operation our field work would have been much less pleasant and effective.

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Appendix 1: Micronesian and Polynesian linyphiids, with known distributions (excluding new species described herein).

Bathyphantes paradoxus Berland – Samoa; *Cnephalocotes simpliciceps* Simon – Hawaii; *Coloncus* sp. – Midway I.; *Eperigone fradeorum* (Berland) – USA, Azores I., South Africa, New Zealand, Cook I.; *E. tridentata* (Emerton) – USA, Hawaii, New Zealand; *E.* sp. – Hawaii; *Erigone autumnalis* Emerton – USA, Hawaii; *E. dentosa* O. P.-Cambridge – USA, Mexico, Guatemala, Hawaii; *E. prominens* Bös. & Strand – Japan, Marshall I., Fiji, New Zealand, Cook I., Caroline I.; *E. stygia* Gertsch – Hawaii; *Ischnyphantes pacificanus* Berland – Marquesas I.; *Labulla graphica* Simon – Hawaii; *L. torosa* Simon – Hawaii; *Lepthyphantes lebronneci* Berland – Marquesas I.; *Linyphia tuasivia* Marples – Samoa, Cook I.; *Meioneta gagnei* Gertsch – Hawaii; *Meioneta* spp. – two species from Hawaii; *Microneta insulana* Simon – Hawaii; *Ostearius melanopygius* (O.P.-Cambridge) – St. Paul I., Austral I., Hawaii, New Zealand, Europe, USA; *Paro simoni* Berland – Rapa I.; *Priperia bicolor* Simon – Hawaii; *Prinerigone vagans* (Audouin) – Hawaii, Singapore, Africa, Madeira I., Azores I.; *Priscipalpus palmarius* (Marples) – Guam, Samoa, Fiji, Cook I.; *Tennesseellum formicum* (Emerton) – USA, Marshall I.; *Uahuka affinis* Berland – Marquesas I.; *U. spinifrons* Berland – Marquesas I.; *Uapou maculata* Berland – Marquesas I.

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Parthenogenesis in the scorpion *Tityus columbianus* (Thorell) (Scorpiones: Buthidae)

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Summary

Parthenogenesis is confirmed in the scorpion *Tityus columbianus* (Thorell) from Colombia in at least one of the three known populations in that country. The region of Mosquera where this population lives is a dry and arid zone dominated by Cactaceae. This stressed environment seems to agree with the rule of geographical parthenogenesis in animals (Cuellar, 1977), i.e., that parthenogenesis predominates throughout the world in disclimax situations.

Introduction

Parthenogenesis was first observed among scorpions in *Tityus serrulatus* Lutz & Mello from Brazil (Matthiesen, 1962). Later, the existence of other parthenogenetic scorpions was observed or suggested by studies of other *Tityus* species such as *T. uruguayensis* Borelli (Zolessi, 1985), *T. trivittatus* Kraepelin (Maury, 1970) and *T. inexpectatus* Moreno (Armas, 1980).

More recently Makioka & Koike (1984, 1985), have drawn attention to the existence of parthenogenetic populations in *Liocheles australasiae* (Fabricius) (Ischnuridae). In every case of parthenogenesis reported so far, the scorpions reproduced by thelytokous parthenogenesis.

The original description of *Tityus columbianus* (Thorell) was based on a single adult female. In my recent study of the *Tityus clathratus* group (Lourenço,

1984) no male specimens of *T. columbianus* were encountered, and until now no conclusive evidence has been presented that males exist in that species.

Material and methods

During a fieldwork trip to Colombia in February 1988, scorpions were collected at two sites in the Departments of Cundinamarca and Boyaca. At the first site, close to the village of Mosquera (Cundinamarca), one day was spent collecting in a very open area at an altitude of 2546m. In this arid area, the predominant vegetation consisted of Cactaceae and Bromeliaceae. Within 5 hours it was possible to obtain 423 specimens of *T. columbianus*. The number of specimens is quite impressive, since they were collected during daylight and without the help of ultraviolet light; scorpions are not usually so abundant. During the same period, only 3 specimens of *Chactas keyserlingi* Pocock (Chactidae) were found. All the scorpions were taken alive to the laboratory in the Muséum National d'Histoire Naturelle, Paris, and upon investigation only adult females and immature females were found to be present.

Since the end of February most of the 423 specimens collected at the first site have been kept alive in captivity. A large number of them, namely 250, were put together in a large terrarium divided into eight cells provided with communication doors. This was done in order to facilitate, in the laboratory, the strong gregarious tendency observed in the field, where up to 25 scorpions were found under the same stone.

At the second site, near Villa de Leiva (Boyaca), only 41 specimens were collected: 40 females and 1 male.

Results

During the first 6 months of laboratory study, 221 females from Mosquera produced broods, and these were reared in groups. The young scorpions in these 221 broods did not reach adulthood. However, after a careful examination of their external morphology it was concluded that they were all females.

Twenty-seven subadults collected in the field were raised separately, and after one or two moults they reached adulthood. In the following two or three months, 11 of these individuals produced broods, without fertilization.

The absence of males and production of broods in the laboratory by the virgin females from Mosquera seems to indicate that this population of *T. columbianus* reproduces by thelytokous parthenogenesis.

Ecological and paleobiogeographical considerations in relation to parthenogenesis

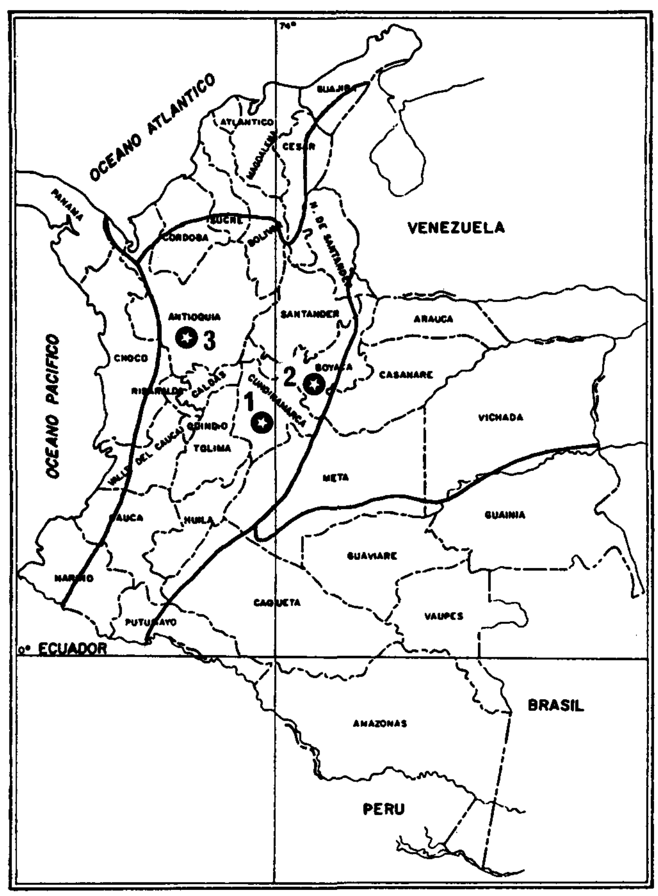
As proposed by Cuellar (1977), parthenogenesis (in both plants and animals) occurs predominantly in disclimax situations. According to Cuellar this is a well-known phenomenon that forms the basis for the rule of "geographical parthenogenesis" in animals.

Cuellar also mentioned two unique features that have been commented on by many workers: (1) The presence of parthenogenetic populations in newly created habitats, and (2) Their higher potential rate of increase compared with bisexual species. He also suggested that parthenogenesis is rare, not because it seldom arises by mutation, but because it can only evolve successfully in special habitats devoid of bisexual species.

How does parthenogenesis in scorpions compare with the model proposed by Cuellar? In *Tityus serrulatus,* a species well known because of its great medical importance (it is the most lethal scorpion in South America), the ecological situation seems to agree well with Cuellar's model. This species lives in the south-eastern part of Brazil, a region well known for the most important urban development in South America. Nearly all the original habitats (forest and savannah) have been destroyed, and the region is in a disclimax situation.

Tityus serrulatus shows enormous ecological plasticity and is capable of ecological readaptation. Being originally a savannah species that probably inhabited palm trees, it is today virtually restricted to human habitations. The populations of *T. serrulatus* are among the densest known; this scorpion can be found in hundreds and even thousands according to the season (Lourenço, 1988).

In contrast, the ecology of *Tityus uruguayensis* is poorly known. This species lives in the "Pampas" of



Map 1: The three known populations of *Tityus columbianus* in Colombia. **1** Mosquera; **2** Villa de Leiva; **3** Angelopolis.

Locality	Latitude/Longitude	Altitude	Ave. temp.
Mosquera	4°42'27"N-74°14'02"W	2546m	14°C
Villa de Leiva	5°38'10"N-73°31'36"W	2143m	17°C
Angelopolis	6°06'50"N-75°42'54"W	1917m	18°C

Table 1: General data on the localities where *T. columbianus* has been found.

Uruguay. These open fields seem to be a natural formation, despite the fact that extensive cattle ranching has been carried out in the area since the beginning of the colonization of Uruguay. This has undoubtedly caused tremendous stress on the environment.

No data are available on the ecology of *Liocheles australasiae,* so comparison with Cuellar's model cannot be made.

Only three apparently endemic populations of *Tityus columbianus* are known in Colombia. The basic data for each of the regions in which the populations occur are summarized in Table 1 (see also Map 1).

According to the vegetation map of Colombia (IGAC, 1985), each of the localities with a population of *T. columbianus* is characterized by arid and dry zone vegetation ("vegetacion de zonas aridas o secas"). These are extreme environments, dominated by Cactaceae and Bromeliaceae in rocky soil covered by grassy vegetation. The climate is dry and cold during the night, and in the Mosquera area, scorpions were found in a lethargic state in the early morning.

Palynological studies on the areas of Bogota and especially of Fuquene by Van der Hammen (1974), show important changes in the vegetation and climate during the Pleistocene and the Holocene, following glacial and interglacial phases. During geological time dry and arid formations arose during the maxima of glacial phases. These formations may, however, also be the consequence of human activity in recent times. For example, the region of Angelopolis seems to have suffered from destruction of the original vegetation since Fuhrmann's expedition worked in the area at the beginning of the 20th century. This expedition collected several different species of scorpions: *Tityus fuhrmanni* Kraepelin, *Chactas reticulatus* Kraepelin, *Chactas scabrimanus* Kraepelin, and the first *Tityus columbianus* from this area which was incorrectly described as a new species: *Tityus parvulus* Kraepelin.

The areas of Mosquera and Villa de Leiva have probably suffered less from human activities. According to Van der Hammen (1965), "along the western and southern edge of the Sabana de Bogota a heavily eroded sequence of quaternary sediments is exposed". This Mondonedo formation is subdivided into Upper, Middle and Lower Mondonedo formations. The Upper Mondonedo formation consists of an Upper recent soil. Charcoal from two sites in the soil-complex was C_{14}-dated as 10,760 ± 160 and 10,840 ± 110 years. This rocky and eroded soil is favourable to Cactaceae. These arid and dry formations were present before historical times. However, it is possible that human deforestation of the dry forests of the Bogota region, and consequent modification of the soil, may have favoured the enlargement of some relict dry and arid formations.

Consequently, these dry and arid formations represent a stressed environment, and can be defined as a disclimax situation. The parthenogenetic population of *T. columbianus* found in Mosquera would therefore follow the rule of geographical parthenogenesis in animals as defined by Cuellar (1977).

The sex ratio of the Villa de Leiva population is greatly skewed in favour of females (1 : 40). However, no data are available at present to explain this. The population could be moving toward parthenogenesis or it might be a population in which bisexuals are recolonizing the area. Further studies will be necessary to elucidate the precise nature of this population of *T. columbianus*.

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