Oraze, M. J., A. A. Grigarick, J. H. Lynch and K. A. Smith. 1988. Spider fauna of flooded rice fields in northern California. J. Arachnol., 16:331-337.

SPIDER FAUNA OF FLOODED RICE FIELDS IN NORTHERN CALIFORNIA

Michael J. Oraze, Albert A. Grigarick, Joseph H. Lynch and Kirk A. Smith

Department of Entomology
University of California
Davis, California 95616 USA

ABSTRACT

A survey of the spiders associated with northern California rice fields was conducted to identify potential biological-control agents of rice feeding insects and mosquitoes. All of the 28 species were collected on the levees; however, only 10 of these were taken in the paddies. *Pardosa ramulosa* (McCook), *Pirata piraticus* (Clerck) and two linyphiid spp. were common throughout the agroecosystem. These spiders exhibited a seasonal succession in relative abundance within the paddy during the growing season. *Pardosa ramulosa* was dominant both on the levees and in the paddies. It comprised ca. 58 and 68% of the fauna in these respective areas. We suggest that the flooded paddies may serve as a refuge for the semiaquatic *P. ramulosa* during the dry summer months and that its abundance in California rice fields is due in part to the similarity of this agroecosystem to the native, pre-agricultural habitat.

INTRODUCTION

Rice, *Oryza sativa* L., was introduced into California in 1912 and is now grown annually on about 161,880 ha (400,000 acres). Rice production is a major industry in the Sacramento Valley where more than 90% of the rice acreage in the state is located. A rice field is a complex agroecosystem, containing many aquatic, semiaquatic, and terrestrial species. Spiders are well represented among the many predators found in this habitat. They feed mostly on insects and may contribute in reducing pest levels. Lower pest densities have been attributed to spider activity in rice fields of Asia (Kiritani 1979) and other agroecosystems worldwide (Riechert and Lockley 1984).

Numerous surveys of spiders have been conducted in the rice growing regions of Asia (Barrion and Litsinger 1984). However, little is known about spiders associated with rice in the United States. Preliminary surveys have been conducted in Texas (Woods and Harrell 1976) and Arkansas (Heiss and Meisch 1985), but no attempt has yet been made to formally describe the California rice field fauna. This paper identifies the spiders collected from the levees and flooded paddies of several California rice fields over a three year period.

MATERIALS AND METHODS

Sampling began in 1983 at the following locations: the Beck ranch near Modesto (Stanislaus County), Van Dyke ranch near Natomas (Sutter County), and in the Lattemore seed-field section of the Rice Expriment Station near Biggs (Butte County). Sampling efforts in 1984-1985 were limited to the Biggs site after it was determined the three areas yielded nearly identical results with respect to common species.

The California rice field habitat and associated common vegetation were described by Barrett and Seaman (1980). Notable differences in vegetation among sampling sites used in this study included dense populations of common cattail (*Typha latifolia* L.) and bermuda grass (*Cynodon dactylon* (L.) Pers.) on the levees at the Modesto and Natomas sites, respectively, but not at Biggs. Monochoria (*Monochoria vaginalis* (Burm. f.) Presl.) and toothcup (*Rotala indica* (Willd.) Koehne) were restricted to and abundant in the paddies at the Rice Experiment Station.

Wide mouth Mason jars (11 cm deep and 7.5 cm in diameter) served as pitfall traps. They were inserted into plastic sleeves that were permanently buried in the levees flush with the soil surface. Ten traps were installed at each site at ca. 8 m intervals in an alternating pattern (north side, center, south side, etc.) along the length of a levee in selected fields. One hundred and fifty ml of 95% ethylene glycol plus 5% liquid detergent was added to each trap. After seven days, the traps were collected. The contents were filtered through a USA Standard Testing Sieve No. 40 and stored in 70% EtOH. This procedure was repeated monthly throughout the growing season (May-September).

Floating sticky traps were made by cutting white styrofoam into triangular wedges 61 cm long, 4.5 cm high, with bases of 9 cm. A thin coat of Stickem Special™ (Seabright Enterprises Ltd.; Emeryville, CA) was brushed on the upper surfaces. Five traps were placed in each field and positioned equidistant from one another (ca. 34 to 92 m apart depending on field size) along a transect connecting the NE and SW corners of the field with the end traps being placed 2 m from the margins. They were held in place with green bamboo stakes in a manner that allowed the traps to move vertically so contact with the fluctuating water surface could be maintained. The stakes also served to mark the position of the traps. After seven days, the traps were collected and the spiders identified (to species when possible) with the aid of a 10X hand lens. The sampling schedule was the same as that for the pitfall traps.

Companion samples were taken in 1983 with a UC-VAC® suction device (Summers et al. 1984) to estimate absolute densities and determine the nature and extent of any bias associated with pitfall and sticky-trap sampling. Ten samples ca. 10 m apart were collected both on the levees and in the paddies. A circular unit-area-sampler, enclosing 0.093 m^2 (1 $ft.^2$) and standing 38 cm (15 in.) high, was placed in the general vicinity of the pitfall and floating sticky traps. The enclosed substrate and vegetation were vacuumed for ca. 90 s. Sampling was conducted between 1200 and 1400 hours. Samples were immediately placed in a cooler with ice for transport, and later processed in Berlese funnels for 48 h.

RESULTS AND DISCUSSION

More than 30,000 specimens were collected in the survey. Species that were taken at all sampling sites in every year—representing 11 families, 22 genera and 28 species—are listed in Table 1. They have been ranked as 4 common, 2

Table 1.—Spiders collected in northern California rice fields (1983-85). a = L, levee; P, paddy. b = R = rare (< 1%); O = occasional (1-5%); C = common (> 5%). Species frequencies determined by averaging counts from UC-VAC (levee) and pitfall-trap samples.

Taxa	Location[a]	Frequency[b]
Dysderidae		
Dysdera crocata C. L. Koch	L	R
Linyphiidae Erigoninae		
Species A	L,P	C
Species B	L,P	C
Araneidae		
Araneus trifolium (Hentz)	L,P	R
Argiope aurantia Lucas	L,P	R
Argiope trifasciata (Forskal)	L,P	R
Tetragnathidae		
Tetragnatha elongata Walckenaer	L,P	R
Tetragnatha laboriosa Hentz	L,P	R
Lycosidae		
Alopecosa kochi (Keyserling)	L	R
Pardosa ramulosa (McCook)	L,P	C
Pirata piraticus (Clerck)	L,P	C
Oxyopidae		
Oxyopes salticus Hentz	L	R
Gnaphosidae		
Drassyllus insularis (Banks)	L	R
Drassyllus saphes Chamberlin	L	R
Micaria sp.	L	R
Trachyzelotes lyonneti (Audouin)	L	R
Urozelotes rusticus (L. Koch)	L	R
Zelotes puritanus Chamberlin	L	R
Thomisidae		
Xysticus californicus Keyserling	L	R
Philodromidae		
Tibellus oblongus (Walckenaer)	L,P	O
Salticidae		
Habronattus klauserii (Peckham & Peckham)	L	R
Metaphidippus vitis (Cockerell)	L	R
Neon ellamae Gertsch & Ivie	L	R
Phidippus californicus Peckham & Peckham	L	R
Phidippus clarus Keyserling	L	R
Phidippus johnsoni (Peckham & Peckham)	L	R
Sitticus dorsatus (Banks)	L	R
Dictynidae		
Tricholathys saltona Chamberlin	L	O

occasional and 22 rare species. All 28 species were collected on the levees (including vegetation) but, only 10 of the species were taken in the paddy. Apparently many of the levee species were incapable of inhabiting an aquatic microhabitat. Only four species—*Pardosa ramulosa* (McCook), *Pirata piraticus* (Clerck) and two linyphiid spp.—were common in the paddy. Other spider species occasionally found in the paddy were generally limited to the paddy margins late in the growing season after the crop canopy had filled in enough to allow plant-to-plant movement and provide adequate sites for web attachment. The four common paddy spiders also dominated the levee fauna.

The number of taxa recorded are generally lower than those reported for other surveys (Paik and Kim 1973). This can be attributed in part to our exclusion of

Table 2.—Relative abundance in percent composition of the major spiders in northern California rice fields. a = 1983; b = Pitfall or sticky-trap catches from 1983-1985.

Taxa	Levee		Paddy	
	UC-VAC[a] (n = 1,099)	Pitfall[b] (n = 16,311)	UC-VAC[a] (n = 614)	Sticky[b] (n = 12,124)
Linyphiid spp.	12.9	3.4	19.3	5.1
Pirata piraticus	8.4	4.0	11.4	6.4
Pardosa ramulosa	57.7	75.2	67.5	87.4
Others	21.0	17.4	1.8	1.1

transient species (species not collected at every sampling site in every year, usually represented by a single specimen). Even so, comparisons of this type may be misleading, as great differences exist among the surveys in terms of the extent and methods of sampling. For example, Woods and Harrell (1976) collected 752 specimens from a single 14.8 ha (37 acre) field during one growing season. In contrast, Barrion and Litsinger (1984) collected 13,270 specimens from 17 localities over three years, and Okuma (1968) collected 1,487 spiders from 22 localities during a 10 day period. Furthermore, Heiss and Meisch (1985) sampled with an aquatic net and metal dipper but Okuma and Wongsiri (1973) utilized a sweep net and observations.

In spite of these differences, three families: Araneidae, including Tetragnathidae; Linyphiidae, including the Erigoninae (Micryphantidae) and Lycosidae dominated the spider fauna in all but one of the surveys of rice fields cited in this paper. In addition, the relative abundances of these families changed with latitude. In semitropical rice-growing areas, such as Taiwan, Thailand and the Philippines, araneids dominated (Okuma 1968; Chu and Okuma 1970; Okuma and Wongsiri 1973; Barrion and Litsinger 1984) while lycosids were more abundant in temperate regions such as Korea and the United States (Paik and Kim 1973; Woods and Harrell 1976; Heiss and Meisch 1985; present study). Lycosids and araneids were also abundant in the rice fields surveyed in Japan, although the fauna was dominated by two theridiid spp. (Paik and Kim 1973).

Pardosa ramulosa was dominant in numbers on the levees and in the paddies (Table 2). It comprised ca. 58 and 68% (UC-VAC samples) of the fauna in these respective areas. The two lycosids, *Pardosa ramulosa* and *Pirata piraticus*, together constituted ca. 80% (UC-VAC samples) of the paddy spiders. They appeared to be well adapted to the water surface where they quickly ran about or remained motionless for long periods. They occasionally went underwater by crawling down emergent vegetation or debris. Other paddy spiders, although capable of limited locomotion on the water surface, spent most of their time on vegetation or in webs constructed among the paddy plants. Linyphiids were also seasonally abundant. However, their contribution to total spider biomass over the growing season was relatively small, compared to that of the common lycosids, because of their small size and ephemeral occurrence.

Sticky and pitfall-trap samples probably overestimated *Pardosa ramulosa* while underestimated linyphiids and *Pirata piraticus* abundances compared to UC-VAC samples (Table 2). Although fewer spiders were collected with the UC-VAC, these data were probably more accurate in estimating relative abundances for the major species. The UC-VAC was not used more extensively because of the much greater

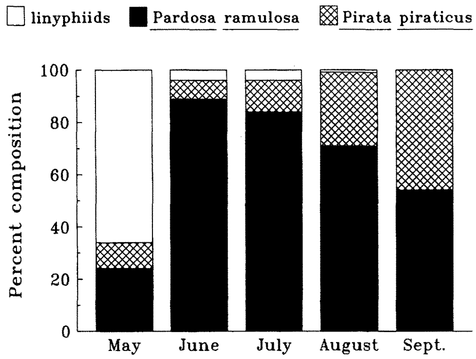

Fig. 1. Relative seasonal abundance of the major paddy spiders in northern California rice fields for 1984 (sticky-trap catches).

relative time and effort it required. Foliage dwelling species such as *Tibellus oblongus* (Walckenaer) were only collected with the UC-VAC whereas nocturnal ground dwellers such as the dictynids and gnaphosids were limited to pitfall traps. This illustrates the importance of utilizing multiple collecting techniques in faunal surveys of spiders.

The major paddy spider species exhibited a seasonal succession in relative abundance during the growing season (Fig. 1). The linyphiids dominated the spider fauna in the paddies shortly after flooding. Their abundance was associated with the spring ballooning period when they arrived in massive numbers. Unlike the other two major paddy species, the linyphiids do not appear to be specifically adapted for, or restricted to, aquatic environments.

Pirata piraticus is distributed throughout Europe and north of the 35th parallel in North America. It is associated with swamps, marshes and the shores of lakes, ponds and streams (Wallace and Exline 1977). It became a major component of the paddy fauna late in the growing season.

Pardosa ramulosa is found throughout California. Its range extends E through southern Nevada into the SW corner of Utah and S into northern Mexico. In California it is one of the dominant lycosids at elevations below 300 m (Hydorn 1977). It is associated with mesic habitats such as salt marshes (Garcia and Schlinger 1972; Greenstone 1980), sewage oxidation ponds (Hydorn 1977), irrigated lawns (Van Dyke and Lowrie 1975) and irrigated crops (Leigh and Hunter 1969; Yeargan and Dondale 1974; Hickle 1981). The prevalence of *P. ramulosa* in rice and other irrigated crops in California is probably related to the seasonal compression of suitable habitat. As drying begins in the spring and continues through the summer these spiders are probably forced to aggregate where moist conditions persist. Irrigated cropland, particularly rice, which is typically continuously flooded from May through September, offers such a refuge. Rice culture in California resembles the native habitat of some areas that existed before the advent of flood control and irrigation projects when many parts of the Sacramento and San Joaquin Valleys were annually flooded from snowmelt. Rice fields probably represent the functional equivalent of the numerous vernal ponds and marshes that were presumably utilized by *P. ramulosa* in its pristine environment, but differ by extending moisture availability, which is essential for this species (Hydorn 1977), throughout the summer. For a large part of the growing season, this native natural enemy is actually favored by, and more abundant in, rice (an introduced annual crop) than in adjacent untilled border areas (Oraze et al. unpublished data). Because of its abundance in, and preadaptation to, the rice field environment, *Pardosa ramulosa* appears to be the spider most likely to contribute to a level of biological control of one or more insect pests in this agroecosystem. The impact of this spider on selected prey species in rice will be presented in a subsequent paper (Oraze and Grigarick 1988).

Our sampling did not include any wild rice (*Zizania aquatica* L.) fields. This crop supports more vegetative growth and is usually produced earlier in the year (February-July) than conventional rice. We suspect that these cultural differences may cause minor differences in the respective spider faunas, and a comparative study would be of value.

ACKNOWLEDGMENTS

We thank M. O. Way for suggesting the project; O. G. Bacon, W. Johnson, and B. Brandon for technical assistance; R. Stein for collecting and counting samples; B. Beck, R. Van Dyke, and the staff at the Rice Experiment Station for the use of their fields; E. I. Schlinger, J. A. Coddington, N. I. Platnick and G. B. Edwards for identifying spiders; R. Karban, D. Spiller, R. F. Chapman and L. E. Ehler for reviewing the manuscript; and G. B. Edwards for his helpful comments. This work was supported by grants from the Entomology Department Univ. of Calif., Davis and the California Rice Research Board. This paper is part of a dissertation submitted by M. J. O. in partial fulfillment of a Ph.D. requirement.

LITERATURE CITED

Barrett, S. C. H. and D. E. Seaman. 1980. The weed flora of Californian rice fields. Aquat. Bot., 9:351-376.

Barrion, A. T. and J. A. Litsinger. 1984. The spider fauna of Philippine rice agroecosystems. II Wetland. Philippine Entomol., 6:11-37.

Chu, Y. and C. Okuma. 1970. Preliminary survey on the spider-fauna of the paddy fields in Taiwan. Mushi, 44:65-88.

Garcia, R. and E. I. Schlinger. 1972. Studies of spider predation on *Aedes dorsalis* (Meigen) in a salt marsh. Pp. 117-118, *In* Proceedings and Papers 40th Annual Conference California Mosquito Control Association.

Greenstone, M. H. 1980. Contiguous allotopy of *Pardosa ramulosa* and *Pardosa tuoba* (Araneae: Lycosidae) in the San Francisco Bay Region, and its implications for patterns of resource partitioning in the genus. American Mid. Nat., 104:305-311.

Heiss, J. S. and M. V. Meisch. 1985. Spiders (Araneae) associated with rice in Arkansas with notes on species composition of populations. Southw. Nat., 30:119-127.

Hickle, L. A. 1981. The biology and ecology of *Pardosa ramulosa* (McCook), (Araneae, Lycosidae), in Imperial Valley, California. Ph.D. dissertation, Univ. of California, Riverside.

Hydorn, S. E. 1977. The biology of *Pardosa ramulosa*. Ph.D. dissertation, Univ. of California, Berkeley.

Kiritani, K. 1979. Pest management in rice. Annu. Rev. Entomol., 24:279-312.

Leigh, T. F. and R. E. Hunter. 1969. Predaceous spiders in California cotton. California Agric., 23:4-5.

Okuma, C. 1968. Preliminary survey on the spider-fauna of the paddy fields in Thailand. Mushi, 42:89-117.

Okuma, C. and T. Wongsiri. 1973. Second report on the spider-fauna of the paddy fields in Thailand. Mushi, 47:1-17.

Oraze, M. J. and A. A. Grigarick. 1988. Biological control of aster leafhopper (Homoptera: Cicadellidae) and midges (Diptera: Chironomidae) by *Pardosa ramulosa* (Araneae: Lycosidae) in California rice fields. J. Econ. Entomol., in press.

Paik, K. and J. Kim. 1973. Survey on the spider-fauna and their seasonal fluctuation in paddy fields of Taegu, Korea. Korean J. Plant Prot., 12:125-130.

Riechert, S. E. and T. Lockley. 1984. Spiders as biological control agents. Annu. Rev. Entomol., 29:299-320.

Summers, C. G., R. E. Garrett and F. G. Zalom. 1984. New suction device for sampling arthropod populations. J. Econ. Entomol. 77:817-823.

Van Dyke, D. and D. C. Lowrie. 1975. Comparative life histories of the wolf spiders *Pardosa ramulosa* and *P. sierra* (Araneae: Lycosidae). Southw. Nat., 20:29-44.

Wallace, H. K. and H. Exline. 1977. Spiders of the genus *Pirata* in North America, Central America and the West Indies (Araneae: Lycosidae). J. Arachnol., 5:1-112.

Woods, M. W. and R. C. Harrell. 1976. Spider populations of a southeast Texas rice field. Southw. Nat., 21:37-48.

Yeargan, K. V. and C. D. Dondale. 1974. The spider fauna of alfalfa fields in northern California. Ann. Entomol. Soc. America, 67:681-682.

Manuscript received March 1988, revised April 1988.