Cytogenetic Studies of the Neotropical Ant Genus *Ectatomma* (Formicidae: Ectatomminae: Ectatommini)

by

Luísa Antônia Campos Barros[1]; Cléa S.F. Mariano[2]; Davileide de Sousa Borges[2]; Silvia G. Pompolo[1] & Jacques H.C. Delabie[2*]

ABSTRACT

The ant genus *Ectatomma* (Hymenoptera: Formicidae) is typically Neotropical and is the only genus of the subfamily Ectatomminae for which no cytogenetic data previously existed. Cytogenetic studies of five species of the *Ectatomma* genus are reported here. Colonies were collected at Viçosa (Minas Gerais, Brazil), Ilhéus and Manoel Vitorino (Bahia, Brazil). In this genus, the chromosome number ranged from 2n=36 to 46: *Ectatomma brunneum* Smith, 2n=44 (karyotype formula: 2K=22M + 22A); *Ectatomma muticum* Mayr, n=20 (K=16M + 4A); *Ectatomma permagnum* Forel, 2n=46 (2K=20M + 26A); *Ectatomma tuberculatum* Olivier, 2n=36 (2K=30M + 6A), while the observed metaphases of *Ectatomma edentatum* Roger, with 2n=46, did not allow a precise karyotype definition. The variations presented by the karyotypes of these ants can be attributed to the increase in the number of acrocentric chromosomes, probably because of rearrangements such as centric fission. This study is important for the understanding of evolutionary processes in the Ectatomminae subfamily.

Key-words: chromosome, karyotype, Minimum Interaction Theory

INTRODUCTION

Many animal studies have proven that cytogenetics is a useful tool for the biological understanding of a species, especially in evolutionary, taxonomic, phylogenetic and speciation mechanism studies, because chromosome alterations are normally significant for species evolution (White 1973; King

[1]Laboratório de Citogenética de Insetos. Departamento de Biologia Geral, Universidade Federal de Viçosa. 36570-000Viçosa-MG, Brazil. luufv@yahoo.com.br, spompolo@ufv.br

[2]U.P.A. Laboratório de Mirmecologia, Convênio CEPEC/UESC, Centro de Pesquisa do Cacau, CEPLAC, Cx. P. 7, 45600-000 Itabuna –BA, Brazil. camponotu@hotmail.com, davyborges@gmail.com, jacques.delabie@gmail.com

* To whom any correspondence should be sent.

1993; Ridley 1996). The parameters usually used in cytogenetic studies are the chromosome number, morphology and structure.

Cytogenetic studies carried out on more than 500 ant species have shown a chromosome variation from 2n=2 to 2n=120, in *Myrmecia croslandi* Taylor (Myrmeciinae) (Crosland & Crozier 1986) and *Dinoponera lucida* Emery (Ponerinae) (Mariano *et al.* 2005), respectively. Karyotype evolution studies have indicated the occurrence of two basic patterns in the ant karyotypes: there is increase and diversification in the chromosome number and morphology in primitive groups like in different poneromorph subfamilies (*sensu* Bolton 2003) and Myrmeciinae, while there is little variation and relative chromosome stability in genera of the more derived subfamilies (Pompolo & Mariano 2003; Mariano 2004).

Cytogenetic studies on the Ectatomminae subfamily were carried out on the genus *Gnamptogenys* in the Neotropics (*Gnamptogenys striatula* Mayr: 2n=34, *Gnamptogenys annulata* (Mayr): 2n=68, *Gnamptogenys* sp.: 2n=46; Borges *et al.* 2003) and Oriental Region (*Gnamptogenys* sp.1: 2n=42, *Gnamptogenys* sp.2: 2n=36, *Gnamptogenys binghamii* (Forel): n=22, *Gnamptogenys menadensis* (Mayr): 2n=42; Gõni *et al.* 1982; Imai *et al.* 1983), on a range of *Rhytidoponera* in the Australian Region (*Rhytidoponera aciculata* (F. Smith): 2n=52, *Rhytidoponera chalybaea* Emery: 2n=42, *Rhytidoponera impressa* (Mayr): 2n=42, *Rhytidoponera metallica* (F. Smith): 2n=22-46, *Rhytidoponera purpurea* (Emery): 2n= 38, *Rhytidoponera maniae* (Forel): 2n=44-48, *Rhytidoponera mayri* (Emery): 2n=50, *Rhytidoponera victoriae* (André): 2n=42; Imai *et al.* 1977) and in the Neotropical genus *Typhlomyrmex* (*Typhlomyrmex meire* Lacau, Villemant & Delabie: 2n=20 and *Typhlomyrmex rogenhoferi* Mayr: 2n=34, 36, 38; Mariano *et al.* 2005).

The *Ectatomma* genus is typically Neotropical, with 12 species (Bolton 2003), several with wide geographic distribution along the whole Neotropical Region (Kempf 1972). They are ants that nest in the soil in different environments, such as forests and open areas (Fernández 1991), and that forage on the floor or on vegetation (Fowler *et al.* 1991).

Until now, *Ectatomma* is the only genus of the Ectatomminae subfamily for which no cytogenetic data was available. The aim of the present study was then to characterize the karyotypes of five species of the *Ectatomma* genus, all sampled in populations from Brazil (States of Bahia and Minas Gerais).

MATERIALS AND METHODS

The *Ectatomma* spp. colonies were collected between August 2001 and November 2005 in Viçosa (Minas Gerais) in a fragment of secondary forest located in the Botanical Garden on the campus of the Federal University of Viçosa with an area of approximately 75 hectares (Paula *et al*. 2002). The colonies from Bahia were collected in the experimental areas of the Cocoa Research Center (CEPEC/CEPLAC) at Ilhéus (Atlantic rainforest bioma) and in the county of Manoel Vitorino (caatinga bioma).

The metaphases were obtained from cerebral ganglia of pharate pupae (pre-pupas) according to the protocol by Imai *et al*. (1988). At least seven individuals from each colony were analyzed, except for *E. permagnum* (Table 1). The metaphases were observed and photographed using an Olympus BX 60 microscope with a 100 X lens, linked to a photographic system.

The nomenclature used in this study to characterize the karyotypes was proposed by Imai (1991). The chromosomes were divided into two groups, the acrocentrics (A) and the metacentrics (M). Conventional staining with Giemsa produced a C banding pattern in ants enabling heterochromatin detection (Imai *et al.* 1988). Adult specimens from each colony were kept as vouchers in the Myrmecology Laboratory Collection at the Cocoa Research Center.

RESULTS AND DISCUSSION

The chromosome number ranged from 2n=36 to 46 in the genus (Table 1). The material obtained for *Ectatomma edentatum* did not allow precise karyotype definition. The other species each presented different karyotypes,

Table 1. Collected species, collection locality, sample size (number of colonies / individuals), diploid (2n) / haploid (n) chromosome number and diploid (2K) / haploid (K) karyotypic formula in *Ectatomma* spp.

Species	Locality	Long., Lat.	col./ind.	2n (n)	2K /(K)
E. brunneum	CEPLAC/CEPEC, Ilhéus, Bahia	14°15'S 39°13'W	3/34	44	2K=22M + 22A
E. edentatum	Jardim Botânico, UFV, Viçosa, Minas Gerais	20°45'S 42°50'W	1/7	46	Not defined
E. muticum	Manoel Vitorino, Bahia	14°21'S 40°11'W	1/13	(20)	K=16M + 4A
E. permagnum	CEPLAC/CEPEC, Ilhéus, Bahia	14°15'S 39°13'W	1/2	46	2K=20M + 26A
E. tuberculatum	CEPLAC/CEPEC, Ilhéus, Bahia	14°15'S 39°13'W	3/41	36	2K=30M + 6A

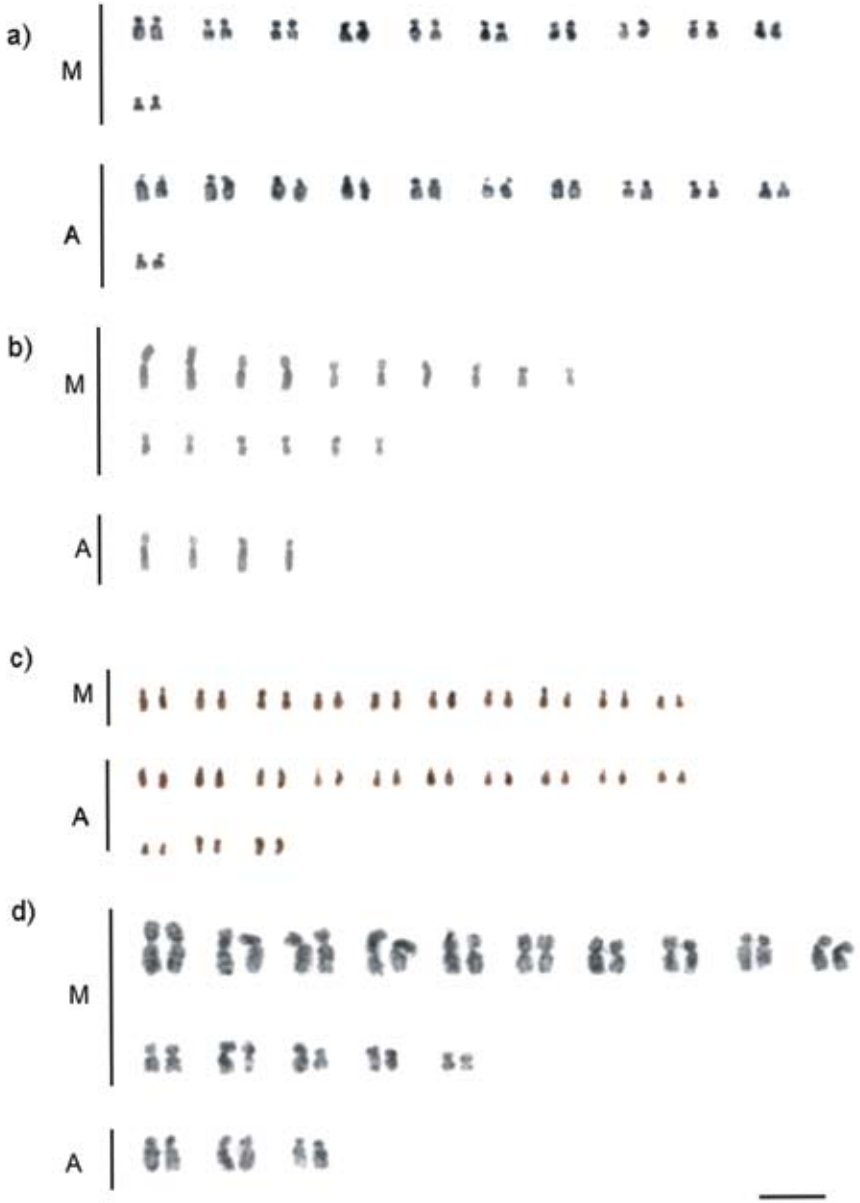

Figure 1: Diploid and haploid karyotypes of four *Ectatomma* species: a) *Ectatomma brunneum*, 2n=34; b) *Ectatomma muticum*, n=20; c) *Ectatomma permagnum*, 2n=46; d) *Ectatomma tuberculatum*, 2n=36. Horizontal bar = 5μm.

all with a high number of chromosomes (n>12, according to Imai *et al.* 1988). Unlike *E. permagnum*, the species *E. muticum* and *E. tuberculatum* showed a greater number of metacentric chromosomes (Table 1, Figure 1). Different populations of the same species were unfortunately not sampled and therefore we have no evidence of any chromosome variation between populations of a single taxon, although it is reasonably possible due to the wide distribution of most of the species studied here, as it occurs, for example, in *T. rogenhoferi* (Mariano *et al*. 2005).

The variations presented by the karyotypes of the species analyzed can be attributed to the increase in the number of acrocentrics, probably because of rearrangements such as centric fission, since as the number of chromosomes increases, the quantity of metacentric pairs tends to decrease. This is supported by the Minimum Interaction Theory (MIT) proposed for ant karyotype evolution (Imai *et al*. 1988, 1994). The increase of the chromosome number decreases the occurrence of deleterious mutations such as reciprocal translocations, because they are rarely observed in animal karyotypes (Imai *et al.* 1977). Obtaining these data is useful for evolutionary studies on the Ectatomminae subfamily and the Formicidae family as a whole, and our observations should be usefully complemented with chromosome banding techniques to identify possible chromosome rearrangements.

ACKNOWLEDGMENTS

This research was supported by CNPq, FAPESB and FAPEMIG agencies, and the PRONEX program. The authors express their acknowledgments to Dr. Riviane R Hora for useful comments on an earlier version of the manuscript and Sr. Manuel José Ferreira, for his help in ant collecting.

REFERENCES

Bolton, B. 2003. Synopsis and classification of Formicidae. The American Entomological Institute. Gainesville, FL. 370p.

Borges, D.S., C.S.F. Mariano, J.H.C. Delabie & S.G. Pompolo 2004. Cytogenetic studies in Neotropical ants of the genus *Gnamptogenys* Roger (Hymenoptera, Formicidae, Ectatomminae). Rev. Bras. Entomol. 48: 481-484

Crosland, M.W.J. & R.H. Crozier 1986. *Myrmecia pilosula,* an ant with only one pair of chromosomes. Science 231: 1278.

Fernández, F. 1991. Las hormigas cazadoras del gênero *Ectatomma* em Colombia. Caldasia 16 (79): 551-564.

Fowler, H.G., L.C. Forti, C.R.F. Brandão, J.H.C. Delabie & H.L. Vasconcelos 1991. Ecologia nutricional de formigas, In: A.R. Panizzi & J.R.P. Parra eds., Ecologia Nutricional de Insetos e suas Implicações no Manejo de Pragas, Editora Manole e CNPq, São Paulo (Brazil), 131-223.

Goñi, B., H.T. Imai, M. Kubota, M. Kondo, H. Yong & Y.P. Tho 1982. Chromosome observations on tropical ants in western Malaysia and Singapore. Ann. Rep. Ntl. Inst. Gen. Jpn. 32: 71-73.

Imai, H.T. 1991. Mutability of constitutive heterochromatin (C-bands) during eukaryotic evolution and their cytological meaning. Jpns. J. Gen. 66: 635-661.

Imai, H.T., R.H. Crozier & R.W. Taylor 1977. Karyotype evolution in Australian ants. Chromosoma 59: 341-393.

Imai, H.T., W.L.,Brown-J, M. Kubota, H. Yong & Y.P. Tho 1983. Chromosome observations on tropical ants from western Malaysia II. Ann. Rep. Ntl. Inst. Gen. Jpn. 34: 66-69.

Imai, H.T., M.W.J. Crosland, R.H. Crozier & R.W. Taylor 1988. Modes of spontaneous chromosomal mutation and karyotype evolution in ants with reference to the minimum interaction hypothesis. Jpns. J. Gen. 63: 159-185.

Imai, H.T., R.H. Crozier & R.W. Taylor 1994. Experimental bases for the minimum interaction theory. I- Chromosome evolution in ants of the *Myrmecia pilosula* species complex (Hymenoptera: Formicidae: Myrmeciinae). Jpns. J. Gen. 69: 137-182.

Kempf, W.W. 1972. Catálogo abreviado das formigas da região Neotropical (Hymenoptera: Formicidae). Studia Entomol. 15: 3-344.

King, M. 1993. Species evolution. The role of chromosome change. Cambridge University Press. Great Britain. 336 p.

Mariano, C.S.F. 2004. Evolução cariotípica em diferentes grupos de Formicidae. Tese D.S. Universidade Federal de Viçosa, MG, Brasil. 205 p.

Mariano, C.S.F., A.L. Lopes, S.G. Pompolo, H.J.A.C. Aguiar, D.S. Borges, S. Campiolo & J.H.C. Delabie 2005. Os cromossomos anãos da formiga-gigante. O significado evolutivo da variabilidade cariotípica nas populações de *Dinoponera lucida* Emery. XVII Simpósio de Mirmecologia – Biodiversidade e Bioindicação. Campus da UNIDERP, Campo Grande, MS (Brazil): 140-142.

Mariano, C.S.F., S. Lacau, S.G. Pompolo, E.C. Sposito, D.S. Borges, J.A. Dergam, C. Villemant & J.H.C. Delabie 2005. Cytogenetic studies in the rare Neotropical ant genus *Typhlomyrmex* Mayr (Ectatomminae: Typhlomyrmecini). Sociobiology 47 (1): 225-234.

Paula, A., A.F. Silva & A.L. Souza 2002. Changes in the floristic composition of wood species observed in a 14 year period in a Seasonal Semideciduous Forest in Viçosa-MG, Southeastern Brazil. Rev.Árvore 26 (6): 743-749.

Pompolo, S.G. & C.F.S. Mariano 2003. Considerações citogenéticas sobre a condição derivada da tribo Attini. Anais do XVI Simpósio de Mirmecologia, UFSC, Florianópolis – SC (Brazil), 536p.

Ridley, M. 1996. Evolution. 2nd. Ed. Blackwell Science. Cambridge, Massachussets USA. 719p.

White, M.J.D. 1973. Animal Cytology and Evolution. Cambridge University Press, 961p.

EDITOR'S CORRECTION

An error was made in the acknowledgment section of the following paper:

Augustin, J. de O. & J.F.L. Santos 2008. Behavior of early generations of *Atta sexdens* (Hymenoptera: Formicidae) workers during preparation of leaf substrate for symbiont fungus garden. Sociobiology 51(1): 265-281.

The section should have read as follows:

We thank CAPES and FAPEMIG for funding and Cristiano Augustin for technical support during the completion of this paper. We are also grateful to Ângelo G. Bicalho, Ariane P. P. Melo, Leandro E. Moraes, Mariana S. Brügger and Nádia B. do E. Santo, who helped in the field and laboratory.

The editor is extremely sorry for the mistake.