Richness and composition of gall-inducing arthropods at Coiba National Park, Panama

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Abstract: Interest in studying galls and their arthropods inducers has been growing rapidly in the last two decades. However, the Neotropical region is probably the least studied region for gall-inducing arthropods. A study of the richness and composition of gall-inducing arthropods was carried out at Coiba National Park in the Republic of Panama. Field data come from samples obtained between August 1997 and September 1999, with three (two-week long) more intensive samplings. Seventeen sites, representing the main land habitats of Coiba National Park were surveyed. 4942 galls of 50 insect and 9 mite species inducing galls on 50 vascular plants from 30 botanical families were collected. 62.7% of the galls were induced by gall midges (Diptera, Cecidomyiidae), 15.3% by mites, Eriophyidae, 8.5% by Homoptera, Psyllidae, 6.8% by Coccidae and 5.1% by Phlaeothripidae (Tysanoptera). The host plant families with the most galls were Myrtaceae with seven, Bignoniaceae with five and Euphorbiaceae, Fabaceae and Melastomataceae with four. Leaf galls accounted for about 93% of collected galls. Most leaf galls were pit/blister galls followed by covering and pouch galls. Gall richness per collecting site was between 1 and 19 species. Coiba’s gall diversity is discussed in relation to data available from other tropical sites from continental Panama and the Neotropical region. Our results support the idea that it may be premature to conclude that species richness of gall inducers declines near the equator. Rev. Biol. Trop. 56 (3): 1269-1286. Epub 2008 September 30.

Key words: Coiba, gall-inducing insects, gall richness, host plant, insect/plant interaction, Panama.

Many groups of insects and mites, estimated in a range from 21 000 to 211 000 species, with an average of 132 930 species (Espírito-Santo and Fernandes 2007), are capable of inducing galls on plants, which are structures that involve active differentiation and growth of plant tissues providing shelter, nutrition and protection for the gall-inducing organism (Meyer 1987, Nieves-Aldrey 1998, Stone and Schönrogge 2003).

Galls and gall-inducing arthropods have been the object of research for the last three centuries by dozens of naturalists and scientists worldwide (Mani 1992, see Raman et al. 2005 for a recent synthesis). Earlier information was compiled in a classic work by Houard (1908-1913, 1922, 1933, 1940). The most important groups of gall-inducing insects are Diptera (Cecidomyiidae), Homoptera (Cicadoidea, Psylloidea, Aphidoidea and Coccoidea), Thysanoptera and the hymenopteran families Tenthredinidae and Cynipidae. Mites inducing galls belong mostly to the family Eriophyidae. These galling-insect groups have different distribution patterns, and their distribution may be correlated with the breaking up and movement of continents (Gagné 1984). Geographic and climatic factors could also have determined the
distribution patterns of gall-inducing arthropods (Schlinger 1974). The most important family of
gall insects is Cecidomyiidae (Diptera), pre-
dominant in almost all zoogeographic regions,
both tropical and temperate. Cynipidae and
Tenthredinidae are mainly holarctic, gall-induc-
ating thrips (Thysanoptera) are restricted mostly
to Western Asia and gall-inducing psyllids and
coccids are predominant in tropical regions
(Felt 1940, Gagné 1984).

Interest in studying galls and their arthro-
pod inducers has been growing rapidly in the
last two decades (Raman et al. 2005). However,
the Neotropical region continuous to be a
poorly studied region for gall-inducing arthro-
pods in general (Espírito-Santo and Fernandes
2007). The most important references are the
classic work by Houard (1933), the book by
Gagné (1994) on gall midges (Cecidomyiidae)
and local studies in Brazil (Maia 2001, 2005,
Gonçalves-Alvin and Fernandes 2001, Maia
and Fernandes 2004, Costa De Oliveira and
Maia 2005, Urso-Guiamares and Scareli-Santos
2006); Costa Rica (Hanson and Goméz-Laurito
2005); Mexico (Cuevas-Reyes et al. 2004a,
2004b) and Panama (Medianero et al 2001).
Future research in the Neotropical region will
likely change the biogeographical patterns
assumed until now for gall inducing insects
(Espírito-Santo and Fernandes 2007).

The aim of this study is to estimate the
richness and composition of gall inducing
arthropod species in an unexplored insular
tropical habitat off the Pacific coast of Panama,
and compare them with data available from
continental Panama.

MATERIALS AND METHODS

Study area: The research was performed
at Coiba National Park (World Heritage Site),
as a part of the Joint Hispanic-Panamanian
Program for National Parks. Coiba National
Park is located in the Panamanian Pacific
Ocean (7°39’-7°18’ N & 81°53’-81°35’W),
22 Km from the mainland, and encompasses
an area of 270 125 ha, of which 53 528 ha are
insular and 216 543 are marine. The insular
area is composed of Coiba (50 314 ha), the
largest island in tropical Pacific America, eight
other minor islands and 30 islets. The maxi-
mum altitude in the Park is 420 m on Coiba
Island. Annual rainfall is 3 483 mm. The yearly
average humidity is 80% and the mean tem-
perature is 25 °C. The area is characterized by
an intense dry season, from December to April
and a rainy season from May to November. The
natural vegetation is well conserved, with about
80% forest coverage. An untouched tropical
moist and wet forest occupies 60% of the park
(Castroviejo 1997). The island of Coiba became
separate from the mainland about 12 000 to 18
000 years ago and houses many endemic species
of animals and plants. The rough forested terrain
has served to make the island inhospitable and
preserved, but even more so the presence of a
prison, consisting of some twenty camps scat-
tered along the coastline, that was in operation
from 1918 to 2004 (Castroviejo 1997, Fontal
and Nieves-Aldrey 2004).

Field and laboratory work: Field data
were obtained from several samples between
August 1997 and September 1999 with three
more intensive samples (two-week long) in
sampling method consisted of transects during
not less than one hour (see Price et al. 1998).
Along the selected collecting sites all plants
were searched for galls. Seventeen sites rep-
resenting the main terrestrial habitats in Coiba
National Park were surveyed (Table 1, Fig. 1).
Plants with galls were collected and photo-
graphed. Specimens of galled plants were dried
and put into a herbarium collection, where
plants were identified later. Samples of the
galls were also stored in 70% ethanol to allow
further dissection and identification. Data of
altitude and geographic position was taken in
the field (Table 1).

The galls were dissected in the laboratory
for adult and larval identification to family
level. Gall-inducing species were separated
by the external morphology of the galls, the
larvae and the host plant. It is assumed in a
study like this that gall morphotype is unique
for each gall-inducing species (Mani 1964, Ananthakrishnan 1984). Yet a very conservative methodology was employed (see Hanson and Goméz-Laurito 2005); galls found in petioles, in leaf blades, as well as in the nerve of a given leaf, and those without differentiation in plant species of the same genus were considered as of the same gall-inducing species.

**Data analysis:** Gall-inducing arthropod species richness (S) was calculated based on the number of different galls found and the alpha diversity index (α) was estimated (Fisher 1943):

\[ S = \alpha \log e (I + N/\alpha). \]

S is the number of species in a sample, N is the number of individuals in a sample and α is the diversity index. This index is not influenced by the two limitations of other known indexes because it is independent of sample size and it does not give more weight to species abundance (Wolda 1983).

To verify sampling efficiency we constructed species accumulation curves with the estimator Chao 1, Bootstrap and Jacknife 1 (100 random). The species accumulation curve is based on individual-based assessment protocol (see Gotelli and Colwell 2001). We used the software EstimatesS® 8 (Colwell 2006).

**RESULTS**

**Taxonomic and faunistic considerations:** A total 4,942 galls of 59 species, 50 insects and 9 mites, associated with 50 species of plants from 37 genera and 30 families were collected at Coiba National Park. It was not possible to identify the genus of nine host plant species.

### TABLE 1

<table>
<thead>
<tr>
<th>Nº</th>
<th>Sampling sites</th>
<th>UTM</th>
<th>ALT (m)</th>
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<tr>
<td>1</td>
<td>Campamento Las Salinas</td>
<td>17NMU1922</td>
<td>0-50</td>
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<td>2</td>
<td>Campamento Playa Blanca</td>
<td>17NMU2615</td>
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</tr>
<tr>
<td>3</td>
<td>Campamento Playa Blanca-Campamento Barco Quebrado</td>
<td>17NMU2615</td>
<td>0</td>
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<tr>
<td>4</td>
<td>Campamento Playa Hermosa and Rio Playa Hermosa</td>
<td>17NMNO532</td>
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<tr>
<td>5</td>
<td>Cerro de la Equis</td>
<td>17NMU1841</td>
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<td>6</td>
<td>Cerro de la Torre</td>
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<td>Estación Biológica</td>
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<td>Estación Biológica – Río Santa Cruz</td>
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<td>Isla Jicarón</td>
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<td>10</td>
<td>Isla Ranchería</td>
<td>17NMU2244</td>
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</tr>
<tr>
<td>11</td>
<td>Playa Hermosa-Santa Clara (La Falla)</td>
<td>17NMU0328</td>
<td>100</td>
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<tr>
<td>12</td>
<td>Playa Rosario</td>
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<td>13</td>
<td>Punta Esquina</td>
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<td>17</td>
<td>Sendero Yuma</td>
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</table>

Numbers represented on map of Figure 1.
mostly Myrtaceae. 62.7% of the galls were induced by species of the family Cecidomyiidae, 15.3% by Eriophyidae, 8.5% by Psyllidae, 6.8% by Coccidae, 5.1% by Phlaeothripidae; one species corresponding to 1.7% could not be determined. 93.1% of the galls were found on leaves, 3.4% on stems and 5.2% on buds (Table 2). The plant families hosting the most gall-inducing species were Myrtaceae with seven, Bignoniaceae with five and Euphorbiaceae, Fabaceae and Melastomataceae with four (Table 3). The plant species with the greatest diversity of galls was Calophyllum longifolium (Clusiaceae) with three, seven species were found with two galls (Amphitecna latifolia, Mansoa sp., Acalypha diversifolia, Casearia commersoniana, Lacistema aggregatum, Cassipourea elliptica and Pouteria foveolata) whilst only one
### TABLE 2

*Number of gall-inducing species per insect family and their affected host plant organ*

<table>
<thead>
<tr>
<th>Gall inducing family</th>
<th>Leaf gall</th>
<th>Stem gall</th>
<th>Bud gall</th>
<th>Total</th>
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<td>Cecidomyiidae</td>
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<td>37</td>
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<td>2</td>
<td>9</td>
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<tr>
<td>Psyllidae</td>
<td>5</td>
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<tr>
<td>Coccidae</td>
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<td>4</td>
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<td>Phlaeothripidae</td>
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### TABLE 3

*Plant family and gall inducing arthropods numbers*

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<tr>
<th>Plant family</th>
<th>No. of species with galls</th>
<th>Total No. of galls</th>
<th>Mites</th>
<th>Midges</th>
<th>Psyllids</th>
<th>Coccids</th>
<th>Thrips</th>
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</table>
A gall-inducing species was found infesting two species of *Ficus*. Alpha diversity was 9.4 but, species accumulation curves did not become asymptotic suggesting than there are more gall-inducing species at Coiba National Park than those collected in this study. Gall-inducing species number increases with individual sample (Fig. 2). Gall richness per collecting site was between 1 and 19 species. 71% of all species were found at only one site, 22% in two, 5% in three, 2% in four, while no species was present in more than four sites. The gall inducing arthropod community studied shows a high complementarity among collecting sites.

![Graph showing species accumulation curves](image)

**Fig. 2.** Species accumulation curves with estimator Chao 1, Bootstrap and Jackknife 1 (100 random).

**List of gall-inducing taxa and host plant species at Coiba National Park (G = Gall).**

**ANNONACEAE**

Gen. Ind.

**G59.** (Fig. 4H). Family gall-inducer: Cecidomyiidae. Leaf gall, ovoid with hairs on upper side.

**BIGNONIACEAE**

*Amphitecna latifolia* (Mill.) A.H. Gentry

**G1** (Fig. 3A). Family gall-inducer: Cecidomyiidae

Leaf gall, spindle shaped, on mid or secondary veins, distinct on both sides of leaf.


**G2.** Family gall-inducer: Coccidae

Leaf gall; blister more distinct on low surface.


*Cydis aequinoctialis* (L) Miers.

**G3** (Fig. 3B). Family gall-inducer: Cecidomyiidae
Leaf gall; spindle shaped, on petiole, mid and secondary veins.
I. Jicarón. 3-X-97. A. Ibáñez leg
I. Ranchería. 7-IX-97. A. Ibáñez leg

Beach estación Biológica. 30-VIII-97. J. L. Nieves leg

Mansoa sp.

**G4.** Family gall-inducer: Cecidomyiidae
Leaf gall, a blister distinct on both sides of leaf.
Sendero Yuma. IX-97. A. Ibáñez leg.

**G4a.** Family Gall Inducer: Cecidomyiidae
Leaf gall, a spindle shaped swelling on mid vein.
Sendero Yuma. IX-97. A. Ibáñez leg.

**BOMBACACEAE**

*Quararibea asterolepis* Pittier

**G5.** Family gall-inducer: Cecidomyiidae
Leaf gall, a small blister distinct on both sides of leaf.
I. Jicarón. 3-X-97. A. Ibáñez leg.

**BURSERACEAE**

*Tetragastris panamensis* (Engl.) Kuntze

**G6.** Family gall-inducer: Psyllidae
Leaf gall, small circular blister more distinct on upper side; on lower side appear as a pit or depression.
Cerro Equis XI-97. A. Ibáñez leg.

*Protium confusum* (Rose) Pittier

**G7.** (Fig. 3C). Family gall-inducer: Psyllidae
Leaf gall, circular, small, distinct on upper side; a pit on low part.
I. Rancheria. 7-IX-97. A. Ibáñez leg
Cerro de la Torre. 12-VI-98. A. Ibáñez leg.

**CELASTRACEAE**

*Maytenus schippii* Lundell

**G9.** Family gall-inducer: Cecidomyiidae
Leaf gall, a median size blister of leaf blade distinct on both sides of leaf.
Río Santa Clara. 29-XI-97. A. Ibáñez leg.

**CHRYSOBALANACEAE**

*Licania hypoleuca* Benth.

**G10.** Family gall-inducer: Cecidomyiidae
Leaf gall, subspherical, small.

*Licania platypus* (Hemsl.) Fritsch

**G11.** Family gall-inducer: Cecidomyiidae
Leaf gall, on blades subspherical, small and abundant.
I. Canal De Afuera. 6-XI-97. A. Ibáñez leg.
Fig. 3. Pictures of galls from Coiba: (A) gall midge on *Amphitecna latifolia*, (B) gall midge on *Cydist aequinoctialis*, (C) psyllid on *Protium confusum*, (D) gall midge on *Manihot esculenta*, (E) gall midge on *Calophyllum longifolium*, (F - G ) gall midge on *Lacistema aggregatum*, (H) psyllid on *Cinnamomum triplinerve*, (I) gall midge on *Lonchocarpus sp.*., (J) gall midge on *Pouteria foveolata*, (K) mite gall on *Miconia lacer*, (L), mite on *Miconia nervosa*, (M) gall midge on *Casearia commersoniana*, (N) psyllid on *Sorocea sp.*, (O) coccoid gall on *Myrtaceae*, (P) thrip gall on *Myrtaceae*, (Q) coccoid gall on *Pelliciera rhizophorae*, (R) gall midge on *Psychotria horizontalis*. 
CLUSIACEAE

Calophyllum longifolium Willd.

G20 (Fig. 3E). Family gall-inducer: Cecidomyiidae
Leaf gall, on blades, bean shaped, big more obvious on underside.
Cerro De La Equis. 21-III-98. A. Ibáñez leg.

G21. Family gall-inducer: Eriophyidae
Gall leaf, on blades, tiny pocks in eyelet shape, on both sides of midrib.
Cerro De La Torre. 18-VII-98. J. L. Nieves leg.

G22. Family gall-inducer: Cecidomyiidae
Gall leaf, small pustule on blades.

COMBRETACEAE

Terminalia amazonia (J.F. Gmel.) Exell

G12. Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid irregular distinct on both sides of leaf.
Cerro de la Torre. 22-VII-98. J. L. Nieves leg.

COMPOSITAE (ASTERACEAE)

Gen. sp. Indet.

G13. Family gall-inducer: Phlaeotripidae
Gall a folded at tip of the leaf blades.

EUPHORBIACEAE

Acalypha diversifolia Jacq.

G14. Family gall-inducer: Eriophyidae
Bud gall, large, subspherical.
Rio Negro. 9-XII-97. A. Ibáñez leg
I. Jicarón. 9-XII-97. A. Ibáñez leg.

G15. Family gall-inducer: Eriophyidae
Leaf gall, a small pouch more obvious on upper side.
Rio Negro. XII-97. A. Ibáñez leg
Cerca De Sta. Cruz. XII-97. A. Ibáñez leg.

Croton schiedeanus Schltdl.

G16. (Fig. 4A).Family gall-inducer: Cecidomyiidae
Leaf gall, small blister on blades, more obvious in underside.
Manila, cerca de la parcela. 19-VI-98. A. Ibáñez leg.

Manihot esculenta Crantz

G17 (Fig. 3D). Family gall-inducer: Cecidomyiidae
Leaf gall, spindle shaped on blades, colour red, more obvious on upper side.

FABACEAE

Inga multijuga Benth.

G25. Family gall-inducer: Cecidomyiidae
Leaf gall, tiny pustule, more obvious on upper side.
Cerro De La Equis. 12-VI-98. A. Ibáñez leg.
Inga sp.

G26. Family gall-inducer: Cecidomyiidae
Leaf gall, small blister.

Lonchocarpus sp.

G27 (Fig. 3I). Family gall-inducer: Psyllidae
Leaf gall, ovoid, on both sides of blades, medial size.

Prioria copaifera Griseb.

G28. (Fig. 4G). Family gall-inducer: Cecidomyiidae
Leaf gall, spherical small, abundant, scar on underside.

FLACOURTIACEAE

Casearia commersoniana Cambess.

G18. (Fig. 3M). Family gall-inducer: Cecidomyiidae
Gall on stems, swelling irregular, mainly on one side.
Rio Negro. 9-XII-97. A. Ibáñez leg.

G19. Family gall-inducer: Cecidomyiidae
Gall on leaf, small pouch on mid vein, more obvious on upper side.
Rio Negro. 9-XII-97. A. Ibáñez leg.

LACISTEMATACEAE

Lacistema aggregatum (Bergius) Rusby

G23 (Fig. 3F). Family gall-inducer: Cecidomyiidae
Leaf gall, spherical in groups, hairy, medial size.
Cerro De La Equis. 25-VIII-97. J. L. Nieves leg

G23a (Fig. 3G)
Family gall-inducer: Cecidomyiidae
Leaf gall, pit gall, cilíndrical distint on low blade of leaf.

LAURACEAE

Cinnamomum triplinerve (Ruiz & Pav.) Kosterm

G24 (Fig. 3H). Family gall-inducer: Psyllidae
Leaf gall, globular on secondary veins, more obvious in upper side.
Cerro De La Torre. 18-VIII-98. J. L. Nieves leg
I. Ranchería. 19-VII-98. J. L. Nieves leg
Cima del Cerro de la Torre. 7-III-98. J. L Nieves leg.

MELASTOMATACEAE

Clidemia discolor (Triana) Cogn.

G29. Family gall-inducer: Eriophyidae
Bud gall, flowers.

Miconia lacera (Bonpl.) Naudin

G31. (Figs. 4K, 5E) Family gall-inducer: Eriophyidae
Gall on buds and stems, subspherical.
Cerro De La Torre. 7-III-98. A. Ibáñez leg.
Miconia minutiflora (Bonpl.) DC.
  **G32.** Family gall-inducer: Eriophyidae
Dense erineum on underside of leaf, hairs red.
Estación Biológica. Otoño 98. A. Ibáñez leg

*Miconia nervosa* (Sm.) Triana
  **G30.** (Fig. 3L) Family gall-inducer: Eriophyidae
Leaf gall, more obvious on underside, blades hair.
Rio Negro. 9-XII-97. A. Ibáñez leg.
Cerro De La Equis. 18-VII-98. J. L. Nieves leg.

**MORACEAE**

*Ficus popenoei* Standl.
  **G33.** Family gall-inducer: Cecidomyiidae
Leaf gall, pouch on blades, small.
Cerro De La Equis. 21-III-98. A. Ibáñez leg.

*Sorocea* sp.
  **G35.** Family gall-inducer: Psyllidae (Fig. 3N)
Leaf gall, spindle shaped, on blades abundant more obvious on upper side.
I. Rancheria. 7-IX-97. A. Ibáñez leg.

**MYRISTICACEAE**

*Virola* sp.
  **G36.** Family gall-inducer: Cecidomyiidae
Leaf gall, spindle shaped, in blades, tiny.
Cerro De La Equis. 12VI-98. A. Ibáñez leg.

MYRSINACEAE
Ardisia sp.
G37. Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid in blades medial size.

MYRTACEAE
Gen. Ind.
G38. Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid, small.
Gen. Ind.
G39 (Fig. 3P). Family gall-inducer: Phlaeotripidae
Bud gall on flower irregular spherical.
Manila. 23-VII-98. J. L. Nieves leg
I. Jicarón. 3-X-97. A. Ibáñez leg.

Gen. Ind. 1, Sp.3
G40 (Fig. 3O). Family gall-inducer: Coccidae
Leaf gall, blister shaped, with opening below.
Río Escondido. Otoño 97. A. Ibáñez leg.

Gen. Ind. 2, Sp. 1
G41. Family gall-inducer: Cecidomyiidae
Leaf gall subspherical irregular on blades.
La Falla. Otoño 97. A. Ibáñez leg.

Gen. Ind. 3, Sp. 4
G42. Family gall-inducer: Eriophyidae
Gall leaf, blister shaped, small more obvious on upper side.

Sp. 5
G43. Family gall-inducer: Cecidomyiidae
Leaf gall, on blades, ovoid small.
Cima del Cerro De La Torre. 7-III-98. A. Ibáñez leg.

Gen. Ind. Sp. 6
G44. Family gall-inducer: Phlaeotripidae
Leaf gall, blades margin folded thick.

NYCTAGINACEAE
Neea sp.
G45. Family gall-inducer: Cecidomyiidae
Leaf gall, blister in blades, distinct in both sides of leaf.
I. Ranchería. 19-VII-98. J. L. Nieves leg
Rio Negro. 9-XII-97. A. Ibáñez leg.

OCHNACEAE
Ouratea lucens (Kunth) Engl.
G46. Family gall-inducer: Indeterminate
Leaf gall, blister in blades.
Cerro De La Equis. VIII-97. J. L. Nieves leg
Subida a la Falla. 21-IX-99. A. Ibáñez leg.

PELLECIERACEAE

Pelliciera rhizophorae Triana & Planch.
G47 (Fig. 3Q). Family gall-inducer: Coccidae
Leaf gall, blister small, abundant.

RHAMNACEAE

Gouania lupuloides (L.) Urb.
G48. Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid on blades with hairs.

RHIZOPHORACEAE

Cassipourea elliptica (Sw.) Poir.
G49. Family gall-inducer: Cecidomyiidae
Leaf gall, spindle shaped, on mid vein, distinct on both sides of blade.
Sendero Yuma. 25-VIII-97. J. L. Nieves leg
G50. Family Gall Inducer: Coccidae
Leaf gall, ovoid small on blade more obvious on upper side.

RUBIACEAE

Faramea occidentalis (L.) A. Rich.
G51 (Fig. 4I). Family gall-inducer: Cecidomyiidae
Leaf gall, blister shaped on mid vein more obvious on underside.
Manila. 23-VII-98. J. L. Nieves leg
I. Ranchería. 7-IX-97. A. Ibáñez leg.

Psychotria horizontalis Sw.
G52 (Fig. 3R). Family gall-inducer: Cecidomyiidae
Leaf gall, blister irregular on mid vein and petioles.
Cerro De La Equis. VIII-97. J. L. Nieves leg
Catival. 18-X-97. A. Ibáñez leg.
Cerro De La Torre. 7-III-98. A. Ibáñez leg.

SAPINDACEAE

Serjania mexicana (L.) Willd.
G53 (Fig. 4 B, F). Family gall-inducer: Cecidomyiidae
Leaf gall on blades, petioles but, mainly on mid and secondary veins.

SAPOTACEAE

Pouteria cf. foveolata T.D. Penn.
G54 (Fig. 4C). Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid small, aligned on blades margin.
Manglar De Sta. Cruz. XI-97. A. Ibáñez leg
Cerro De La Equis. XI-97. A. Ibáñez leg
Cerro De La Torre. 22-VII-98. J. L. Nieves leg
G55 (Fig. 3J). Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid small on leaf blade.
Cerro De La Torre. 22-VII-98. J. L. Nieves leg

**STERCULIACEAE**
*Theobroma angustifolium* Moç. & Sessé ex DC.
**G56**. Family gall-inducer: Cecidomyiidae
Leaf gall, small spindle in leaf blade.
I. Jicarón. 3-X-97. A. Ibáñez leg.

**VERBENACEAE**
*Lantana camara* L.
**G57** (Fig.5D). Family gall-inducer: Eriophyidae
Leaf gall; a small pouch on leaf blades.

**VITACEAE**
*Cissus microcarpa* Vahl
**G58**. Family gall-inducer: Cecidomyiidae
Leaf gall, ovoid abundant, distinct in both sides of blades, medial size.

**DISCUSSION**
Gall-inducing arthropods have been more thoroughly sampled in temperate regions than in tropical regions. Indeed, from the perspective of biodiversity inventories, we have barely scratched the surface of the tropical faunas (Hanson and Goméz-Laurito 2005). A global pattern in local number of gall-inducing insects was described recently (see Price et al. 1998). The study pointed to a greater richness of gall-inducing insects in warm dry regions, while temperate and tropical areas with humid, mesic vegetation showed lower gall richness indices. However, as recently acknowledged by Espírito-Santo and Fernandes (2007), these results could be affected by an under-sampling of tropical rain forests, where gall richness could be higher than predicted by Price et al. (1998).

Our results show than the moist and wet tropical forests of Coiba National Park revealed a rich diversity of gall-inducing arthropods, with species richness numbers higher than those registered in continental Panama (see Price et al. 1998) and other parts of the Neotropical region (see Cuevas et al. 2004a, Costa De Oliveira and Maia 2005) (Table 4). Although we did not collect all species in Coiba Island, the total of fifty nine species, with a range of one to nineteen gall inducer species per site, in Coiba National Park is more that the twelve proposed for mesic vegetation in the literature (see Price et al. 1998). Coiba National Park diversity is similar
**TABLE 4**

*Comparison of gall inducing arthropods species richness of Coiba Nacional Park and literature data from the Neotropical Region*

<table>
<thead>
<tr>
<th>Region</th>
<th>Site</th>
<th>No. Gall inducers species</th>
<th>Average range</th>
<th>Method</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coiba Island</td>
<td>17 sites</td>
<td>59</td>
<td>1-19</td>
<td>Two weeks per year for 3 years of intensive sampling</td>
<td>Present paper</td>
</tr>
<tr>
<td>Mainland Panama</td>
<td>9 sites</td>
<td>0-19</td>
<td>9 samples of 10 hours each one</td>
<td>Barrios &amp; Medianero 1999</td>
<td></td>
</tr>
<tr>
<td>Park. Nat. Metropolitan</td>
<td>50</td>
<td>2-15</td>
<td>Sampling of 138 plants species for 15 months</td>
<td>Medianero <em>et al.</em> 2003</td>
<td></td>
</tr>
<tr>
<td>San Lorenzo</td>
<td>58</td>
<td>13-30</td>
<td>Sampling of 120 plants species for 12 months</td>
<td>Medianero <em>et al.</em> 2003</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>Jalisco</td>
<td>39</td>
<td>30 transects of 50 x 5 m</td>
<td>Cuevas <em>et al.</em> 2004</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Cerrado do Cipo</td>
<td>49</td>
<td>14-15</td>
<td>2 samples of 45 trees, 100 shrubs and 1000 herbs</td>
<td>Price <em>et al.</em> 1998</td>
</tr>
<tr>
<td>Cerrado</td>
<td>49</td>
<td>17</td>
<td>43 samples of 45 trees, 100 shrubs and 1000 herbs</td>
<td>Price <em>et al.</em> 1998</td>
<td></td>
</tr>
<tr>
<td>Campo sujo</td>
<td>31</td>
<td>13</td>
<td>3 samples of 45 trees, 100 shrubs and 1000 herbss</td>
<td>Gonçalves-Alvin &amp; Fernandes 2001</td>
<td></td>
</tr>
<tr>
<td>Cerradão</td>
<td>23</td>
<td>8</td>
<td>3 samples of 45 trees, 100 shrubs and 1000 herbss</td>
<td>Gonçalves-Alvin &amp; Fernandes 2001</td>
<td></td>
</tr>
<tr>
<td>Canga</td>
<td>33</td>
<td>13</td>
<td>3 samples of 45 trees, 100 shrubs and 1000 herbss</td>
<td>Gonçalves-Alvin &amp; Fernandes 2001</td>
<td></td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>43</td>
<td>6 sites collection of 30 minutes between 2002-2004</td>
<td>Costa de Oliveira &amp; Maia 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>São Paulo</td>
<td>36</td>
<td>36</td>
<td>Sampling per 10 years</td>
<td>Urso-Guiamares &amp; Scarello-Santos, 2006</td>
<td></td>
</tr>
<tr>
<td>Minas Gerais</td>
<td>137</td>
<td>36</td>
<td>36 samples of 8 hours each one</td>
<td>Maia &amp; Fernandes 2004</td>
<td></td>
</tr>
<tr>
<td>Costa Rica</td>
<td>Different sites</td>
<td>967</td>
<td>Sampling per 10 years</td>
<td>Hanson &amp; Goméz-Laurito 2005</td>
<td></td>
</tr>
</tbody>
</table>
to that found at San Lorenzo ($\alpha = 9.3$), a six ha rain forest area on the Panamanian mainland (Medianero et al. 2003). Our results suggest that, according to insular biogeography theory (MacArthur and Wilson 1967), that Panama’s continental territory, where close to 11000 species of plants have been identified (Correa 2001), as well as other sites in the Neotropical region, must be richer in arthropods than indicated by recorded data in literature. Certain climatic and edaphic factors can produce higher than expected gall-inducing species richness in certain warm temperature regions. Plant diversity is the predominant factor producing high gall-inducing species richness in wet tropical regions (Yukawa et al. 2001; Hanson & Gómez-Laurito 2005). Our results support the idea that it may be premature to conclude that species richness of gall inducers declines near the equator (Hanson and Gómez-Laurito 2005). Furthermore there is an urgent need for more investigation of gall-inducing arthropods in the Neotropics, a region where as many as 20.000 gall-midge species (Cecidomyiidae), could exist (Espírito-Santo and Fernandes 2007).

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**RESUMEN**

El interés por el estudio de las agallas y los artrópodos que las inducen ha crecido en todo el mundo en los últimos veinte años. Sin embargo, los artrópodos que inducen agallas en la región Neotropical son probablemente los menos estudiados. Un estudio de la riqueza y composición de artrópodos que inducen agallas fue desarrollado en el Parque Nacional Coiba en la República de Panamá. Los datos provienen de muestreos intensivos de dos semanas, efectuados entre agosto de 1997 y septiembre de 1999, en 17 sitios del área insular del Parque Nacional Coiba. Un total de 4942 agallas, que corresponden a 50 especies de insectos y nueve de ácaros, fueron colectadas en 50 especies de plantas vasculares de 30 familias. El 62.7% de las agallas correspondieron a especies de la familia Cecidomyiidae (Diptera), el 15.3% a ácaros de la familia Eriophyidae, el 8.5% a Psyllidae (Homoptera), un 6.8% a Coccidae y el 5.1% a Phlaeothripidae (Tysanoptera). Las familias de plantas con más especies de inductores de agallas fueron Myrtaceae con siete, Bignoniaceae con cinco y Euphorbiaceae, Fabaceae y Melastomataceae con cuatro. Las agallas formadas en hojas representaron el 93% del total. El número de inductores de agallas por sitio osciló entre uno y diecinueve. La riqueza de artrópodos inductores de agallas del Parque Nacional Coiba se discute con datos disponibles de la literatura para el área continental de Panamá y el Neotrópico. Nuestros resultados apoyan la idea de que es prematuro concluir que la riqueza de artrópodos que inducen agallas disminuye hacia el Ecuador.

**Palabras clave:** Coiba, insectos gallícolas, riqueza de agallas, plantas hospedadoras, interacción planta/insecto, Panamá.

**REFERENCES**


