Survey of the leg exocrine glands in termites (Isoptera)[1]

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Abstract. A survey of the leg exocrine glands in the termite workers of 16 species of the families Kalotermitidae and Termitidae was carried out through scanning electron microscope. Glandular openings were not found in the legs of *Anoplotermes* **sp.**, *Ruptitermes* **sp.** (Apicotermitinae, Termitidae) or *Glyptotermes planus* (Kalotermitidae), but they are present, spread over the ventral surface of the first, second and third tarsomeres of other Termitidae such as *Armitermes euamignathus, Cornitermes cumulans, Nasutitermes coxipoensis, Rhynchotermes nasutissimus, Syntermes nanus, Embiratermes festivellus* (Nasutitermitinae), *Amitermes beaumonti, Hoplotermes amplus, Microcerotermes* **sp.**, *Neocapritermes opacus, Orthognathotermes* **sp.**, *Spinitermes brevicornutus* and *Termes* **sp.** (Termitinae). The pores are usually isolated but they can also be grouped inside a round depression. The occurrence of leg exocrine glands in the family Termitidae is reported for the first time.

Keywords. Exocrine gland; leg; morphology; scanning electron microscopy; termite.

INTRODUCTION

The leg exocrine glands of Isoptera were first described by Bacchus (1979), who investigated 12 species of termite (Rhinotermitidae, Kalotermitidae, Termopsidae and Termitidae) through scanning electron microscope. The author found such glands only in species of Rhinotermitidae (*Reticulitermes lucifugus, Heterotermes perfidus, Coptotermes formosanus, Schedorhinotermes putorius* and *Termitogeton planus*). The glandular openings correspond to pore plates with different sizes and shapes. The pore plates were observed on the three leg pairs of the reproductive and sterile castes and were present on the distal tibia and on the ventral surface of the first and second tarsomeres.

Later contributions also revealed the presence of glandular openings in Serritermitidae (*Serritermes serrifer*) and Kalotermitidae (*Kalotermes flavicollis*). The glandular pores of *S. serrifer* are located on the ventral surface of the first and second tarsomeres, associated with papilar structures and not arranged in plates (Costa-Leonardo 1994). In *K. flavicollis*, the pores are located on the ventral surface of the first and second tarsomeres and in the lateral part of the third tarsomere and distal tibia (Faucheux 1994).

This study presents the first record of leg exocrine glands in 13 species of the family Termitidae.

MATERIAL AND METHODS

In this research it was used termite workers collected from nests or soil baits at different sites. The following species were analysed: *Glyptotermes planus* (Kalotermitidae), *Armitermes euamignathus, Cornitermes cumulans, Embiratermes festivellus, Nasutitermes coxipoensis, Rhynchotermes nasutissimus, Syntermes nanus* (Termitidae, Nasutitermitinae), *Armitermes beaumonti, Hoplotermes amplus, Neocapritermes opacus, Microcerotermes* **sp.**, *Orthognathotermes* **sp.**, *Spinitermes brevicornutus, Termes* **sp.** (Termitidae, Termitinae), *Anoplotermes* **sp.**, *Ruptitermes* **sp.** (Termitidae, Apicotermitinae).

The material was fixed in Karnovsky mixture or 80% alcohol. Ten specimens of each species were cleaned with ultrasonic vibration in a detergent solution, dehydrated in a graded alcohol and acetone series, dried in a critical point Balzers CPD 030 dryer and coated with gold in a Balzers SCD 050 sputterer. The material was examined with a JEOL JSM-P 15 scanning electron microscope.

Voucher specimens are deposited in the collection of the Centro de Insetos Sociais (CEIS), Rio Claro, SP, Brazil.

RESULTS

The pores were present in all pairs of worker legs of the

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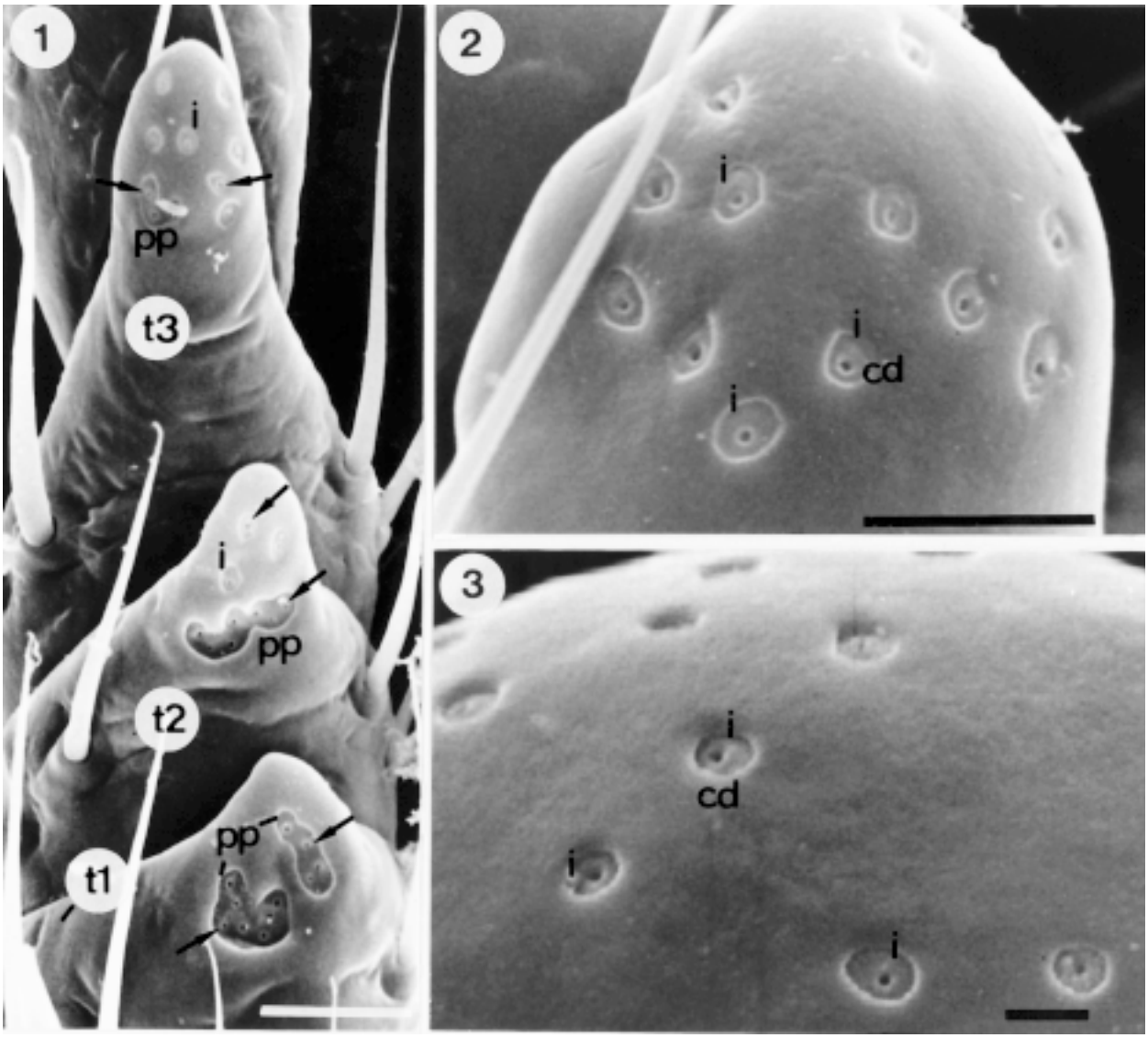


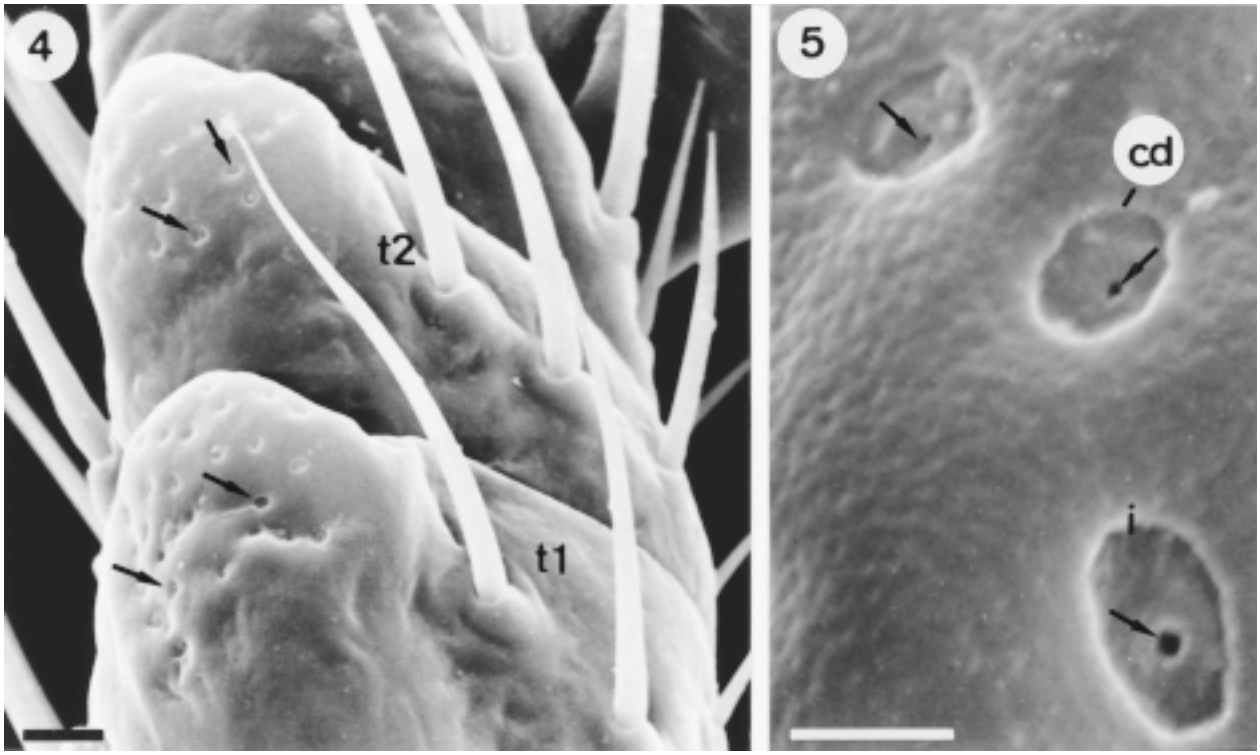
Figs. 1-3. 1, Ventral surface of the tarsal segments 1 to 3 of a *Termes* **sp.** worker (left hind leg); the arrows indicate the glandular openings; scale: 10 µm. **2**, Detail of the isolated pores (i) on the third tarsal segment of a *Termes* **sp.** worker (right midleg); scale: 5 µm. **3**, Detail of isolated pore (i) on the second tarsomere of *Embiratermes festivellus* worker (right midleg); scale: 1 µm. cd = cuticular depression; i = isolated pore; pp = pore plate; t1 = first tarsomere; t2 = second tarsomere; t3 = third tarsomere.

following Termitidae species: *Armitermes euamignathus, Cornitermes cumulans, Nasutitermes coxipoensis, Rynchotermes nasutissimus, Syntermes nanus, Amitermes beaumonti, Hoplotermes amplus, Microcerotermes* **sp.**, *Neocapritermes opacus, Embiratermes festivellus, Orthognathotermes* **sp.**, *Spinitermes brevicornutus,* and *Termes* **sp.** (Figs. 1-9).

The pores were predominantly located on the ventral surface of the first, second and third tarsal segments. Several morphological types of glandular openings were identified in the different termite species.

According to the results, the glandular openings can be classified into four morphological types (Table I).

Pore plate and isolated pore in a cuticular depression – *Termes* **sp.** and *Amitermes beaumonti* presented isolated pores inserted in cuticular depressions and pores grouped into plates. The pore plates were located mainly on the first and second tarsomeres in *Termes* **sp.** (Figs. 1, 2), containing each from 2 to 7 pores. All pores were inserted in cuticle depressions and usually in rounded shape. When only one pore was present its diameter ranged from 1.09 to 1.35 µm but when there were two or more pores their diameters ranged from 1.60 to 4.04 µm. The pore diameters of the different tarsomeres were almost constant (0.25 – 0.27 µm). In some specimens, isolated pores were occasionally found in the lateral regions of the first and second tarsal segments, a feature that seems to be exclusive of *Termes* **sp.**

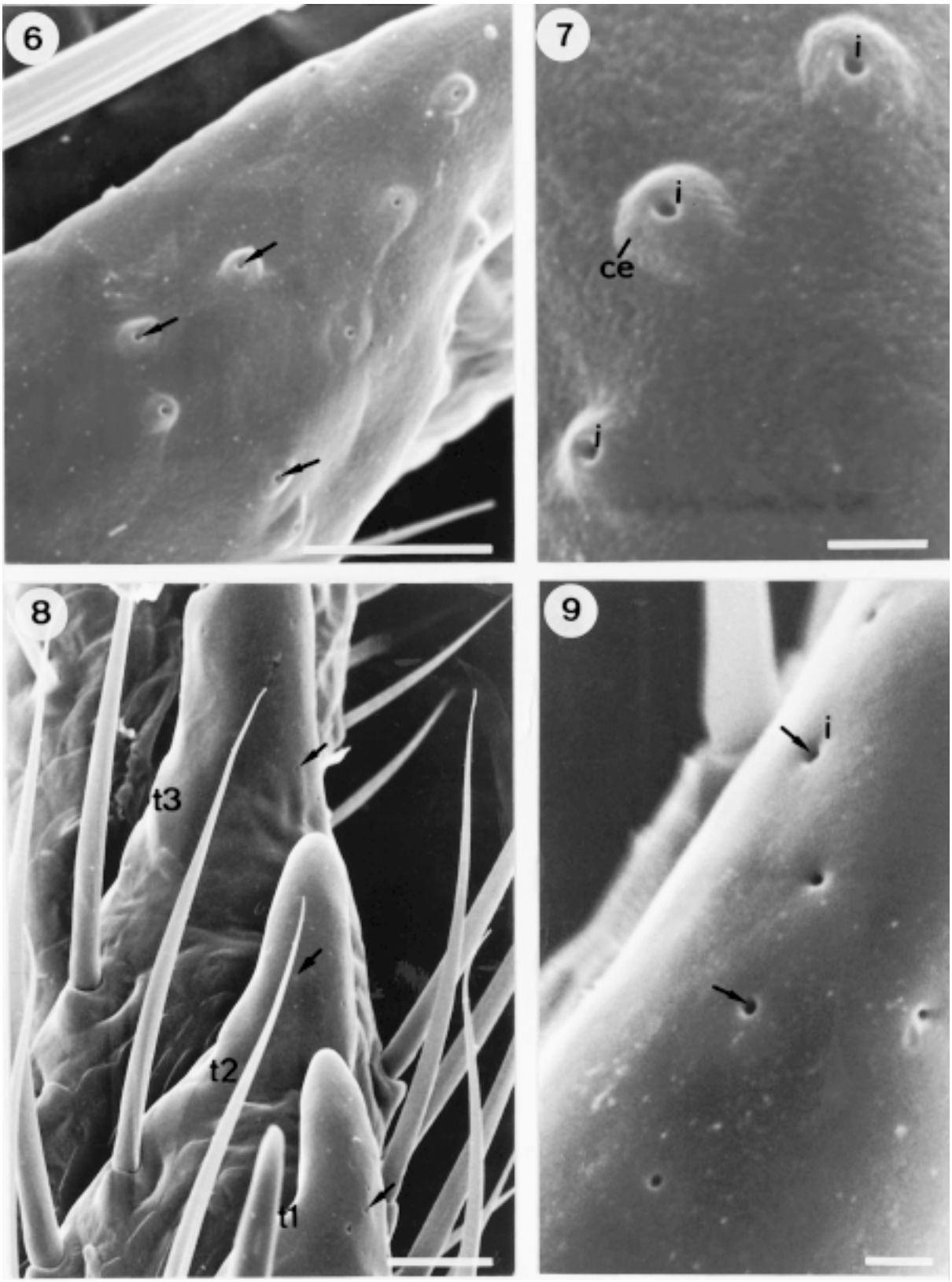


Figs. 4, 5. Scanning electron micrography of the leg's exocrine glands of *Spinitermes brevicornutus*. **4**, Ventral view of the first and second tarsomeres of a worker's left foreleg showing the glandular openings (arrows); scale: **5** µm. 5, Detail of the glandular openings (arrows) present on the first tarsal segment of a worker's left foreleg; note the cuticular rugosity of the surface; scale: 5 µm. cd = cuticular depression; i = isolated pores; t1 = first tarsomere; t2 = second tarsomere.

Table I. Morphological patterns of the glandular openings in the legs of worker Termitidae.

Family	Subfamily	Species	Part of leg				Pattern
			1st tars.	2nd tars.	3rd tars.	tibia	
Termitidae	Nasutitermitinae	*Armitermes euamignathus*	+	+	+	-	C
		Cornitermes cumulans	+	+	+	-	B
		Embiratermes festivellus	+	+	+	-	C
		Nasutitermes coxipoensis	+	+	+	-	D
		Rhynchotermes nasutissimus	+	+	+	-	C
		Syntermes nanus	+	+	+	-	B
		Amitermes beaumonti	+	+	+	-	A
		Hoplotermes amplus	+	+	+	-	C
		Microcerotermes **sp.**	+	+	+	-	C
		Neocapritermes opacus	+	+	+	-	B
		Orthognathotermes **sp**	+	+	+	-	D
		Spinitermes brevicornutus	+	+	+	-	C
		Termes **sp.**	+	+	+	-	A + C

+ presence of glandular opening; - absence of glandular opening; A pore plate; B isolated pore without cuticular specialization; C isolated pore inserted in a cuticular depression; D isolated pore on a cuticular elevation.



Figs. 6-9. 6, Ventral surface of the third tarsomere of *Nasutitermes* **sp.** worker (right midleg); the arrows indicate the glandular openings; scale: 5 µm. **7**, Detail of isolated pores (i) of the same tarsomere; note the cuticular elevation (ce); scale: 1 µm. **8**, Ventral surface of the first to third tarsomeres of *Cornitermes cumulans* worker (right midleg); the arrows indicate the glandular openings; scale: 10 µm. **9**, Detail of the glandular openings (arrows) on the third tarsomere of *Neocapritermes opacus* (left foreleg); scale: 5 µm. ce = cuticular elevation; i = isolated pores; t1 = first tarsomere; t2 = second tarsomere; t3 = third tarsomere.

Table II. Morphological data of the glandular openings of the legs of nine species of Termitidae.

Species	Number of pores			Pore diameter (μm)	Depression diameter (μm)
	1st tarsomere	2nd tarsomere	3rd tarsomere		
Armitermes euamignathus (n= 8)	11-12	11-12	13	0.15-0.16	0.88-1.02
Cornitermes cumulans (n= 7)	14-15	12-13	11	0.12	-
Nasutitermes coxipoensis (n= 8)	9-14	10-13	-	0.14-0.16	-
Syntermes nanus (n= 6)	-	12	-	0.18	-
Microcerotermes **sp.** (n= 7)	9-10	12	15-20	0.23	0.91
Neocapritermes opacus (n= 9)	10	10	9-14	0.18-0.25	-
Embiratermes festivellus (n= 9)	10-16	10-18	14-24	0.10-0.14	0.67-0.68
Orthognathotermes **sp.** (n= 5)	-	-	20-30	0.12	-
Spinitermes brevicornutus (n= 8)	22-32	20-23	17-18	0.15-0.16	0.87

n = number of specimens analysed.

The glandular openings on the tarsomeres of *Amitermes beaumonti* showed the same characteristics as those described for *Termes* **sp.** The pore plates also predominated on the first and second tarsomeres and contained up to four pores.

The other 11 species of Termitidae presented isolated pores spread throughout the ventral surface of the first three tarsal segments (Figs. 3-9).

Isolated pore inserted in a cuticular depression - Each pore was individually inserted in a round cuticular depression in *Spinitermes brevicornutus, Embiratermes festivellus, Microcerotermes* **sp.**, *Armitermes euamignathus, Rhynchotermes nasutissimus,* and *Hoplotermes amplus* (Figs. 3-5).

Isolated pore in a cuticular elevation – The individual pores were inserted in a cuticular elevation in *Nasutitermes coxipoensis* and *Orthognathotermes* **sp.** (Figs. 6, 7). *Orthognathotermes* **sp.** showed many pores in its tarsomeres, however, it was possible to analyze only the third tarsomere, which contained a maximum of 30 pores.

Isolated pore without cuticular specialization – The individual pore was not surrounded by a cuticular specialization in *Cornitermes cumulans*, *Neocapritermes opacus* and *Syntermes nanus* (Figs. 8,9).

Table II shows the data concerning the number of pores present in the different tarsomeres and their diameter range (0.67 to 1.02 μm). The pores varied in number and diameter according to the species. The number of pores was higher in *Spinitermes brevicornutus* and *Embiratermes festivellus*. In general, the pore diameter ranged from 0,10 to 0.23 μm.

No sensory structures were found associated with the glandular openings in the species studied. The cuticle that surrounded the pores was smooth, except in *Spinitermes brevicornutus* legs that presented a certain rugosity (Fig. 5). Glandular openings were not observed in the legs of *Anoplotermes* **sp.**, *Ruptitermes* **sp.** (Termitidae, Apicotermitinae) or *Glyptotermes planus* (Kalotermitidae).

DISCUSSION

The present results and the available literature data are summarized in Table III. The location of the exocrine glands seems to be constant in the tarsi of all Nasutitermitinae and Termitinae (Termitidae). An exception is *Longipeditermes longipes* (Nasutitermitinae), where such gland is not found (BACCHUS 1979). However, the lack of observation of cuticular pores on the tarsomeres of that species by that author may have been due to the dirt on material, as often observed in our specimens.

The taxonomic value of the 4 pore patterns (Table I) recognized in the present study is still not clear for Termitidae. Nevertheless, for Rhinotermitidae, FAUCHEUX (1994) and LEBRUN & FAUCHEUX (1994), separated species of *Reticulitermes* according to differences in the glandular openings of the legs.

We believe that there is no pattern in the number and location of the pores in the tarsomeres, but future analyses of a larger number of specimens will be more conclusive.

Glandular openings were not found in the specimens of Apicotermitinae studied here, in agreement with data obtained by BACCHUS (1979), who did not observe glands on the legs of *Jugositermes tuberculatus* (Apicotermitinae).

The leg exocrine glands are present only in some Kalotermitidae species. Glandular openings were not observed on the legs of *Glyptotermes planus* or *Cryptotermes brevis* (BACCHUS, 1979). FAUCHEUX (1994) observed the presence of cuticular pores on the first, second and third tarsomeres and tibia of all castes of *Kalotermes flavicollis*. We also found

Table III. Summary of the bibliographic data about the exocrine glands on the legs of termites.

Family / Subfamily	Genus/Species	Castes W	S	R	Localization of the glandular openings	Reference
Mastotermitidae	*Mastotermes darwiniensis*	a	-	-	-	Bacchus, 1979
Termopsidae	*Zootermopsis nevadensis*	a	-	-	-	Bacchus (1979)
Kalotermitidae	*Cryptotermes brevis*	a	-	-	-	Bacchus (1979)
	Glyptotermes planus	a	-	-	-	Soares & Costa-Leonardo, (2002)*
	Kalotermes flavicollis	p	p	p	t1, t2, t3, dt	Faucheux (1994)
Serritermitidae	*Serritermes serrifer*	p	p	p	t1, t2, t3	Costa-Leonardo (1994)
Rhinotermitidae						
Coptotermitinae	*Coptotermes havilandi*	p	-	-	t1, t2, dt	Soares & Costa-Leonardo (2002)*
						Soares & Costa-Leonardo (2002)*
	Coptotermes formosanus	p	-	-	t1, t2, dt	Bacchus (1979)
Heterotermitinae	*Heterotermes perfidus*	p	-	-	t1, t2, dt	Bacchus (1979)
	Heterotermes tenuis	p	p	p	t1, t2	Costa-Leonardo (1994)
		p	-	-	t1, t2, dt	Soares & Costa-Leonardo (2002)*
	Reticulitermes lucifugus	p	-	-	t1, t2, dt	Bacchus (1979)
		-	-	p		Lebrun & Faucheux (1994)
		p	p	p		Faucheux (1994)
	Reticulitermes santonensis	p	p	p	t1, t2, dt	Lebrun & Faucheux (1994)
		p	p	p	t1, t2, dt	Faucheux (1993)
	Termitogeton planus	p	-	-	t1, t2, dt	Bacchus (1979)
Termitogetoninae						
Rhinotermitinae	*Schedorhinotermes putorius*	p	-	-	t1, t2, dt	Bacchus (1979)
Termitidae						
Apicotermitinae	*Jugositermes tuberculatus*	a	-	-	-	Bacchus (1979)
	Ruptitermes sp.	a	-	-	-	Soares & Costa-Leonardo (2002)*
	Anoplotermes sp.	a	-	-	-	Soares & Costa-Leonardo (2002)*
Nasutitermitinae	*Armitermes euamignathus*	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Cornitermes cumulans	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Embiratermes festivellus	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Nasutitermes coxipoensis	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Longipeditermes longipes	a	-	-	-	Bacchus (1979)
	Rhynchotermes nasutissimus	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Syntermes nanus	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
Termitinae	*Amitermes beaumonti*	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Hoplotermes amplus	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Neocapritermes opacus	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Microcerotermes sp.	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Orthognathotermes sp.	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Spinitermes brevicornutus	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
	Termes sp.	p	-	-	t1, t2, t3	Soares & Costa-Leonardo (2002)*
Macrotermitinae	*Microtermes thoracalis*	a	-	-	-	Bacchus (1979)
	Macrotermes bellicosus	a	-	-	-	Bacchus (1979)

a absence of exocrine gland; p presence of exocrine gland; - caste not analised; * present paper; dt distal tibia; R reproductives; S soldier; t1 first tarsomere; t2 second tarsomere; t3 third tarsomere; W worker and/or pseudo-worker.

isolated pores on all tarsomeres of a Kalotermitidae alate, probably of the genus *Neotermes* (Soares & Costa-Leonardo, unpublished data).

According to Faucheux (1994) the presence of isolated glandular pores on the legs of *Kalotermes flavicollis* (Kalotermitidae) is an ancestral characteristic in relation to the pore plate observed in the species of *Reticulitermes* (Rhinotermitidae). In the present study, we found isolated pores on the tarsomeres of several Termitidae, a result showing a non-linear evolution of this characteristic. Because of this fact and due to the scarce phylogenetic studies available, further knowledge of these glands in Isoptera is needed to confirm the observations of Faucheux (1994).

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