Galls of *Juncus scirpoides* Formed by *Livia maculipennis* (Liviidae, Homoptera)

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Introduction

During a study of the vascular flora of the Indiana State University Field Campus at Brazil, Clay Co., IN, a member of the Juncaceae, *Juncus scirpoides*, was found to have abnormally large flower structures which turned out to be galls. Identification of infested individuals within this population as *J. scirpoides* would not have been possible except that a few heads had both infested and normal flowers. Dissection revealed nymphs of *Livia maculipennis* (Fitch) (Liviidae, Psylloidea, Homoptera) within the flowers. *Juncus scirpoides* is common around the pond at the entrance to the field campus. A small uninfested population occurs at another lake closest to the pond.

Juncus scirpoides is described by Britton and Brown (1913) as an erect rush growing 20 to 100 cm high from horizontal rootstocks. Its numerous flowers appear in 2-30 globose heads per plant. The 4-7 mm flowers are complete with six perianth parts, stamens, and a one-celled pistil.

The Psylloidea have five nymphal instars and the nymph stages are plant host specific (Hodkinson & White, 1979). Most of the psylloids infest one or two plant species within a genus. The adults commonly use the host plant for feeding, but may use other plants. The species of Psylloidea are dioecious and the ratio when the adults emerge is 1:1. Field ratios are often weighted toward the females, since they usually live longer. Most species have a single generation per year, but one species has three and another takes two years for one generation.

In Britain the life cycles fall into four categories (Hodkinson & White, 1979):

1. Overwintering in egg stage in dormant buds of host plant. Development begins in spring with bud burst.
2. Overwintering as nymphs on the host plants.
3. Overwintering as adults on the host plant with ovipositing occurring in late winter to early spring.
4. Overwintering as adults by moving to a shelter plant in autumn, moving back to host plant in spring to oviposit and possibly mate. A wide variety of evergreens serve as host plants.

Hodkinson and White (1979) reported several psylloids forming galls or pseudogalls in several species of British plants. Tassel galls are formed by *Livia juncorum* (Latreille) on seven species of *Juncus*, roll leaf galls are caused by *Psyllopsis fraxini* (Low) on *Fraxinus excelsior*, and pit galls are formed by *Trichochermes walkeri* (Forster) on *Rhamnus*, spp. and *Trioza remota* (Foerster) on *Quercus*, spp.

Members of the Psylloidea infest many plant species. Best-known in this country, because of their economic importance, are *Psylla pyricola* (Foerster? and *P. mali* (Schmidberger) pests of pear and apple respectively. The common gall on hackberry, *Celtis occidentalis*, is formed by the psyllid *Pachypsylla celtisdismamma* (Riley) (Borror, et. al., 1981).

The major purpose of this study was to assess the relationship between the psylloid and *Juncus scirpoides* and the effects of the psylloid on the plant. Specific objectives were to (1) identify the psylloid and its life stages and (2) determine the effects of the psylloid on the plant, particularly as related to plant height, number of flower heads, number of flowers per head, and flower length.

FIGURE 1. Normal Flower Head of *Juncus scirpoides*

Methods

The study was carried out along the 177 meters of unmowed shore of a pond at the north end of the Indiana State University Field Campus (east of the entrance road), south of Brazil, Clay County, Indiana. The lawn is kept mowed to about 10

meters from the pond. The unmowed area includes *Typha latifolia* and several species of Cyperaceae and Graminae. The pond is approximately 190 meters in circumference.

The affected plants were discovered on 31 July 1984 and the first detailed observations were made on 2 and 3 August 1984. The study was continued in 1985 from 22 July to 3 August.

The total population of plants the first year was quite large, perhaps 350 plants. The plants were too numerous to examine every one, thus the shore line was measured and marked at 5 meter intervals, and six locations, 25 m apart, were chosen for sampling.

At each 25 meter location, the closest 20 individuals of *J. scirpoides* plants were examined and 1) categorized as infested or normal (any plant with at least one abnormal flower was counted as infested), 2) measured for height (total height of plant, not the location of the head), and 3) the number of heads on each plant was counted.

The closest normal and infested plant at each of the 25-meter locations was taken for laboratory observation. These 12 plants (6 normal, 6 infested) were used to count the numbers of flowers per head and measure the length of the flowers. Only one plant was infested externally with adult psylloids, and this was quite heavily so. This plant was also collected for further study.

Three normal plants were randomly selected from the six to determine the average number of flowers per head. Fifteen normal flowers were measured for length. The flowers in each flower head were counted, the length and width of the flowers were measured and dissected to count nymphs in all six infested plants. Some heads of infested plants had normal flowers. These were also counted and measured.

During the second year, the population of *J. scirpoides* was greatly reduced (157 plants total) and it was possible to examine all plants to determine the degree of infestation.

Results

The insect causing the gall has been tentatively identified as *Livia maculipennis*, (Fitch) (Liviinae, Psyllidae, Homoptera) (Crawford, 1914). This has been confirmed by I.D. Hodkinson, Liverpool Polytechnic, Liverpool, England.

Degree of Infestation

In 1984, 55 of the 120 plants examined were infested, for a frequency of 45.8%. In the second year the population was reduced and all 157 plants were examined; of which 127, or 80.9%, were infested.

Plant Height

The height in 65 normal plants averaged 64.45 cm, with a range of 35 to 149 cm, SD = 22.86 cm; whereas the height of the 55 infested plants averaged 21.02 cm, with a range of 5 to 69 cm, SD = 14.75 cm. The infested plants averaged about one-third the height of the non-infested plants. This reduction was significant ($t = 12.11$, 95% conf. level, 118 df).

Number of Flower Heads

Flower heads numbers were assessed with the same 120 plants. Sixty-five normal plants had 194 heads and ranged from 1 to 8 heads per plant with a mean of 2.98, SD = 1.67; while 55 infested plants had 64 heads and ranged from 1 to 6 heads per plant with a mean of 1.16, SD = 0.76. This reduction by more than half was also significant ($t = 7.44$, 95% conf. level, 118 df).

In 1984, the closest infested plant to each of the 25-meter locations was used to determine the number of flowers per head and measure flower length. Since only

FIGURE 2. Gall formed by *Livia maculipennis* on *Juncus scirpoides*.

37 normal plants were observed the second year, every seventh plant was taken to measure flower reduction. The five plants averaged 4.4 heads per plant. The average number of flowers per head ranged from 48 to 186 with a mean of 98.5, SD = 38.62. The six infested plants (each had one head) ranged from 1 to 15 flowers per head with a mean of 6.7, SD = 6.12. This ten-fold reduction of flowers per head was also significant (t = 5.73, 26 df).

Length of Flowers

Fifteen normal flowers ranged from 5 to 6 mm (X = 5.6 mm, SD = .51 mm). Forty infested flowers ranged from 6 to 100 mm (X = 30.8 mm, SD = 20.68 mm). Thus the infested flowers were of much greater and of much more variable length. This six-fold increase in flower length was also significant (t = 4.69, 53 df).

Discussion

The overall effect of *Livia maculipennis* on *Juncus scirpoides* has been found to be significant in four areas, summarized in Table 1. The height of the plant is reduced

TABLE 1. Summary of information of *Livia maculipennis* infesting *Juncus scirpoides*

Type of Effect	*Normal*	*Infested*	
Frequency of infestation (1984)	65	55	45.8%
Frequency of infestation (1985)	30	127	80.9%
Plant Height (mean)	64.45 cm	21.02 cm	
Flower heads per plant (mean)	2.98	1.16	
Flowers per flower head (mean)	98.5	6.7	
Flower length (mean)	5.6 mm	30.8 mm	

by two-thirds, the number of flower heads per plant is reduced by more than half, the number of flowers per head is reduced about ten fold, and the flower length is increased about six times.

The enlarged flowers of the infested plants have many tepal-like bracts, while normal flowers have just six tepals. It appears that the gall is formed by incorporating parts, including bracts, of several nearby developing flowers in the head, making it appear as one flower. This is confirmed by Weiss and West (1922) who reported that the floral parts were aborted and bracts of the inflorescence increased to many times normal size and form closely imbricated structures.

Infested flowers lacked reproductive floral parts, had a reduced number of flowers per head, and a reduced number of heads per plant; thus *Livia maculipennis* is obviously greatly reducing the reproductive ability of the plant.

The degree and increase of infestation over the two year period seems to indicate that *L. maculipennis* is radically eradicating itself in this population through eradicating its host plant. The estimated population in 1984 was around 350 plants. Approximately 20 plants were removed that year, so at least 330 plants ought to have been present the next year, but only 157 plants remained. The estimated mortality is then 173. It is likely that the decrease in the *J. scirpoides* population from one year to the next could have been caused by the *L. maculipennis* infestation. The frequency of infestation the first year was 45.8%. If none of the infested plants returned the theoretical mortality would be 151 (330 X .458). If the *L. maculipennis* population had to infest

the same number of plants to maintain itself and none of the infested plants from the previous year returned, the frequency of infestation would become larger.

Heslop-Harrison (1949) reports that the overwintering females of *Livia juncorum* lay their eggs in the shoot of the plant as it is emerging in the srping. This happens before the inflorescence appears, but the inflorescence is the affected part of the plant. The significant height reduction shown in the present study supports this.

Future studies could include a full-year study observing the life cycles and overwintering methods of *Livia maculipennis* and *Juncus scirpoides*, how the presence of the developing nymphs effect the plant tissue growth, and the determination whether a relation exists between the number of nymphs developing in the gall and the size of the gall. It was also observed that there seems to be two types of infestation: 1) short plants with one large-flower galls and 2) regular-sized plants with many small-flowered galls. This possibly could be a matter of whether *Livia maculipennis* infested the plant in the early stage or infested after the plant had reached full height and the inflorescences were beginning to form. Additional study could test this hypothesis.

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ABSTRACT

A study was conducted on the effects of *Livia maculipennis* (Liviidae, Homoptera) on *Juncus scirpoides* (Juncaceae). *Livia maculipennis* causes galls on several species of *Juncus* in North America. The closely related *L. juncorum* causes tassel galls in *Juncus* spp. in Great Britain.

The present study was conducted at a pond at the Indiana State University Field Campus near Brazil, Clay Co., IN July, 1984 and 1985.

Livia maculipennis on *Juncus scirpoides* causes the height of the plant to be reduced by up to two-thirds, the number of flower heads per plant to be reduced by more than half, the number of flowers per head to be reduced about ten fold, and the flower length to be increased about six times.