

JÖRG RÖMBKE & WERNER HANAGARTH

The present faunistic knowledge on terrestrial Oligochaeta from Bolivia

Abstract

An overview on the terrestrial Oligochaeta found in Bolivia is given. The 50 species listed belong to the families Enchytraeidae, Lumbricidae, Glossoscolecidae, Ocnerodrilidae, Octochaetidae, Acanthodrilidae and Megascolecidae. Included in this contribution are informations from ZICSI (in press) who studied 28 species from Bolivia, describing one new genus and six new species. Roughly one half of all terrestrial Oligochaeta known from Bolivia are peregrine species, introduced by man, both from the temperate regions (e.g. lumbricids from Europe) and from other tropical areas (e.g. *Amyntas corticis* from Asia). The other species, mainly Glossoscolecidae, are either widely distributed in tropical South America or seem to be endemic to Bolivia (*Anteoides rosai*, *Andiorrhinus* (*Amazonidrilus*) *bolivianus*, *Andiorrhinus* (*Andiorrhinus*) *montanus*, *Inkadrilus hanagarthi*, *Martiodrilus bolivianus*, *Martiodrilus silvestris*, *Tamayodrilus roembkei*, *Belladrilus* (*Belladrilus*) *vaucheri*). In comparison to better investigated countries like Brazil or Ecuador it can be assumed that today only a very small percentage of the Bolivian oligochaete fauna is known to science.

Zusammenfassung

Der gegenwärtige Kenntnisstand der Verbreitung terrestrischer Oligochäten in Bolivien

Die bisherigen Kenntnisse über die Verbreitung der terrestrischen Oligochaeten in Bolivien werden zusammengefasst. Die aufgeführten 50 Arten gehören zu den Familien Enchytraeidae, Lumbricidae, Glossoscolecidae, Ocnerodrilidae, Octochaetidae, Acanthodrilidae und Megascolecidae. Aufgenommen wurden auch Nachweise von 28 Arten aus Bolivien (einschließlich einer neuen Gattung und sechs neuen Arten), die von ZICSI (im Druck) parallel zusammengestellt wurden. Ungefähr die Hälfte aller bisher aus Bolivien bekannten terrestrischen Oligochaeta sind peregrine, d.h. durch menschliche Aktivitäten eingeführte Arten, und zwar sowohl aus der gemäßigten Zone (z.B. Lumbriciden aus Europa) wie auch aus anderen tropischen Regionen der Welt (z.B. *Amyntas corticis* aus Asien). Von der anderen Hälfte der Arten, meist Glossoscolecidae, sind einige weit im tropischen Südamerika verbreitet, während andere (*Anteoides rosai*, *Andiorrhinus* (*Amazonidrilus*) *bolivianus*, *Andiorrhinus* (*Andiorrhinus*) *montanus*, *Inkadrilus hanagarthi*, *Martiodrilus bolivianus*, *Martiodrilus silvestris*, *Tamayodrilus roembkei*, *Belladrilus* (*Belladrilus*) *vaucheri*) endemisch für Bolivien zu sein scheinen. Im Vergleich zu besser untersuchten Staaten wie Brasilien oder Ecuador ist anzunehmen, daß bis heute nur ein sehr kleiner Teil der bolivianischen Oligochaetenfauna bekannt ist.

Resumen

El actual conocimiento sobre la distribución de los oligochetos en Bolivia

Se presenta un sumario de los conocimientos sobre la distribución de los oligochetos en Bolivia. Las 50 especies tratadas, pertenecen a las familias Enchytraeidae, Lumbricidae, Glossoscolecidae, Ocnerodrilidae, Octochaetidae, Acanthodri-

lidae y Megascolecidae. Se incluyeron también informaciones de ZICSI (en prensa), quién estudió 28 especies de Bolivia, describiendo un nuevo género y seis nuevas especies. Aproximadamente la mitad de todos los oligochetos terrestres, conocidos de Bolivia son especies peregrinas, introducidas por actividades humanas, tanto de las zonas templadas (p.e. los Lumbricidae desde Europa) como también de otras regiones tropicales del mundo (p.e. *Amyntas corticis* desde Asia). De la otra mitad de las especies, principalmente Glossoscolecidae, varias tienen una distribución amplia en la Sudamérica tropical, mientras que otras (*Anteoides rosai*, *Andiorrhinus* (*Amazonidrilus*) *bolivianus*, *Andiorrhinus* (*Andiorrhinus*) *montanus*, *Inkadrilus hanagarthi*, *Martiodrilus bolivianus*, *Martiodrilus silvestris*, *Tamayodrilus roembkei*, *Belladrilus* (*Belladrilus*) *vaucheri*) parecen ser endémicas de Bolivia. En comparación con otros países mejor investigados, como son Brasil o Ecuador, se puede suponer, que hasta la fecha se conoce solo una muy pequeña parte de la fauna de oligochetos de Bolivia.

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1. Introduction

During the first decades of the 20. century different surveys, mainly by European scientists, were carried out to get a first insight into the earthworm fauna of Bolivia (COGNETTI 1902, CERNOSVITOV 1934, 1935). Unfortunately, nearly no information was gained during the following years. Only recently, the knowledge of the distribution and the taxonomic situation of these important members of the soil biocenosis increased considerably (ZICSI in press). We wish to thank Prof. Dr. ZICSI for the possibility to incorporate these informations from his manuscript in this overview. In his paper the results of own sampling as well as collections from different authors are presented, thus nearly doubling the number of records.

Investigations at limnic sites also added new informations as many oligochaete species, at least those belonging to the enchytraeid and ocnerodrilid families, prefer semi-aquatic habitats. In any case, the differentiation between aquatic and terrestrial species is not easy in other oligochaete families, too. Since the information concerning the distribution of Oligochaeta in Bolivia was never compiled up to now a comprehensive synopsis of the knowledge, including some previously unpublished records, should be of interest.

arbeit leisten als Voraussetzung der Untersuchung von Mechanismen der Aufrechterhaltung tropischer Diversität. Zwischen den verschiedenen Arbeitsgruppen gibt es Querverbindungen, die teilweise zu enger Zusammenarbeit zwischen einzelnen Forschern geführt hat, wie ebenfalls an einigen Aufsätzen des vorliegenden Bandes deutlich wird.

Ökologische Untersuchungen an tropischen Wirbelloren können oft nur dann erfolgreich durchgeführt werden, wenn Ökologen und Taxonomen eng zusammenarbeiten. Schon die Präzisierung ihrer Fragestellungen macht es erforderlich, daß sich Tropenökologen mit Hilfe von Taxonomen und deren Sammlungen an den Museen intensiv in ihre Tiergruppen einarbeiten. Ebenso kann die Beteiligung von Taxonomen an den Feldarbeiten die Qualität derselben erheblich verbessern.

Als besonders wertvoll hat sich bei unseren eigenen Untersuchungen in Südamerika die enge Zusammenarbeit mit Wissenschaftlern, sowohl Taxonomen als auch Ökologen, des jeweiligen Gastlandes erwiesen, die erfreulicherweise im Rahmen des Schwerpunktprogramms durch begleitende Mittel des Bundesministeriums für wirtschaftliche Zusammenarbeit über die Gesellschaft für Technische Zusammenarbeit finanziell unterstützt wurde. Auch dies wird durch eine Reihe der nachfolgenden Aufsätze belegt.

Die Beiträge des vorliegenden **andrias**-Bandes sind sämtlich zoologischen Inhalts und behandeln schwerpunktmäßig zwei Tiergruppen, Spinnen und Ameisen, zwei der wichtigsten Prädatoren-Gruppen terrestrischer Lebensräume der Tropen; darüber hinaus zeigen sie einen geographischen Schwerpunkt der Arbeiten auf, die Neotropen und dort vor allem das Amazonasgebiet. Besonders der geographische Schwerpunkt spiegelt eine lange Tradition deutscher Tropenforschung wider – und eine kleine Tradition der Karlsruher tropenökologischen Arbeitsgruppe. Diese geht zurück auf den Doktorvater des Erstautors, auf FRIEDRICH SCHALLER, der 1956/57 auf seiner ersten großen Forschungsreise in die Tropen mehrere Wochen in Lima zu Gast war bei HANS-WILHELM und MARIA KOEPCKE. Somit ist es kein Zufall, daß wir diesen **andrias**-Band HANS-WILHELM KOEPCKE, nachmalig Professor an der Universität Hamburg, gleichzeitig stellvertretend für seine Ehefrau MARIA KOEPCKE widmen.

Wir möchten damit einen der Pioniere tropenökologischer Forschung ehren, der den Großteil seines Lebens mit der Erforschung tropischer Diversität verbracht hat. Prof. KOEPCKE, geboren am 23. Juni 1914, ging nach dem 2. Weltkrieg zusammen mit seiner Frau, der Ornithologin Dr. MARIA KOEPCKE, nach Peru, wo beide mehr als 20 Jahre als Wissenschaftler am Museo de Historia Natural „Javier Prado“ in Lima tätig waren. Von der Küstenwüste angefangen über die westlichen Andenabhängige bis zum andinen Hochland erforschten sie gemeinsam dieses äußerst vielfältige Land. Ihr Studium tropischer Lebensräume gipfelte 1968 in der Gründung der Regenwald-Forschungsstation „Panguana“ am Río

Yuyapichis im Einzugsgebiet des Río Ucayali. Prof. KOEPCKE umfangreiche Forschungen fanden ihren Niederschlag insbesondere in dem zweibändigen Werk „Die Lebensformen“, das bis heute eine Fundgrube der beschreibenden Ökologie geblieben ist.

Mit Prof. KOEPCKE und seiner Forschungsstation Panguana verbindet die Karlsruher Arbeitsgruppe aber nicht nur die lose historische Verknüpfung einer Begegnung ihrer „wissenschaftlichen Väter“ in Peru, sondern auch die wesentlich engere Beziehung zweier jüngerer Mitarbeiter der Arbeitsgruppe, WERNER HANAGARTH und MANFRED VERHAAGH. Beide, auch Autoren von Aufsätzen dieses Bandes, weilten in den 70er und 80er Jahren jeweils mehr als zwei Jahre lang in Panguana, erster als Doktorand Prof. KOEPCKE, und beide konnten manche seiner Beobachtungen und Anregungen in der eigenen Arbeit aufgreifen.

Abschließend möchten wir noch einmal die Aufmerksamkeit auf die Bedeutung der Sammlungen in den naturkundlichen Museen lenken; diese Sammlungen sind nicht nur unentbehrliche Basis vieler tropenökologischer Arbeiten, sondern stellen angesichts der Zerstörung tropischer Lebensräume auch einzigartige Dokumente derselben dar. Die Museen sind bei der Erfüllung ihrer Aufgabe als Dokumentationszentren auf die Mitarbeit aller Forscher angewiesen, die Beleg- und Begleitmaterial ihrer Untersuchungen den Sammlungen in den Museen zukommen lassen sollten.

Dabei ist der Vorrang der wissenschaftlichen Sammlungen in den tropischen Herkunftsländern mittlerweile eine Selbstverständlichkeit. Gerade die beiden Länder, mit denen das Karlsruher Museum geographisch die intensivsten Beziehungen unterhält, Bolivien und Brasilien, haben in den letzten beiden Jahrzehnten große und gutgeführte Sammlungen aufgebaut, wie beispielsweise die Colección Boliviana de Fauna in La Paz und die Sammlungen des Instituto Nacional de Pesquisas da Amazônia in Manaus. Das Karlsruher Museum tauscht mit beiden Sammlungen südamerikanisches Belegmaterial, wobei Holotypen und die Hälfte der Paratypen neu beschriebener Arten stets in den Herkunftsländern archiviert werden. Dieser Austausch von Belegmaterial dient der Erweiterung der Kenntnisse über die naturräumlichen Grundlagen in diesen Ländern und trägt so nicht unerheblich zu einem besseren Verständnis für die Natur und letztlich zu deren Schutz bei.

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2. Material and Methods

Most of the sampling was done using different modifications of handsorting methods. In nearly no case ecological studies like the assessment of density or biomass per area were intended. In fact, up to now no ecological investigations except the study of ERGUETA (1985) in Huaraco were performed. We tried to collect all information from the literature on Bolivian terrestrial Oligochaeta; also, previously unpublished data from sampling surveys done by several persons are included. Species which

are with no doubt limnic or marine are not listed (e.g. *Marionina riparia* BRETSCHER, 1899, and other Enchytraeidae from the genus *Lumbricillus*).

Chapter 3 briefly outlines the geographical and ecological division of Bolivia. In chapter 4 all species known from Bolivia are listed (species N° are the same as in table 1.) First, it is shown whether a species occurs in other South American countries and/or in other continents. Then, each sampling site in Bolivia is described including available ecological informations (see also tab. 1). In some cases taxonomic and distributional

Table 1. Sampling sites of Oligochaeta with altitude (approx.), affiliated political units and gross ecological characterization (see chapter 3). Species N° refer to species N° in chapter 4 (Enchy. = Enchytraeidae, Lumbr. = Lumbricidae, Gloss. =

Glossoscolecidae, Ocner. = Ocnerodrilidae, Octo. = Octochaetidae, Acan. = Acanthodrilidae, Mega. = Megascolecidae). N° of sampling sites are the same as in figure 1.

N°	Sampling site	altitude	Provincia	Departamento	ecological zone	Enchy.	Lumbr.	Gloss.	Ocner.	Octo.	Acan.	Mega.
1.	area of Unduavi	4650 m	Nor Yungas	La Paz	moist puna		6,7,9,10,13				49	
2.	road to Zongo	4100 m	Murillo	La Paz	moist puna		7					
3.	Serranía Macho Pelehuco & Serr. de Charazani	4060 m	Franz Tamayo	La Paz	moist puna			32				
4.	Unduavi	3800-3900 m	Nor Yungas	La Paz	yungas-páramo			17,18				
5.	Huacullani at Lago Titicaca	3850-3890 m	Ingavi	La Paz	moist puna		7					
6.	Copacabana (Kusijata) at Lago Titicaca	3810 m	Manco Capac	La Paz	moist puna	2,3	6,7,8	25				
7.	different sites at Lago Titicaca	3800-3850 m		La Paz	moist puna		6,10,11,13				49	
8.	Laguna Viscachani Valle de Zongo	3750 m	Murillo	La Paz	yungas-páramo	1,3,4	7,9,11,12					
9.	Rio Pazña affluent of Lago Poopó	3800-3900 m	Poopó	Oruro	dry puna		6					
10.	Caiza	3700-3800 m	Quijarro	Potosí	dry puna			31	39			
11.	Huaraco	3650 m	Aroma	Oruro	dry puna		6,7					
12.	Chasquipampa	3600 m	Murillo	La Paz	dry puna		5					
13.	area of La Paz	3600 m	Murillo	La Paz	dry puna		6,7				47,48	
14.	area of Cambaya Valle de Zongo	3250 m	Murillo	La Paz	elfin forest		7					
15.	Cotapata	2900 m	Nor Yungas	La Paz	elfin forest (Ceja de Montaña)			27				
16.	Sorata	2680 m	Larecaja	La Paz	humid mountain forest		6					
17.	Cambaya Valle de Zongo	2500 m	Murillo	La Paz	humid mountain forest		7,9,10,13	26				50
18.	Valle de Zongo	1150-2000 m	Murillo	La Paz	humid mountain forest							50
19.	15 km E of Tarija	1860 m		Tarija	humid mountain forest		6,10		33,38			
20.	Mapiri	610 m	Larecaja	La Paz	tropical rain forest			14		45		
21.	between Teoponte and Alcoche	550 m	Nor Yungas	La Paz	tropical rain forest			29	38			
22.	Rio Quiquibey	300 m	Ballivan	Beni	tropical rain forest			21,22				
23.	Guayaramerín	125 m	Vaca Diez	Beni	tropical rain forest			15,21,22, 24,30	34,35,36, 41,42	43,44,46		
24.	Espíritu	170 m	Ballivan	Beni	inundation savanna			22,28,30				
25.	Puerto Suarez	145 m	Chiquitos	Santa Cruz	inundation savanna (pantanal)				35			
26.	Aguaienda	200 m	Gran Chaco(?)	Tarija	chaco woodland			20,23	39,40			
27.	Rio Pilcomayo	200 m	Gran Chaco(?)	Tarija	chaco woodland				37			

remarks are added. At the end of the species list of each family, the biogeographic situation of the family is briefly outlined. A general discussion is given in chapter 5.

3. Geographical division of Bolivia

Geographically, Bolivia can be divided into four main regions: the Andes, the Amazon lowland, the Gran

Chaco, and the Cerrados. These regions can be concisely characterized as follows (for a detailed description see KILLEEN et al. 1993):

The Bolivian Andes are very heterogenous concerning climate and soil types, and therefore in their ecology. The upland in its western part (2500 - 4000 m above sea level), called Altiplano, is mainly a grassland with a mean annual temperature of 10 °C or less and an average precipitation between 600 and 1000 mm/y in

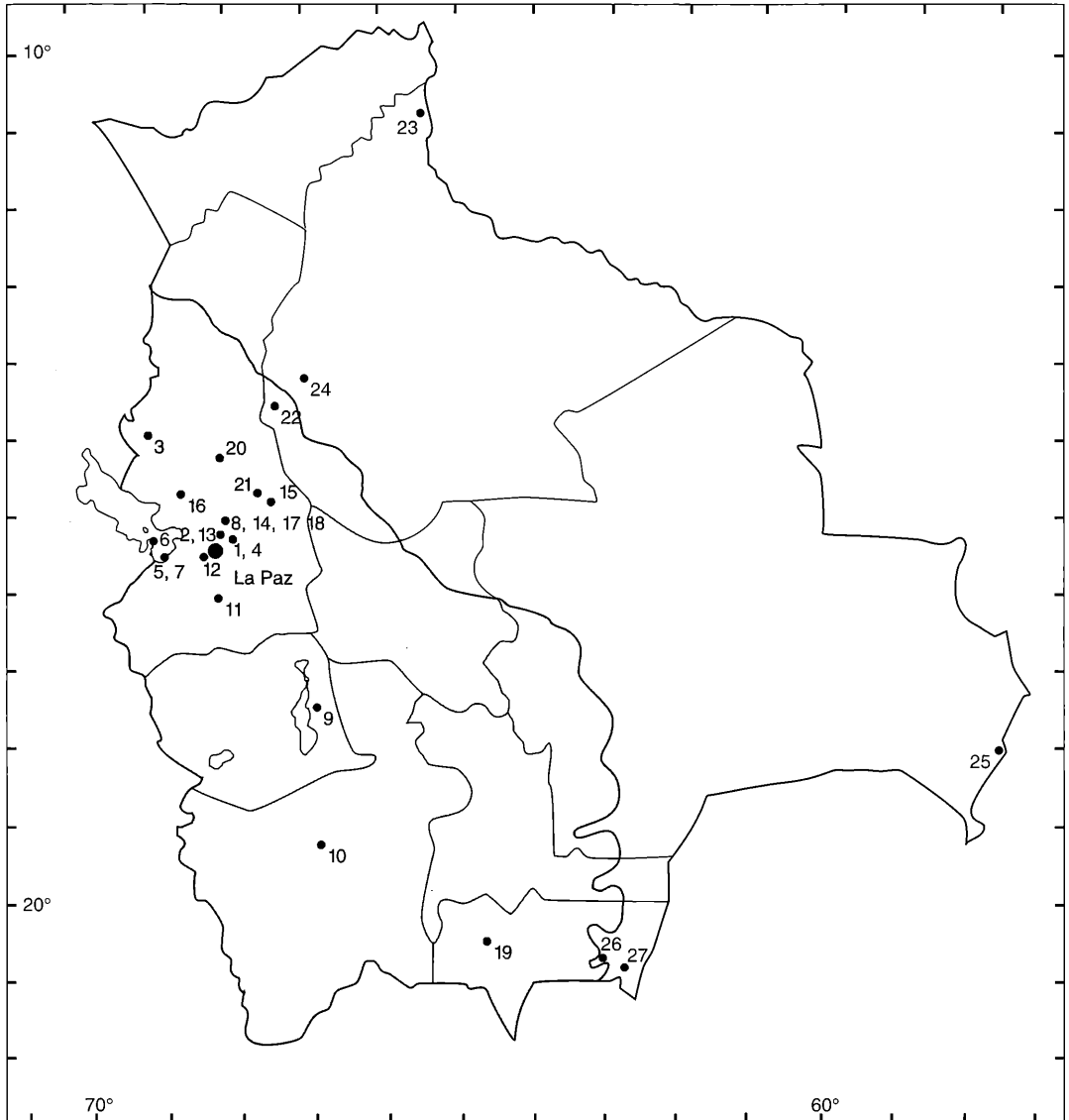


Figure 1. Map of Bolivia, indicating the limits of „departamentos“ and the sampling sites of Oligochaeta. Nº of sampling sites are the same as in table 1. The Andean region is marked grey.

the north (moist Puna) and 400 mm/y or less in the south (dry Puna). Between the Altiplano and the eastern edge of the Andes dry valleys are situated (500 - 3300 m above sea level), with different deciduous forests and arid plant associations. Altiplano as well as Andean valleys are influenced by man since thousands of years, and different plants and animals from other continents have been introduced by the European colonizers.

The eastern slopes of the Andes are mainly covered with humid mountain forests (Yungas). Climate is very moist (mean precipitation 2000 - 3500 mm/y; in extreme cases up to 6000 mm/y) and warm (mean annual temperature 17 - 24 °C). Above the Yungas, between 2700 - 3500 m, follows the „Ceja de la Montaña“ densely covered with foggy Elfin forest. This region often lies in clouds, and temperatures only rise to 10 - 14 °C. The vegetation belt between Elfin forest and moist puna is called „Yungas-Páramo“ in Bolivia, to distinguish it from the Colombian-Ecuadorian Páramos. The soils of the eastern Andean slope are relatively poor in nutrients, despite the fact that they are not much weathered. Colonization by European settlers started only 50 years ago except in Valle de Zongo, a valley close to the capital La Paz, that has been used for a long time past to gather fire-wood.

The north of the Bolivian Amazon lowlands is covered with true lowland tropical rain forest and characterized by high temperatures (26 - 27 °C) and rainfall (1800-2000 mm/y) with 1 to 3 arid months. Further in the south, separated by a large area of cerrados and savannas, grow the humid forests of the Beni plain. This region is also very warm, but the precipitation decreases from the Andes to the Brazilian border (from >2000 to 1500 mm). The Beni forests adjoin in the east the humid forests of the Brazilian Precambrian shield, and in the southeast the drier Chiquitanian semi-deciduous forests, both interspersed with Campos cerrados. The soils of this whole area are mostly very old, weathered and acidic, and concretions of ferric oxides (laterites) can often be found.

The centre of the Beni plain is dominated by savannas of which the northern part is similar to the Campos cerrados. The southern part is a vast inundation area (>80.000 km²) which is flooded for several months every year. The soils are much younger and more heterogenous than in the other regions of the Beni department. In some places even alkaline subsoils were found but the upper soil layers show neutral or slightly acidic reactions because of the high precipitation. In both parts of the Beni savannas earthworms play an important role in the formation of the soil micro-relief (see chapter 4: species N° 23: *Enantiodrilus borellii* and plate 1 a, b). Large parts of the central Beni are now used as extensive pastures for cattle.

The southern lowlands of Bolivia are called the „Gran Chaco“ Climate is warm (22 - 26 °C) but not very

moist (mean 500 - 1000 mm/y). The dry Chaco forest grows partly on sodium-rich, alkaline soils. European influence is partly still very young in this region. In the southeastern parts of Bolivia the Pantanal - an inundation area similar to the Beni savannas - reaches into the country.

4. Faunistic data

Enchytraeidae

1. *Buchholzia appendiculata* (BUCHHOLZ, 1862)

Distribution: Europe

Site: Laguna Viscachani, Valle de Zongo, Prov. Murillo, Dpto. La Paz; close to or in a small river (MARTINEZ-ANSEMIL & GIANI 1986).

Remarks: The sampling site „lago pequeño de Viscachuni“ in MARTINEZ-ANSEMIL & GIANI (1986) is identical with the little lake called „Laguna Viscachani“ in this paper.

2. *Enchytraeus buchholzi* VEJDovsky, 1879

Distribution: Argentina, Brazil, Venezuela, worldwide

Site: Uruni Bay, Lago Titicaca, Dpto. La Paz; at a depth of 1.3 m (CERNOSVITOV 1939).

Remarks: Both the determination, based on a single macerated specimen, and the sampling site (belonging to Peru or Bolivia?) are doubtful; we did not find a place with this name on maps at the Lago Titicaca, but there is an „Estancia Uruna“, about 10 km from Tiquina on the way to Copacabana at Lago Titicaca (3812 m), Prov. Manco Capac, Dpto. La Paz. However, this cosmopolitan species (group of species?) seems to be common in many areas of South America where it has been introduced by man.

3. *Fridericia* sp.

Distribution: Worldwide

Site: Laguna Viscachani, Valle de Zongo, Prov. Murillo, Dpto. La Paz; close to or in a small river (MARTINEZ-ANSEMIL & GIANI 1986).

Site: Copacabana (3812 m), Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; close to a small road near a village, under stones (leg. W. HANAGARTH, February 3, 1985).

4. *Henlea perpusilla* FRIEND, 1911

Distribution: Europe

Site: Close to the Laguna Viscachani, Valle de Zongo, Prov. Murillo, Dpto. La Paz (MARTINEZ-ANSEMIL & GIANI 1986).

Without doubt the species shown here (fig. 1, tab. 1) represent only a negligible percentage of the enchytraeid fauna of Bolivia. The species *Hemienchytraeus*

stephensoni (COGNETTI, 1927), probably very common in tropical South America, was described from the Peruvian lake Laguna Lagunilla by CERNOSVITOV (1939), and was wrongly counted for Bolivia by DOZSA-FARKAS (1989). The worms described as *H. stephensoni* seem to belong to a group of at least four closely related species (CHRISTOFFERSEN 1979, DOZSA-FARKAS 1989).

With the exception of *H. stephensoni* the other species are typically found in disturbed soils, e.g. at ruderal places, where they quickly spread partly due to their mode of reproduction: parthenogenesis or fragmentation. In addition to these introduced or pantropical species it can be expected that other genera (e.g. *Achaeta*, *Marionina* and *Guaranidrilus*) are common in this country, especially as there is some evidence that the Enchytraeidae might have been arisen in South America or a continuous southern land mass (COATES 1989).

Lumbricidae

5. *Aporrectodea* sp.

Distribution: Worldwide

Site: Chasquipampa (3.600 m), Prov. Murillo, Dpto. La Paz (leg. W. HANAGARTH, February 10, 1985).

6. *Aporrectodea caliginosa* (SAVIGNY, 1826)

Distribution: Bolivia, Argentina, Brazil, Chile, Ecuador, French Guayana, Paraguay, Peru, Uruguay, worldwide
Site: Sorata, Prov. Larecaja, Dpto. La Paz (MICHAELSEN 1902).

Site: Near the Río Pazña, affluent of the Lago Poopó, Prov. Poopó, Dpto. Oruro (CERNOSVITOV 1934, 1935).

Site: Close to the Río Bamba, Dpto. (?) (CERNOSVITOV 1934, 1935).

Remarks: We did not find any Río Bamba in Bolivia, but rivers with this name exist in Peru and Ecuador.

Site: Huaraco (3650 m), Prov. Aroma, Dpto. La Paz; in dry puna (leg. W. HANAGARTH, July, 1983).

Remarks: During an ecological study at five different sites (November 1982 - October 1983; ERGUETA 1985) which were characterized by their plant cover more than 95% of all Oligochaeta belonged to this species. The biomass of *A. caliginosa* per square meter varied strongly between the different plant formations (characterized by *Parastrephia lepidophylla*, *Baccharis incarum*, *Stipa ichu*, *Trifolium amabile* and *Medicago sativa*). Few earthworms were found in Quinoa-fields, and none in soil without plant cover. The abundance of this endogeic species fluctuated considerably during the course of the year; approximately 40% were living at 10 - 20 and at 20 - 30 cm depth, respectively.

Site: Kusijata near Copacabana (3812 m), Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; especially close to paths and irrigation channels in moist puna (leg. W. HANAGARTH, July 10, 1991).

Site: Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; in moist puna (leg. W. HANAGARTH, 1980).

Site: Different localities close to La Paz (3.600 m), Prov. Murillo, Dpto. La Paz (ZICSI in press = *Allolobophora caliginosa trapezoides*).

Site: Unduavi (4654 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press = *Allolobophora caliginosa trapezoides*).

Site: 15 km from Tarija to Entre Ríos, Dpto. Tarija (ZICSI in press = *Allolobophora caliginosa trapezoides*).

7. *Aporrectodea rosea* (SAVIGNY, 1826)

Distribution: Bolivia, Argentina, Brazil, Chile, Columbia, Ecuador, Peru, Uruguay, worldwide

Site: area of Cambaya (2500 - 3250 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; four sites in mountain and elfin forest (RIGHI & RÖMBKE 1987).

Site: Close to the road to Zongo (4.100 m), Prov. Murillo, Dpto. La Paz; moist place adjacent to a creek in moist puna (leg. W. HANAGARTH, February 23, 1980).

Site: Laguna Viscachani (3750 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; 10 - 50 m from the shore line (leg. J. RÖMBKE, March 19, 1985).

Site: Kusijata near Copacabana (3812 m), Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; especially close to paths and irrigation channels in moist puna (leg. W. HANAGARTH, July 10, 1991).

Site: Huacullani, Lago Titicaca (3.850 - 3.890 m), Prov. Ingavi, Dpto. La Paz; in moist puna (leg. W. HANAGARTH, February 10, 1980).

Site: Huaraco (3.650 m), direction to Oruro, Prov. Aroma, Dpto. La Paz; moist sites in the dry puna (leg. W. HANAGARTH, April 27, 1980).

Site: Different localities close to La Paz (3.600 m), Prov. Murillo, Dpto. La Paz (ZICSI in press = *Allolobophora rosea*).

Site: Unduavi (4654 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press = *Allolobophora rosea*).

8. *Dendrobaena* sp.

Site: Copacabana (3812 m), Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; in moist puna close to a small road near a village, under stones (leg. W. HANAGARTH, February 3, 1985).

9. *Dendrobaena octaedra* (SAVIGNY, 1826)

Distribution: Bolivia, Chile, Columbia, Ecuador, worldwide

Site: Cambaya (2500 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; in humid mountain forest (leg. J. RÖMBKE, March 19, 1985).

Site: Laguna Viscachani (3750 m), Prov. Murillo, Dpto. La Paz; 10 - 50 m from the shore line (leg. J. RÖMBKE, March 19, 1985).

Site: Unduavi (4654 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press).

10. *Dendrodrilus rubidus* (SAVIGNY, 1826)

Distribution: Bolivia, Argentina, Brazil, Chile, Columbia, Uruguay, worldwide

Site: Cambaya (2500 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; in humid mountain forest (leg. J. RÖMBKE, March 19, 1985).

Site: Unduavi (4654 m), Prov. Murillo, Dpto. La Paz (ZICSI in press).

Site: Lago Titicaca, Dpto. La Paz (ZICSI in press).

Site: 15 km from Tarija to Entre Ríos, Dpto. Tarija (ZICSI in press).

11. *Eiseniella tetraeda* (SAVIGNY, 1826)

Distribution: Bolivia, Argentina, Chile, Ecuador, Peru, worldwide

Site: Laguna Viscachani (3750 m), Prov. Murillo, Dpto. La Paz; 10 - 50 m from the shore line (leg. J. RÖMBKE, March 19, 1985).

Site: Lago Titicaca, Dpto. La Paz (CERNOSVITOV 1939).

Site: Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; in moist puna (leg. W. HANAGARTH, 1980).

Remarks: It seems that most of the sampling sites in the Titicaca basin mentioned by CERNOSVITOV (1939) are located in Peru. However, it is evident that this species is common in the whole area.

12. *Lumbricus rubellus* (SAVIGNY, 1826)

Distribution: Bolivia, worldwide

Site: Laguna Viscachani (3750 m), Prov. Murillo, Dpto. La Paz; 10 - 50 m from the shore line (leg. J. RÖMBKE, March 19, 1985).

13. *Octolasion tyrtaeum* (SAVIGNY, 1826)

Distribution: Bolivia, Argentina, Brazil, Chile, Ecuador, Peru, Uruguay, worldwide

Site: Cambaya (2500 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; in humid mountain forest (RIGHI & RÖMBKE 1987).

Site: Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; in moist puna (leg. W. HANAGARTH, 1980).

Site: Unduavi (4654 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press = *Octolasion lacteum*).

All Lumbricidae found in Bolivia belong to the group of approximately 20 species, mainly of central European origin, which were widely distributed by man during the last five centuries (LEE 1985). Except *L. rubellus* all were found many times in other South American countries. Out of this group *A. caliginosa* seems to be the most successful one, maybe due to its relatively long individual and reproductive lifespan rather than due to a quick reproduction (BENGTSOON et al. 1979). Another explanation for its broad ecological tolerance might be the fact that the same name is used for a group of closely related species with different ecological demands. Looking at the distribution map (fig. 1, tab. 1), it seems that Lumbricidae were introduced by early European settlers into central and southern Andine areas suitable for agriculture where they reach very high dominance values (close to 100%).

Glossoscolecidae

14. *Andiorrhinus* (*Andiorrhinus*) sp.

Distribution: South America

Site: Mapiří, Prov. Larecaja, Dpto. La Paz (ZICSI in press).

15. *Andiorrhinus* (*Amazonidrilus*) *bolivianus* ZICSI, in press

Distribution: Bolivia

Site: Guayaramerín (Estancia Esperanza), Prov. Vaca Díez, Dpto. Beni (ZICSI in press).

16. *Andiorrhinus* (*Amazonidrilus*) *holmgreni* MICHAELSEN, 1918

Distribution: Bolivia, Brazil

Site: Site of original description not known.

Remarks: Mentioned for Bolivia by RIGHI (1971) and RIGHI (1990); in the former case as *A. paraguayensis holmgreni*.

17. *Andiorrhinus* (*Amazonidrilus*) c.f. *holmgreni* MICHAELSEN, 1918

Distribution: Bolivia, Brazil

Site: Unduavi (3800 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press).

Remarks: According to ZICSI (in press) the taxonomic relationships between *A. (A.) holmgreni*, *A. (A.)* c.f. *holmgreni*, *A. (A.) evelinae* and *A. (A.) paraguayensis* are not yet clear.

18. *Andiorrhinus* (*Andiorrhinus*) *montanus* ZICSI, in press.

Distribution: Bolivia

Site: Unduavi (3.900 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press).

19. *Andiorrhinus* (*Andiorrhinus*) *salvadori* COGNETTI, 1908

Distribution: Bolivia, Brazil, Paraguay, Venezuela

Site: Site of original description not known.

Remarks: Mentioned for Bolivia by CORDERO (1945), OMODEO (1954) and RIGHI (1990).

20. *Anteoides rosae* COGNETTI, 1902

Distribution: Bolivia, Argentina

Site: Aguiarenda, Prov. Gran Chaco (?), Dept. Tarija (COGNETTI 1902).

21. *Diaguita* sp.

Distribution: Bolivia

Site: Río Quiquibey (300 m), Prov. Ballivan, Dpto. Beni; in tropical rain forest (leg. W. HANAGARTH, March 9, 1982).

Site: Guayaramerín (Nicolas Suarez Island), Prov. Vaca Diez, Dpto. Beni (ZICSI in press).

Remarks: All specimens of this genus sampled in Bolivia up to now were juvenile; thus it was not possible to determine the species.

22. *Enantiadrilus borellii* (COGNETTI, 1902)

Distribution: Bolivia, Argentina, Brazil

Site: Different localities (Río Urioste, Espíritu viejo) close to Espíritu (170 m), Prov. Ballivian, Dpto. Beni; in inundation savanna and pastures (leg. W. HANAGARTH, May 10, 1985).

Site: Different localities (Estancia Esperanza, Nicolas Suarez Island) close to Guayaramerín, Prov. Vaca Diez, Dpto. Beni; forest adjacent to the Río Mamoré (ZICSI in press).

Site: Río Quiquibey (300 m), Prov. Ballivan, Dpto. Beni; in tropical rain forest (leg. W. HANAGARTH, March 10, 1982).

Remarks: This is a taxonomically very interesting species since it is relatively isolated within the Glossoscolecidae. It seems to be the most abundant species in the inundation savannas of the Dpto. Beni where the worms are very important for the micro-relief of the soil surface. When the area is about to be flooded, the worms flee the water saturated soil and concentrate on bunches of grass where they deposit their casts. By the time they build in this way 20 - 40 cm high small soil towers („sartenejales“) which rise above the water level (HANAGARTH 1993). Similar worm shaped micro-reliefs are also known from Colombia („zurales“, GOOSEN 1971) and Venezuela („lombricales“, SARMIENTO 1984). The „sartenejales“ can cover wide areas and are then very characteristic for the whole landscape (plate 1 a, b).

23. *Glossodrilus peregrinus* (MICHAELSEN, 1897)

Distribution: Bolivia, Caribbean Area

Site: Aguiarenda, Prov. Gran Chaco (?), Dept. Tarija (COGNETTI 1902 = *Glossoscolex peregrinus*)

Remarks: The species, originally described as *Tykonos peregrinus* by MICHAELSEN and later named *Andioscolex peregrinus*, is now placed into the genus *Glossodrilus* (RIGHI 1975).

24. *Goiascolex vanzolinii* RIGHI, 1984

Distribution: Bolivia, Brazil

Site: Guayaramerín (Nueva Cuba), Prov. Vaca Diez, Dpto. Beni (ZICSI in press).

25. *Inkadrilus hanagarthi* ZICSI, in press

Distribution: Bolivia

Site: Kusijata near Copacabana (3812 m), Lago Titicaca, Prov. Manco Capac, Dpto. La Paz; at a depth of 30 cm (ZICSI in press).

Remarks: For the first time since 1900 a specimen of the genus *Inkadrilus* was re-discovered. Other, closely related species of this genus were described from Colombia and Peru (MICHAELSEN 1935).

26. *Martiodrilus bolivianus* RIGHI & RÖMBKE, 1987

Distribution: Bolivia

Site: Cambaya (2500 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; in humid mountain forest (RIGHI & RÖMBKE 1987).

27. *Martiodrilus silvestris* ZICSI, in press

Distribution: Bolivia

Site: Cotapata (2900 m), Prov. Nor Yungas, Dpto. La Paz; natural forest (Ceja de Montaña), in the root layer of the soil (ZICSI in press).

28. *Periscolex* sp.

Distribution: South America

Site: Espíritu (Río Yacuma), Prov. Ballivian, Dpto. Beni (ZICSI in press).

Remarks: The specimens were so softened that it was not possible to determine the species.

29. *Periscolex yuya* RIGHI & RÖMBKE, 1987

Distribution: Bolivia, Peru

Site: Between Teoponte, Prov. Larecaja, and Alcoche (550 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI 1992).

30. *Pontoscolex corethrurus* (MÜLLER, 1857)

(plate 1 c)

Distribution: Bolivia, Argentina, Brazil, British Guayana, Chile, Ecuador, French Guayana, Peru, Paraguay, Suriname, Venezuela, worldwide

Site: Espíritu (170 m), Prov. Ballivian, Dpto. Beni; in forest island in inundation savanna (leg. T. BECK & W. HANAGARTH, March 3, 1993).

Site: Different localities (Nicolas Suarez Island) close to Guayaramerín, Prov. Vaca Diez, Dpto. Beni; plantation adjacent to the Río Mamoré (ZICSI in press).

31. *Rhinodrilus parvus* (ROSA, 1895)

Distribution: Bolivia, Argentina

Site: Caiza, Prov. Quijarro, Dpto. Potosí (COGNETTI 1902)

32. *Tamayodrilus roembkei* ZICSI, in press

Distribution: Bolivia

Site: Serranía Macho Pelechuco and Serranía de Charazani (4060 m), Prov. Franz Tamayo, Dpto. La Paz (ZICSI in press).

Glossoscolecidae were found in Bolivia in the Andes as well as in the Amazonian lowland of the Beni Department (fig. 1, tab. 1). The absence of records in vast areas in the south and east of Bolivia can be explained simply by the fact that no one sampled there since in

adjacent Brazilian provinces many species were described (RIGHI 1990). *P. corethrurus*, coming originally from the Guayana Plateau in northern South America (RIGHI 1984), is the only peregrine species of this family, living pantropically today. All other species are restricted to Central and South America. At the moment it is not possible to assess the true size of their geographical range. Up to now seven species (*Anteoides rosai*, *Andiorrhinus* (*Amazonidrilus*) *bolivianus*, *Andiorrhinus* (*Andiorrhinus*) *montanus*, *Inkadrilus* *hanagarthi*, *Martiodrilus* *bolivianus*, *Martiodrilus* *silvestris*, *Tamayodrilus* *roembkei*) seem to be endemic to Bolivia.

Ocnerodrilidae

33. *Belladrilus* (*Belladrilus*) *vaucheri* ZICSI, in press

Distribution: Bolivia

Site: 15 km from Tarija to Entre Ríos, Prov. Gran Chaco (?), Dpto. Tarija (ZICSI in press).

34. *Eukerria asuncionis* (ROSA, 1895)

Distribution: Bolivia, Argentina, Paraguay

Site: Guayaramerín, Prov. Vaca Díez, Dpto. Beni; plantation adjacent to the Río Mamoré (ZICSI in press).

35. *Eukerria eiseniana* (ROSA, 1895)

Distribution: Bolivia, Argentina, Brazil, Paraguay

Site: Puerto Suarez, Prov. Chiquitos, Dpto. Santa Cruz (RIGHI 1990).
Site: Guayaramerín, Prov. Vaca Díez, Dpto. Beni; park, garden (ZICSI in press).

36. *Eukerria garmani* (ROSA, 1895)

Distribution: Bolivia, Brazil, Paraguay

Site: Guayaramerín, Prov. Vaca Díez, Dpto. Beni; park, garden (ZICSI in press).

37. *Eukerria halophila* (BEDDARD, 1892)

Distribution: Bolivia, Argentina

Site: Tributaries of the Río Pilcomayo, Prov. Gran Chaco (?), Dpto. Tarija; in exceedingly salt and bitter water (COGNETTI 1905).

38. *Eukerria saltensis* (BEDDARD, 1896)

Distribution: Bolivia, Argentina, Brazil, Chile

Site: Between Teoponte, Prov. Larecaja, and Alcoche (550 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press).
Site: 15 km outside of Tarija, Prov. Gran Chaco (?), Dpto. Tarija (ZICSI in press).

39. *Eukerria subandina* (ROSA, 1895)

Distribution: Bolivia, Argentina, Brazil

Site: Caiza, Prov. Quijarro, Dpto. Potosí (COGNETTI 1902 = *Kerria subandina*).
Site: Aguiarenda, Prov. Gran Chaco (?), Prov. Tarija (COGNETTI 1902 = *Kerria subandina*).

40. *Ilyogenia paraguayensis* (ROSA, 1895)

Distribution: Bolivia, Argentina, Paraguay

Site: Aguiarenda, Prov. Gran Chaco (?), Prov. Tarija (COGNETTI 1902 = *Ocnerodrilus* (*Ilyogenia*) *paraguayensis*).

41. *Ilyogenia tuberculatus* EISEN, 1900

Distribution: Bolivia, Guatemala

Site: Nueva Cuba close to Guayaramerín, Prov. Vaca Díez, Dpto. Beni; park (ZICSI in press).

42. *Ocnerodrilus occidentalis* EISEN, 1878

Distribution: Bolivia, Argentina, Brazil, worldwide

Site: Different localities close to Guayaramerín, Prov. Vaca Díez, Dpto. Beni (ZICSI in press).

The ocnerodrilids are included here since they, usually found in more or less limnic habitats, can also live in very moist soils (fig. 1, tab. 1). With the exception of *B. vaucheri* and, partly, the *Ilyogenia* species, they seem to be very common in wide areas of South America. Especially *O. occidentalis*, probably originally from Central America, is now found pantropical, sometimes even in temperate regions (LEE 1985). It can be expected that species of this family are inhabitants of all very moist soils in Bolivia.

Octochaetidae

43. *Dichogaster affinis* (MICHAELSEN, 1890)

Distribution: Bolivia, Argentina, Brazil, Chile, Columbia, Ecuador, Paraguay, Peru

Site: Guayaramerín, Prov. Vaca Díez, Dpto. Beni; park (ZICSI in press).

Remarks: Mentioned for north Bolivia by CSUZDI & ZICSI (1991).

44. *Dichogaster bolau* (MICHAELSEN, 1891)

Distribution: Bolivia, Argentina, Brazil, Chile, Columbia, Ecuador, French Guayana, Paraguay, Venezuela, worldwide

Site: Guayaramerín, Prov. Vaca Díez, Dpto. Beni (CSUZDI & ZICSI 1991).

Site: Urucum, 18 km southeast of Corumba (COGNETTI 1905).

Remarks: This locality is situated in the Brazilian pantanal. COGNETTI (1905) cites the place in the same paper once for Bolivia (p. 42) and once for Brazil (p. 55).

45. *Dichogaster modigliani* (ROSA, 1896)

Distribution: Bolivia, Brazil, Columbia, Ecuador, French Guayana, Peru, Venezuela, worldwide

Site: Mapi, Prov. Larecaja, Dpto. La Paz; in a forest (ZICSI in press).

Remarks: Mentioned for north Bolivia by CSUZDI & ZICSI (1991).

46. *Dichogaster saliens* (BEDDARD, 1892)

Distribution: Bolivia, Argentina, Brazil, Ecuador, Paraguay, Peru, worldwide

Site: Different localities (Nicolas Suarez Island) close to Guayaramerín, Prov. Vaca Díez, Dpto. Beni (ZICSI in press).

Remarks: Mentioned for north Bolivia by CSUZDI & ZICSI (1991).

All Octochaetidae reported from Bolivia up to now, especially *D. bolauí*, belong to a group of peregrine species which are pantropically (and partly in temperate regions, too) distributed today (fig. 1, tab. 1). Probably, they originate from West Africa (LEE 1985).

Acanthodrilidae

47. *Microscolex dubius* (FLETCHER, 1887)

Distribution: Bolivia, Argentina, Brazil, Chile, Paraguay, Uruguay, worldwide

Site: La Paz (3.600 m), Prov. Murillo, Dpto. La Paz (ZICSI in press).

48. *Microscolex phosphoreus* (ANT. DÜGES, 1837)

Distribution: Bolivia, Argentina, Chile, Ecuador, Paraguay, worldwide

Site: La Paz (3.600 m), Prov. Murillo, Dpto. La Paz (ZICSI in press).

49. *Yagansia peruana* CERNOSVITOV, 1939

Distribution: Bolivia, Peru

Site: Between Unduavi and Cota (4.654 m), Prov. Nor Yungas, Dpto. La Paz (ZICSI in press).

Site: Different localities at Lago Titicaca (3.800 - 3.850 m), Dpto. La Paz; e.g. under stones at the shoreline (ZICSI in press).

Y. peruana belongs to a genus of which the distribution center seems to be Chile (ZICSI 1989), whereas the other acanthodrilids found in Bolivia (fig. 1, tab. 1) are truly peregrine species. The two *Microscolex* species, probably originating from southern South America (Patagonia ?), are now established by human activities throughout the southern temperate zone and also in North America and in Europe, mainly in agricultural and pastoral areas (LEE 1985).

Megascolecidae

50. *Amyntas corticis* (KINBERG, 1867)

Distribution: Bolivia, Brazil, worldwide

Site: Cambaya (2500 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz; in humid mountain forest (RIGHI & RÖMBKE 1987 = *Amyntas diffringens*).

Site: Valle de Zongo (2000 m), Prov. Murillo, Dpto. La Paz; open sandy area in humid mountain forest (leg. L. Beck, August 5, 1993).

Site: Estación Cahua (= Calwa, 1150 m), Valle de Zongo, Prov. Murillo, Dpto. La Paz (ZICSI in press).

Remarks: According to EASTON (1982), *Amyntas diffringens* (BAIRD, 1869) is a synonym of this species.

This striking species, probably coming from Southeastern Asia, belongs to the „Pheretima“-group which is peregrine in tropical areas (EASTON 1979). Up to now, *A. corticis* seems to be restricted to humid mountain forests close to La Paz (fig. 1, tab. 1), where it is usually found at the edge of natural forests, especially abundant close to or beneath dung pats of horses. Probably, it has been introduced but in recent times.

5. Discussion

The terrestrial oligochaete fauna of Bolivia is composed of four different groups:

A. – widely distributed species of European origin, probably introduced by early settlers;

B. – species originated from tropical regions of Central America or Asia, and with a pantropical distribution today due to human activities;

C. – species found in at least two South American countries;

D. – species endemic to Bolivia.

From the 50 species (including those which were not determinable to the species level) listed here 13 (26%) belong to group A, 9 (18%) to group B, 20 (40%) to group C, and 8 (16%) to group D, respectively. Thus, nearly half of all earthworms found in Bolivia up to now were introduced by man during the last centuries. Very probably, this ratio will change in favor to South American species when more sampling has been done.

Regarding the geographical distribution (fig. 1, tab. 1) it seems to be evident, even with such a limited number of data, that the introduced lumbricid species are common in the Andes, especially in agricultural areas, whereas the pantropical species live in all not too cold (Alpine regions) parts of Bolivia. Despite the fact that the ways of dispersal and, at least partly, the reasons for their advantages compared to non-peregrine species are known (LEE 1985), it is still a matter of debate whether they have displaced native species or whether they mainly inhabited areas formerly free of earthworms. Species of the family Glossoscolecidae can be found in both parts of the country. Our knowledge on the distribution of these worms is yet too small to decide how many of them are really endemic to Bolivia. However, most of them seem to be distributed in a wide range of tropical areas in South America, including at least western Brazil, Paraguay and northern Argentina. The geographical distribution of terrestrial Oligochaeta in Bolivia is far from being well investigated. The sites

listed here show mainly where some early investigators and modern scientists made their collections, most of them not regarding earthworms as their main point of interest. In fact, the distribution maps (fig. 1, tab. 1) show clearly which areas are relatively easy to reach (e.g. surroundings of La Paz, Valle de Río Zongo) whereas whole departments, in the Andes (e.g. Oruro, Potosí) as well as in the lowlands (e.g. Pando, Santa Cruz) of Bolivia have never been studied.

Therefore, and in comparison to better investigated countries like Brazil or Ecuador, it can be assumed that only a very small percentage of the Bolivian oligochaete fauna is known to science today. For example, in the adjacent Brazilian states of Mato Grosso and Rondônia RIGHI (1990) found 45 species belonging to the families Glossoscolecidae, Ocnodrilidae, Octochaetidae and Acanthodrilidae, excluding introduced Lumbricidae and Megascolecidae, in comparison to 29 species described here from a comparable area of Bolivia. Since in this country the percentage of natural biotopes is quickly decreasing (e.g. by agriculture), the investigation of these ecologically very important organisms should be promoted in the future.

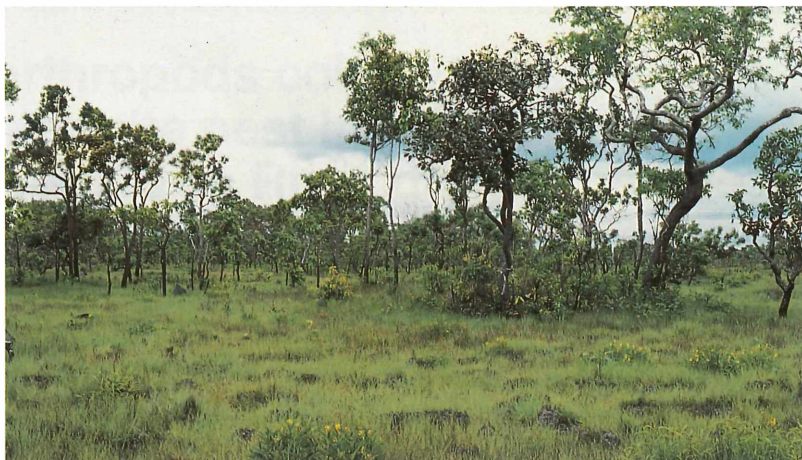
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Plate 1. a) Earthworm-termites-Sartenejal of North Beni inundation savanna: Earthworm mounds between the grass; trees and bushes grow on decayed termite mounds.



b) Earthworm-Sartenejal south of Río Yata, South Beni: Mounds are about 30 cm high; during the rainy season the area is inundated by backwater leaving only the upper parts of the mounds uncovered.



c) *Pontoscolex corethrurus* (Glossoscolecidae).



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