Breeding of *Ornidia obesa* (Diptera: Syrphidae: Eristalinae) on Pig Carcasses in Brazil

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ABSTRACT *Ornidia obesa* F. (Diptera: Syrphidae) is usually neglected in forensic entomology, although adults are rather frequent on vertebrate carrion. In this study, conducted in southeastern Brazil in 2008, we used two pig carcasses, one killed by cocaine overdose and the other by shooting, to evaluate mainly the possible influences of the type of death on the larval development of *O. obesa* in the pig remains. We recorded the breeding of 218 adult specimens of this syrphid fly from the carcass killed by shooting, and none from the carcass killed by cocaine. These observations may open a new perspective for the use of *O. obesa* in forensic studies, considering its breeding preferences and its complete development on vertebrate carrion.

KEY WORDS flower fly, tribe Volucellini, vertebrate carcass, forensic entomology

Adult syrphid flies feed basically on pollen and nectar, and are therefore important pollinators of many plant species (Gilbert 1981). In contrast, their larvae have a wide variety of feeding habits, including saprophagy, phytophagy, predation, and scavenging (Roberts 1970, Thompson 1982). The subfamily Eristalinae is particularly wide ranging in this regard, comprising species whose larvae feed on fungi, vascular plants, decaying plant matter, nests of some hymenopterans, and dung (Vockeroth and Thompson 1987).

Ornidia (Lepeletier and Serville 1828), recently revised by Carvalho Filho and Esposito (2009), is a syrphid genus with five recognized species: *Ornidia major* Curran, *Ornidia aemula* Williston, *Ornidia whiteheadi* Thompson, *Ornidia therezinhae* Carvalho-Filho & Esposito, and *Ornidia obesa* F. The genus is Neotropical, but *O. obesa* F., the most widespread species, is also found in the Old World tropics (Thompson 1991, Whittington and Rotheray 1997), since its accidental introduction through human activities. *O. obesa* has been reported as a mechanical vector of pathogenic bacteria such as *Salmonella* and *Shigella* (Greenberg 1971), which is particularly worrying in view of its synanthropic behavior. Moreover, the larva of *O. obesa* was recorded as the causative agent of pseudomyiasis in humans (Machado 1937, Monteiro et al. 2008).

Although its biology is incompletely known, *O. obesa* frequently breeds on several types of semiliquid synanthropic material, such as animal dung, human feces, sewage, and rotten fruits and vegetables (Sack 1921, Thompson 1991, Whittington and Rotheray 1997, Carvalho Filho and Esposito 2009). There is only one report on nonsynanthropic breeding sites for this species, in exuding sap on Guanacaste trees, *Enterolobium cyclocarpum* (Mimosoideae) (Rotheray et al. 2005). In spite of their well-known morphology (Whittington and Rotheray 1997, Rotheray et al. 2005), the development time of *O. obesa* immatures has not been sufficiently studied, making it worthwhile to attempt to estimate this period.

In the field of forensic entomology, *O. obesa* is usually neglected, although adults are rather frequent on vertebrate carrion (Moretti et al. 2008). Larvae, in contrast, have never been reported on this resource. There are no definitive investigations on the possible role of this syrphid (or other species of flower flies) in the sarcosaprophagous arthropod community, and the general tendency is to include this family either in the category of predators (Wolff et al. 2001) or accidentals (Payne and Crossley 1966). Moreover, the possible effects of gunshot and illicit drugs present in remains on oviposition and development of *O. obesa* are unknown.

In this study, we report on the presence and breeding of *O. obesa* on exposed pig carcasses in a rural area of São Paulo State, Brazil, in an attempt to gather enough data to support the inclusion of this syrphid fly in the ecological category of necrophagic insects. Also, we aimed to evaluate the possible influences of the type of death (cocaine overdose and gunshot), temperature, and relative humidity on the attraction of

All procedures for killing and use of the pig carcasses followed the ethical norms of the Brazilian College of Animal Experimentation and the Ethical Committee of Animal Experimentation of São Paulo State University (Universidade Estadual Paulista) (protocol 78/08-CEEA).

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adults and on the larval development of *O. obesa.* We chose to compare these two causes of death because they are among the most ordinary ones in any part of the world. Besides, in many cases of deaths resulting from drug abuse, the body is found in an advanced stage of decay, when entomological methodologies seem to be particularly valuable (Goff and Lord 2010). Finally, we wanted to know whether the attractiveness of adults of *O. obesa* to the carcasses resulted in the breeding of this fly on this type of substrate.

Materials and Methods

Study Site. This is a rural area of the Municipality of Pedregulho (20°15′25″S, 47°28′37″W), northeast region of São Paulo State, Brazil, situated 1,063 m above sea level, with vegetation composed of Atlantic Forest and *Cerrado* (savanna) vegetation (IBGE 2007). The climate is tropical and distinctly seasonal, with a warm rainy season from October to March, and a dry season from April to September.

Experimental Model, Trap Description, and Field and Laboratory Procedures. The experiment was conducted from 5-III-2008–21-III-2008. Two male pig carcasses (*Sus scrofa* L.) weighing ~14 kg were used. One of them had been shot three times with 0.38-gauge bullets, one in the head (resulting in instant death of the animal) and the other two in the thorax and abdomen. The other pig had been killed by cocaine overdose (7 mg/kg) administered subcutaneously.

Both carcasses were placed simultaneously and arranged 10 m apart. They were positioned inside metal-frame cages, to prevent vertebrate scavengers from reaching the carcasses. An inverted funnel-shaped frame (1.90 m in height and 0.81 m^2 at the base), made of polyvinyl chloride (PVC) and covered with organza, similar to the type used by Carvalho et al. (2000), was placed over each cage. A 2-liter plastic bottle was installed on the top of the frame, through a cube-shaped box made of zinc (edge: 18 cm), with one of its faces containing a hole connected to an open-ended cylinder (10 cm in diameter), which allowed the bottle to fit into the frame (Fig. 1). All flying insects were collected from the plastic bottle every 24 h, placed in plastic vials, and stored at −20°C for later identification. Weather conditions in the field and carcass temperatures were measured daily with a Celsius thermometer (model MM 5202-Incoterm). Further meteorological data were obtained from the Miguelópolis meteorological station (20°10′44″S, 48°01′55″W).

Underneath the cages, metal trays with sawdust were placed to collect all postfeeding larvae that naturally abandoned the carcasses for pupation. These specimens were collected through daily screening of the trays, and were placed in plastic vials containing sawdust and covered with organza. The date of collection was recorded. Small amounts of carrion, occasionally attached to immatures, were kept in the vials. The vials were placed in controlled laboratory conditions (26 ± 2°C, 66 ± 10% RH) and were examined daily for the occurrence of emergence, and the time from postfeeding larvae to emergence of adults was recorded. All emerged insects were stored at −20°C for later identification. The experiment was halted when the emergence of adult insects in the laboratory ceased. Both carcasses were photographed daily to follow all stages of decomposition over the course of the experiment.

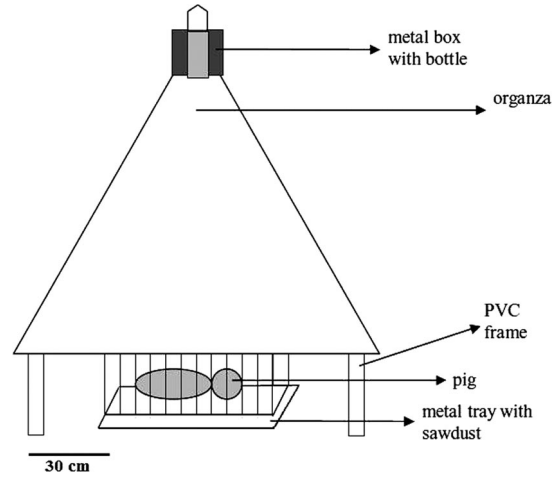

Fig. 1. Schematic drawing of the trap.

O. obesa was identified according to Carvalho Filho and Esposito (2009). Voucher specimens have been deposited in the Escola Superior de Agricultura Luiz de Queiroz Entomological Museum (Department of Entomology and Acarology, Escola Superior de Agricultura Luiz de Queiroz/University of São Paulo, Piracicaba, São Paulo, Brazil).

Results

Adults Collected in the Field (n = 7). Two adult specimens of *O. obesa* were collected from the carcass killed by cocaine overdose on the 13th postmortem day. From the carcass killed by shooting, we collected a total of five specimens on days 5, 9, 13, and 15 after the carcass was placed. From day 10 of exposure on, we could not obtain mouth and anus temperature for the carcasses, because they were already in an advanced stage of decomposition (Table 1).

Immatures Collected in the Field and Bred in the Laboratory (n = 218). All postfeeding larvae of *O. obesa* were collected from the carcass killed by shooting on days 14, 15, and 16 after the carcass was placed. Some third instars, washed away by rain and found in the tray, were also collected. The external temperature of the pig, local temperature, air relative humidity, and the decay stage of the carcass are shown in Table 1. The plastic vials and the sawdust had to be replaced on the sixth day after the end of the field experiment, when we realized that the original containers were very humid and undersized, which could have damaged the maggots and prevented their development. After that modification, all immatures of *O. obesa* developed normally to the adult stage. The

Table 1. Abundance and circumstances of the collections of immature and adult specimens of *Ornidia obesa* on pig carcasses

Days		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Adults (*n*)						1				2				2 / 1		1		
Immatures (*n*)															113	102	3	
Environment temperature °C		34.5	28.7	34.3	29	30.3	29.9	26.1	18.8	28.8	24.5	22	24	29.5	30.8	30.5	23	25
Relative humidity %				<70				75	>80		75	>80						75
Decomposition stages		Fresh		Bloated		Decaying						Dry						
		Fresh		Bloated				Decaying					Dry					
Temperature °C	Carcass	39	30.6	39	31.3	36	28.9	25.9	19.5	27.8	25	23	23.7	29.5	30.2	31	24	
		38.5	36.6	41	28.8	44	36.8	32.7	21.6	31.2	28.2	23	25	30	32.3	31.5	24	25.5
	Mouth	41.4	32.8	29.6	27.6	30.7	29.2	34.9										
		40.8	37.7	31.8	33.5	39.2	29.9	26.1	21.7	29.5								
	Anus	42	31.3	38.8	28.3	30.8	28.3	27.2	19.8	26.7								
		40.4	32.6	37.5	29.4	37.4	37.1	42.4	19.9	28.3								

Cocaine; shooting.

postfeeding larvae collected on the 14th ($n = 113$) and 15th ($n = 102$) days of exposure emerged after 61 d in the laboratory, whereas those collected on day 16 ($n = 3$) emerged after 72 d. The rearing success rate and time of emergence that we found are merely estimates, because they were obtained in laboratory conditions.

Decomposition Process. The decay sequence was as follows: fresh (early microbial decomposition by the autolytic process), bloated (active microbial decomposition), decaying (advanced decomposition of cadaver with destruction of almost all the remaining soft tissues), dry (the remains of the cadaver disappear and the skeleton begins to be visible as separate bones), and adipocere-like (with hydrolysis of some soft fatty tissues), according to the classification proposed by Reed (1958) and Rodriguez and Bass (1983). The carcass killed by overdose contained more maggots and decomposed more rapidly (within 16 d). The carcass killed by shooting was entirely decomposed after 17 d.

Discussion

During daily observations of the pig carcasses, we found some large-bodied larvae, resembling third-instar flesh flies maggots at first glance, at least for an observer with a poor taxonomic background. This erroneous assumption was because of the similarity in size (≈20 mm) and in the behavior of burying themselves in the carcass, shared by both syrphid and sarcophagid third instars.

The emergence of adults of *O. obesa* in the laboratory was unexpected, and to the best of our knowledge this is the first report of this species breeding on vertebrate carrion. Nevertheless, a similar scenario occurred in another study conducted in the municipality of Ubatuba (23°26′02″S, 45°04′15″W), southeast region of São Paulo State, also in 2008. The city is surrounded by a dense Atlantic Forest fragment and situated in a biogeographical zone of complex faunistic transition, as a result of the seasonal environmental variations in this region (Palácio 1982). Two maggots of this syrphid fly were obtained from a 10-kg male pig carcass on the 15th day of exposure, already at the beginning of skeletonization (local temperature, 22°C; rainfall, 18 mm). The reason for the small number of larvae of *O. obesa* found in this carcass was probably because of its dry condition, which may prevent the larvae from developing.

The finding of larvae of *O. obesa* on vertebrate carcasses may indicate that they are consuming this resource, suggesting a necrophagic behavior and the possible usefulness of this syrphid fly in the forensic field. The larvae may affect both the colonization of carrion insects and postmortem interval estimation, by competing for carcasses with maggots of Calliphoridae, Sarcophagidae, and Muscidae. For example, we collected 71 specimens of the calliphorid *Lucilia eximia* Wiedemann and 203 of the muscid *Ophyra aenescens* Wiedemann from the carcass killed by cocaine overdose, whereas no specimens of *L. eximia* and 125 of *O. aenescens* were found on the carcass killed by shooting. These two are among the most common species of forensic importance in South America (Carvalho and Mello-Patiu 2008).

We do not know exactly whether cocaine could prevent the larval development of *O. obesa* on pig carrion. Nevertheless, if this hypothesis is plausible, perhaps it could explain why we only collected maggots of this species from the carcass killed by shooting. Unfortunately, there is not much information on this point in literature, except for the observations by Goff et al. (1989), who concluded that larvae of the flesh fly *Boettcherisca peregrina* (Robineau-Desvoidy) reared on rabbit carrion containing several dosages of cocaine developed more rapidly, which could lead to inaccuracies in the estimation of the postmortem interval. However, we do not have specific information on the possible deterrent effect of cocaine on the oviposition behavior of *O. obesa.*

Behavioral changes, which could indicate a stage of biological transition, are not uncommon in flies. According to Madeira et al. (1989), some calliphorids, attempting to avoid competition with other carrion blowfly species, may exploit living tissues of animals. Moreover, this finding may suggest occupation of new niches by the species, contributing to fill some of the

gaps in knowledge of the general biology of this syrphid fly.

The real extent of flesh removal by these larvae awaits investigation, as also with, e.g., carrion wasps (O'Donnell 1995). Predation by *O. obesa* on adult or immature members of the carrion-visiting fauna, and the consequent reduction of blowfly and flesh fly larvae populations, is an unlikely possibility: the mouthparts of both the adult, adapted to collect nectar from plants, and the larva, modified for filter feeding, of *O. obesa* seem to be inadequate to tear solid tissues (Roberts 1970). Adults were collected only on days of high relative humidity or rain, which could have added some moisture to the carcass, allowing the larvae to survive.

Because of the lack of investigations on the developmental time of *O. obesa* larvae, it is impossible to compare the data obtained in the current study with previous investigations. The long time from postfeeding larvae to adult that we observed is probably the result of the inadequate conditions in which the immature forms were kept at the beginning.

According to Morse (1981), dominant Syrphidae on flowers may displace other insects, mainly small-bodied ones. This situation could also occur in carcasses, with the displacement of adult specimens of Calliphoridae and Sarcophagidae, leading to changes in the carrion insect composition.

Arthropods that are not traditionally used in estimating the postmortem interval should be collected and identified, because they also can provide useful information about the circumstances of death (Catts and Haskell 1990).

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