

Termite (Insecta, Isoptera) assemblage of a gallery forest relic from the Chaco province (Argentina): taxonomic and functional groups

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Godoy, M. C., Laffont, E. R., Coronel, J. M. & Etcheverry, C., 2012. Termite (Insecta, Isoptera) assemblage of a gallery forest relic from the Chaco province (Argentina): taxonomic and functional groups. *Arxius de Miscel·lània Zoològica*, 10: 55–67, Doi: <https://doi.org/10.32800/amz.2012.10.0055>

Abstract

Termite (Insecta, Isoptera) assemblage of a gallery forest relic from the Chaco province (Argentina): taxonomic and functional groups.— Termite fauna of the gallery forest in the Colonia Benitez Reserve (Chaco province, Argentina) were analyzed using the rapid diversity assessment protocol (100 x 2 m transects). Twelve species, 10 genera and two families (Kalotermitidae and Termitidae), were detected, comprising the four feeding groups recognized for termites. True soil-feeders (IV) showed the highest species richness, and dead wood and grasses feeders (II) had the highest relative abundance. The most frequently occupied microhabitats were dead wood pieces lying on the ground. These results indicate that the Reserve harbors a diverse termite community similar to the 'monte fuerte' isopteran fauna (91.6% shared species). Our findings also support the Reserve's value as a well-preserved fragment of the original gallery forest and emphasize the need to promote its conservation.

Key words: Termite community, Neotropical region, Feeding groups

Resumen

Comunidad de termitas (Insecta, Isoptera) de un relicto de selva en galería del Chaco (Argentina): grupos taxonómicos y funcionales.— Se analizó la termitofauna de la selva en galería de la Reserva Colonia Benítez (provincia del Chaco, Argentina) mediante el protocolo de estimación de la diversidad de isópteros (transectos de 100 x 2 m). Se detectaron 12 especies incluidas en 10 géneros y dos familias (Kalotermitidae y Termitidae) pertenecientes a los cuatro grupos de termitas establecidos en función de su alimentación, con mayor riqueza de los que se alimentan a partir del suelo (IV) y mayor abundancia relativa de los que se alimentan de madera muerta y hierbas (II). Los microhábitats más frecuentes fueron piezas de madera muerta húmeda depositadas sobre el suelo. Los resultados indicaron que la Reserva alberga una comunidad taxonómica y funcionalmente diversa de termitas, similar a la del "monte fuerte" (91,6% de especies comunes). Además, confirman el valor del área como fragmento bien preservado de la selva en galería original y la necesidad de promover su conservación.

Palabras clave: Comunidad de termites, Región neotropical, Grupos tróficos

Received: 04/10/2012; Conditional acceptance: 10/02/2013; Final acceptance: 19/03/2013

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Introduction

Termites are involved in plant material degradation processes and play an important ecological role as 'ecosystem engineers'. The type of food consumed by each species varies from living plants to organic matter within mineral soil (Wood & Sands, 1978; Bignell & Eggleton, 2000; Eggleton & Tayasu, 2001; Bignell, 2006). Besides decomposition, the ecosystem services provided by termites include carbon and nitrogen cycling, modification of physical and chemical soil properties, and microbial diversity enhancement (Lobry de Bruyn & Conacher, 1990; Ackerman et al., 2007; Jouquet et al., 2011).

In addition, these insects are considered good indicators of environmental perturbations because of the changes seen in the composition and structure of their assemblages due to habitat fragmentation and agricultural land use (DeSouza & Brown, 1994; Davies et al., 1999, 2003; Barros et al., 2002; Davies, 2002; Eggleton et al., 2002; Sena et al., 2003; Roisin & Leponce, 2004; Attignon et al., 2005). Analysis of their communities can thus provide clues about the conservation status of fragmented natural areas, such as that in the Chaco Reserve analyzed in this study.

It is therefore interesting to characterize the Isoptera fauna from diverse environments and determine the processes in which they participate (Dawes–Gromadzki, 2008). This is especially significant in South American subtropical and semi–arid biomes where such surveys are still scarce. Only a few studies have been conducted to date in Argentina (Domingos et al., 1986; Martius et al., 1999; Laffont et al., 2004; Roisin & Leponce, 2004; Constantino, 2005; Torales et al., 2007; Vasconcellos et al., 2010; Jones & Eggleton, 2011; Palin et al., 2011).

With regard to ecosystems in protected areas of Eastern Chaco, previous termite surveys correspond to xerophytic forests in Chaco and Pilcomayo National Parks and the Pampa del Indio Reserve (Laffont et al., 2004; Roisin & Leponce, 2004; Torales et al., 2007, 2009), but the termite fauna from the Colonia Benitez Reserve (Chaco province) are unknown.

The aim of this study was to analyze the Isoptera assemblage in the Colonia Benitez Strict Nature Reserve and determine the taxonomic and functional group composition in order to help evaluate its conservation status.

Material and methods

Study site

The Colonia Benitez Strict Nature (27° 19' 10" S, 58° 57' 09" W, 10 ha) is situated in the Chaco province (NE Argentina), about 20 km N from Resistencia city. It is managed by the National Parks (APN, 2013).

The Reserve has a humid mesothermal climate with little winter rainfall, and the average annual temperature is above 18°C. Phytogeographically, the area belongs to the Eastern District of the Humid Chaco, characterized by grasslands, floating islands ('embalsados'), gallery forests and xerophytic forests ('monte fuerte') (Cabrera, 1976; Cabrera & Willink, 1980).

Although the Reserve is situated in the area with the highest population density of the Chaco province (Argentina), it has retained samples of the natural environments of the Chaco biogeographical region. This Reserve is considered to be of high biological and educational value despite its small size (Chébez et al., 1998, 2005; Soria, 2000; INTA, 2013). While its ecosystems are

apparently little altered, the area shows signs of isolation because it is surrounded by environments mostly dedicated to farming. The flora has been extensively surveyed, but with respect to wildlife, its small size prevents the development of large vertebrate populations (Heinonen Fortabat & Chébez, 1997; Chébez et al., 1998, 2005; Soria, 2000). Only a few groups of invertebrate fauna have been surveyed (Gomez Lutz & Godoy, 2010; Lazzeri et al., 2011).

The study was conducted in one of the physiognomic units of the Reserve, a gallery forest relict (3 ha) with large arboreal vegetation on an old bank of the Negro river. The upper stratum of the gallery forest is formed by trees such as *Peltophorum dubium*, *Enterolobium contortisiliquum*, *Tabebuia heptaphylla*, *Tabebuia pulcherrima*, and *Astronium balansae*.

Sampling protocol

We used the standardized protocol for rapid assessment of termite diversity (Jones & Eggleton, 2000). This consisted of 100 x 2 m transects, divided into 20 successive sections of 5 x 2 m. Each section was intensively searched for one man–hour period. The search included all microhabitats (trees, shrubs, stumps, branches, fallen logs, grasses, and herbaceous vegetation), as well as litter and the underlying humus layer. At each section, five randomly distributed excavations (12 x 12 x 10 cm) were also performed to detect termites in the upper soil layers. Epigeal and arboreal nests up to a height of 2 m were measured and dissected. Complementary sampling was made around transects.

Two transects (T1 and T2) were conducted at the gallery forest during the warm season (spring–summer) 2010–2011. This number of strips was due to the small size of the forest in the Reserve and the need to locate the strips 50 m away from the limits (to avoid border effects) and between them.

Sample identification and classification

Termite samples were identified to species or morphospecies level with the help of identification keys and specialized literature (Mathews, 1977; Fontes, 1985, 1992; Constantino, 1991, 1999, 2002, 2012). The specimens were compared with samples from previous studies conducted in the region (Laffont et al., 2004; Torales et al., 2007, 2009).

The material (annex 1) was deposited in the Isoptera Collection of the Facultad de Ciencias Exactas y Naturales y Agrimensura, Universidad Nacional del Nordeste, Corrientes, Argentina (FACENAC).

Termites were also classified according to the ecological or functional groups proposed by Donovan et al. (2001) and Eggleton & Tayasu (2001). Six morphological characters were analyzed: shape of pronotum in side view, development of the molar plate ridges of the right mandible, number and attachment of the Malpighian tubules, development of enteric valve ridges, and ornamentation of the enteric valve wall between and beyond ridges (Godoy, in prep.).

Data analysis

The software Estimates 8.2.0 (Colwell, 2006) was used to determine α diversity through S (richness expressed as the number of species), to build the species accumulation curve, and to calculate the nonparametric estimators (first–order and second–order Jackknife).

The software Statistica (Statsoft, 1999) was used to assess the quality of sampling. The species accumulation curve was adjusted to the Clench function by nonlinear estimation with the Simplex & Quasi Newton algorithm. This function has proved a good fit for many situations and taxa (Jiménez–Valverde & Hortal, 2003).

All tests were performed with a significance $\alpha = 0.05$. As usual for social insects, we considered the number of occurrences of each species (encounters) instead of the total number of individuals (Leponce et al., 2004).

Results

A total of 30 Isoptera encounters were recorded from the gallery forest. Thirty-one termite samples were obtained, four of which were composed of two species. The sections that were positive to termites were 30% (T1) and 80% (T2), respectively.

Twelve species ($S = 12$), representing 10 genera and two families, were identified (table 1). Termitidae was the dominant family both in species richness (83.3%) and relative abundance (90%), while Kalotermitidae was represented by only two species (fig. 1). Within Termitidae, Apicotermitinae was the most species-rich subfamily with four species, but Nasutitermitinae dominated the community, representing 46.6% of encounters. The most common termite species were *Diversitermes diversimiles* with seven encounters, and *Nasutitermes nordesnkioeldi* with six.

Table 1. Termites from Colonia Benitez Reserve: species list, number of encounters (E), feeding groups (FG: I. No-Termitidae wood-feeder; II. Liiter- and wood- feeders Termitidae; III. Organic-rich upper layers of the soil feeders; IV. True soil-feeders) (according to Donovan et al., 2001), microhabitats occupied (M: B. Fallen branches; T. Fallen trunks; RD. Runways on dead trees; RL. Runways on living trees; S. Superficial soil; S1. Soil at 15 cm depth) and nesting habits (Nh: A. Arboreal nest; H. Hypogeal nest; Mo. Mound; W. Nest in wood).
 Tabla 1. Termitas de la Reserva Colonia Benítez: lista de especies, número de encuentros (E), grupos tróficos (FG: I. Termitas que no se alimentan de madera; II. Termitas que se alimentan de detritos y madera; III. Termitas que se alimentan a partir de las capas superiores del suelo ricas en materia orgánica; IV. Termitas que se alimentan verdaderamente del suelo) (según Donovan et al., 2001), microhábitats ocupados (M: B. Ramas caídas; T. Troncos caídos; RD. Túneles sobre árboles secos; RL. Túneles sobre árboles vivos; S. Suelo superficial; S1. Suelo a 15 cm de profundidad) y tipos de nidos (Hh: A. Nido arbóreo; H. Nido hipogeo; Mo. Montículo; W. Nido en madera).

Taxa	E	FG	M	Nh
Kalotermitidae				
<i>Rugitermes rugosus</i>	2	I	B, T	W
<i>Tauritermes triceromegas</i>	1	I	B	W
Termitidae				
Nasutitermitinae				
<i>Diversitermes diversimiles</i>	7	II	B, T, RD	H, Mo
<i>Nasutitermes aquilinus</i>	1	II	RL	A
<i>Nasutitermes nordesnkioeldi</i>	6	II	RL, RD, B, T	A
Apicotermitinae				
<i>Anoplotermes</i> sp.	1	IV	S	H, Mo
<i>Grigiotermes</i> sp. a	2	IV	T	H, Mo
<i>Grigiotermes</i> sp. b	1	IV	S	H, Mo
<i>Ruptitermes reconditus</i>	1	IV	S	H, Mo
Termitinae				
<i>Dihoplotermes inusitatus</i>	1	IV	T	H, Mo
<i>Microcerotermes strunckii</i>	4	II	RL, RD	A
<i>Neocapritermes opacus</i>	3	III	S, S1	H, Mo

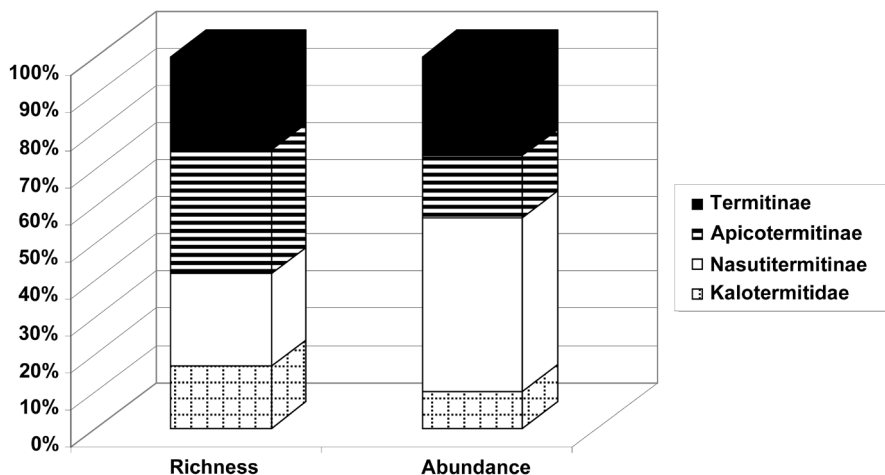


Fig. 1. Taxonomic groups of the termite assemblage: richness and relative abundance based on number of encounters.

Fig. 1. Grupos taxonómicos de la comunidad de termitas: riqueza y abundancia relativa según el número de encuentros.

The estimated species richness (Jackknife 1 and 2) were 17.8 and 21.7, respectively (fig. 2), indicating that the sampling effort allowed capture of between 55 and 67% of the gallery forest species. Moreover, the species accumulation curve fitted the Clench function (fig. 3) with $R^2 = 0.999$; the value of the curve slope was 0.12, and the asymptote (estimated species) was 19.8, with an estimated capture success of 60%.

The termite assemblage comprised the four feeding groups recognized by Donovan et al. (2001) for termites (fig. 4). The true soil-feeders (group IV) showed the highest species richness (five), comprising the soldierless Apicotermitinae and *Dihoplotermes inusitatus* that consume ligno-cellulose substrates in an extremely amorphous and refractory form. Nevertheless, the litter- and wood- feeders Termitidae (group II) had the highest relative abundance (60% of the encounters), comprising the Nasutitermitinae species and *Microcerotermes strunckii*, feeding mainly on dead wood. No-Termitidae wood-feeders (group I) were recorded: *Tauritermes triceromegas* and *Rugitermes rugosus*. Only one species that consumes the organic-rich upper layers of the soil (group III) was recorded (*Neocapritermes opacus*).

The microhabitats most frequently occupied by termites (50% of the encounters) were pieces of dead wood (fallen branches and trunks), generally with high humidity content, lying on the ground of the gallery forest (fig. 5). We verified a close relationship between the colonized microhabitats and the nesting and feeding habits of each species. Thus, the wood-nesting and xylophagous kalotermitids were found inside galleries excavated in fallen trunks and branches. The three species with arboreal nests and wood-eating habits (feeding group II) (*Nasutitermes aquilinus*, *N. nordenskiöldi* and *M. strunckii*) were detected inside their nests and covered runways on living and dead trees. Arboreal nests of *N. aquilinus* (two) and *M. strunckii* (one) were detected in the surroundings of the strips, built on living trees.

The other species, with hypogean nests or frequent inhabitants of other Termitidae nests (inquilines), were detected in highly degraded pieces of dead wood, such as hollow branches filled with mineral soil (*D. diversimiles*, *Grigiotermes* sp. a and *D. inusitatus*), or inside the soil (*N. opacus* and the remaining Apicotermitinae).

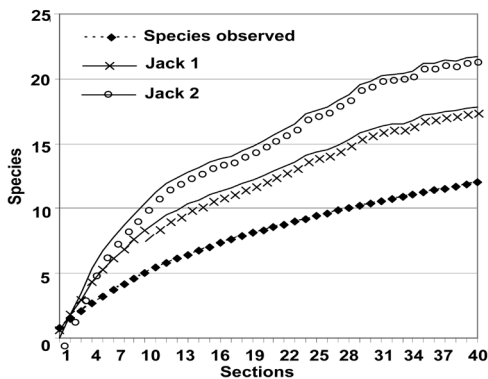


Fig. 2. Termite species richness: observed and estimated by first-order and second-order Jackknife.

Fig. 2. Riqueza de especies de termitas observada y estimadas mediante Jackknife de primer y segundo orden.

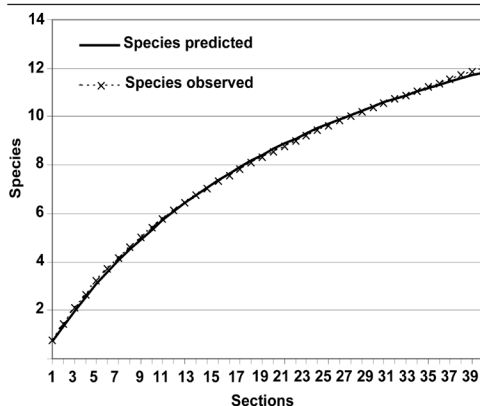


Fig. 3. Termite species accumulation curves: observed and prediction of the Clench model.

Fig. 3. Curva de acumulación de especies de termitas: observadas y predicción mediante el modelo de Clench.

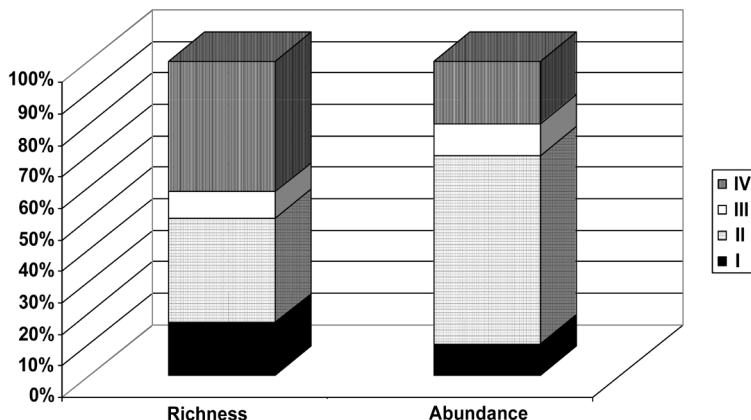


Fig. 4. Feeding groups (I–IV) of the termite assemblage: richness and relative abundance based on number of encounters. (For the abbreviations of feeding groups see Results.)

Fig. 4. Grupos tróficos (I–IV) de la comunidad de termitas: riqueza y abundancia relativa según el número de encuentros. (Para las abreviaturas de los grupos tróficos, ver los Resultados.)

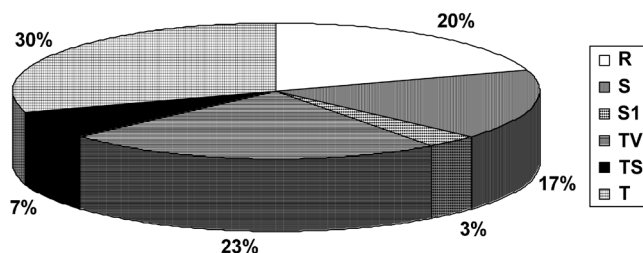


Fig. 5. Microhabitats occupied by termites in the Reserve, as a proportion of total termite encounters. (For abbreviations of microhabitats see table 1.)

Fig. 5. Microhábitats ocupados por termitas en la Reserva, en proporción al número total de encuentros. (Para las abreviaturas de los microhábitats, ver tabla 1.)

Discussion

The current study is the first systematic survey of termites in a gallery forest relict of the Humid Chaco. Previous studies have been performed in semideciduous xerophytic forests ('quebrachal' or 'monte fuerte') (Laffont et al., 2004; Roisin & Leponce, 2004; Torales et al., 2007). Despite the floristic differences between gallery forests and 'monte fuerte', the termite fauna showed high similarity, with 11 (91.6%) shared species. The morphospecies *Grigiotermes* sp. b, previously detected at the Paranaense biogeographical region (Torales et al., 2005) is reported for the first time from Chaco. This record increases the number of termite species within this region to 79 (Torales et al., 2009).

These results indicate that the Colonia Benitez Reserve harbors a taxonomically and functionally diverse subsample of termites, having 18.7% of the 64 species previously reported for the Humid Chaco District (Torales et al., 2009). The presence of soil-feeding termites, which contribute to soil fertility and appear to be more affected by anthropogenic disturbances in humid forests, is particularly significant (Eggleton et al., 1995, 1996, 2002; Davies et al., 2003; Jones et al., 2003; Hemachandra et al., 2010). The diversity and abundance of this feeding group in Colonia Benitez provides evidence that the Isoptera assemblage was not severely affected by these processes.

In addition to soil feeding, other termite activities such as litter and dead wood consumption and decomposition, nest building and tunneling on vegetation were recorded in the area. The participation of these insects in diverse processes in the Reserve contributes to the provision of essential ecosystem services such as organic matter decomposition and recycling (Jouquet et al., 2011).

Besides the need to increase the sampling effort, the lower number of species collected may be because only one physiognomic unit of the Reserve was analyzed or because the area of the Reserve was small. In fact, termite communities, like those of other insects such as ants and crickets, are reported to have lower species richness in smaller forests remnants than in large undisturbed areas. This is mainly due to mechanisms of deterioration that act in isolated fragments, such as restriction of population size and immigration, deforestation—related disturbance and edge effects (De Souza & Brown, 1994; Turner & Corlett, 1996; Davies, 2002; Ribas et al., 2005; Nichols et al., 2007).

Several studies, however, have confirmed the value of small fragments of undisturbed or partially altered environments such as habitats for a significant number of plant, invertebrate and small vertebrate species whose populations can persist for long periods of time (Shafer, 1995; Oertli et al., 2002; Miller & Hobbs, 2002).

Our results support the importance of the Colonia Benitez Reserve as a well-preserved fragment of the original gallery forest and also emphasize the need to promote conservation of this area and similar small fragments of the Chacoan Region due to their natural and educational value. Additional studies of other plant and animal groups should be performed to enable accurate evaluation of the regions conservation status and implement effective management and protection strategies.

Acknowledgements

We would like to thank the National Park Administration (APN, Argentina) for permission to conduct research at the Colonia Benitez Reserve, and park wardens Andrés Lanfiutti and Claudio Oneto for their support during field work. We also thank Tiago F. Carrijo, an anonymous referee, and *Arxius de Miscel·lània Zoològica* editor Francesc Uribe for constructive comments on the manuscript. Funding was provided by the Secretaria General de Ciencia y Técnica (Universidad Nacional del Nordeste).

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Annex 1. List of collected samples of termites from Colonia Benitez Reserve with information on field and FACENAC numbers, collection (date, microhabitat, collector) and taxonomic determination: FRN. Field register number; FN. FACENAC number; Date. Collection date.

Annexo 1. Lista de muestras de termitas recolectadas en la Reserva Colonia Benitez, con información de los números de registro de campo y FACENAC, datos de recolección (fecha, microhábitat, recolector) y determinación taxonómica: FRN. Número de registro de campo; FN. Número del FACENAC; Date. Fecha de recolección.

Family / Subfamily

Taxon	FRN	FN	Date	Collector	Microhabitat	Determinador
Family Kalotermitidae						
<i>Rugitermes rugosus</i>	T2–M3	2340	31/05/11	E. Laffont	Interior de rama caída muy húmeda	J. M. Coronel
<i>Rugitermes rugosus</i>	T2–M5	2341	31/05/11	E. Laffont	Interior de tronco caído muy húmedo	J. M. Coronel
<i>Tauritermes triceromegas</i>	T1–M1	2342	15/11/10	J. M. Coronel	Rama seca caída	J. M. Coronel
Family Termitidae / Subfamily Nasutitermitinae						
<i>Diversitermes diversimiles</i>	T2–M1	2343	31/05/11	C. Etcheverry	Interior de rama caída	M. C. Godoy
<i>Diversitermes diversimiles</i>	T2–M2	2344	31/05/11	M. C. Godoy	Interior de tronco muerto	M. C. Godoy
<i>Diversitermes diversimiles</i>	T2–M3	2345	31/05/11	E. Laffont	Interior de rama caída muy húmeda	M.C. Godoy
<i>Diversitermes diversimiles</i>	T2–M4	2346	31/05/11	M. C. Godoy	Interior de tronco muerto caído	M. C. Godoy
<i>Diversitermes diversimiles</i>	T2–M6	2347	31/05/11	J. M. Coronel	Interior de rama caída	M. C. Godoy
<i>Diversitermes diversimiles</i>	T2–M7	2348	31/05/11	E. Laffont	Interior de tronco caído muy húmedo	M. C. Godoy
<i>Diversitermes diversimiles</i>	T2–M20	2349	01/06/11	J. M. Coronel	Arbol seco en pie, bajo corteza	M. C. Godoy
<i>Diversitermes diversimiles</i>	T2–M22	2350	01/06/11	C. Etcheverry	Bajo tronco caído	M. C. Godoy
<i>Nasutitermes aquilinus</i>	T1–M7	2351	15/11/10	E. Laffont	Sobre árbol seco	J. M. Coronel
<i>Nasutitermes aquilinus</i>	T1–M8	2352	15/11/10	M. C. Godoy	Sobre espina corona	J. M. Coronel
<i>Nasutitermes nordesnkoeldi</i>	T2–M15	2353	31/05/11	E. Laffont	Túneles sobre árbol vivo caído	J. M. Coronel
<i>Nasutitermes nordesnkoeldi</i>	T2–M17	2354	01/06/11	E. Laffont	Interior de tronco muerto	J. M. Coronel
<i>Nasutitermes nordesnkoeldi</i>	T2–M18	2355	01/06/11	E. Laffont	Rama seca caída	J. M. Coronel

Annex 1. (Cont.)

Family / Subfamily

Taxon	FRN	FN	Date	Collector	Microhabitat	Determinador
<i>Nasutitermes nordesnkoeldi</i>	T2–M19	2356	01/06/11	C. Etcheverry	Túneles sobre árbol vivo	J. M. Coronel
<i>Nasutitermes nordesnkoeldi</i>	T2–M20	2357	01/06/11	J. M. Coronel	Arbol seco en pie, bajo corteza	J. M. Coronel
<i>Nasutitermes nordesnkoeldi</i>	T2–M21	2358	01/06/11	C. Etcheverry	Túneles sobre árbol vivo	J. M. Coronel
<i>Nasutitermes nordesnkoeldi</i>	T2–M23	2359	01/06/11	E. Laffont	Interior de tronco muerto	J. M. Coronel
Family Termitidae / Subfamily Apicotermitinae						
<i>Anoplotermes</i> sp.	T2–M8	2360	01/06/11	M. C. Godoy	Suelo superficial cerca de raices de bromeliaceas	M.C. Godoy
<i>Grigiotermes</i> sp. a	T2–M12	2361	31/05/11	J. M. Coronel	Interior de tronco muerto	M. C. Godoy
<i>Grigiotermes</i> sp. a	T2–M13	2362	31/05/11	J. M. Coronel	Interior de tronco muerto	M. C. Godoy
<i>Grigiotermes</i> sp. b	T2–M16	2363	31/05/11	J. M. Coronel	Suelo superficial	M. C. Godoy
<i>Ruptitermes reconditus</i>	T2–M14	2364	31/05/11	E. Laffont	Suelo superficial	M. C. Godoy
Family Termitidae / Subfamily Termitinae						
<i>Dihoplotermes inusitatus</i>	T2–M2	2365	31/05/11	M. C. Godoy	Interior de tronco muerto	M. C. Godoy
<i>Microcerotermes strunckii</i>	T1–M5	2366	15/11/10	E. Laffont	Túneles sobre árbol vivo	M. C. Godoy
<i>Microcerotermes strunckii</i>	T1–M6	2367	15/11/10	M. C. Godoy	Túneles sobre árbol vivo (guayacán)	M. C. Godoy
<i>Microcerotermes strunckii</i>	T1–M7	2368	15/11/10	M. C. Godoy	Sobre árbol seco	M. C. Godoy
<i>Microcerotermes strunckii</i>	T2–M9	2369	31/05/11	C. Etcheverry	Interior de tronco muerto con túneles	M. C. Godoy
<i>Microcerotermes strunckii</i>	T2–M10	2370	31/05/11	C. Etcheverry	Túneles sobre árbol vivo	M. C. Godoy
<i>Microcerotermes strunckii</i>	T2–M11	2371	31/05/11	J. M. Coronel	Túneles sobre árbol vivo	M. C. Godoy
<i>Neocapritermes opacus</i>	T1–M2	2372	15/11/10	J. M. Coronel	Suelo a 15 cm	M. C. Godoy
<i>Neocapritermes opacus</i>	T1–M3	2373	15/11/10	M. C. Godoy	Suelo superficial	M. C. Godoy
<i>Neocapritermes opacus</i>	T1–M4	2374	15/11/10	J. M. Coronel	Suelo superficial	M. C. Godoy