Seasonal Occurrence of *Calleida viridipennis* (Say) and *Plochionus timidus* Haldeman (Coleoptera: Carabidae), Predators of the Fruittree Leafroller, *Archips argyrospila* (Walker), in Louisiana[1]

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ABSTRACT *Calleida viridipennis* (Say) and *Plochionus timidus* Haldeman overwinter as adults under the bark of baldcypress, *Taxodium distichum* (L.) Richard, (diam. at breast height (DBH) > 30 cm) and black willow, *Salix nigra* Marsh, (DBH > 15 cm) at a height more than 40 cm above the water level in forested wetlands. Both carabid species were found to be spring breeders, with adults surviving approximately one year. Adults of both species emerged from overwintering in late February or early March when the fruittree leafroller, *Archips argyrospila* (Walker), caterpillars were active on baldcypress. Carabid eggs were distributed among foliage and host webs from mid- or late-March to late-September with larvae occurring from late-March to early or mid-October. Both carabid species were found to be associated with the fall webworm, *Hyphantria cunea* (Drury), after the univoltine fruittree leafroller larvae completed their development.

KEY WORDS Insecta, Carabidae, fruittree leafroller, *Calleida viridipennis, Plochionus timidus,* baldcypress, predator, behavior.

Calleida viridipennis (Say) and *Plochionus timidus* Haldeman are arboreal carabid species with all life stages occurring on baldcypress. In Louisiana forested wetlands, they are found associated with the fruittree leafroller, *Archips argyrospila* (Walker) (Lepidoptera: Totricidae). Prior to 1983, the fruittree leafroller was unknown on baldcypress in Louisiana (Goyer and Lenhard 1988). Since then, extensive defoliation on baldcypress has occurred as a result of larval feeding by the leafroller (Goyer 1991). The fruittree leafroller may be endemic in at least portions of these forested wetlands but has recently undergone a population explosion and expansion of its ecological and geographical range. Because of persistent inundation, few insect herbivores and natural enemies survive on the "ground." Those few species of herbivores adapted to baldcypress occur at sporadic intervals at levels capable of sustaining predacious species. Few alternate hosts for natural enemies are present in these forested wetlands. Only the fruittree leafroller, the forest tent caterpillar, *Malacosoma disstria* (Hübner), on tupelo, *Nyssa aquatica* L., and the fall webworm, *Hyphantria cunea* (Drury), occur with regularity. Of these, only the fall webworm is multi-voltine and, thus, capable of sustaining arboreal predators throughout the season.

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A great deal of information about the life cycle and biology of ground beetles is available (Thiele (1977, Erwin et al. 1979, den Boer et al. 1986), but relatively little is known about arboreal species of carabids, especially *C. viridipennis* and *P. timidus,* two native species in the United States. *Plochionus timidus* was previously reported as a predator of the fall webworm in several states (Britton 1918, Murfeldt 1892) and in Louisiana by Oliver (1964). Braun et al. (1990) collected adults and larvae of these two carabid species with burlap bands and sticky traps when fruittree leafroller larvae were abundant. The larvae and adults of both species were observed on baldcypress foliage, feeding on leafroller larvae in webs of cypress foliage. Braun et al. (1990) document that these two carabid species make up an important component of the arboreal predator complex feeding on larvae and pupae of the leafroller in flooded and seasonally flooded ecosystems.

The purpose of the present study was twofold: (1) to identify the overwintering habitat and life stage(s) of *C. viridipennis* and *P. timidus,* and (2) to determine the seasonal distribution of these two species in southern Louisiana.

Materials and Methods

Overwintering *C. viridipennis* and *P. timidus* were collected from three field areas in southern Louisiana. One area, ca. 3 km southeast of Bayou Pigeon in Iberville Parish, is located along Grand River and serves as its seasonal overflow. The leafroller has been defoliating trees in this area since 1983. *Calleida viridipennis* and *P. timidus* were previously found feeding on leafroller larvae and pupae at a nearby research plot, where Braun et al. (1990) conducted a study of the biology and mortality agents of the fruittree leafroller on baldcypress from 1984 to 1988. The dominant trees at the site are baldcypress, water tupelo, and black willow (*Salix nigra* Marsh), with green ash [*Fraxinus pennsylvanica* (Borkh.) Sarg.] and red maple (*Acer rubrum* L.) as subdominant species. The second area, Bayou Chévreuil, on the boundary of St. James and Lafourche parishes, is approximately 14 km northeast of Chackbay. The area contains seasonally and permanently flooded areas with a second-growth mixed baldcypress-water tupelo forest. The leafroller has caused noticeable defoliation of cypress in that area since 1989 (Goyer, unpublished). The third area is along Bayou Milhomme located north of Lake Palourde, in St. Martin Parish, approximately 40 km south of Bayou Pigeon. Baldcypress trees at the third site were along the edge of a bayou and were permanently flooded. Black willow and water tupelo were associated with the dominant baldcypress trees. The leafroller has defoliated the trees at this site since 1986 or 1987 (Meeker 1992).

In all three areas, baldcypress, tupelo, black willow, and red maple, ranging in diameter at breast height (DBH) from ca. 10 to 80 cm, were searched for *C. viridipennis* and *P. timidus.* Two collection methods, "bark searching" and "burlap band trapping," were used to collect carabids.

The "bark searching" method consisted of peeling 2-5 cm-wide sections of tree trunk bark from the lower 200 cm by hand and/or with the aid of knives or screwdrivers to expose any hidden, overwintering carabid adults. The surface

area of bark removed was dependent upon the texture of the tree bark, with large, older trees containing a greater amount of loose outer bark than younger, smaller trees. The adults were collected and placed into glass Mason® jars with moist paper toweling. The bark searching was conducted during January and February in 1991 and 1992 at approximately one-week intervals. The sex ratio of the adults collected was analyzed for each species by using Chi-square Goodness of Fit Test.

In January 1991, burlap band traps were placed on trees in the Bayou Pigeon area after the procedures of Braun et al. (1990). Burlap bands (30 cm wide) were tied with string to trunks of baldcypress (n = 18), black willow (n = 18), water tupelo (n = 18), and red maple trees (n = 18) , at approximately head height. The bands were folded to provide a secluded habitat to concentrate leafrollers and carabids. Burlap bands were checked at two-week intervals from late January to March, and leafrollers and/or carabids were removed and identified. Carabid larvae were identified by the criteria described by Zhou and Goyer (in press). Voucher specimens are deposited in the LSU Entomology Museum.

In addition to these collection methods, branches of flooded baldcypress, water tupelo, black willow, and red maple trees were checked periodically throughout the season by striking with a walking stick. Insects falling onto the water surface were collected and identified. This method was conducted concurrently with the bark searching and burlap band trapping.

Studies to determine the seasonal distribution of eggs, larvae, pupae, and adults of both carabid species, and their relationship with alternate hosts were conducted from February 1991 to August 1992 at the three field sites. The search methods included collecting foliage, beating lower branches, and trapping carabids with burlap bands.

During the fruittree leafroller feeding period, cypress foliage was collected weekly. After that, fall webworm webs on the foliage of pecan, black willow, red maple, or green ash were collected at two-week intervals, examined in the laboratory, and the numbers of carabid eggs, larvae (by instar), pupae, and adults of each carabid were recorded.

In addition to burlap band traps established at Bayou Pigeon, 14 band traps were set up on baldcypress at the Bayou Milhomme site on April, 1991, and were used to trap leafroller and carabid larvae, pupae, or adults during the time of maximum feeding activity. The burlap bands were checked weekly during the larval feeding season and at two-week intervals after that. The foliage-beating technique was used to augment observations of the seasonal abundance of carabid adults. Fifty samples (5 per tree from 10 trees) of the foliage of the dominant trees such as baldcypress, black willow, red maple, green ash, and tupelo were taken randomly during each investigation at approximately half-month intervals from April to October.

To determine whether the newly-emerged females of both carabid species oviposit eggs in the first year in 1991, 16 (8 female and 8 male) *P. timidus* adults were paired in separate one pint Mason® jars one month after emergence and in 1992, 8 (4 female and 4 male) *C. viridipennis* adults were paired in separate jars as soon as they emerged. All jars were kept in a 30°C environmental control chamber at 12 L: 12 D photoperiod and provided with

early instar larvae of fall webworm and other artificially produced hosts such as the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), as prey and checked for eggs at two-day intervals.

Results and Discussion

Bark searching, branch beating, and burlap trapping indicated that *C. viridipennis* and *P. timidus* overwinter under tree bark in the adult stage, similar to other arboreal species such as *Calleida onoha* Bates and *C. lepida* Redtenbacher that overwinter under tree bark as adults in Japan (Habu 1967). No carabid adults were found under burlap bands nor were they found by branch beating until the fruittree leafrollers were in late larval instars in the foliage.

One hundred and forty-six adult *C. viridipennis* and 55 *P. timidus* were collected from mid-January to late February in 1991 and 1992 and the sex ratio (female to male) was 1.1:1 in both species. Chi-square test indicated that the observed sex ratio for each species did not differ significantly from the expected ratio (1:1) (Table 1). It appears that overwintering adults remain under the bark until the temperature is suitable or food sources are available.

On the first searching day, January 17, 1991, only five *P. timidus* adults were collected due to our lack of experience. Further sampling indicated that these two arboreal species usually overwinter under the loose bark scales of baldcypress (DBH > ca. 30 cm) and black willow (DBH > ca. 15 cm) trunks at a height more than 40 cm above the water level. No carabids were found on tupelo, red maple, sapling cypress (DBH < ca. 15 cm), or black willow (DBH < ca. 10 cm) apparently because the bark was too thin or tight for the carabids to hide under. The two species often were found on the same tree, although never together under a bark strip. Most adults were collected from ca. 40 cm to ca. 150 cm above the level of water.

In Louisiana, diapausing eggs of the fruittree leafroller begin to hatch concurrent with bud break and initial leaf expansion of the majority of baldcypress trees during late February and early March. Adults of *C. viridipennis* and *P. timidus* emerged from overwintering concurrent with the appearance of leafroller caterpillars in the field. Eggs of both carabid species were first collected from baldcypress foliage in mid- to late March at the time when the earliest emerging leafroller larvae had molted to the third instar. Larval carabids were observed from late March to mid-May, and 23 April was the earliest carabid pupae were found under the burlap bands. Both species pupated under the bark of baldcypress trees, inside leafroller webs, and under burlap bands. The number of days from first egg hatch to first pupation of the carabids was approximately one month in the field. Laboratory development studies are reported elsewhere (Zhou 1992). All immature stages (egg, larva, prepupa, and pupa) of the carabids overlapped on foliage sampled from a single baldcypress tree. This overlap is consistent with the observed variation in the hatching date and subsequent developmental rate of the leafrollers. We found at least three larval instars concurrently on individual trees.

Carabid life history patterns are often divided into "spring breeder" and "autumn breeder" based on their hibernation habit as adults or as larvae.

Table 1. Numbers of *Calleida viridipennis* and *Plochionus timidus* adults collected by searching bark during the winters of 1991 and 1992.

Date Collected	Place Collected	*C. viridipennis*			*P. timidus*		
		Female	Male	Total	Female	Male	Total
1991							
Jan 17	Bayou Pigeon	0	0	0	1	2	3
Jan 31	B. Pigeon	5	3	8	2	2	4
Feb 7	B. Pigeon	8	9	17	2	1	3
Feb 14	Bayou Milhomme	8	5	13	6	4	10
Feb 26	B. Pigeon	12	11	23	0	2	2
	Subtotal	33	28	61	11	11	22
1992	B. Pigeon	8	9	17	5	1	6
Jan 9	B. Chevreuil	8	7	15	1	3	4
Jan 15	B. Chevreuil	7	5	12	8	9	17
Jan 21	B. Pigeon	19	16	35	3	3	6
Jan 30	B. Milhomme	2	4	6	1	0	1
Feb 20	B. Pigeon	0	0	0	1	0	1
Mar 3	**Subtotal**	44	41	85	19	16	35
	Total	77	69	146	30	27	57
Sex Ratios	(female : male)	1:1 : 1*			1:1 : 1†		

* $\chi^2 = 0.44$, df = 1, $P > 0.1$.

† $\chi^2 = 0.15$, df = 1, $P > 0.1$.

Spring breeders give rise to summer larvae and overwinter in the adult stage. Autumn breeders only lay eggs during the fall season with overwintering in the larval stage (Lindroth 1949, Mitchell 1963, Rivard 1964). Based on their criteria, *C. viridipennis* and *P. timidus* would be best classified as spring breeders. However, in our study, eggs and immatures of these two species, especially *P. timidus,* were found not only in the spring (on fruittree leafrollers) but also in summer and fall (on fall webworms) (Table 2). This means that carabid immatures occur, periodically, from late March to October and emergence of new imagos begin in early or mid-May, extending, again periodically, until late October. Collection of fall webworm webs indicated that the carbabid adults of both species usually laid their eggs in limited numbers in webs during the first fall webworm larval instar, and the carabid eggs hatched when the prey molted to the second instar. No carabid eggs were found in webs where prey were larger than late second instar. In each web, usually 10 or less larvae were found, and no webs were found containing both carabid species.

The newly-emerged adults from the brood feeding concurrently with the leafrollers remained active at least four to five months before they overwintered under bark until the following spring. This is similar to other spring-breeding carabids, like *Carabus yaconinus* Bates, a univoltine species, which lays eggs from April to August (Sota 1985). Sota (1986) believed that newly-emerged adults of this species did not lay eggs in the field before they overwintered, although they matured within 50 days and produced eggs in the laboratory. It was possible that the photoperiod (daylength < 14 h) and temperature (> 25° C) in the field suppressed ovarian maturation in his study.

Laboratory experiments indicated that newly-emerged adults of both carabid species laid eggs at 12 L:12 D photoperiod and 30° C conditions about one month after adult emergence. In 1991, five of eight *P. timidus* females, after being paired for 5 days, oviposited a mean (± SEM) of 19 ± 4.4 eggs per female (range 4-28 eggs) in the period from 27 August to 23 September. All of these adults died before mid-November. In 1992, one of four newly-emerged *C. viridipennis* females laid a total of 37 eggs from late June to early August. These experiments suggested that adults emerging in May have a chance to oviposit at the same time of the year as overwintering adults, resulting in bivoltism. Masaki (1972) and Roff (1980) maintained that the optimal number of generations in a year should increase systematically as the length of season in which development and reproduction increases. According to this theory, the environmental conditions in wetland ecosystems may favor carabids having bivoltine or trivoltine life cycles due to suitability of temperatures for development and survival, and the availability of food resources. However, the exact reproductive activity in the field of *C. viridipennis* and *P. timidus* needs further investigation.

No adults of the two carabid species were trapped by burlap bands. However, final-instar larvae of both predator and prey gathered under the burlap bands where they pupated from late April to late May during the leafroller season. Braun et al. (1990) observed that ca. 200 carabid larvae concentrated under a single burlap band along with ca. 400 leafroller larvae and pupae in early May. Interestingly, no carabid larvae or pupae were found under the bands after June, although they were still collected from fall

Table 2. Number of *Calleida viridipennis* and *Plochionus timidus* collected from fall webworm webs in the field, 1991 and 1992.

Date Collected	Fall Webworm (FWW)			*C. viridipennis*			*P. timidus*		
	# webs Coll.	# with Carabids	Instar of FWW	Eggs	Larvae	Adults	Eggs	Larvae	Adults
1991									
June 5	2	1	2nd	–	1(2nd)	–	–	–	–
June 17	7	2	3rd	–	1(2nd)	–	–	–	1
July 9	7	7	1s t-2nd	–	3(1st)	1	–	64(1st)	1
July 19	12	4	1st-2nd	–	4(1st)	–	–	12(2nd)	–
July 23	6	1	2nd-4th	–	–	–	–	4(3 3rd) (1 2nd)	–
July 30	2	2	1st-2nd	–	6(1st)	–	–	9(1st)	–
Aug. 6	3	2	1st-2nd	–	–	–	6	2(1st)	1
Aug. 29	6	5	2nd-4th	–	–	–	–	5(2 3rd) (3 2nd)	12
Sept. 6	2	1	2nd-3rd	–	–	–	–	1(1st) 6(2nd)	–
Oct. 1	3	1	2nd-4th	–	–	–	–	3(2nd)	–
Subtotal	50	26		–	15	1	6	99	15
1992									
Apr. 7	2	0	1st-3rd	–	–	–	–	–	–
Apr. 16	7	5	1st-3rd	2	3(1st)	1	32	5(1st)	1
Apr. 30	6	2	3rd	–	–	–	–	6(2nd)	2
May 21	1	1	2nd-3rd	–	–	–	–	5(2nd-3rd)	–
May 23	2	2	2nd	–	–	–	–	–	4
May 25	2	1	2nd-4th	–	–	–	–	6(2nd-3rd)	
Subtotal	20	11		2	3	1	32	22	7
Total	70	37		2	18	2	38	121	22

webworm webs. One reason for this may be that the temperature was too high under the bands for them to hide or there was little or no food available on baldcypress and they dispersed to other tree species in search of prey. Twenty-seven *C. viridipennis* and 11 *P. timidus* adults were collected by beating foliage from April to early September, 1991. These adults were found in the foliage of trees, including baldcypress, blackwillow, green ash, and tupelo. Except tupelo, these trees are hosts to fall webworms.

Overall, these two carabid species appeared to respond to the expansion of the fruittree leafroller populations in the spring in Louisiana forested wetlands and rely on other prey such as the fall webworm later in the season. Thus, they appear to be important natural mortality factors of insect pests in wetland ecosystems where limited numbers of insect herbivores and beneficial species normally occur.

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References Cited

Braun, D. M., R. A. Goyer and G. J. Lenhard. 1990. Biology and mortality agents of the fruittree leafroller (Lepidoptera: Tortricidae), on baldcypress in Louisiana. J. Entomol. Sci. 25: 176-184.

Britton, W. E. 1918. The fall webworm *Hyphantria cunea* (Drury). Connecticut Agri. Expt. Stn. Bull. No. 203, pp. 319-324.

den Boer, P. J., M. L. Luff, D. Mossakowski and F. Weber. 1986. Carabid beetles: their adaptations and dynamics/XVII. Internat. Congr. Entomol., Gustav Fischer, Stuttgard, New York. 551 pp.

Erwin, T. L., G. E. Ball and D. R. Whitehead. 1979. Carabid beetles: their evolution, natural history, and classification. The Hague, Boston. 665 pp.

Goyer, R. A. 1991. Integrated pest management of forest defoliators in the southeastern United States. For. Ecol. Manage. 39: 131-142.

Goyer, R. A. and G. J. Lenhard. 1988. A new insect pest threatens baldcypress. La. Agric. 31: 16-17, 21.

Habu, A. 1967. Fauna Japonica, Carabidae, Truncatipennis group (Insecta: Coleoptera). Biogeograp. Soc. Japan. 1: 338 pp.

Lindroth, C. H. 1949. Die fennoskandischen Carabidae, Eine tiergeographische Studies. Part III. Allgemeiner Teil. Göteborgs Kungl. Vetenskaps-och Vitterhets-Samhälles Handlingar, Ser. B, 4(3): 1-911.

Masaki, S. 1972. Climatic adaptation and photoperiodic response in the band-legged ground cricket. Evolution 26: 587-600.

Meeker, J. R. 1992. Host quality and baldcypress and its influence on fruittree leafroller, *Archips argyrospila* (Walker) (Lepidoptera: Tortricidae), performance in forested wetlands of Louisiana. Ph.D. dissertation. Louisiana State University, Baton Rouge. 157 pp.

Mitchell, B. 1963. Ecology of two carabid beetles, *Bembidion lampros* (Herbst) and *Trechus quadristriatus* (Schrank), I. life cycles and feeding behavior. J. Anim. Ecol. 32: 289-299.

Murtfeldt, M. E. 1982. The web-worm tiger (*Plochionus timidus* Hald.). Can. Entomol. 24: 279-282.

Oliver, A. D. 1964. Studies on the biological control of the fall webworm, *Hyphantria cunea* (Drury), in Louisiana. J. Econ. Entomol. 57: 314-318.

Rivard, I. 1964. Observations on the breeding periods of some ground beetles (Coleoptera: Carabidae) in Eastern Ontario. Can. J. Zool. 42: 1081-1084.

Roff, D. 1980. Optimizing development time in a seasonal environment: The 'ups and downs' of clinal variation. Oecologia 45: 202-208.

Sota, T. 1985. Activity patterns, diets and interspecific interactions of coexisting spring and autumn breeding carabids, *Carabus yaconinus* and *Leptocarabus kumagaii,* (Coleoptera, Carabidae). Econ. Entomol. 10: 315-324.

1986. Effects of temperature and photoperiod on the larval development and gonad maturation of a carabid beetle, *Carabus yaconinus* (Coleoptera: carabidae). Appl. Entomol. Zool. 21: 89-94.

Thiele, H. 1977. Carabid beetles in their environments (Zoophysiology and Ecology; V. 10). Spinger-Verlag, Berlin, Heidelberg, New York. 369 pp.

Zhou, J. 1992. Biology and description of immatures of *Calleida viridipennis* (Say) and *Plochionus timidus* Haldeman (Coleoptera: Carabidae), predators of the fruittree leafroller, *Archips argyrospila* (Walker), in Louisiana. M. S. Thesis, LSU, Baton Rouge, LA.

Zhou, J. and R. A. Goyer. 1993. Descriptions of the immature stages of *Calleida viridipennis* (Say) and *Plochionus timidus* Haldeman (Coleoptera: Carabidae: Lebiini). Coleopt. Bull. (In press).