in the field. According to Pinto (1999), there is no information that any introduced species has become established in a South American country. However, *T. pintoi* Voegelé originating from Africa was recovered and considered as naturalized in Peru (Whu & Valdivieso, 1999).

This study offers an overview of the current distribution of *Trichogramma* species in South America, aiming to serve as a foundation for future applied research. However, the possibility of discovering new species or recovering apparently non-established introduced species remains ever present. The geographic distribution of *Trichogramma* species is dynamic, requiring ongoing taxonomic studies for continual updating. At least two conditions are paramount for this endeavor: (***i***) fostering the training of new taxonomists and (***ii***) promoting awareness among entomologists regarding the importance of depositing voucher specimens in publicly accessible collections.

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