RED IMPORTED FIRE ANT IMPACT ON NATIVE ANTS AND LITTER REMOVAL IN THE POST OAK SAVANNAH OF CENTRAL TEXAS

A Thesis

by

THERESA LOUISE BEDFORD

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2005

Major Subject: Wildlife and Fisheries Sciences

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Approved as to style and content by:

William E. Grant (Co-Chair of Committee)	S. Bradleigh Vinson (Co-Chair of Committee)
Thomas W. Boutton (Member)	Robert D. Brown (Head of Department)

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ABSTRACT

Red Imported Fire Ant Impact on Native Ants and Litter Removal in the Post Oak Savannah of Central Texas. (May 2005)

Theresa Louise Bedford, B.S., Texas A&M University

Co-Chairs of Advisory Committee: Dr. William E. Grant
Dr. S. Bradleigh Vinson

I examined the impacts of the invasive red imported fire ant (RIFA, *Solenopsis invicta*) on native ants (*Monomorium minimum*, *Paratrechina* sp., *S. krockowi*, *Pheidole metallescens*, *Forelius pruinosus*, and *Camponotus americanus*) and litter removal in a post oak savannah community in central Texas. The study site was divided into 3 adjacent areas, and ant-toxic bait was used, along with additional colonies of RIFA, to establish 3 different densities of RIFA (naturally occurring, low, and high). I surveyed the ants in the 3 density areas and calculated the catch per unit effort for each species. Litter baits were placed in the 3 density areas for 14 12-hour trials. The masses of the litter removed were measured, and means were calculated for each species-density/trial/date/period/bait combination. The average amounts of litter removed by RIFA and native ant were different in the 3 density areas (0.42 g, 0.0 g, and 0.75 g for RIFA in the natural RIFA density area, low RIFA density area, and high RIFA density area, respectively; 0.0 g, 0.16 g, and 0.15 g for native ants in the natural RIFA density area, low RIFA density area, and high RIFA density area, respectively), indicating that RIFA does have an effect on native ant habitat use.

DEDICATION

To my husband, Kelly, for whose love and patience I am most thankful.

ACKNOWLEDGMENTS

I give heartfelt thanks to all of the people who made this thesis possible. At the top of the list is my committee: Bill Grant, Brad Vinson, and Tom Boutton. Their wisdom and guidance helped establish a foundation and framework for this research. In addition, I respect and admire these men for their knowledge, character, and professionalism. I will be a better person because they became a part of my life's journey.

Throughout these past years, so many colleagues have been a part of my graduate school process. I owe them all a debt of gratitude. Sherry Ellison, a remarkable person who manages the Entomology Research Laboratory, was always there with a smile and a helping hand. My field assistants: Angel Lanier, Margaret Schell, Ann Thornton, and Rebel Rainwater, worked many long and hard hours in the unpredictable Texas weather, with endless energy and positive attitudes. Graduate students from the Ecological Modelling lab: Ellen Pederson, Michael Corson, Selma Glasscock, Mike Kjelland, Edith Gonzalez, and Magui Mieres, always were there for me with insights, encouragement, and laughter. Likewise, the Entomology Research Lab staff and graduate students: Ken Helms, Jim Martin, Asha Rao, Indira Kuriachan, Steve Rauth, and Sean O'Keefe, could be counted on to give advice, support, and a helping hand when needed.

My family and friends are my life. They give me strength, love, and joy. Without them, I would be lost. While many of the people mentioned above also are included in this group, I would like to extend special thanks to those nearest and dearest to my heart: my husband, Kelly Bedford; my mom, Ginny Noel; my mother-in-law, Dorothy Bedford; my sister, Becky Pollinzi; and my best friend, Darrell Oldham. They gave me the freedom to explore a new path, cheered on my efforts, and believed in my ability to succeed.

Finally, my thanks go to the State of Texas Red Imported Fire Ant Research and Management Plan for funding this research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE Page

INTRODUCTION

The red imported fire ant (RIFA), *Solenopsis invicta* (Hymenoptera: Formicidae), was first introduced into the United States between 1933 and 1945 (Vinson and Greenberg 1986). A native of South America's Pantanal area, in the state of Mato Grosso, Brazil (Buren et al. 1974), RIFA entered the United States through the port of Mobile, Alabama, perhaps in soil used as ballast in ships transporting produce (Vinson and Sorensen 1986). RIFA's spread across the southern United States was rapid (Vinson and Sorensen 1986), covering 25 million ha in 8 states by 1958 (Callcott and Collins 1996), when federal control efforts were initiated (Hinkle 1982). RIFA was first detected in Texas in 1953 (Culpepper 1953), and entered Brazos County between 1967 and 1973 (Hung and Vinson 1978). By 1985, RIFA had invaded 101 million ha (Vinson and Sorensen 1986), and by 1995, RIFA's range had expanded to include 114 million ha in 11 states and Puerto Rico (Callcott and Collins 1996). Since then, RIFA has expanded into 2 more states, California and New Mexico (Cook 2003). Before range limits are reached, almost one quarter of the continental United States may be infested by RIFA (Vinson and Sorensen 1986).

Originally introduced as single-queen (monogyne) colonies, reports of multiple-queen (polygyne) colonies in the United States began to appear in the mid 1970s (Glancey et al. 1973), and by the late 1980s multiple-queen colonies had invaded much

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This thesis follows the style and format of The Southwestern Naturalist.

of Texas (Porter et al. 1991). The average mound densities for monogyne populations range from 150 per ha (Macom and Porter 1996) to 295 per ha (Porter et al. 1991), while polygyne population mound densities average between 470 per ha (Macom and Porter 1996) and 680 per ha (Porter et al. 1991).

RIFA is a successful invader for several reasons (Porter and Savignano 1990) including a wide range of climate tolerances, a broad range of food resources, rapid reproduction, and rapid colony establishment, especially in disturbed habitats (Vinson and Greenberg 1986). RIFA is an aggressive exotic that alters the species composition of infested communities (Porter et al. 1988, Porter and Savignano 1990, Jusino-Atresino and Phillips 1994, Vinson 1994). Vertebrates may be negatively affected (Maxwell et al. 1982, Allen et al. 1994), as is indicated by reports of RIFA effects on amphibians (Freed and Neitman 1988), reptiles (Landers et al. 1980, Mount et al. 1981, Allen et al. 2001), birds (Ridlehuber 1982, Sikes and Arnold 1986, Drees 1994, Pedersen et al. 1996), and small mammals (Smith et al. 1990. Killion and Grant 1993, Ferris 1994, Killion et al. 1995, Allen et al. 1997, Pedersen et al. 2003). RIFA also are known to disrupt arthropod communities (Porter and Savignano 1990). RIFA will consume any dead arthropods it encounters and exclude the resource from other arthropods (Vinson 1990). Other ants have been out-competed (Porter et al. 1988, Vargo and Porter 1989, Vinson 1990), and native ant and other arthropod diversity has decreased (Whitcomb et al. 1972, Porter and Savignano 1990, Morris and Steigman 1993, Wojcik 1994, Gotelli and Arnett 2000, Cook 2003).

However, some native ant species are able to persist and coexist (Helms and Vinson 2001, Morrison and Porter 2003) by using aggressive (Blum et al. 1980, Buren 1983, Jones and Phillips 1987), defensive (Baroni Urbani and Kannowski 1974, Wilson 1976, Adams and Traniello 1981, Jones and Phillips 1987), and/or avoidance behavior (Baroni Urbani and Kannowski 1974, Claborn et al. 1988, Stein and Thorvilson 1989, Porter and Savignano 1990, Jusino-Atresino and Phillips 1994). Some native ant species can invade small RIFA colonies, prey upon brood, or prevent workers from leaving their nest (Rao and Vinson 2002). One long-term study found native ant diversity had rebounded to preinvasion levels, 12 years after the initial invasion (Morrison 2002).

In addition to the impact of RIFA on structure of these communities, RIFA may also have important impact on community functions. Perturbations caused by introduced species on 1 trophic level may indirectly change a community on other trophic levels (Carpenter et al. 1985). RIFA is extremely efficient in locating food (Baroni Urbani and Kannowski 1974), and in high densities, RIFA dominates food sources (Vinson 1990). Polygyne RIFA is more disruptive to native food webs, community structure, and energy flow because both the numbers of ants and ant mounds can be much higher than monogyne RIFA (Porter and Savignano 1990, Vinson 1994).

While studies suggest that RIFA can alter community composition and the process of succession within decomposer communities (Vinson 1991, Stoker et al. 1995), few quantitative studies exist comparing energy flow in RIFA-infested areas with non-infested areas, especially in areas with similar structure and composition. Also, the amount of ground litter removed in the presence and absence of RIFA has not been quantified.

My research examined the impact of RIFA on litter removal in a grassland ecosystem, by experimentally assessing the amount of ground litter removal by both RIFA and native ants in areas with different densities of RIFA. More specifically, I compared amounts of removal of litter baits in naturally occurring densities of RIFA, in low densities of RIFA, and in the presence of high densities of RIFA.

The following hypothesis was tested: Litter baits will be removed in equal amounts by both RIFA and native ants in areas with naturally occurring RIFA densities, areas from which RIFA densities have been experimentally reduced, and areas with artificially high RIFA densities.

METHODS AND MATERIALS

The study area is an ungrazed 30- by 150-m (0.45 ha) meadow located 11 km south of College Station, Brazos County, Texas. A post oak savannah (Gould et al. 1960, Gould 1975), the meadow contains *Aristida*, *Dicanthelium*, *Eragrostis*, *Paspalum*, and *Schizachyrium* grasses, and is surrounded by a post oak (*Quercus stellata*) forest community (Helms and Vinson 2001). The meadow was divided into three adjacent areas that were manipulated to contain different densities of RIFA: (1) naturally occurring, (2) low, and (3) high. To inhibit movement of RIFA between the three areas, 30-cm high metal sheeting was installed as fencing. Vegetation was cleared from 15 cm on either side of the sheeting to discourage ants from using plant stems to cross the sheeting barrier. A 2.5- by 2.5-m, flagged grid in each area was used to survey the ant populations, as well as treat ants with Amdro® (an approved, short-life insecticide; active ingredient: hydramethylnon 0.73%) to reduce ant densities in specified areas. Two ground litter removal stations were centrally located in each area. Ten specially designed buckets, which allowed workers to exit and enter while retaining the queen, were used to transplant additional colonies of RIFA into the area with high fire ant density. A five-strand electric fence encircled the entire area to deter feral pigs (*Sus scrofa*), stray cattle (*Bos taurus*), and coyotes (*Canis latrans*) from entering the study site.

From July 1998 until March 2000, an ant population survey that estimated densities of both RIFA and native ants was conducted, within an hour of sunrise, once per week during the late spring, summer, and early fall when RIFA is most active, and once per month in winter. A bi-weekly census was conducted during the 2000 high-activity period, April to August (the end of the study). A 1.5- by 5-cm plastic scintillation vial containing two pellets of Happy Cat® cat food (24.0 % protein, 8.5% fat, 3.5% fiber, and 39.0% moisture; Lofgren et al. 1961, Stein et al. 1990) was placed at the base of each flag in the 2.5- by 2.5-m ant survey grid. After 15 minutes of ant recruitment, the vials were collected, capped, transported to the Entomology Research Lab (ERL) at Texas A&M University, and frozen for 24 hours. The collected ants were counted and identified to genus, and species whenever possible. Catch per unit effort (CPUE) was calculated for RIFA and each native ant species.

Specific ants were treated with Amdro® during each ant survey. To reduce the number of RIFA in the low fire ant density area, a vial half full of Amdro® was placed at the base of an ant survey grid flag immediately upon collection of any survey vial that contained fire ants. The treatment vial was collected after 30 minutes, capped, and transported to the laboratory for disposal. Native ants (i.e. *Paratrechina* sp., *Monomorium minimum*, and *S. molesta*) that compete with RIFA, were treated in the high fire ant density area (Edmonson 1981, Apperson et al. 1984). Vials containing Amdro® replaced survey vials that had native ants in them when collected, remained at the bases of the high-density area grid flags for 30 minutes, and then were collected. Treatment of native ants in the high fire ant density area continued until October 1998; at which time, the specially designed buckets containing colonies of fire ants were transplanted into the area. After the addition of the fire ant colonies, treatment vials also contained fire ants, which were not intended for treatment in this area, thus lowering the effect of treating native ants in order to increase the fire ant density.

Each litter removal station consisted of 3 6-oz "tin" cans arranged in a circle 1.6 m in diameter. A screen mesh was placed over all cans to deter animals. A 1.3 x 1.3-cm wire mesh placed beneath each can kept vegetation, which ants could use as a bridge, from getting too near the can. To keep the can and its contents from being knocked or blown over, a large spike was hammered through the bottom of the can, the mesh screen, and into the ground. Silicon stripping was used as a sealant between the head of the spike and the hole in the bottom of the can.

Since back-to-back trials were run during some 24-hour intervals, it was necessary to randomly alternate between the 2 litter removal stations located in each of the 3 RIFA density areas. Thus, ants foraging in a can containing the previous trial's bait would not have unfair access to the next trial's bait.

Fourteen litter removal trials were run between 21 September and 21 October 1999, when the RIFA densities had reached the appropriate levels (naturally occurring, low, and high) in all 3 areas. A trial ran from just before sunset or just after sunrise to the corresponding period, just after sunrise or just before sunset, approximately 12 hours later.

For each trial, at the ERL, a weighboat for each litter removal station can was filled with the appropriate bait and weighed to the nearest 0.1 mg. The ground litter baits were either (1) 10 crickets (*Acheta domestica)*, (2) 30 mealworms *(Tenebrio* *molitor)*, or (3) mixed seeds (30 sunflower, *Helianthus annuus*; 30 millet, *Brachiaria texana*; and 10 corn, *Zea mays*).

After being transported to the study site, the weighboats containing the baits were carefully placed inside their assigned litter removal station cans, using forceps. The baits remained in the cans for approximately 12 hours, after which the weighboats, and any remaining baits, were carefully removed from the litter removal station cans, using forceps. Notes were made about the species and relative numbers of any ants that were present in the litter removal station cans, the condition of the baits, and any other items of interest.

The weighboats and remaining baits were transported back to the lab, placed in a freezer to kill any live ants, and then dried in a 60˚C oven for 24 hours. The cooled weighboats and baits were then weighed to the nearest 0.1 mg. After subtracting the masses of the weighboats, the masses of the remaining baits were converted back to wet weights, using a wet weight/dry weight conversion factor. The mass of litter removed was calculated by subtracting the remaining bait wet weight from the starting bait mass. Means were calculated for each mass of litter removed per can combination (species-density/trial/date/period/bait), for which a single foraging ant species was known.

Voucher specimens of ants have been placed in the insect collection at Texas A&M University, and retained by myself.

RESULTS

The ants collected throughout the duration of the study included: *S. invicta* (RIFA), *Monomorium minimum*, *Paratrechina* sp. (*P. vividula* or *P. terricola*; identification, based on worker morphology, of these species is unreliable [Trager 1984]), *S.* (*Diplorhoptrum*) *krockowi*, *Pheidole metallescens*, *Forelius pruinosus*, and *Camponotus americanus*. The RIFA at the site were judged to be the monogyne form, based on mound density in the naturally occurring density area and the aggressive behavior of the ants toward the RIFA colonies brought into the high density area (Morel et al. 1990, Obin et al. 1993). RIFA, *M. minimum*, and *Paratrechina* sp. made up 99.04% of the total ants collected at the site (Table 1). During the baseline survey conducted 1 July 1998, immediately prior to the first Amdro® treatment, the percentages of the total number of ants collected that were RIFA in the naturally occurring, low, and high density areas were 45.73%, 22.47%, and 7.16%, respectively (Table 2).

The RIFA and native ant foraging activity, based on CPUE, was highest during July, August, and September (Figures 1 and 2). However, low numbers of ants were collected during August and September 1998, when large amounts of rain fell on the study site. Two rain episodes in particular were associated with this period, when tropical storms Charley (20-23 August) and Frances (10-16 September) both came ashore on the Texas coast. The lowest CPUEs, for both RIFA and native ants, were recorded during the cooler months, between October and April.

RIFA CPUE in the low RIFA density area dropped immediately following the 1 July 1998 Amdro® treatment (Figure 1), and remained low throughout most of the study

Table 1—Numbers and percentages of ants collected, per species, during the entire study. **P. vividula* or *P. terricola*.

	Entire Site		Natural RIFA Density Area		Low RIFA Density Area		High RIFA Density Area	
Species	Total ants	% of ants	Total ants	% of ants	Total ants	% of ants	Total ants	% of ants
Red imported fire ant	161578	64.32	77584	82.66	12201	25.95	71793	65.07
Monomorium minimum	73287	29.17	11097	11.82	28939	61.55	33251	30.14
Paratrechina sp.*	13933	5.55	4667	4.97	4666	9.92	4600	4.17
Solenopsis krockowi	1092	0.43	215	0.23	637	1.35	240	0.22
Pheidole metallescens	803	0.40	192	0.20	363	0.77	248	0.22
Forelius pruinosus	515	0.21	105	0.11	212	0.45	198	0.18
Camponotus americanus	4	<0.01	0	0	2	<0.01	2	<0.01

Table 2—Numbers and percentages of ants collected, per species, during the baseline survey conducted 1 July 1998. **P. vividula* or *P. terricola*.

	Entire Site		Natural RIFA Density Area		Low RIFA Density Area		High RIFA Density Area	
Species	Total ants	% of ants	Total ants	% of ants	Total ants	% of ants	Total ants	% of ants
Red imported fire ant	3189	28.54	1880	45.73	1179	22.47	130	7.16
Monomorium minimum	7447	66.65	2024	49.23	3907	74.45	1516	83.53
Paratrechina sp.*	538	4.81	207	5.04	162	3.09	169	9.31

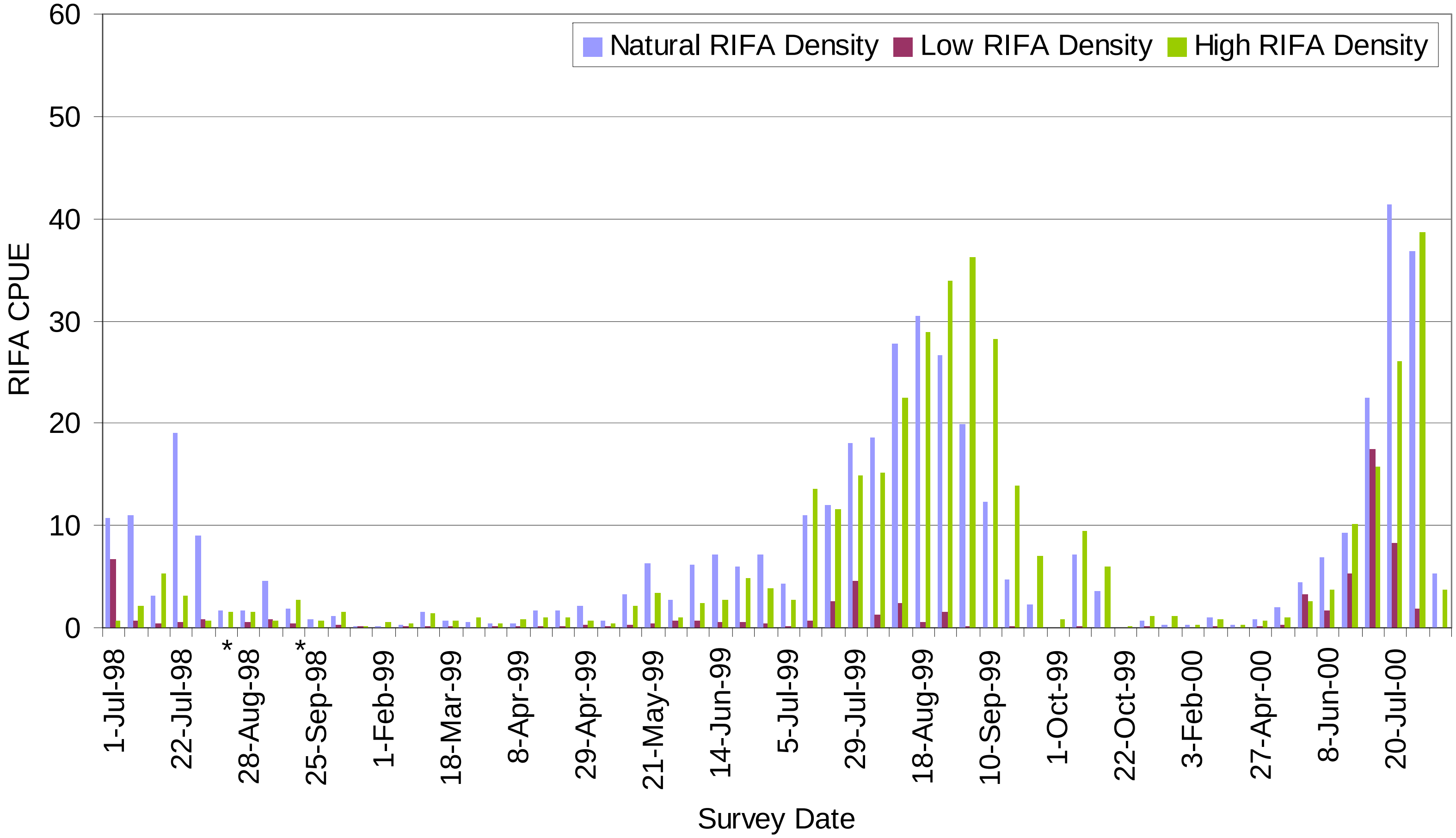

Figure 1—Red imported fire ant catch per unit effort per survey date, in each density area. *Tropical storms Charley (20-23 August) and Frances (10-16 September).

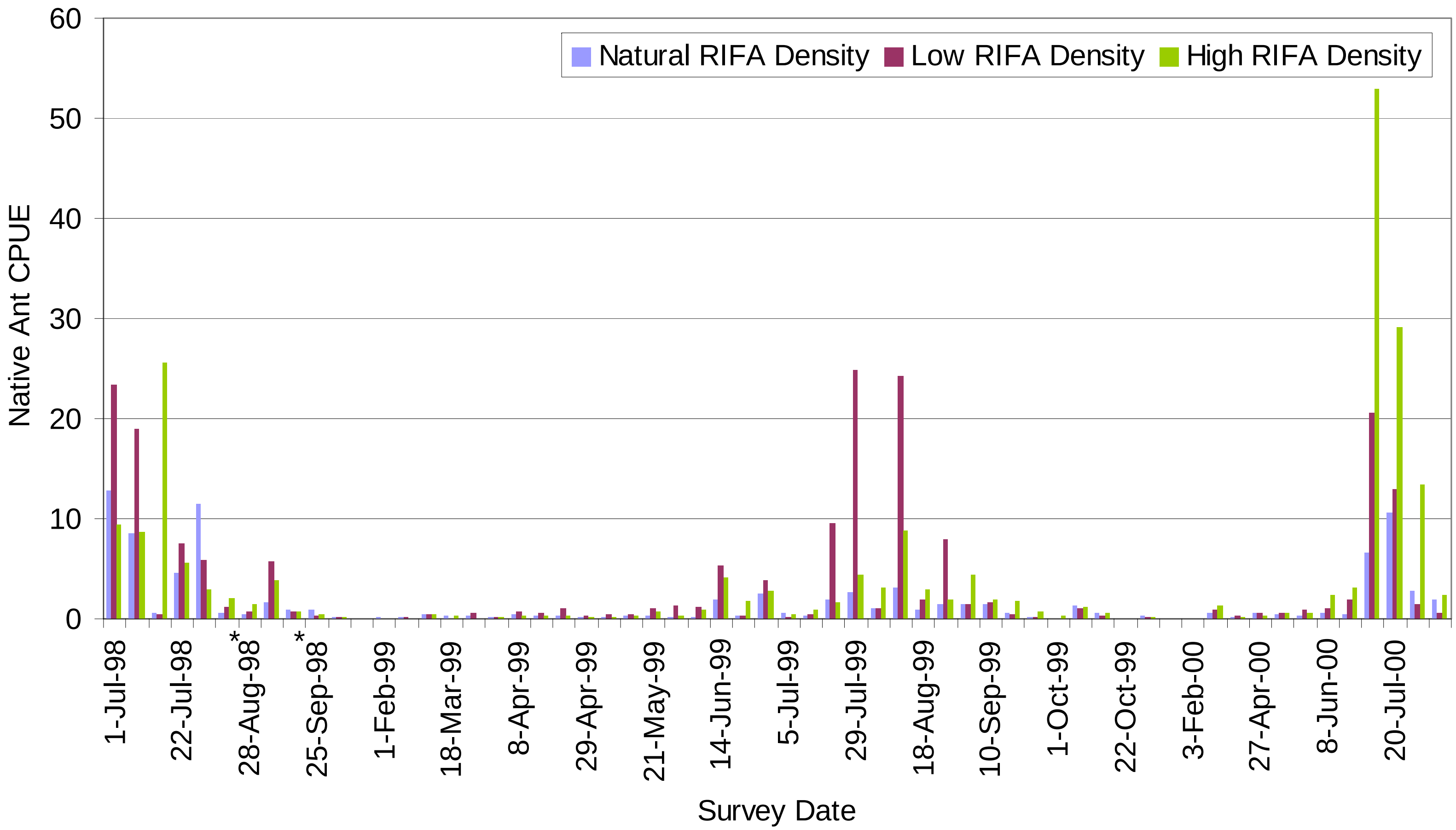

Figure 2—Native ant catch per unit effort per survey date, in each density area. *Tropical storms Charley (20-23 August) and Frances (10-16 September).

period. Although fire ant colonies were added to the high RIFA density area in October 1998, and replaced as needed when the observed colony activity dropped to zero, an increase in the RIFA CPUE was not seen until 1999. Native ant CPUE was higher in the low RIFA density area than in the naturally occurring RIFA density area. The highest native ant CPUEs were found in the high RIFA density area during July 2000.

M. minimum CPUEs are the highest among the native ants in all RIFA density areas, for most of the study period (Figures 3-5). However, for all surveys during September and October, and surveys conducted during August in the naturally occurring RIFA density area, *Paratrechina* sp. have the highest CPUEs.

The relative RIFA densities (naturally occurring, low, and high) needed for the litter removal portion of the study, were first observed during consecutive surveys in late August and early September 1999 (Figure 1). Cold weather in late October 1999 curtailed ant foraging, and the litter removal trials were discontinued. The appropriate relative densities were not re-established in 2000.

In the litter removal trials, which were run between 21 September and 21 October 1999, 4 species of ants were observed in the litter removal station cans. Of the 126 cans of bait used throughout the 14 trials, RIFA was observed as the lone species in 48 cans, *M. minimum* only was found in 7 cans, just *Paratrechina* sp. was in 4 cans, and 1 can contained only *F. pruinosus*. Two cans, which contained multiple species (1 with RIFA and *M. minimum*, 0.3871 g of litter removed; 1 with *M. minimum* and *Paratrechina* sp., 0.0637 g of litter removed), were not used in the calculations of mean mass of litter removed.

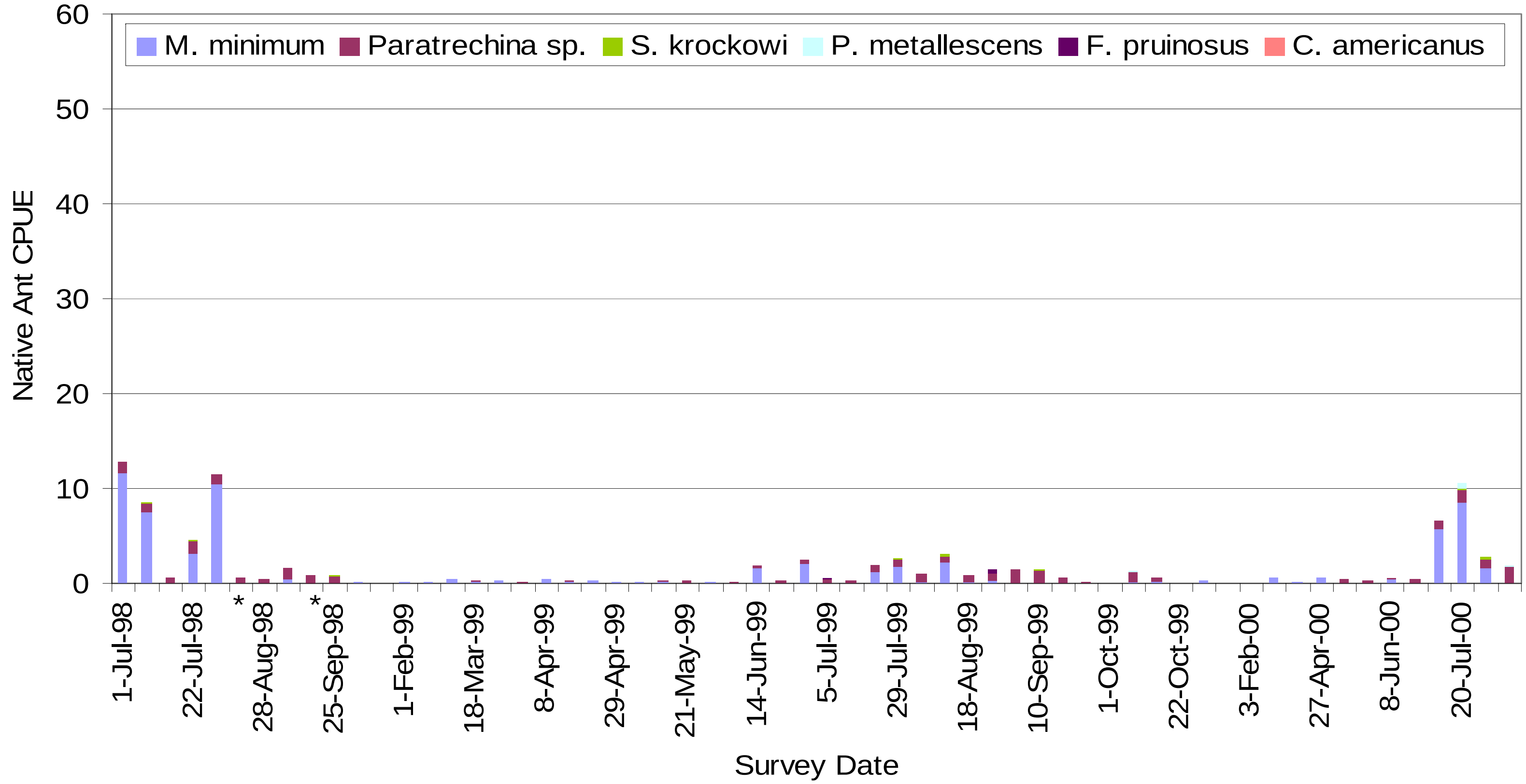

Figure 3—Native ant catch per unit effort per survey date, in the natural red imported fire ant density area, for each native ant species (*Monomorium minimum*, *Paratrechina* sp.—*P. vividula* or *P. terricola*, *Solenopsis krockowi*, *Pheidole metallescens*, *Forelius pruinosus*, and *Camponotus americanus*). *Tropical storms Charley (20-23 August) and Frances (10-16 September).

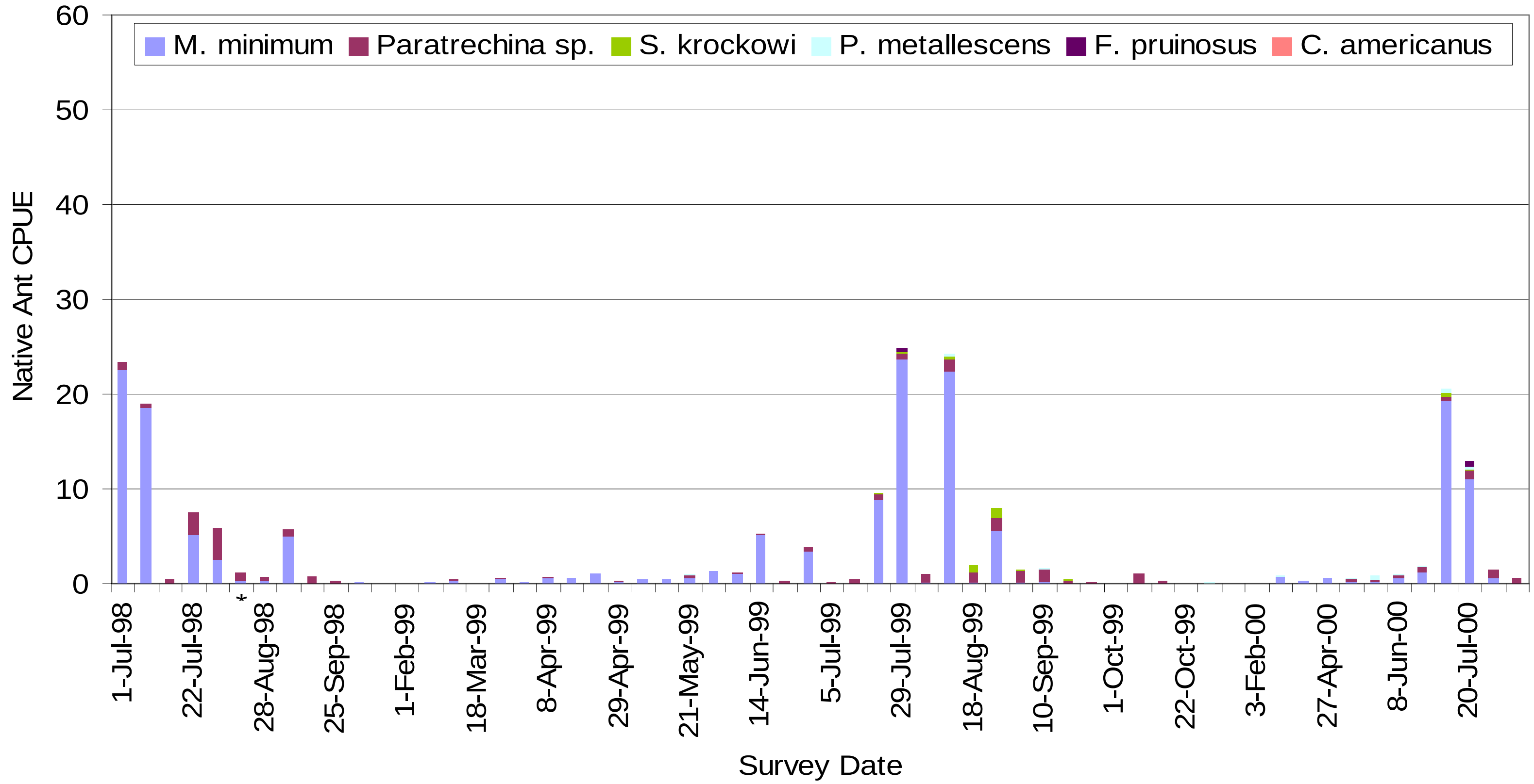

Figure 4— Native ant catch per unit effort per survey date, in the low red imported fire ant density area, for each native ant species (*Monomorium minimum*, *Paratrechina* sp.—*P. vividula* or *P. terricola*, *Solenopsis krockowi*, *Pheidole metallescens*, *Forelius pruinosus*, and *Camponotus americanus*). *Tropical storms Charley (20-23 August) and Frances (10-16 September).

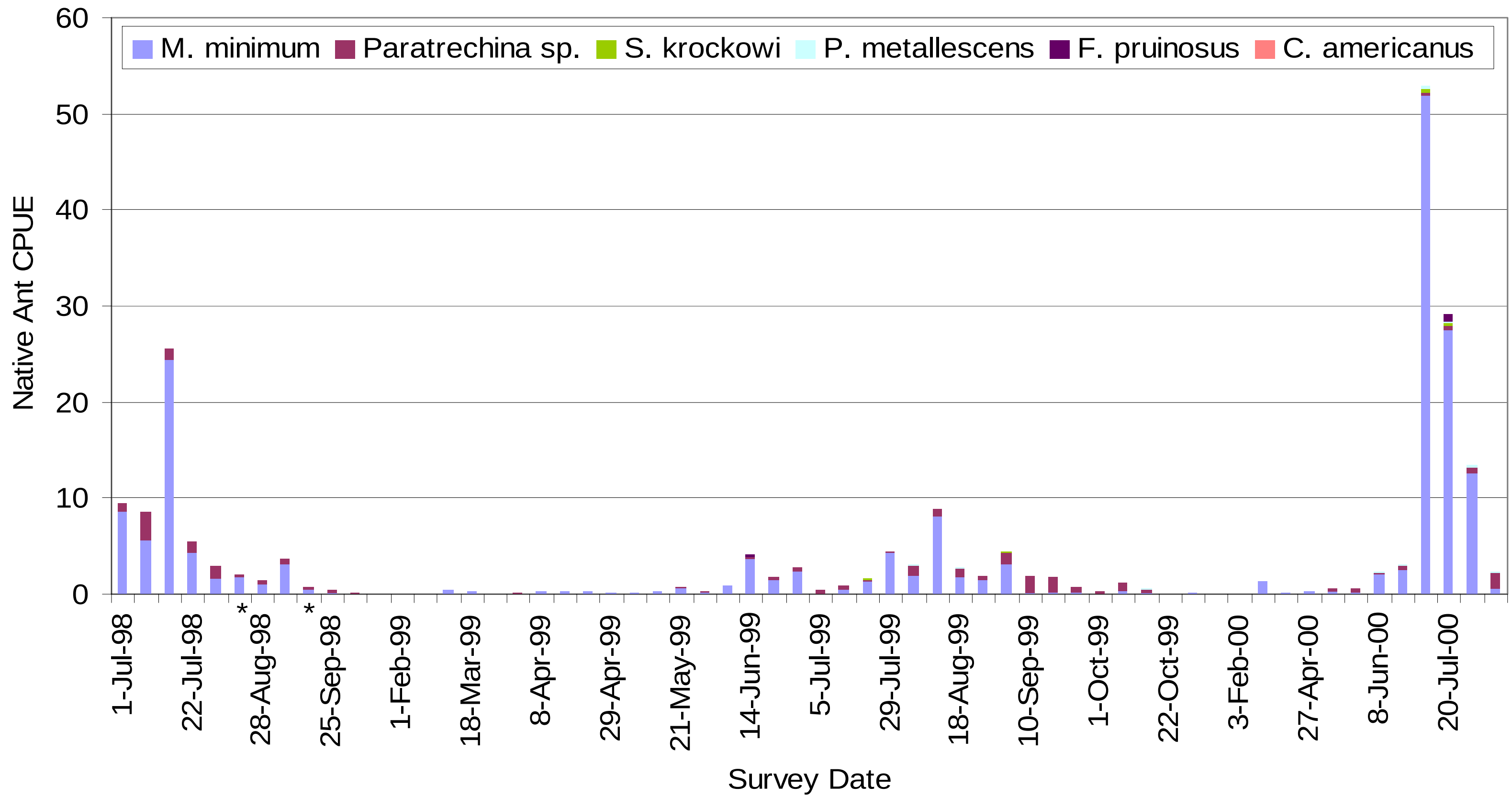

Figure 5— Native ant catch per unit effort per survey date, in the high red imported fire ant density area, for each native ant species (*Monomorium minimum*, *Paratrechina* sp.—*P. vividula* or *P. terricola*, *Solenopsis krockowi*, *Pheidole metallescens*, *Forelius pruinosus*, and *Camponotus americanus*). *Tropical storms Charley (20-23 August) and Frances (10-16 September).

The average mass of litter removed per can was 0.55 g (n = 48, σ = 0.31) for RIFA and 0.16 g (n = 12, σ = 0.04) for native ants (Figure 6). The individual means for the 3 species of native ants observed in the cans were 0.16 g (n = 7, σ = 0.04), 0.14 g (n = 4, σ = 0.03), and 0.22 g (n = 1) of litter removed by *M. minimum*, *Paratrechina* sp., and *F. pruinosus*, respectively (Figure 7).

The mean mass of litter removed per can by RIFA was higher in the high RIFA density area, at 0.75 g (n = 19, σ = 0.31), than in the naturally occurring density area, at 0.42 g (n = 29, σ = 0.24) (Figure 8). While no fire ants were observed during collection of bait from the low RIFA density area litter removal stations, all 3 native ant species were found in the cans. *M. minimum* removed 0.16 g (n = 7, σ = 0.04) of litter per can, *Paratrechina* sp. removed 0.12 g (n = 2, σ = 0.008) per can, and *F. pruinosus* removed 0.22 g (n = 1) (Figure 9). *Paratrechina* sp. (removing 0.15 g of bait per can; n = 2, σ = 0.04) was the only native ant seen in the high RIFA density area. No native ants were in naturally occurring RIFA density litter removal cans.

No cans contained ants of any species during the collection of baits at the end of trial 13 (Figure 10). RIFA was found in cans for all the other trials, which covered all the dates (Figure 11). Native ants were observed in trials: 2 (*M. minimum* and *F. pruinosus*; 22 September), 4 and 5 (*M. minimum*; 23 September and 5 October, respectively), 6 (*Paratrechina* sp.; 5 October), 7 (*M. minimum*; 6 October), 9 (*Paratrechina* sp.; 12 October), and 10 (*M. minimum*; 13 October) (Figures 12 and 13).

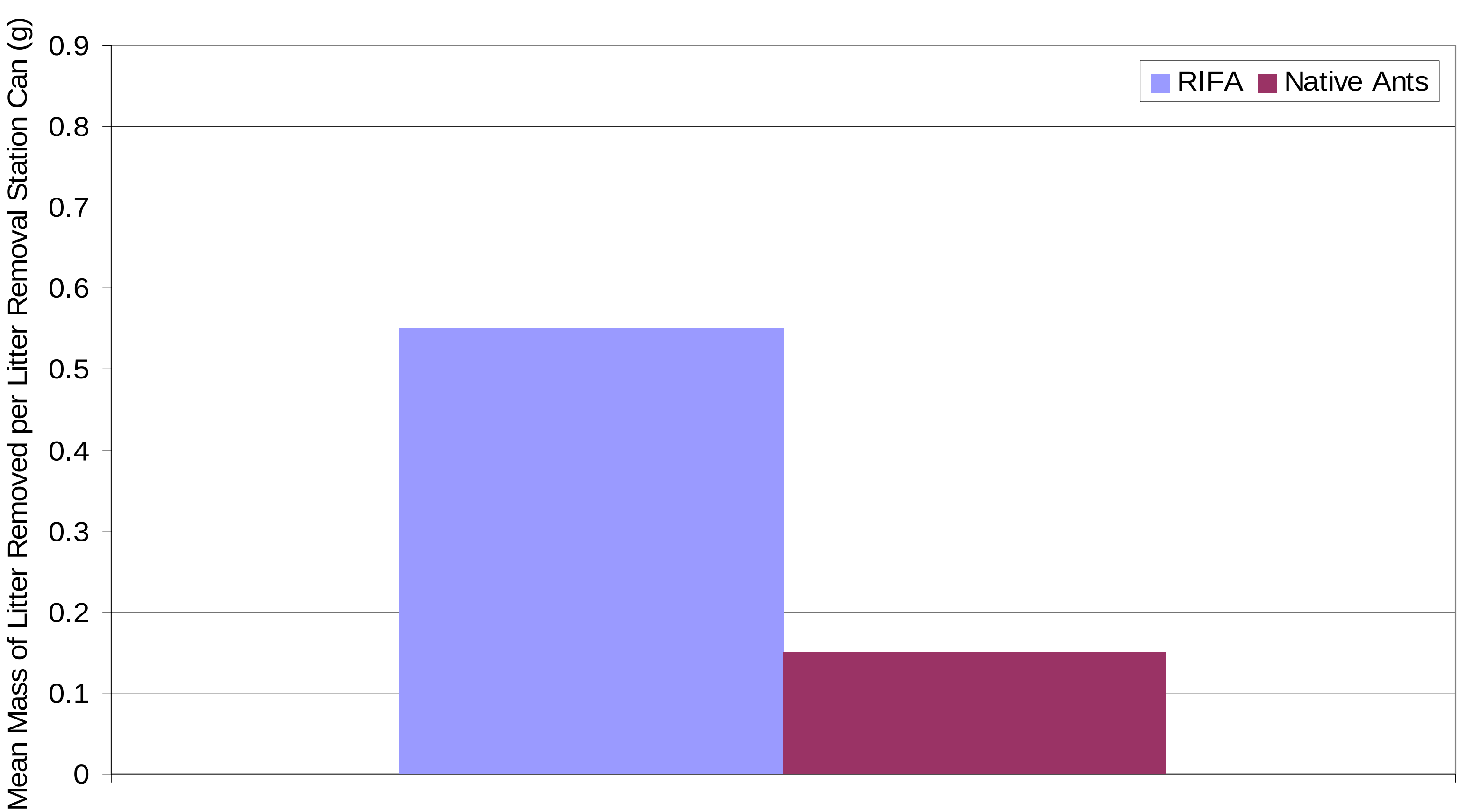

Figure 6—Mean mass of litter removed per litter removal station can, in grams, for red imported fire ants and native ants.

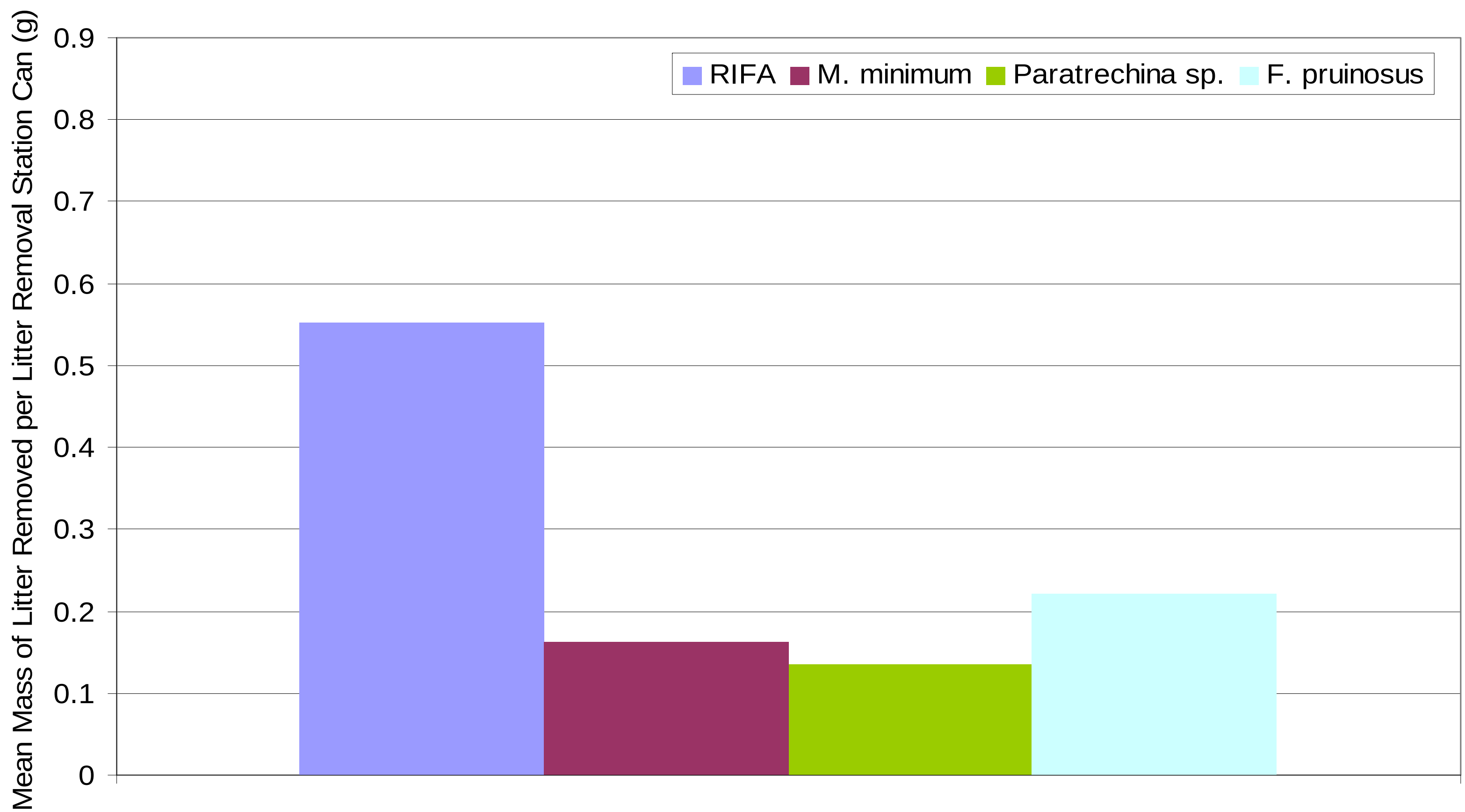

Figure 7—Mean mass of litter removed per litter removal station can, in grams, for red imported fire ants, *Monomorium minimum*, *Paratrechina* species (*P. vividula* or *P. terricola*), and *Forelius pruinosus*.

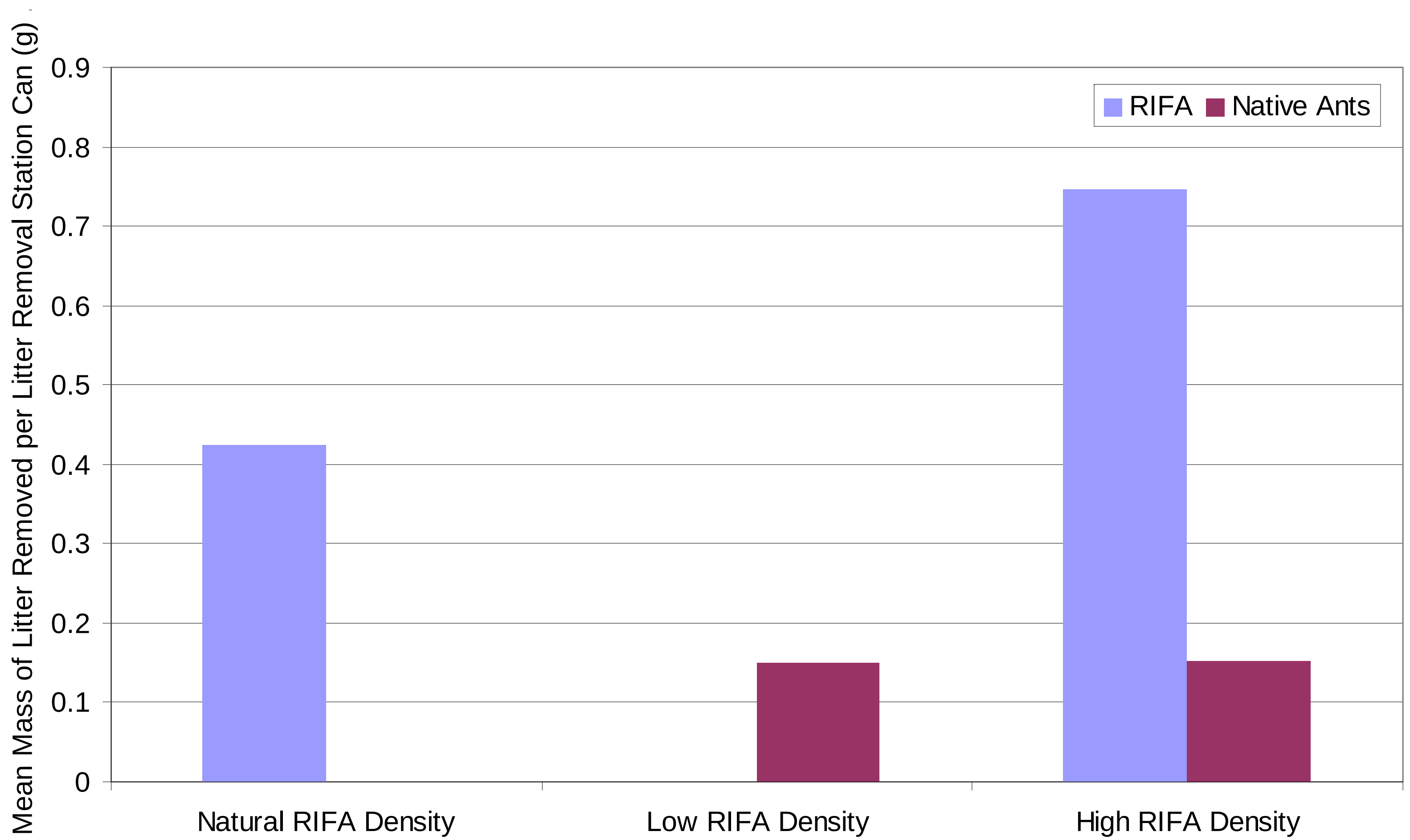

Figure 8—Mean mass of litter removed per litter removal station can, in grams, per red imported fire ant density area, for red imported fire ants and native ants.

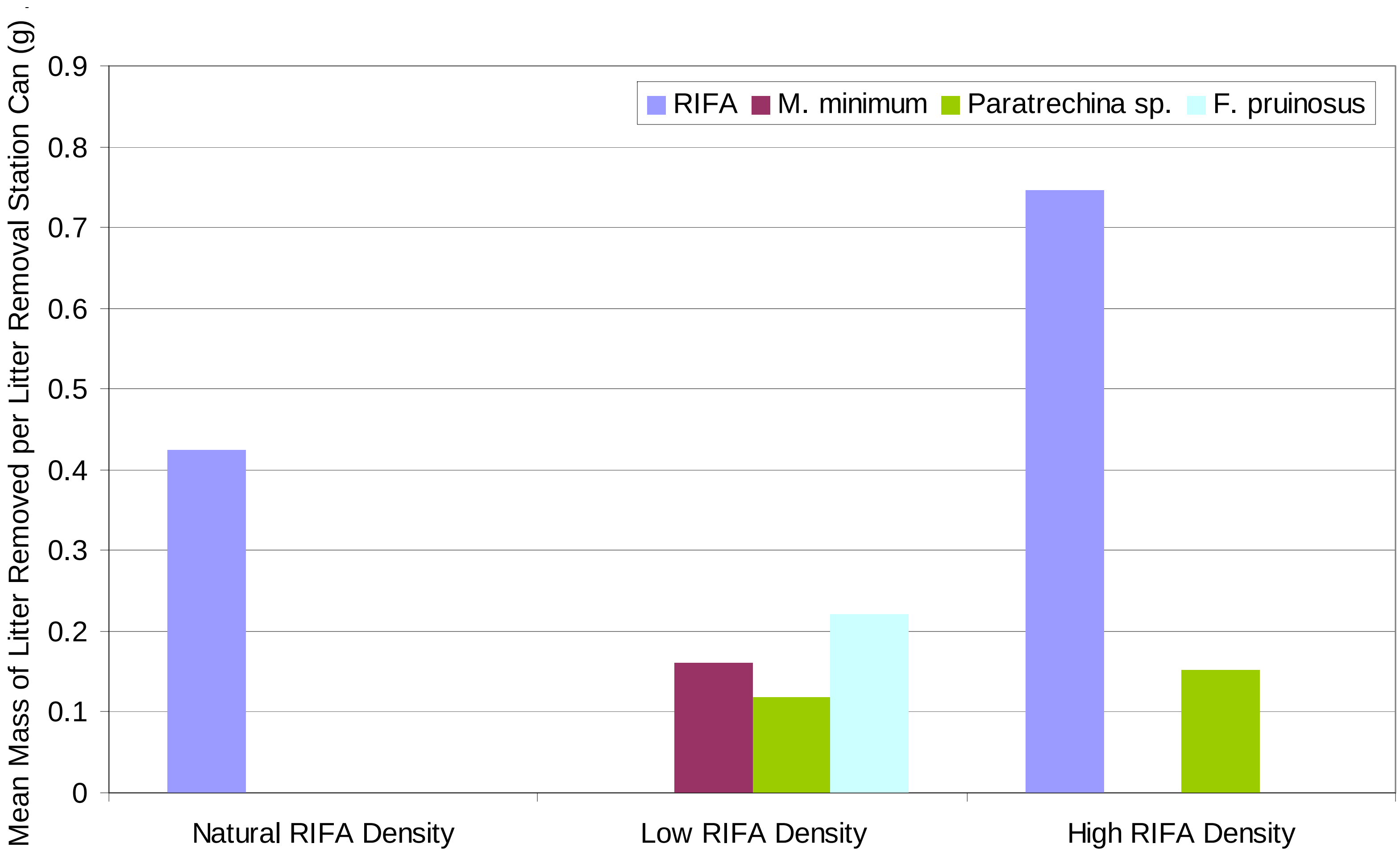

Figure 9—Mean mass of litter removed per litter removal station can, in grams, per red imported fire ant density area, for red imported fire ants, *Monomorium minimum*, *Paratrechina* species (*P. vividula* or *P. terricola*), and *Forelius pruinosus*.

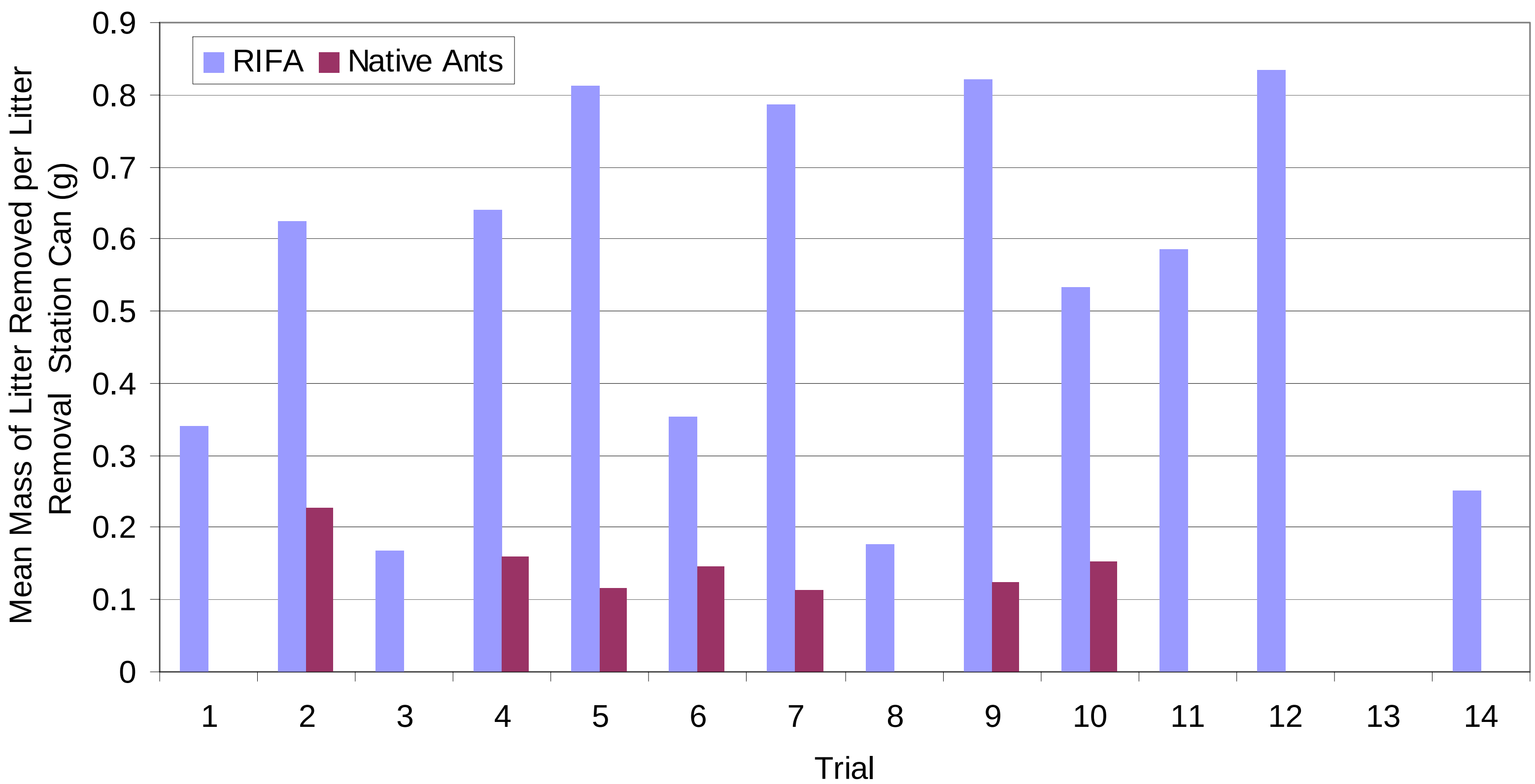

Figure 10—Mean mass of litter removed per litter removal station can, in grams, per trial, for red imported fire ants and native ants.

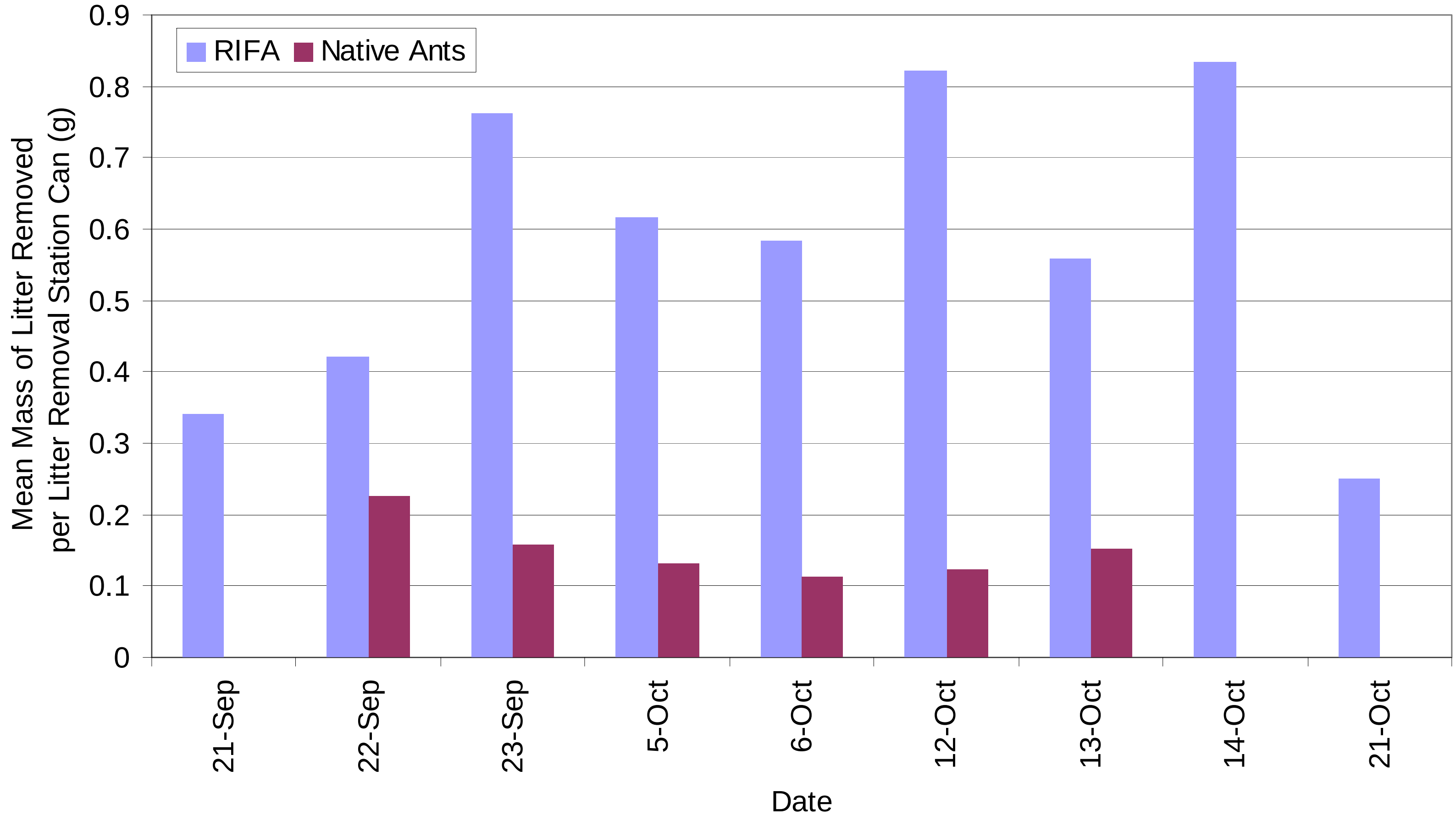

Figure 11—Mean mass of litter removed per litter removal station can, in grams, per trial date, for red imported fire ants and native ants.

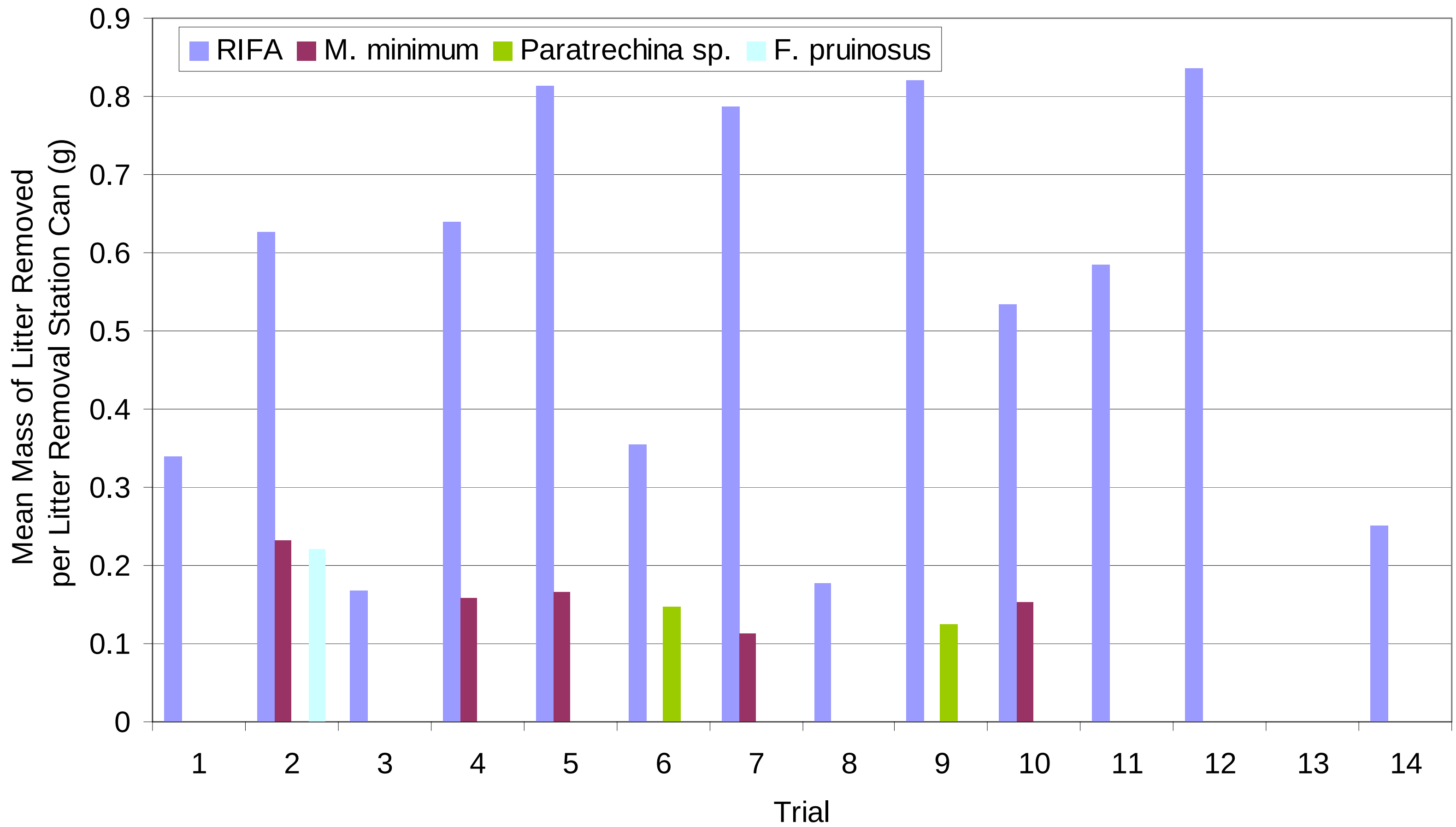

Figure 12—Mean mass of litter removed per litter removal station can, in grams, per trial, for red imported fire ants, *Monomorium minimum*, *Paratrechina* species (*P. vividula* or *P. terricola*), and *Forelius pruinosus*.

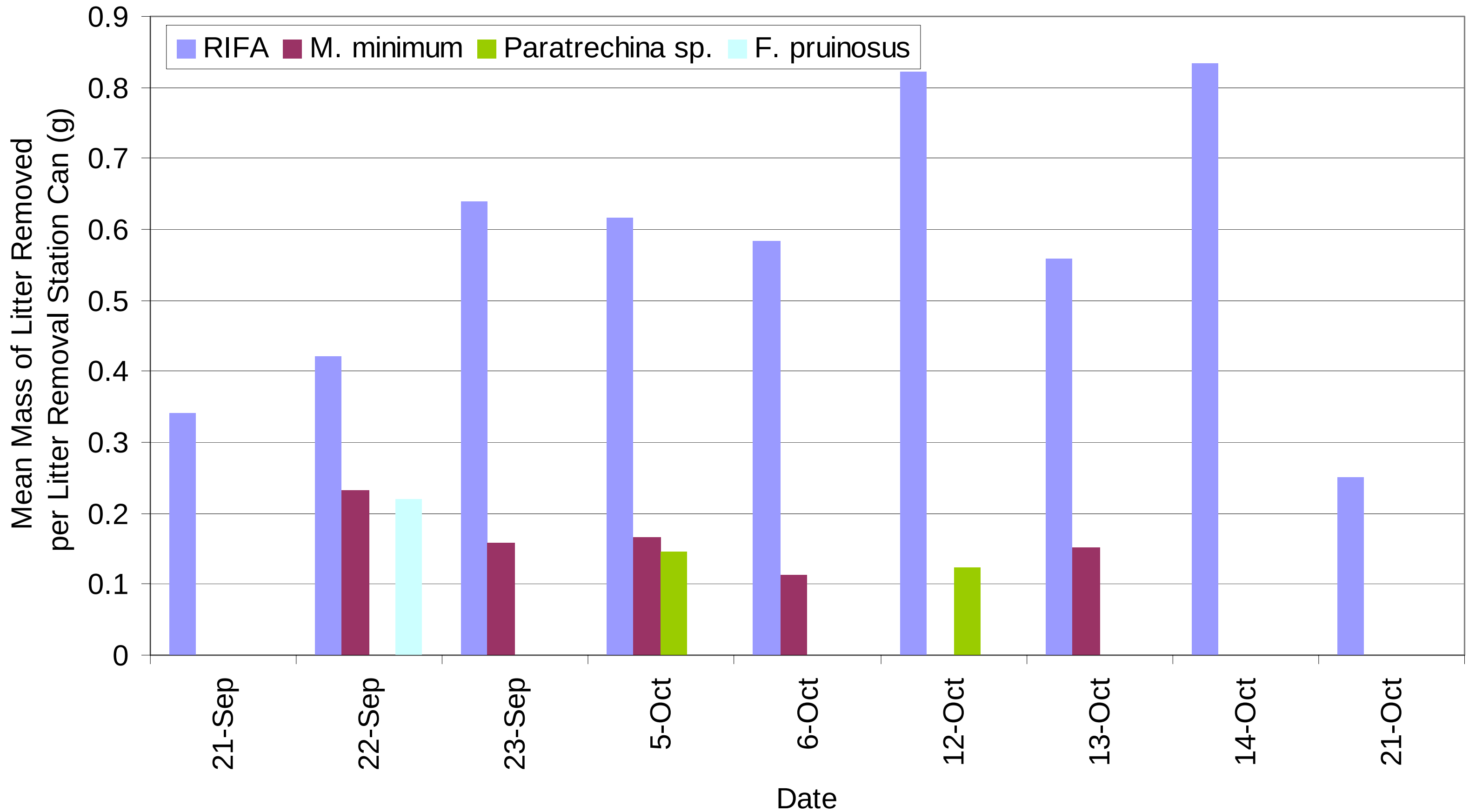

Figure 13—Mean mass of litter removed per litter removal station can, in grams, per trial date, for red imported fire ants, *Monomorium minimum*, *Paratrechina* species (*P. vividula* or *P. terricola*), and *Forelius pruinosus*.

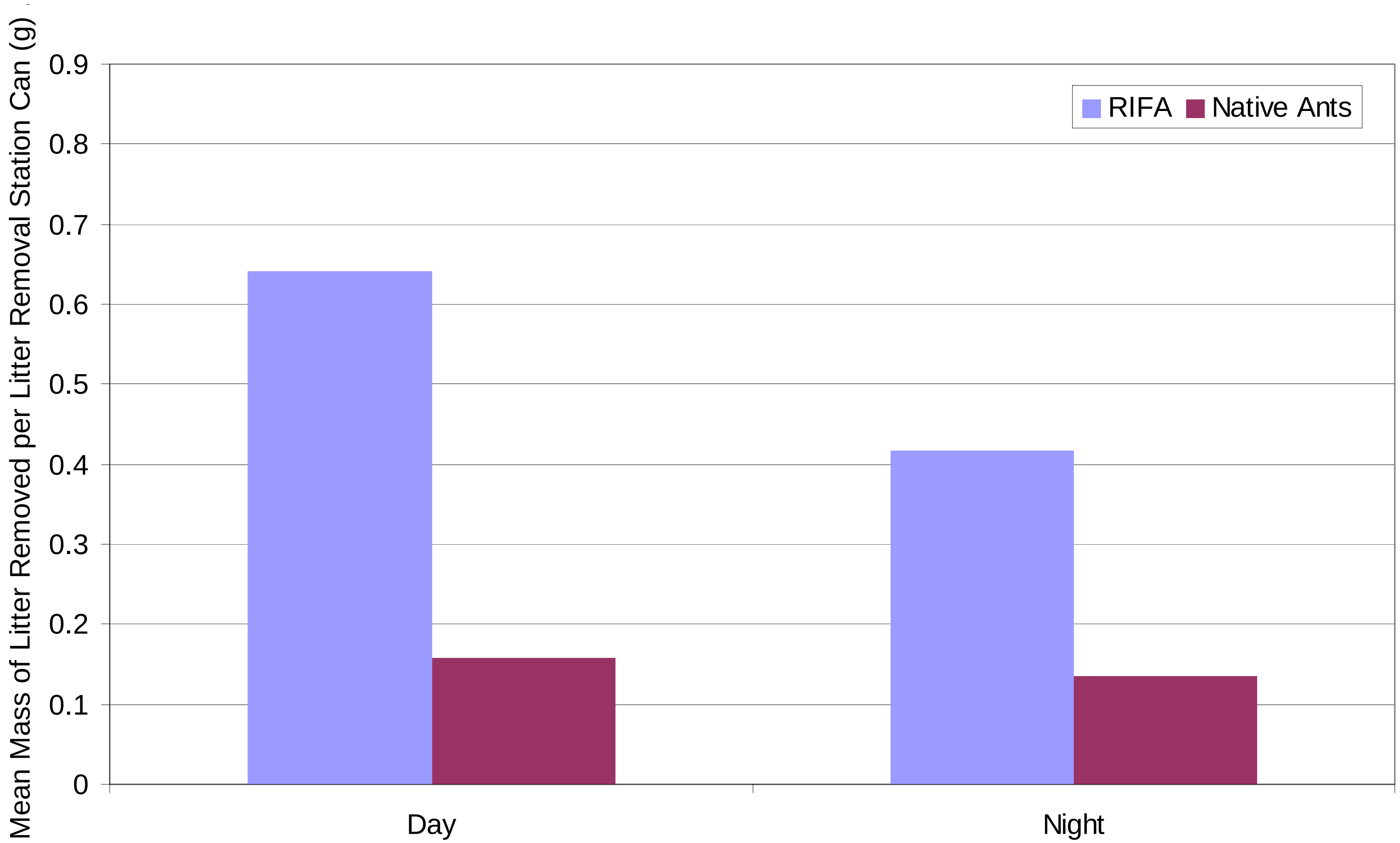

Figure 14—Mean mass of litter removed per litter removal station can, in grams, per period, for red imported fire ants and native ants.

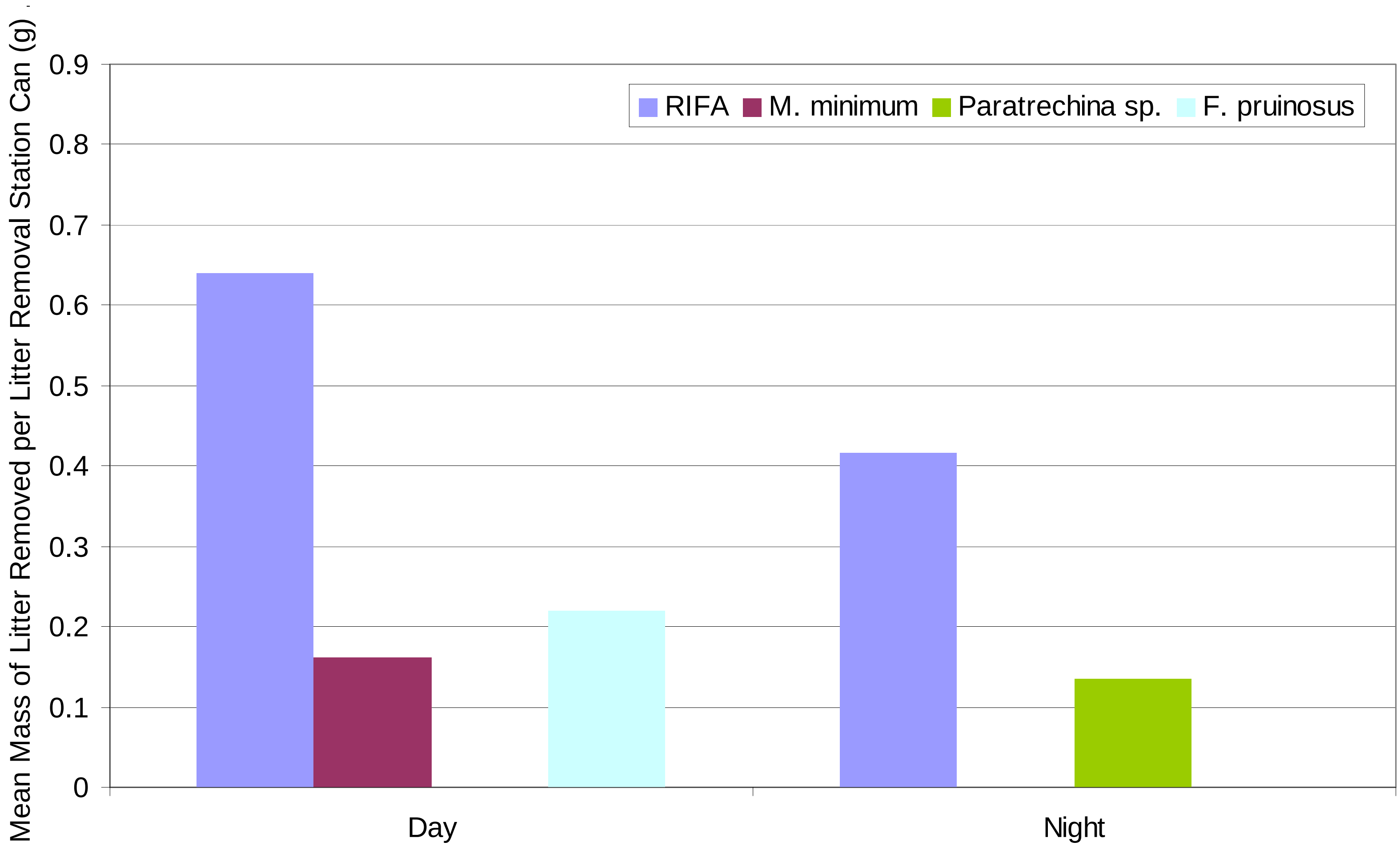

Figure 15—Mean mass of litter removed per litter removal station can, in grams, per period, for red imported fire ants, *Monomorium minimum*, *Paratrechina* species (*P. vividula* or *P. terricola*), and *Forelius pruinosus*.

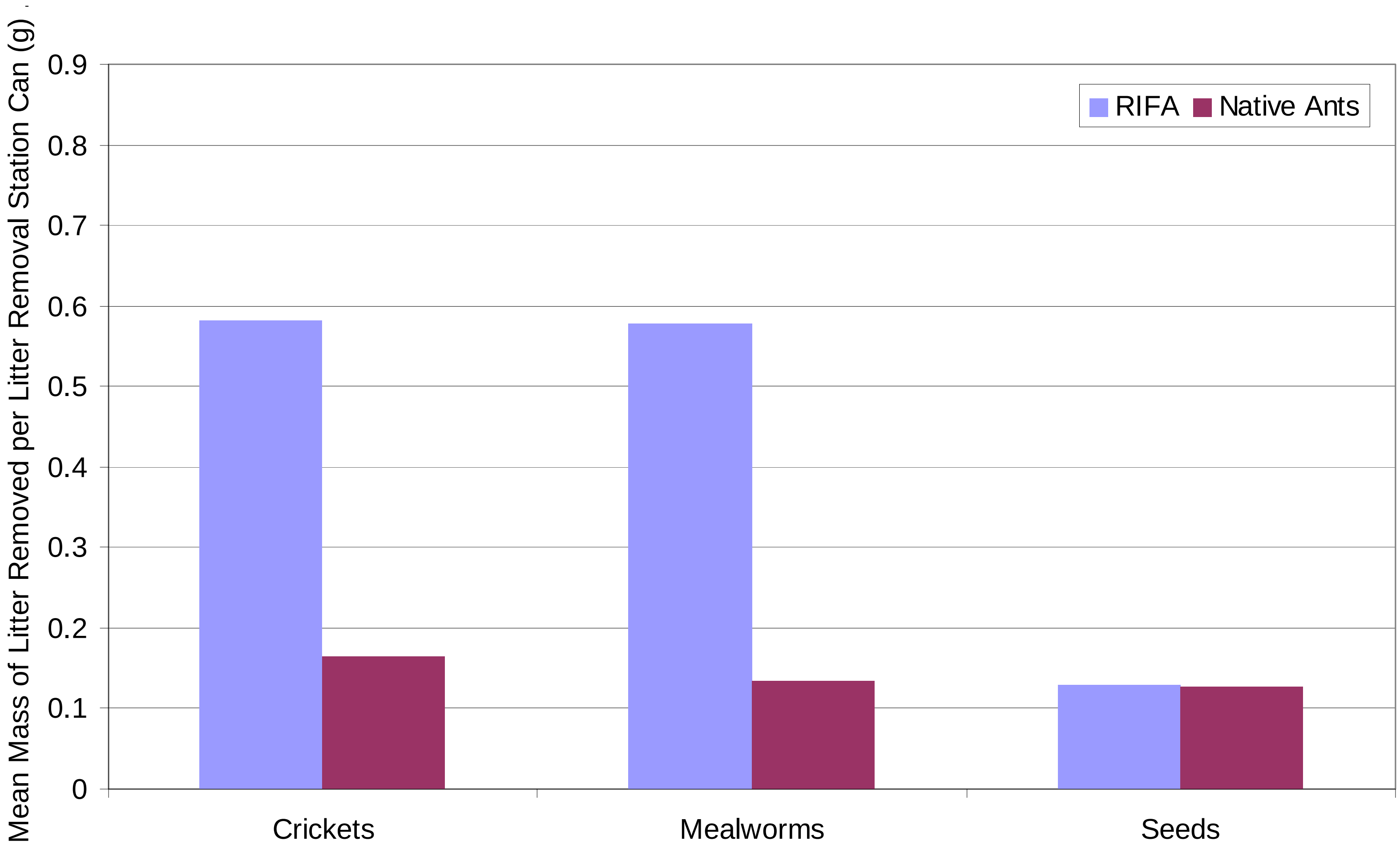

Figure 16—Mean mass of litter removed per litter removal station can, in grams, per bait type, for red imported fire ants and native ants.

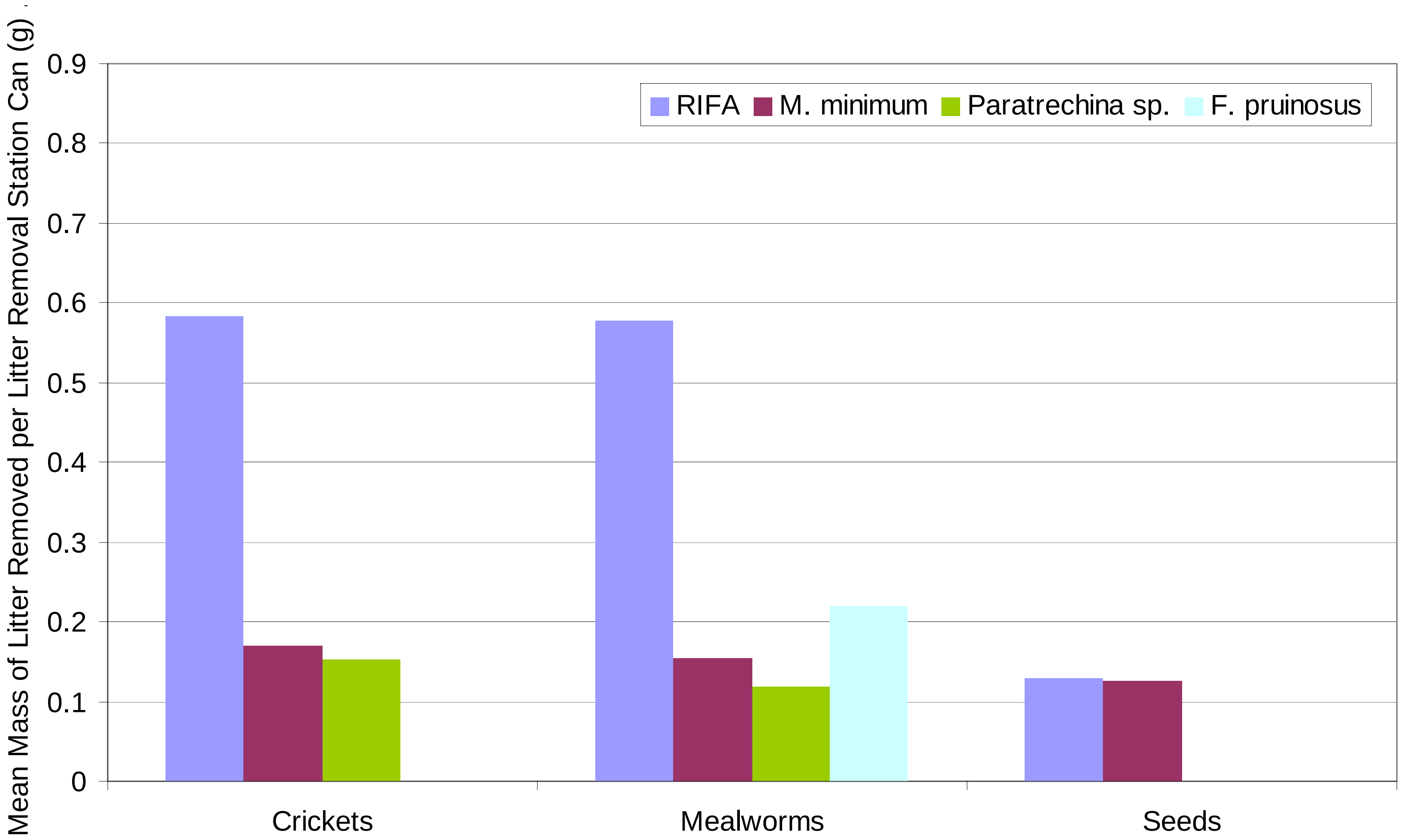

Figure 17—Mean mass of litter removed per litter removal station can, in grams, per bait type, for red imported fire ants, *Monomorium minimum*, *Paratrechina* species (*P. vividula* or *P. terricola*), and *Forelius pruinosus*.

RIFA removed a mean mass of litter per can of 0.64 g (n = 29, σ = 0.31) by day and 0.42 g (n = 19, σ = 0.27) by night, while native ants removed mean masses of 0.17 g (n = 8, σ = 0.04) by day and 0.14 g (n = 4, σ = 0.03) by night (Figure 14). However, only *M. minimum* and *F. pruinosus* was found in day trials, while *Paratrechina* sp. only was observed with night trials (Figure 15).

RIFA removed similar mean masses of crickets (0.58 g; n = 21, σ = 0.33) and mealworms (0.58 g; n = 24, σ = 0.28), but considerably less seeds (0.13 g; n = 3, σ = 0.07) (Figure 16). This mean mass of seed removal was equal to the seed removed by *M. minimum*, the only native ant found in seed bait cans (0.13 g; n = 1) (Figure 17). *M. minimum* also was observed in cricket (0.17 g removed, on average; n = 5, σ = 0.04) and mealworm (0.15 g removed; n = 1) cans, as was *Paratrechina* sp., with 0.15 g (n = 2, σ = 0.04) and 0.12 g (n = 2, σ = 0.008) mean removal for crickets and mealworms, respectively. *F. pruinosus* removed 0.22 g (n = 1) of mealworms, only.

SUMMARY AND DISCUSSION

This study examined the impact of RIFA on habitat use by native ants in the post oak savannah of Brazos County, Texas, by comparing the mean masses of litter baits removed by these ants from 3 areas with different RIFA densities. First, I surveyed the ants, and manipulated the RIFA and native ant populations by using Amdro® and adding RIFA colonies, to establish: (1) an area with a naturally occurring RIFA density, (2) an area with a low density of RIFA, and (3) an area with a RIFA density that was higher than what occurred there naturally. Once I established these relative RIFA densities, I placed baits in litter removal stations located in the 3 areas, and measured the masses of litter remaining after 12-hour trials. I calculated the mean masses removed by RIFA, native ants, and each species of ant: (1) for the entire experiment, (2) in each density area, (3) during the 14 trials, (4) on each date, (5) for both day and night exposures, and (6) for the 3 baits used.

The ant surveys ran from 1 July 1998 to 11 August 2000. The initial numbers of RIFA collected in the 3 areas were very different, perhaps due to variations in vegetation composition. McCartney rose, *Rosa bracteata*, an invasive woody plant, was found in greater numbers in the high RIFA density area, and was thinned to resemble the other 2 areas. In addition, beginning within an hour of sunrise, each ant survey was conducted in the same sequence: first the natural RIFA density area, then the low RIFA density area, and lastly the high RIFA density area. Ant foraging varies with temperature (Baroni Urbani and Kannowski 1974, Claborn and Phillips 1986, Porter and Tschinkel 1987, Claborn et al. 1988, Stein and Thorvilson 1989, Jusino-Atresino and Phillips

1994, Helms and Vinson 2005). Ants that forage in warmer temperatures, which are observed as the day progresses, would be collected in larger numbers, and vise versa. Thus, *M. minimum* and *F. pruinosus* numbers would rise, and RIFA and *Paratrechina* sp. numbers would decrease. Therefore, the initial RIFA density may have been more uniform throughout the study site than it appears in Table 2 and Figure 1.

Seasonal variation in temperature may account for the *Paratrechina* sp. CPUEs being greater than *M. minimum* CPUEs in September and October, and during the early morning in the natural RIFA density area collections in August (Figures 3-5). Cooler months and early mornings would favor a species such as *Paratrechina* sp., which forages during cooler temperatures.

The Amdro® treatments immediately reduced RIFA numbers in the low density area, and RIFA CPUE remained low there, relative to the other areas, for the duration of the study. Amdro's® effects on the native ants in the high density area were not as pronounced. So, beginning in October 1998, polygyne (based on head capsule measurements; Greenberg et al. 1985) RIFA colonies were added to that area, in an effort to increase the fire ant density. Also, Amdro® treatments were discontinued there, after the treatment following the bucket colonies' installation, because RIFA were being recruited to the Amdro® too, thus reducing the intended treatment effect of increasing RIFA density. Cooler weather soon reduced all foraging activity until the following spring.

Higher than natural RIFA CPUE was first seen and maintained in the third density area, in late August 1999, at which time preparations were begun for the litter removal experiment. Litter removal trials were conducted until cooler weather again reduced ant foraging activity. The relative RIFA densities necessary for the litter removal trials were not seen again during the remainder of the study. This, again, could be a reflection of survey sequence for the 3 areas, where RIFA foraging, and therefore RIFA CPUE, decreases as the day progresses and temperatures increase.

Of the 126 litter baits that were placed in the "tin" cans during the study period, only 60 baits had a single ant species (48 had RIFA, 7 had *M. minimum*, 4 had *Paratrechina* sp., and 1 had *F. pruinosus*) on them at the end of the 12-hour exposure period, and were used in calculating the mean mass of litter removed.

The mean mass of litter removed by RIFA during the entire experiment was greater than the mean mass removed by all native ants combined. RIFA not only discovers food sources quicker than many native ant species, it recruits large numbers of foragers to the food source, and thus removes food more quickly (Holway at al. 2002).

Each trial had its unique weather conditions. Nights were cooler than days, and the temperatures in October were lower than those in September. Mornings in October had heavy dew on the ground, while trials during September had none. Generally the mean mass of litter removed for night trials and those later in the season were lower than the day trials and those in September. The exception was trial 9, a night trial, which had the second highest mean mass of litter removed by RIFA. The temperature recorded during the placement of the bait for that trial was 36.6˚C, which was the highest temperature recorded during the bait removal study. The low of 17.2˚C for trial 9 was the highest low. The optimal temperature for RIFA foraging (28.3˚C, Cokendolpher and

Francke 1985) was maintained longer throughout the night; therefore, a larger amount of litter could be removed.

Native ants did not remove litter during all trials. When native ants were observed in the bait cans, *M. minimum* and *F. pruinosus* were present only during day trials, while *Paratrechina* sp. were present only during night trials.

This study's purpose was to compare litter removal by RIFA and native ants within the 3 RIFA density areas. RIFA was not observed in the bait cans in the low density area. Native ants were not found in the bait cans in the natural density area. Therefore the amount of litter removed by these ants is not equal in the 3 RIFA density areas, and the null hypothesis is rejected. RIFA does have an effect on habitat use by native ants, in this study.

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APPENDIX

Ten specially designed buckets were used to transplant additional colonies of RIFA into the area with high fire ant density. Holes were drilled into the lid (2), bottom (2), and lower edge (4) of each 22.7-L plastic bucket. On the inside of the buckets, wire-mesh screen was stapled over each 5-cm hole, fiberglass resin was applied to the screen edges, and hot glue was applied along the edge of the drilled hole, to seal the screen. Workers would be able to enter and exit the bucket through the mesh; however, the queens would be too large to fit through. The bottoms of the buckets were lined with 6-8 cm of river gravel, to help with the drainage of rainwater.

On 29 October 1999, polygyne colonies acquired from various locations in Brazos, Burleson, and Montgomery counties were placed, soil and all, in the buckets. After the lids were pounded into place, the buckets were sealed with duct tape, and transported to the field site.

The buckets were checked periodically for RIFA activity. If there was no sign of RIFA present (or very low numbers for several weeks), the bucket was opened and the soil was examined for live and/or dead RIFA. Replacement colonies were added to empty buckets. All replacement colonies were dripped, and ant head-capsules were measured in the ERL. Then the colonies were transported to the field in clear plastic shoe boxes, and placed in the empty buckets.

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