

**Pollenivory in larval and adult flower flies:  
pollen availability and visitation rate by  
*Toxomerus politus* SAY (Diptera: Syrphidae)  
on sorghum *Sorghum bicolor* (L.) MOENCH (Poaceae)**

[Pollenverzehr bei Schwebfliegenlarven und -imagines:  
Pollenverfügbarkeit und Besuchshäufigkeit von *Toxomerus politus* SAY (Diptera: Syrphidae)  
bei der Mohrenhirse *Sorghum bicolor* (L.) MOENCH (Poaceae)]

by

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**Abstract**

The larvae and adults of both sexes of *Toxomerus politus* SAY, 1823, were observed visiting the flowers of *Sorghum bicolor* (L.) MOENCH (Poaceae) in Brazil, where female flies were also seen ovipositing. The relationship between sorghum pollen availability and the visitation rates was examined, as well as the diurnal changes in the sex ratio of adult flies visiting the flowers. The feeding behaviours of adults and larvae were also studied. Highest visitation rates occurred early in the morning, before 09:00, when pollen was adhering to the anthers and relatively small amounts of pollen were in the air. The adult sex ratio for visitation rates indicates that more females than males visit the flowers. This suggests that females need more pollen than do males, as a protein source to develop their reproductive organs and eggs. The larvae of *T. politus* were also found to feed on sorghum pollen, and records of pollen-feeding syrphid larvae are exceptionally rare. The larvae of other *Toxomerus* species are insectivorous. It seems from these results that *T. politus* uses the pollen of at least some Poaceae for its entire life cycle.

**Key words**

Syrphidae, *Toxomerus politus*, Neotropical Region, ecology, pollenivory, diel behaviour, Poaceae, *Sorghum bicolor*, pollination.

**Zusammenfassung**

Wir beobachteten die Imagines beider Geschlechter sowie Larven von *Toxomerus politus* SAY, 1823 in Brasilien, wie sie die Blüten von *Sorghum bicolor* (L.) MOENCH (Poaceae) besuchten und zwar dort, wo auch eiablegende Weibchen auftraten. Wir untersuchten daraufhin die Beziehung zwischen Pollenverfügbarkeit und Blütenbesuchshäufigkeit sowie die Frage, ob sich das Geschlechterverhältnis bei den Blüten besuchenden Imagines im Tagesverlauf verändert. Ferner beobachteten wir das Fressverhalten von Imagines und Larven. Die höchsten Besuchshäufigkeiten traten am frühen Morgen auf, vor 09:00 Uhr, wenn der Pollen an den Antheren haftete und sich nur relativ geringe Pollenmengen in der Luft befanden. Das Geschlechterverhältnis weist darauf hin, dass mehr Weibchen als Männchen die Blüten besuchen. Das kann damit zusammenhängen, dass Weibchen mehr Pollennahrung als Männchen benötigen, und zwar als Eiweißquelle zur Entwicklung ihrer Reproduktionsorgane und Eier. Auch Larven von *T. politus* wurden beim Fressen von Mohrenhirse-Pollen angetroffen, was insofern überrascht, als dass es nur wenige Nachweise von Pollen fressenden Syrphiden-Larven gibt und die Larven anderer *Toxomerus*-Arten Insektenfresser sind. Es scheint, dass *T. politus* während ihres gesamten Lebenszyklus von den Blüten mindestens einiger Poaceen abhängig ist.

**Stichwörter**

Syrphidae, *Toxomerus politus*, Neotropische Region, Ökologie, Pollenverzehr, 24-h-Aktivitätsrhythmus, Poaceae, *Sorghum bicolor*, Bestäubung

## Introduction

Pollen consumed by female and male flies is a source of protein. The protein is used to develop the reproductive organs and to produce the nitrogen reserves deposited in the eggs (GILBERT 1986, HASLETT 1989). The consumption of pollen in Syrphidae is essential for the normal functioning of the ovaries (SCHNEIDER 1969). Generally, gravid females have more pollen in their guts than



**Fig. 1:** Female syrphid (*Toxomerus politus* SAY) ovipositing on a sorghum (*Sorghum bicolor*) inflorescence.

do non-gravid females (IRVIN et al. 1999). Flower flies feed on pollens from many species of plants (ROBERTSON 1928, GILBERT 1986), including grasses (Poaceae) (e. g. MORALES & KÖHLER 2008, REEMER & ROTHERAY 2009). TERRELL & BATRA (1984) observed *Toxomerus politus* SAY, 1823, our study-insect, visiting flowers of *Zizania aquatica* L. (Poaceae) in Maryland, USA, and CLEVELAND & HAMILTON (1958) observed it visiting apple flowers in southern Indiana, USA.

Immature flower flies (maggots) have a diverse range of feeding habits, from predators on various homopterous pests, to phytophagy (plant feeders), to mycophagy (feeding on fungi), to saprophagy (feeding on rotten material), to filter-feeding in aquatic niches (rat-tailed maggots) and to specialized inquiline predation in social hymenopteran nests (ROTHERAY & GILBERT 1999, STÄHLS et al. 2003). There

are few records of larval syrphids feeding directly on pollen from the anthers of flowers. To the best of our knowledge, only larvae of *T. politus* and *T. apeiensis* have been recorded feeding on pollen at anthers of maize (*Zea mays*) (RILEY & HOWARD 1888, RICHARDSON 1915) and



**Figs 2, 3:** Sorghum field in Baixo Jaguaribe, Brazil. – 2: Pollen trap on the sorghum field. – 3: Sorghum pollen dispersed into the air.

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*Olura obliquifolia* (Poaceae) (REEMER & ROTHERAY 2009), respectively, and larvae of *Allograpta micrura* at anthers of *Castilleja talamancensis* (Scrophulariaceae) in the highlands of Costa Rica (WENG & ROTHERAY 2009).

Large numbers of larvae of *T. politus*, and of visiting adults of both sexes, were found on the flowers of *Sorghum bicolor* (L.) MOENCH (Poaceae) in production fields in Limoeiro do Norte (05°08'44"S 38°05'33"W) in the Baixo Jaguaribe region of Ceará in Brazil. Our objectives were to examine the relationship between sorghum pollen availability and the visitation rates by *T. politus* and to see if the sex ratio of the adults visiting the flowers changed over the day. The feeding behaviours of males, females and larvae, and also oviposition, were observed. Inferences were then made about the potential role of these insects as sorghum pollinators.

## Material and methods

From preliminary observations from 16 to 19 May, 2008 on several production fields of sorghum we chose one field for further study from 20 to 21 May, 2008. The Baixo Jaguaribe region climate is semi-arid and there are two seasons during the year, a rainy season (“winter”, from January to June) and a dry season (“summer”, from July to December). The mean annual temperature varies between 26 °C and 28 °C (INSTITUTO DE PESQUISA E ESTRATÉGIA ECONÔMICA DO CEARÁ 2005).

The insects were identified by F. C. THOMPSON as *Toxomerus politus* SAY. The genus *Toxomerus* is restricted to the New World and includes 152 species (BORGES & COURI 2009). This species was originally described by SAY (1823: 88) and today is recognized as widespread, ranging from southeastern Canada (Ontario) south to northern Argentina (Jujuy) (VOCKEROTH 1992: 386). Five voucher specimens are deposited at the University of Guelph Insect Collection (identifiers: debu00339953, debu00339954, debu00339955, debu00339956, debu00339957).

We studied three behavioural aspects of *T. politus*: 1) the number of visits of adult flies to single inflorescences of sorghum per hour (five minutes per plant, 8 plants) and the sex of these adults, 2) the movement pattern of the adults in the inflorescences, and 3) their activity (feeding and/or oviposition). Although we noted ovipositions (Fig. 1), we did not quantify their frequency. A surrogate for the sex ratio of the adult flies in the general environment was found by sampling the numbers of male and female adults around the legs of the observers once every hour.

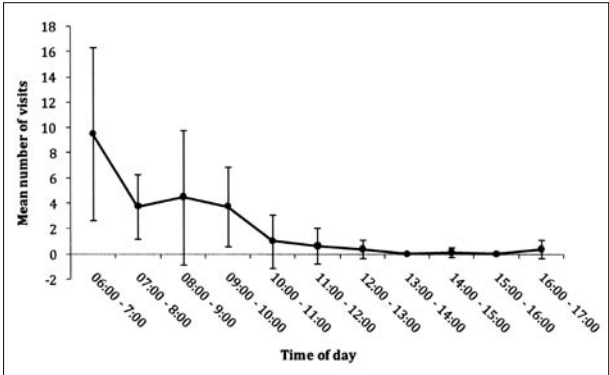
We recorded when the larvae were on the inflorescences and what they were doing. It was not possible to count the larvae accurately because they cryptically blend in with the inflorescence, were very numerous, and often well hidden within the plant parts. Male and female adults and larvae were collected for dissection to examine their gut contents under a binocular dissecting microscope. Pollen collected directly from sorghum was used for microscopic comparison with pollen taken from the insects' guts.

We studied the floral biology of *S. bicolor*, recording 1) stigmatic receptivity with hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) (four stigmas per hour from the same inflorescence), 2) the phases of the anthers in relation to pollen release, 3) the presence of pollen on stigmas (one inflorescence was collected per hour in the field and four stigmas of each were checked with microscope in the laboratory); and 4) availability of pollen in the air using four pollen traps (Fig. 2) with four megastigmas each (16 megastigmas per hour; pollen from one megastigma per trap per hour was analyzed) [all methods in DAFNI et al. (2005), KEVAN et al. (2006)].

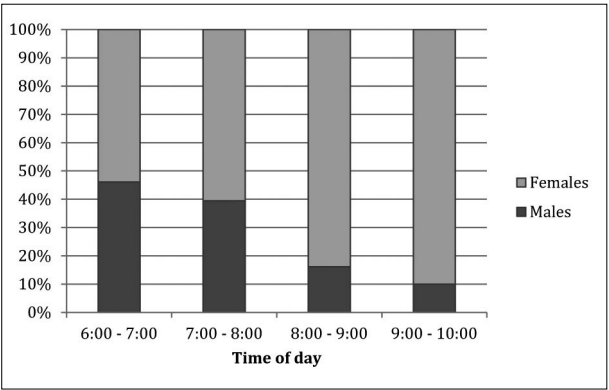
We also related the activities of the flies, adults and larvae, to the availability of pollen on the inflorescences, and its dispersal into the air. The wind speed during our observations was

Time of day	6:00–7:00	7:00–8:00	8:00–9:00	9:00–10:00
Males	12	15	5	1
Females	14	23	26	9
Males - control	23	37	15	14
Females - control	17	33	10	27

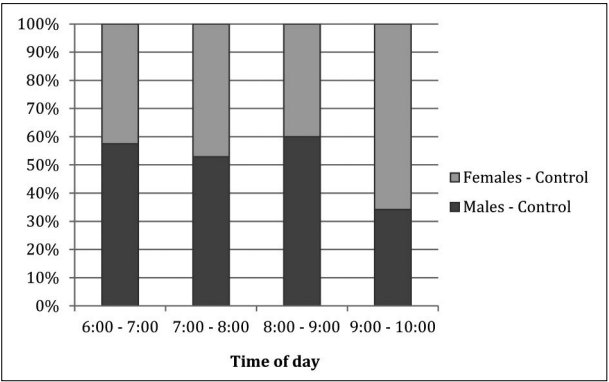
**Tab. 1:** Total number of males and females of *Toxomerus politus* SAY visiting the inflorescences of sorghum per hour from 6:00 to 10:00 in 20 and 21 May, 2008. The standard for the sex ratio of the adult flies in the general environment was that of the adults collected on the legs of the observers.



**Fig. 4:** Mean number of visits of *Toxomerus politus* SAY to sorghum (*Sorghum bicolor*) inflorescences throughout the day.



**Fig. 5:** Syrphid (*Toxomerus politus* SAY) sex ratio. Syrphids visiting the inflorescences of *Sorghum bicolor*.



**Fig. 6:** Syrphid (*Toxomerus politus* SAY) sex ratio in the control (legs of observers).

measured each hour with a hand-held anemometer (accuracy  $\pm 0.2$  m/s) (Dwyer Instruments Inc., Michigan City, Indiana).

## Results

### Insect biology

The greatest visitation rate of adult flies to the sorghum flowers occurred between 06:00 and 10:00 (GMT – 3 hours). After this time, the number of visits decreased rapidly and visitation had all but ceased by noon (Fig. 4). It was not possible to make observations before 06:00 because the day dawned only at 05:33.

The abundance of females visiting the inflorescences was greater than that of males throughout the day (Kruskal-Wallis test,  $p < 0.05$ ) (Tab. 1) but the sex ratio of the flies visiting the flowers changed between 06:00 and 10:00, with males becoming much less represented (Fig. 5) even though the sex ratio of flying adults was mostly male biased, at least until 09:00 (Fig. 6).

We observed both male and female *T. politus* feeding on sorghum pollen: their proboscides being applied to the anthers. Microscopic dissection confirmed that adults of both sexes had pollen in their guts. The flies landed on the inflorescence, held the anthers with the front legs and ate the pollen directly from their chosen anther. Having fed on one anther, they walked on the inflorescence until they found another. The flies were too abundant and moved too rapidly to quantify their movements.

Adult females were seen ovipositing on the inflorescences, especially between 10:00 and 12:00. The larvae were found on sorghum, mostly on the inflorescences, and a few were seen on the stems, between 06:00 and 07:00. On the inflorescences, they crawled around until their heads touched the anthers. Their movements, at that time, indicated that they were feeding. Microscopic dissection of the guts of collected maggots confirmed that they had eaten pollen. Despite our searching, the larvae seemed to vanish from the plants after about 07:00.

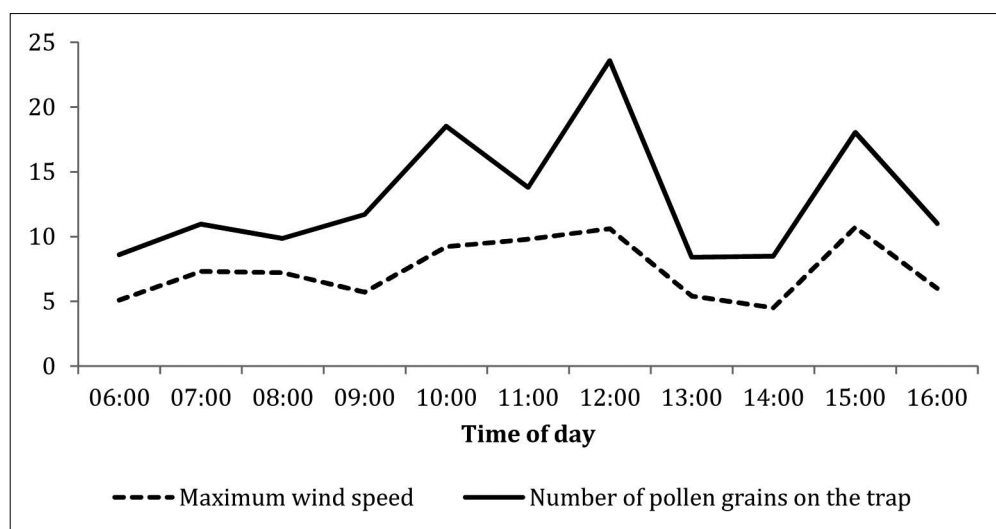


Fig. 7: Maximum wind speed (m/s) and mean number of pollen grains on the pollen traps during the day.

## Floral biology

Before 08:00 the anthers were turgid and presented pollen on their surface, but it was still not being dislodged and dispersed greatly by the wind. After about 09:00, the anthers dried and the pollen started being dispersed in clouds by the wind (Figs 3, 7). The stigmas were receptive only from 06:00 to 11:00. The number of sorghum pollen grains found in the pollen traps varied with the wind speed, although not statistically significantly so (Fig. 7) ( $r_s = 0.61$ ;  $p > 0.05$ ). There was a negative correlation ( $r_s = -0.25$ ;  $p < 0.05$ ) between the amount of pollen found on the traps and the visitation rates of *T. politus* to the inflorescences (Fig. 8).

## Discussion

As expected, the number of sorghum pollen grains found on the traps varied with the wind speed and changed over the course of the day. The greatest visitation rates of *T. politus* to the sorghum inflorescences occurred early in the morning, before 09:00, while pollen was adhering to the

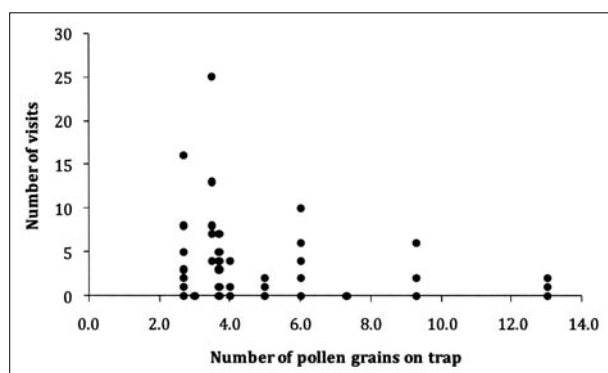


Fig. 8: Relationship between the number of visits of *Toxomerus politus* SAY to the inflorescences of *Sorghum bicolor* and the mean number of pollen grains on the pollen traps.

anthers and relatively small amounts of pollen were in the air (Fig. 8). The sex ratio of adults visiting the inflorescences, as compared to that in the 'general' population, indicates that more females than males visit the flowers. This indicates that females need more pollen than do males, reflecting females' need for more protein to develop their reproductive organs and eggs (GILBERT 1986, HASLETT 1989, SCHNEIDER 1969). That same feeding pattern was observed by RICHARDSON (1915), but in maize in Jobstown (Burlington Conty, N. J., USA). In Brazil (Rio Grande do Sul State, Cinturão Verde region), *T. politus* has been recorded visiting flowers of four species of Poaceae (three unidentified and *Paspalum conspersum* SCHRAD.), but more details about their activities were not recorded (MORALES & KÖHLER 2008).

Larvae were found feeding on sorghum, not on other insects as is usual for the genus (REEMER & ROTHERAY 2009), but directly on pollen. RILEY & HOWARD (1888) and RICHARDSON (1915) also observed larvae from *T. politus* feeding on pollen from anthers, but of maize.

Casual observations made during our study from 16–21 May, 2008 indicate that females visited the inflorescences and oviposited in the spaces between flowers (Fig. 1), where pupae were also found. Thus, it seems that *T. politus* depends on flowers of at least some Poaceae for its entire life cycle.

Although sorghum is wind pollinated, and self compatible insect pollination (by pollen-collecting bees) has also been indicated (SCHMIDT & BOTHMAN 2005), it is possible that *T. politus* also contributes to sorghum pollination, but probably only in a minor way. While these syrphids visit the inflorescence, they touch both female and male reproductive organs, and the period of their visits coincides with the time when the stigma is receptive. Nevertheless, the apparently tight correspondence between *T. politus* and the pollen ripening in the plants that it visits is

reminiscent of the mutualisms between pollinators and their host plants in *Yucca*, oil palm, and a few other plants where the larvae of the pollinators also thrive on the reproductive organs of the host plants (COOK 2003, PELLMYR 2003, SAKAI 2002, SYED 1979).

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