Higher Ant Diversity in Native Vegetation Than in Stands of the Invasive Arundo, Arundo donax L., Along the Rio Grande Basin in Texas, USA

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ABSTRACT: Our hypothesis was that there will be greater ant biodiversity in heterogeneous native vegetation compared with Arundo stands. Changes in ant biodiversity due to Arundo invasion may be one of the ecological changes in the landscape that facilitates the invasion of cattle fever ticks from Mexico where they are endemic. Ants collected in pitfall traps were identified and compared between native vegetation and stands of Arundo, Arundo donax L., monthly for a year at 10 locations. A total of 82752 ants representing 28 genera and 76 species were collected. More ants were collected in the native vegetation which also had greater species richness and biological diversity than ants collected from Arundo stands. It is suggested that the greater heterogeneous nature of native vegetation provided greater and more predictable nourishment in the form of nectars and more abundant arthropod prey when compared with Arundo stands.

KEYWORDS: Ant diversity, extrafloral nectaries, pitfall traps

Introduction

Incidence of cattle fever ticks, Rhipicephalus (=Boophilus) spp, breaching the US quarantine zone along the Rio Grande is on the increase motivating studies of ecological changes occurring concurrent to the establishment of the invasive Arundo donax L. (Poales: Poaceae). Arundo, also known as giant reed or carrizo cane, is native to the Mediterranean coasts of Europe and North Africa to south Asia. Arundo donax is an invasive weed of riparian habitats of the southwestern United States.1,3-11 Classified as an invasive perennial species, it spread widely in riparian zones of Texas where it has altered wildlife habitats, created fire hazards, compromised water conservation efforts, affected flood control, and reduced visibility for law enforcement officers along the international border with Mexico. Arundo might also facilitate cattle fever tick, Rhipicephalus (=Boophilus) spp, invasion into the permanent quarantine zone along the Rio Grande between Del Rio and Brownsville, TX, by harboring known mammalian host such as white-tailed deer, Odosicoleus virginianus (Zimmermann).4-6

Ants were chosen as a survey taxon because they are known predators of ticks7-10 and are often represented by multiple species demonstrating high diversity.11,12 The diversity and abundance of ants in native vegetation and Arundo along the Rio Grande basin in Texas have not been previously studied. The objective of this study was to compare and contrast ant diversity between Arundo and native vegetation along the Rio Grande River at the Texas-Mexico border.

The hypothesis was that there will be greater biodiversity in heterogeneous native vegetation compared with Arundo stands. Native vegetation containing a variety of plant species provides for greater occurrences of various edges and niches increasing opportunities for various ant species to have survival advantages over competitors including predator avoidance and opportunities for specialized relationships with myrmecophytic plants when contrasted with a monoculture.13 Changes in ant biodiversity due to Arundo invasion may be one of the ecological changes in the landscape that facilitates the invasion of cattle fever ticks from Mexico where they are endemic.13

Materials and Methods

Study Sites

Ant samples were collected from 10 Texas research sites located just north of the Rio Grande along the Texas-Mexico border (Table 1, Figure 1).

Ant Sampling

Ants were sampled using pitfall traps (Figure 2). A trap comprised 470-mL polypropylene container (Ball, Fishers, IN, USA) 10.5 cm × 9.9 cm × 7.0 cm (height × top diameter × bottom diameter). A plywood shelter (30.5 cm × 30.5 cm) was supported 1.3 cm above the trap. Each trap contained a 50:50 mixture of propylene glycol and water. Trapping intervals were 30 d. Four traps were located 10 m apart within an Arundo stand, and 4 traps were similarly placed in native vegetation at each of the 10 locations.
Monthly pitfall trap collections were conducted during January to December 2014 at each site. Ant identification was conducted with a stereoscopic microscope using taxonomic ant keys. A survey of plants and the presence of extrafloral nectaries was conducted at each study site.

**Statistical analysis**

Diversity profile estimations were calculated using Spade (Species Prediction and Diversity Estimation). Continuous diversity profile including species richness, Shannon entropy, Simpson index, and Chao2 as well as their effective numbers of species based on incidence data were calculated using species richness prediction and diversity estimation. Shannon entropy provides expected mean which increases with a species richness and evenness. Simpson index values increase as diversity decreases, whereas the inverse Simpson index values increase as diversity increases providing a dominance index giving more weight to common or dominant species. Chao2 estimates true species diversity of a sample using incidence data. Value differences were considered significant when their confidence intervals did not overlap. The program iNEXT was used to plot sample size–based rarefaction and extrapolation sampling curves where this curve plots the species richness estimates for a rarefied and extrapolated sample with respect to sample size following bootstrapping 100 times.

Table 1. Ant sample study site locations along the Rio Grande, TX, USA.

| LOCATION                          | COUNTY           | LATITUDE, LONGITUDE          |
|----------------------------------|------------------|-----------------------------|
| Los Indios                       | Cameron          | 26.05, −97.74               |
| North American Butterfly Association (NABA) | Hidalgo          | 26.180243, −98.364973       |
| Bentsen-Rio Grande State Park   | Hidalgo          | 26.1731300, −98.3825200     |
| San Ygnacio                      | Zapata           | 27.048175, −99.430788       |
| Laredo Community College (LCC)  | Webb             | 27.5084, −99.5214           |
| La Bota Ranch                    | Webb             | 27.6161258, −99.569872      |
| Comanche Ranch                   | Maverick         | 28.643901, −100.444024      |
| Rosita Ranch                     | Maverick         | 28.643901, −100.444024      |
| Sycamore Creek                   | Kinney           | 29.4410659, −100.1228475    |
| Del Rio                          | Val Verde        | 29.3709, −100.8959          |

Figure 1. Study sites in the cattle fever tick quarantine zone along the Texas-Mexico border.
After 12 months, a total of 82,752 ants representing 28 genera and 76 species were captured (Table 2). Only 7 species were captured from all 10 locations (see Table 2). Twenty species were captured at single locations (Table 2). Seven of the ant species were found only in the southern most test sites, Los Indios, North American Butterfly Association (NABA), or Bentsen R.G. In addition, 11 species were found only in the northernmost test sites, Comanche Ranch, Rosita Ranch, Sycamore Creek, or Del Rio. *Pheidole* was the most diverse genus represented by 21 species (Table 2).

Excluding the NABA site, 2-fold to 15.5-fold greater abundances of ants were captured, and more species were encountered, in the native vegetation than in *Arundo* at each test site (Table 3). Ant dominance (number of traps with ants × number of species captured at the respective locations) was higher in native vegetation (Table 3). With the exception of Bentsen R.G., all calculated estimates of biodiversity were greater in native vegetation than in *Arundo* (Table 4). Chao2 estimated that species richness was greater in at least 70% of the test sites. Diversity indicated by the exponential of Shannon index was greater in native vegetation compared with *Arundo* at 40% of the sites: Laredo Community College, Comanche Ranch, Sycamore Creek, and Del Rio (Table 4). Biodiversity as quantified using the inverse of the Simpson index was also greater in native vegetation than in *Arundo* at 40% of the sites. The number of estimated species shared between native vegetation and *Arundo* at each study site ranged from 40.9% to 23.7% (Table 3).

Total ants collected (mean ± SEM) were greater in native vegetation (6793.3 ± 1593.8) compared with *Arundo* (1421.2 ± 374.2: \( F = 10.768; df = 1, 19; P = .004 \)). Ant dominance (mean ± SEM) was greater in native vegetation (216.0 ± 18.1) compared with *Arundo* (113.9 ± 11.6: \( F = 22.476; df = 1, 19; P < .001 \)). Total species collected (mean ± SEM) was greater in native vegetation (27.4 ± 1.4) compared with *Arundo* (19.2 ± 1.4: \( F = 11.913; df = 1, 19; P = .003 \)). Native vegetation has greater diversity than the *Arundo* with both the empirical and extrapolated calculations (Table 4, Figure 3). Greater species richness is found in natural vegetation than is found in *Arundo* indicated by nonoverlap of confidence limits (Table 4, Figure 4). More than 76% of the native vegetation possessed extrafloral nectaries (Table 5).

**Discussion**

Pitfall trapping of ants has been recognized as an effective monitoring technique.\(^{26,27}\) The magnitude and diversity of ant assemblages reflect the responses of individual species to environmental conditions of native vegetation and *Arundo* stands. *Arundo* stands represent a new environmental setting different from native vegetation where food resources for ants differ. Thus, species distribution appears driven by resources resulting in the observed ant species assemblages.\(^{28}\)

In the case of Los Indios, for example, the native vegetation has greater diversity than the *Arundo* with both the empirical and extrapolated calculations (Figure 3). Greater species richness in Los Indios natural vegetation is than found in *Arundo* indicated by nonoverlap of confidence limits (Figure 4). For Los Indios, the sample completeness curve indicates that the number of samples provided is adequate coverage of study area as indicated by the plateauing of the curve (Figure 4). The completeness curve provides a bridge between sample size-based and coverage-based rarefaction and extrapolation. Similar comparisons were conducted for all study sites as summarized in Table 4.

Presence of renewable and predictable food sources on vegetation will support greater populations of ants.\(^{29–31}\) Composition of ant fauna differs between heterogeneous native vegetation and *Arundo* stands with the former supplying a heterogeneous supply of extrafloral nectaries and a greater
Table 2. Presence/absence of ants captured in pitfall traps in tick quarantine zone.

| SPECIES                       | SUBFAMILY | LI | NABA | BRG | SY | LCC | LB | CR | RR | SC | DR |
|-------------------------------|-----------|----|------|-----|----|-----|----|----|----|----|----|----|
| Aphaenogaster texana texana   | Myrmicinae| +  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Atta texana                  | Myrmicinae| 0  | 0    | +   | +  | 0   | 0  | +  | +  | 0  | 0  | 0  |
| Brachymyrmex depilis         | Formicinae| 0  | 0    | 0   | +  | +   | 0  | +  | +  | 0  | 0  | +  |
| Brachymyrmex patagonicus     | Formicinae| +  | +    | +   | +  | +   | +  | +  | +  | +  | +  | +  |
| Camponotus festinatus        | Formicinae| 0  | +    | 0   | 0  | 0   | +  | 0  | +  | 0  | 0  | 0  |
| Camponotus floridanus        | Formicinae| +  | +    | +   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Camponotus planatus          | Formicinae| +  | +    | +   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Camponotus sayi              | Formicinae| +  | +    | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  | +  |
| Camponotus texanus           | Formicinae| 0  | 0    | +   | +  | +   | 0  | 0  | 0  | 0  | 0  | 0  |
| Cardiocondyla emeryi         | Myrmicinae| 0  | 0    | 0   | 0  | +   | 0  | 0  | 0  | 0  | 0  | 0  |
| Crepatagaster crinosa        | Myrmicinae| 0  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Crepatagaster laeviuscula    | Myrmicinae| +  | +    | +   | +  | +   | +  | +  | +  | +  | +  | +  |
| Crepatagaster lineolata      | Myrmicinae| 0  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Crepatagaster torosa         | Myrmicinae| +  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Cyphomyrmex rimosus          | Myrmicinae| +  | +    | +   | +  | +   | +  | +  | +  | 0  | 0  | +  |
| Dorymyrmex bicolor           | Dolichoderinae| 0 | 0   | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  | +  |
| Dorymyrmex flavus            | Dolichoderinae| +  | +    | +   | 0  | +   | +  | +  | +  | +  | +  | +  |
| Dorymyrmex insanus           | Dolichoderinae| 0 | 0   | 0   | 0  | +   | +  | 0  | +  | +  | +  | +  |
| Forelius mccooki             | Dolichoderinae| +  | +    | +   | +  | +   | +  | +  | +  | +  | +  | +  |
| Formica pallidefulva         | Formicinae| 0  | 0    | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  | 0  |
| Hypoponera opaciceps         | Ponerinae| 0  | 0    | 0   | 0  | 0   | 0  | +  | 0  | 0  | 0  | 0  |
| Hypoponera opacior           | Ponerinae| 0  | +    | 0   | 0  | 0   | +  | +  | +  | +  | +  | +  |
| Hypoponera punctatissima     | Ponerinae| 0  | 0    | 0   | +  | 0   | 0  | 0  | +  | 0  | 0  | 0  |
| Labidus coecus               | Dorylinae| +  | +    | +   | +  | 0   | 0  | +  | +  | +  | +  | +  |
| Leptogenys elongata          | Ponerinae| +  | +    | +   | 0  | 0   | 0  | +  | +  | +  | +  | +  |
| Monomorium minimum           | Myrmicinae| +  | 0    | 0   | 0  | 0   | +  | 0  | +  | 0  | +  | +  |
| Monomorium pharoanis         | Myrmicinae| 0  | 0    | 0   | 0  | 0   | 0  | +  | 0  | 0  | 0  | 0  |
| Myrmecocystus mendax         | Formicinae| 0  | 0    | 0   | 0  | 0   | 0  | 0  | +  | 0  | 0  | 0  |
| Neivamyrmex nigrescens       | Dorylinae| 0  | +    | +   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Neivamyrmex swainsonii       | Dorylinae| 0  | +    | +   | 0  | +   | +  | +  | +  | 0  | 0  | +  |
| Neivamyrmex texanus          | Dorylinae| 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| Odontomachus clarus          | Ponerinae| 0  | 0    | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  | +  |
| Pachycondyla harpax          | Ponerinae| 0  | 0    | 0   | +  | 0   | +  | 0  | 0  | 0  | 0  | 0  |
| Paratrechina terricola       | Formicinae| +  | +    | +   | 0  | +   | +  | +  | +  | +  | +  | +  |
| Pheidole bicarinata          | Myrmicinae| +  | +    | +   | 0  | +   | +  | +  | +  | +  | +  | +  |
| Pheidole cockerelli          | Myrmicinae| 0  | 0    | +   | 0  | 0   | +  | 0  | 0  | 0  | 0  | 0  |
| Pheidole dentata             | Myrmicinae| +  | +    | +   | +  | +   | +  | +  | +  | +  | +  | +  |
| SPECIES                  | SUBFAMILY    | LI | NABA | BRG | SY | LCC | LB | CR | RR | SC | DR |
|-------------------------|--------------|----|------|-----|----|-----|----|----|----|----|----|
| 40. Pheidole flavens    | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 41. Pheidole floridana  | Myrmicinae   | +  | +    | +   | +  | +   | +  | +  | +  |    |    |
| constipata              |              |    |      |     |    |     |    |    |    |    |    |
| 42. Pheidole floridana  | Myrmicinae   | +  | +    | 0   | 0  | +   | 0  | 0  | +  | 0  | 0  |
| floridana               |              |    |      |     |    |     |    |    |    |    |    |
| 43. Pheidole humeralis  | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 44. Pheidole hyatti     | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 45. Pheidole lamia      | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 46. Pheidole mera       | Myrmicinae   | +  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 47. Pheidole metallescens| Myrmicinae  | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 48. Pheidole moerens    | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 49. Pheidole nuculiceps| Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 50. Pheidole pelor      | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 51. Pheidole porcula    | Myrmicinae   | +  | 0    | +   | +  | +   | 0  | +  | +  |    |    |
| 52. Pheidole sciara     | Myrmicinae   | 0  | 0    | 0   | +  | 0   | +  | +  | 0  |    |    |
| 53. Pheidole spadonia   | Myrmicinae   | +  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 54. Pheidole tetra      | Myrmicinae   | 0  | 0    | +   | 0  | +   | 0  | 0  | +  | 0  | 0  |
| 55. Pheidole texana     | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 56. Pheidole tysoni     | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 57. Pheidole vallicola  | Myrmicinae   | 0  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | +  | 0  |
| 58. Pogonomyrmex barbatus| Myrmicinae | +  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 59. Pogonomyrmex rugosus| Myrmicinae  | 0  | 0    | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  |
| 60. Pseudomyrmex gracilis | Pseudomyrmecinae  | 0  | +    | +   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 61. Pseudomyrmex pallidus| Pseudomyrmecinae | 0  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 62. Solenopsis aurea    | Myrmicinae   | 0  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 63. Solenopsis gminata  | Myrmicinae   | 0  | 0    | +   | 0  | +   | +  | +  | +  | 0  | 0  |
| 64. Solenopsis invicta  | Myrmicinae   | +  | +    | +   | +  | +   | +  | +  | +  |    |    |
| 65. Solenopsis molesta  | Myrmicinae   | +  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 66. Solenopsis texana   | Myrmicinae   | +  | +    | +   | +  | +   | +  | +  | +  | +  | +  |
| 67. Strumigenys boneti  | Myrmicinae   | +  | 0    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 68. Strumigenys louisiana| Myrmicinae | 0  | +    | 0   | 0  | +   | +  | 0  | +  | +  | +  |
| 69. Strumigenys membranifera| Myrmicinae  | 0  | 0    | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  |
| 70. Tapinoma litorale   | Dolichoderinae| 0  | 0    | +   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 71. Tetramorium subditivus| Myrmicinae | +  | +    | +   | +  | 0   | +  | +  | +  | +  | +  |
| 72. Tetramorium perpandei| Myrmicinae | 0  | +    | 0   | 0  | 0   | +  | 0  | +  | +  | +  |
| 73. Tetramorium bicarinatum| Myrmicinae | 0  | +    | 0   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 74. Tetramorium caldarium| Myrmicinae | 0  | 0    | 0   | 0  | 0   | +  | 0  | 0  | 0  | 0  |
| 75. Tetramorium lanuginosum| Myrmicinae | 0  | 0    | +   | 0  | 0   | 0  | 0  | 0  | 0  | 0  |
| 76. Tetramorium spinosum| Myrmicinae   | +  | 0    | +   | +  | +   | +  | 0  | 0  | 0  | 0  |
| 77. Trachymyrmex turriflex| Myrmicinae  | 0  | +    | 0   | +  | +   | +  | +  | +  | +  | +  |

Abbreviations: BRG, Bentsen R.G.; CR, Comanche Ranch; DR, Del Rio; LB, La Bota; LCC, Laredo Community College; LI, Los Indios; NABA, North American Butterfly Association; RR, Rosita Ranch; SC, Sycamore Creek; SY, San Ygnacio.
Table 4. Ant biodiversity in *Arundo* stands and mixed native vegetation (±SE).

| LOCATION          | NO. OF OBSERVED SPECIES | CHAO2 ESTIMATED SPECIES RICHNESS | EXPONENTIAL OF SHANNON INDEX | INVERSE OF SIMPSON INDEX | CHAO2 ESTIMATED SHARED SPECIES (OBSERVED) |
|-------------------|-------------------------|-----------------------------------|-----------------------------|--------------------------|--------------------------------------------|
| **Los Indios**    |                         |                                   |                             |                          |                                            |
| *Arundo*          | 23                      | 24.6 ± 2.1a                       | 19.0 ± 1.5a                 | 15.0 ± 1.7a              | 19.3 ± 0.9 (19)                           |
| Native            | 29                      | 33.1 ± 4.8b                       | 19.7 ± 1.1a                 | 14.8 ± 0.9a              |                                             |
| **NABA**          |                         |                                   |                             |                          |                                            |
| *Arundo*          | 25                      | 29.4 ± 4.7a                       | 14.8 ± 1.3a                 | 9.5 ± 0.7a               | 28.3 ± 12.0 (19)                          |
| Native            | 30                      | 46.3 ± 14.5a                      | 14.9 ± 1.1a                 | 9.4 ± 0.5a               |                                             |
| **Bentsen R.G.**  |                         |                                   |                             |                          |                                            |
| *Arundo*          | 24                      | 73.6 ± 59.1a                      | 14.1 ± 2.2a                 | 6.4 ± 1.1a               | 24.9 ± 8.1 (18)                           |
| Native            | 24                      | 27.5 ± 3.8a                       | 19.2 ± 1.4a                 | 15.1 ± 1.4b              |                                             |
| **San Ygnacio**   |                         |                                   |                             |                          |                                            |
| *Arundo*          | 14                      | 16.2 ± 3.3a                       | 11.4 ± 1.5a                 | 8.1 ± 1.3a               | 12.0 ± 2.5 (11)                           |
| Native            | 20                      | 28.8 ± 10.0b                      | 13.1 ± 0.9a                 | 10.4 ± 0.6a              |                                             |
| **LCC**           |                         |                                   |                             |                          |                                            |
| *Arundo*          | 18                      | 20.6 ± 3.4a                       | 11.1 ± 0.9a                 | 8.2 ± 0.6a               | 14.5 ± 1.4 (14)                           |
| Native            | 26                      | 32.0 ± 6.0b                       | 14.6 ± 0.8b                 | 10.0 ± 0.5a              |                                             |
| **La Bota**       |                         |                                   |                             |                          |                                            |
| *Arundo*          | 20                      | 51.8 ± 39.4a                      | 10.7 ± 1.2a                 | 6.6 ± 0.7a               | 18.3 ± 7.8 (11)                           |
| Native            | 22                      | 34.2 ± 10.5a                      | 11.5 ± 1.0a                 | 7.2 ± 0.6a               |                                             |
| **Comanche Ranch**|                         |                                   |                             |                          |                                            |
| *Arundo*          | 15                      | 24.5 ± 2.2b                       | 8.3 ± 1.5a                  | 4.7 ± 0.5a               | 10.5 ± 2.5 (9)                            |
| Native            | 23                      | 28.7 ± 1.1a                       | 13.2 ± 0.6b                 | 9.6 ± 0.5b               |                                             |
| **Rosita Ranch**  |                         |                                   |                             |                          |                                            |
| *Arundo*          | 31                      | 54.5 ± 19.8a                      | 17.9 ± 1.3a                 | 11.2 ± 0.8a              | 27.3 ± 10.7 (18)                          |
| Native            | 33                      | 44.8 ± 9.5b                       | 19.1 ± 1.5a                 | 12.4 ± 0.8a              |                                             |
| **Sycamore Creek**|                         |                                   |                             |                          |                                            |
| *Arundo*          | 23                      | 36.2 ± 12.2a                      | 14.4 ± 1.5a                 | 8.2 ± 0.9a               | 32.4 ± 11.6 (19)                          |
| Native            | 40                      | 47.4 ± 5.85b                      | 22.2 ± 1.2b                 | 13.9 ± 0.8b              |                                             |
| **Del Rio**       |                         |                                   |                             |                          |                                            |
| *Arundo*          | 12                      | 19.3 ± 8.0b                       | 6.2 ± 1.1a                  | 3.4 ± 0.4a               | 15.3 ± 11.8 (8)                           |
| Native            | 21                      | 26.1 ± 5.3a                       | 11.7 ± 0.7b                 | 8.0 ± 0.6b               |                                             |

Abbreviations: LCC, Laredo Community College; NABA, North American Butterfly Association. Chao2 estimation of species richness is equivalent of diversity of order 0; exponential of Shannon index is equivalent of diversity of order 1; inverse of Simpson index is equivalent of diversity of order 2 (Chao et al., 2015). *a,b*Mean values in a column from the same location pair followed by the same letter are not significantly different as indicated by overlap of 95% confidence intervals.
Figure 3. Los Indios ant diversity index Hill number plots, native vegetation (left), and Arundo (right) (Chao et al., 2015).

Figure 4. Los Indios ant species richness and diversity comparing Arundo and natural habitat. Chao2 (Chao and Jost, 2012) used as estimator of species richness and suggested estimator of sample coverage. (A) Sample size–based rarefaction and extrapolation sampling curve: species richness estimates for a rarefied and extrapolated sample with sample size up to double the reference sample size. (B) Sample completeness curve: sample completeness (as measured by sample coverage) with respect to sample size. This curve provides a bridge between sample size–based and coverage-based rarefaction and extrapolation. (C) Coverage-based rarefaction and extrapolation sampling curve: species richness estimates for rarefied sample and extrapolated sample with sample coverage up to double the reference sample size.
reservoir of arthropods. Many species of the native flora have extrafloral nectaries including trees and shrubs (Table 5). Reducing the dominance of *Arundo* and the subsequent re-establishment of native vegetation could increase the diversity and abundance of ant communities within the cattle fever tick permanent quarantine zone.

Extrafloral nectar is important for ant survival and growth and vitality of ant colonies. Ant richness and abundance will be higher where the availability of resources is greatest from water to extrafloral nectar to flower nectar being particularly important during dry periods. Ants are obligated to search for other alternate sources of food and water including arthropod plant pests as prey where acquisition of resources by generalists with ant presence is influenced by availability of resources.

*Arundo* stands provide a simpler environment with less resources when compared with native vegetation which results in repressed ant communities with less biodiversity.

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### Author Contributions

All authors contributed equally.

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### Table 5. Presence/absence of plants and EFNs at 10 sample sites along the Rio Grande in Texas January to December 2014.

| SPECIES               | EFN   | COMMON NAME       | LI | NABA | BRG  | SY   | LCC  | LB   | CR  | RR  | SC  | DR  |
|----------------------|-------|-------------------|----|------|------|------|------|------|-----|-----|-----|-----|
| Prosopis glandulosa  | +     | Mesquite          | +  | 0    | 0    | +    | +    | +    | +   | +   | +   | +   |
| Celtis laevigata     | 0     | Hackberry         | 0  | +    | 0    | 0    | +    | +    | +   | +   | +   | 0   |
| Ulmus crassifolia    | +     | Cedar elm         | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Acacia spp           | +     | Acacia            | 0  | +    | 0    | 0    | 0    | +    | +   | +   | 0   | 0   |
| Acacia rigidula      | +     | Blackbrush        | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Celtis pallida       | +     | spiny hackberry   | +  | 0    | +    | 0    | +    | +    | 0   | 0   | 0   | 0   |
| Acacia smallii       | +     | Huisache          | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Mimosa pigra         | 0     | Mimosa            | 0  | 0    | 0    | +    | 0    | +    | +   | +   | +   | 0   |
| Opuntia lindheimeri  | +     | Prickly pear cactus| + | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Triadica sebifera    | +     | Chinese tallow    | +  | +    | 0    | +    | +    | 0    | +   | +   | +   | +   |
| Ricinus communis     | 0     | Castor bean       | 0  | +    | 0    | 0    | 0    | +    | 0   | +   | 0   | 0   |
| Cenchrus ciliaris     | +     | Buffel grass      | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Panicum maximum      | +     | Guinea grass      | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Triadica sebifera    | +     | Chinese tallow    | +  | +    | 0    | +    | +    | 0    | +   | +   | +   | +   |
| Ricinus communis     | 0     | Castor bean       | 0  | +    | 0    | 0    | 0    | +    | 0   | +   | 0   | 0   |
| Cenchrus ciliaris     | +     | Buffel grass      | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |
| Panicum maximum      | +     | Guinea grass      | +  | +    | +    | +    | +    | +    | +   | +   | +   | +   |

Abbreviations: BRG, Bentsen R.G.; CR, Comanche Ranch; DR, Del Rio; EFNs, extrafloral nectaries; LB, La Bota; LCC, Laredo Community College; LI, Los Indios; NABA, North American Butterfly Association; RR, Rosita Ranch; SC, Sycamore Creek; SY, San Ygnacio.
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