POLLINATORS OF *Oxypetalum* (ASCLEPIADACEAE) IN SOUTHEASTERN BRAZIL

VIEIRA, M. F.[1] and SHEPHERD, G. J.[2]

[1] Departamento de Biologia Vegetal, Universidade Federal de Viçosa, CEP 36571-000, Viçosa, MG, Brazil

[2] Departamento de Botânica, IB, Universidade Estadual de Campinas, C.P. 6109, CEP 13083-970, Campinas, SP, Brazil

Correspondence to: Milene Faria Vieira, Departamento de Biologia Vegetal, Universidade Federal de Viçosa, CEP 36571-000, Viçosa, MG, Brazil, e-mail: mfvieira@mail.ufv.br

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ABSTRACT

Floral visitors of seven species of *Oxypetalum* were registered in Viçosa, State of Minas Gerais. *O. appendiculatum*, *O. banksii* subsp. *banksii*, *O. alpinum* var. *alpinum* and *O. pachyglossum* are pollinated by wasps, being *Polybia ignobilis* (Vespidae) a pollinator of these four species. It seems that *P. ignobilis* promotes interspecific pollinations mainly between *O. alpinum* var. *alpinum* and *O. pachyglossum*, two species with very similar floral morphology. *O. jacobinae*, *O. mexiae* and *O. subriparium* are pollinated by bees. Wasps and bees carry one, two, three or several pollinaria in the mouthparts. *O. mexiae*, an endemic species in Viçosa, seems to present reproductive limitations, since its flowers are seldom visited.

Key words: bees, interspecific pollination, *Oxypetalum*, *Polybia*, wasps.

RESUMO

Polinizadores de *Oxypetalum* (Asclepiadaceae) no Sudeste do Brasil

Foram registrados os visitantes florais de sete espécies de *Oxypetalum*, em Viçosa, Estado de Minas Gerais. *O. appendiculatum*, *O. banksii* subsp. *banksii*, *O. alpinum* var. *alpinum* e *O. pachyglossum* são polinizadas por vespas, sendo *Polybia ignobilis* (Vespidae) uma polinizadora dessas quatro espécies. *P. ignobilis* parece promover polinizações interespecíficas, principalmente entre *O. alpinum* var. *alpinum* e *O. pachyglossum*, espécies com morfologia floral muito semelhante. *O. jacobinae*, *O. mexiae* e *O. subriparium* são polinizadas por abelhas. As vespas e abelhas carregam um, dois, três ou vários polinários no aparelho bucal. *O. mexiae*, endêmica da região de Viçosa, parece apresentar limitações reprodutivas, pois suas flores são raramente visitadas.

Palavras-chave: abelhas, polinização interespecífica, *Oxypetalum*, *Polybia*, vespas.

INTRODUCTION

Pollination of Asclepiadaceae flowers occurs with removal of pollinaria (each consisting of a translator apparatus and two pollinia) and pollinia insertion into the stigmatic chambers, activities performed by insects (Macior, 1965; Bookman, 1981; Kunze, 1991). Species of this family can present either a generalist strategy with respect to pollination, i.e., they are pollinated by a wide variety of Hymenoptera and Lepidoptera (Willson *et al*., 1979; Bertin & Willson, 1980; Kephart, 1983; Morse & Fritz, 1983; Morse, 1985; Jennersten & Morse, 1991) or they are dependent upon a specific group of pollinators: Hymenoptera (Wanntorp, 1974; Eisikowitch, 1986; Forster, 1994), Lepidoptera (Forster, 1992b), Coleoptera (Forster, 1989), and Diptera (Forster, 1992a; Chaturvedi, 1993; Meve & Liede, 1994; Lumer & Yost, 1995). Little has been studied on the partitioning of pollinators among co-occuring species, with Kephart's (1983) work being the most important; she has registered three species of *Asclepias* shared by the same pollinators, a fact which could promote interspecific pollinations.

The genus *Oxypetalum* R.Br. consists of about 170 species, all exclusively neotropical, of which 115 are found in Brazil; of this total, 42% occur in Minas Gerais, the Brazilian state that presents the greatest diversity of this genus (Occhioni, 1953; 1956). Eight species of *Oxypetalum*, all with climbing habit, occur in the municipality of Viçosa, State of Minas Gerais. With the exception of studies of Vieira & Shepherd (1995), no information is available on the relationship between species of this genus and their pollinators.

The objectives of this work were: (a) to identify the pollinators of seven *Oxypetalum* species in Viçosa region (20°45'S and 42°51'W); and (b) to verify whether co-occuring species can share the same pollinators.

MATERIAL AND METHODS

The studied species were found at nine sites, in different habitats, here named S1 to S9 (Table 1); sites were set apart from one another a minimum of 0.5 km and a maximum of 15 km. They were identified by a specialist and voucher specimens were deposited in the VIC and UEC herbaria (*Departamento de Biologia Vegetal, Universidade Federal de Viçosa* and *Departamento de Botânica*, *Universidade Estadual de Campinas*, respectively).

TABLE 1

Studied species of *Oxypetalum*, their habitats and sites of occurrence.

Species	Habitats	Study sites[1]
O. alpinum (Vell.) Font. & Schw. var. *alpinum*	marsh	S1
O. pachyglossum Decne.	marsh	S1
O. appendiculatum Mart.	pasture and road margins	S1, S3, S4, S6, S8 and S9
O. banksii Roem & Schult. subsp. *banksii*	pasture and road margins	S1, S3, S5, S6, S8 and S9
O. jacobinae Decne.	pasture and road margins	S3, S6, and S8
O. subriparium Malme	pasture and margins of road and forest	S2, S3, S5, S6, and S9
O. mexiae Malme	forest margins, along water stream	S7

[1] S1, S8 and S9: pasture and neighboring marsh; S3, S4, S5 and S6: pasture near brushwood located at road margins; S2 and S7: forest margins (biological reserves).

Floral visitors of each species were observed along the day, mainly between 1000 and 1400 hr. Captured insects were analyzed for pollinaria presence, number and disposition as well as place they attach to in the body. Insect identification was carried out by specialists and voucher specimens were deposited in the *Museu Entomológico* of *Universidade Federal de Viçosa*.

Insect frequency was observed in flowers of *O. appendiculatum* and *O. banksii* subsp. *banksii*. The chosen individuals of these species were found at the same site (S9, Table 1). Visitors' frequency in these plants was registered during four non-consecutive days, four consecutive hours per day. These daily hours were divided into 25 min. periods, so that data were taken by alternating the species. Number of open flowers was counted in the chosen individuals, one for each species, the same individual being used during four days.

RESULTS AND DISCUSSION

Individuals of the studied *Oxypetalum* species were observed growing together at some sites, except *O. mexiae* (Table 1), an endemic species from Viçosa region (Fontella-Pereira, pers. comm.). The other species, except *O. appendiculatum*, are restricted to the Brazilian territory (Fontella-Pereira *et al.*, 1971; Fontella-Pereira & Schwarz, 1984; Fontella-Pereira *et al.*, 1984). All species flower along the year, except *O. jacobinae* and *O. subriparium*, which flower between November and July (Vieira, 1998).

The studied species present white-greenish or yellow-greenish flowers, short corolla and nectar accumulation occurring at the base of the floral tube. This corolla morphology prevents the pollinators from entering into the flower interior, except their mouthparts; thus, pollination was

performed with the pollinaria attached mainly to the insect's mouthparts, as observed in *Leptadenia reticulata*, *Wattakaka volubilis* (Pant *et al*., 1982), *Vincetoxicum officinale* (Kunze, 1991), *Sarcostemma clausum* (Kunze & Liede, 1991) and *V. nigrum* (Lumer & Yost, 1995). Insects of different orders were observed visiting the flowers of all species (Table 2), but only a few bees and wasps (Hymenoptera) were carrying pollinaria (Table 2) and, therefore, very likely acting as pollinators. The other insects were considered as nectar thieves, as is commonly observed in Asclepiadaceae (Willson & Bertin, 1979; Willson *et al*., 1979; Morse, 1985; Liede & Whitehead, 1991; Forster, 1994).

The studied species can be divided into two groups in regard to pollinator type: group 1 – pollinated by wasps (*O. appendiculatum*, *O. banksii* subsp. *banksii*, *O. alpinum* var. *alpinum* and *O. pachyglossum*); and group 2 – pollinated by bees (*O. jacobinae*, *O. mexiae* and *O. subriparium*).

Pollinators of group 1 species belong to the families Vespidae and Pompilidae (Table 2). The wasps are commonly found taking nectar from flowers, but they are rarely considered as specific pollinators (Heithaus, 1979; Proctor *et al*., 1996). Flower features of this group are similar to those of other flowers also visited by wasps, i.e., short corolla and green, yellow-green, or white flowers (Heithaus, 1979). According to this author, 80.4% of the plants visited by wasps in Costa Rica present these floral features.

Flowers of *O. appendiculatum* were pollinated by *Polybia* wasps (Vespidae, Table 2). These insects, when visiting flowers, landed on the corolla, leaning principally on the apical portion of its tube (Fig. 1a), subsequently introducing the mouthparts into the floral tube. These wasps carried no more than one pollinarium (Fig. 1b) and, usually, left the entire pollinarium in the flower with its pollinia inserted together in a stigmatic chamber. In this way, these insects do not present accumulated translator apparatus in their mouthparts.

O. banksii subsp. *banksii* flowers were pollinated mainly by wasps of the Vespidae family (Table 2). When visiting the flower, theses insects landed on the corolla, leaning principally on the apical portion of the floral tube and on corona elements (Fig. 1c), introducing the mouthparts into the floral tube. It was observed that wasps were carrying up to three pollinaria in their mouthparts (Fig. 1d), presenting accumulated translator apparatus, since only the pollinia are left inserted in the stigmatic chamber of the flower. The accumulated translator apparatus do not establish chains of pollinaria (cf. Macior, 1965; Bookman, 1981). *O. banksii* subsp. *banksii* was visited by several insects, besides the pollinators (Table 2), with different morphological features and visitor behavior. Floral features, such as reflexed corolla and lax elements of the corona, which facilitate the access to the nectar were probable reasons for these visits.

The flowers of *O. alpinum* var. *alpinum* and *O. pachyglossum* were pollinated by wasps of the families Pompilidae and Vespidae (Table 2). In their visit to the flowers, they leaned on the inflorescence (Fig. 1e) and, to collect the nectar, they separated the corona elements which cover the interior of the floral tube; to do this, they used the mouthparts, which they introduced into the tube. These insects were observed carrying several pollinaria in the mouthparts (up to 11 pollinaria were found in one insect), presenting accumulated translator apparatus with the formation of pollinaria chains (Fig. 1f).

Oxypetalum species of the group 1 flower at the same period, can be found at the same place (Table 1) and be visited by the same pollinators, the wasp *Polybia ignobilis* (Vespidae, Table 2). This wasp presented visitor behavior and pollinaria number and arrangement in the mouthparts which are peculiar for the species of group 1 and seem to function as barrier that maintain the reproductive isolation of the species, except *O. alpinum* var. *alpinum* and *O. pachyglossum*. Flowers of these plants and, principally, the pollinaria are very similar; since these are arranged as chains, this permits a mixed load of pollinaria in wasps' mouthparts and, thefore, favoring interspecific pollinations (cf. Macior, 1965).

TABLE 2

Insects with pollinarium in mouthparts (MP), anterior legs (AL), middle legs (ML) or without pollinarium (WP), which visit flowers of seven *Oxypetalum* species.

Order/Family **Species**	***O. appendiculatum***	***O. banksii* subsp. *banksii***	***O. alpinum* var. *alpinum***	***O. pachyglossum***	***O. subriparium***	***O. jacobinae***	***O. mexiae***
Coleoptera/Cantharidae							
Unknwn species		WP					
Coleoptera/Cleridae							
Enoclerus sp.		WP					
Hemiptera/Coreidae							
Sphictyrtus chryseis		WP					
Hemiptera/Largidae							
Largus humilis		WP					WP
Hemiptera/Pentatomidae							
Mormidea sp.							WP
Hemiptera/Phymatidae							
Phymata sp.		WP					
Hemiptera/Pyrrhocoridae							
Dysdercus sp. 1		WP					WP
Dysdercus sp. 2							WP
Dysdercus sp. 3							WP
Hymenoptera/Anthophoridae							
Ceratina sp.							**MP**
Osiris variegatus							WP
Osiris sp.							WP
Hymenoptera/Apidae							
Apis mellifera					**MP**	**MP**	
Exomalopsis sp.			WP				
Nannotrigona testaceicornis		**MP**			**MP**		
Plebeia droryana					**MP**		
Plebeia sp.					**MP**		

TABLE 2

Insects with pollinarium in mouthparts (MP), anterior legs (AL), middle legs (ML) or without pollinarium (WP), which visit flowers of seven *Oxypetalum* species. (*Continued*.)

Order/Family **Species**	***O. appendiculatum***	***O. banksii* subsp. *banksii***	***O. alpinum* var. *alpinum***	***O. pachyglossum***	***O. subriparium***	***O. jacobinae***	***O. mexiae***
Hymenoptera/Apidae							
Scaptotrigona xanthotricha					WP		
Scaptotrigona sp.					**MP**		WP
Schwarziana quadripunctata					**MP**		
Tetragonisca angustula							
Trigona sp.		WP					
Hymenoptera/Colletidae							
Colletes punctatissimus	WP		WP				
Hymenoptera/Formicidae							
Camponotus sp. 1		WP					
Camponotus sp. 2	WP						
Crematogaster sp.		WP					
Pseudomyrmex sp. 1		WP					
Pseudomyrmex sp. 2	WP						
Pseudomyrmex sp. 3	WP						
Zacryptocerus pusillus		WP					
Hymenoptera/ Halictidae							
Augochlora sp. 1					WP		
Augochlora sp. 2							WP
Augochlora sp. 3						WP	
Augochloropsis (*A.*) *callichroa*			WP				
Augochloropsis (*Paraugochloropsis*) *electra*				WP	WP	**MP**	
A. (*P.*) *smithiana*			WP				
Augochloropsis (*P.*) sp. 1						WP	

TABLE 2

Insects with pollinarium in mouthparts (MP), anterior legs (AL), middle legs (ML) or without pollinarium (WP), which visit flowers of seven *Oxypetalum* species. (*Continued*.)

Order/Family **Species**	***O. appendiculatum***	***O. banksii* subsp. *banksii***	***O. alpinum* var. *alpinum***	***O. pachyglossum***	***O. subriparium***	***O. jacobinae***	***O. mexiae***
Hymenoptera/Halictidae							
Augochloropsis (*P.*) sp. 2				WP			
Augochloropsis (*P.*) sp. 3					WP		
Augochloropsis (*P.*) sp. 4					WP		
Hymenoptera/Pompilidae							
Priocnemioides luteicornis		**MP**					
Unknown species 1		WP	WP	**MP**			
Unknown species 2			**MP**				
Hymenoptera/Sphecidae							
Tachytes hades		WP	WP	WP			
T. setosus		AL	WP	WP			
Hymenoptera/Vespidae							
Apoica sp.		**MP**					
Brachygastra augusti		**MP**					
B. lecheguana		**MP**					
Hylaeus sp.		WP					
Polistes sp.		**MP**					
Polybia flavifrons	**MP**	**MP** e AL					

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Insects with pollinarium in mouthparts (MP), anterior legs (AL), middle legs (ML) or without pollinarium (WP), which visit flowers of seven *Oxypetalum* species. (*Continued*.)

Order/Family **Species**	***O. appendiculatum***	***O. banksii* subsp. *banksii***	***O. alpinum* var. *alpinum***	***O. pachyglossum***	***O. subriparium***	***O. jacobinae***	***O. mexiae***
Hymenoptera/Vespidae							
Protopolybia sedula		WP					
Synoeca sp.		**MP**					
Lepidoptera/Amatidae							
Unknown species				WP			
Lepidoptera/Hesperiidae							
Urbanus dorantes			WP				
Unknown species							WP
Lepidoptera/Nymphalidae							
Adelpha erotia							WP
Heliconius sp.							WP
Philaetria sp.							WP
Unknown species							WP

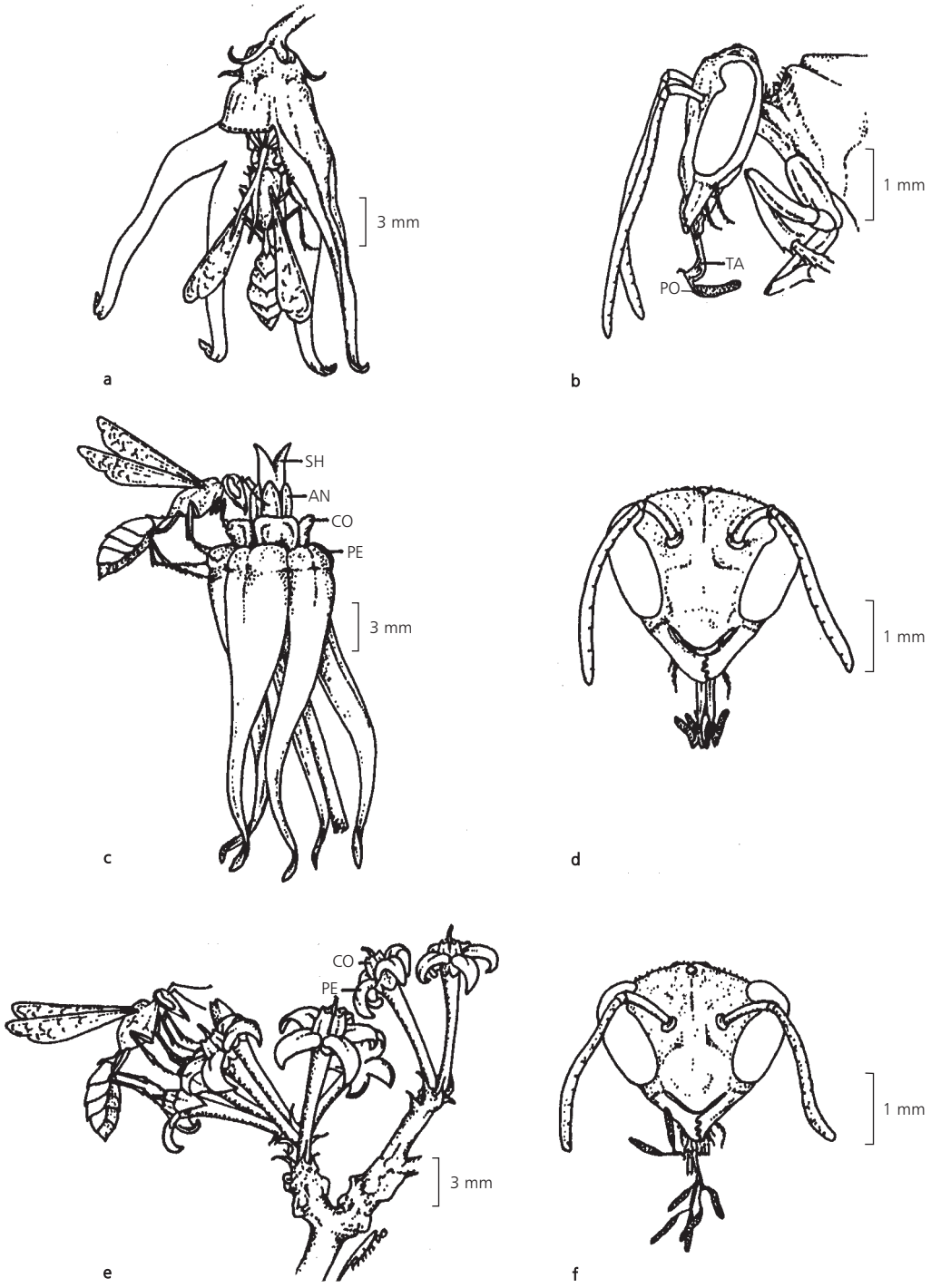

Fig. 1 — *Polybia ignobilis* (Hymenoptera, Vespidae) visiting flowers of *Oxypetalum* spp. and with different arrangements of pollinaria in mouthparts, (a) in a pendent flower of *O. appendiculatum* (part of one petal was removed), (b) carrying pollinarium from *O. appendiculatum* (lateral view; TA = translator apparatus, PO = pollinium), (c) in the flower of *O. banksii* subsp. *banksii* (PE = petal, CO = corona, AN = androecium, SH = bifurcate style head), (d) carrying two pollinaria of *O. banksii* subsp. *banksii* (frontal view), (e) on the inflorescence of *O. alpinum* var. *alpinum* (PE = petal, CO = corona), (f) carrying chains of pollinaria from *O. alpinum* var. *alpinum* (frontal view).

Furthermore, individuals of these species, in the same study site, presented gradual morphologic variations, which can be explained by hybridization and as result of introgression, similar to those registered from natural hybrids and from their introgressive populations (e.g. Tomlinson *et al*., 1978; Grant & Wilken, 1988). According to Occhioni (1953), *O. umbellatum* (=*O. alpinum* var. *alpinum*, Fontella-Pereira & Schwarz, 1984) presents a great polymorphism, which motivates the description of varieties and even of new names, and has affinity with *O. pachyglossum*, both occuring in the same habitat. Further studies are necessary to understand the causes of morphologic variations in these plants in order to clarify their taxonomic status.

Ants (Hymenoptera, Formicidae, Table 2) were not considered in the frequency of visiting insects of the flowers of *O. appendiculatum* and *O. banksii* subsp. *banksii* (Fig. 2); the ants are constant visitors and nectar thieves. Visiting fauna of wasps in *O. banksii* subsp. *banksii* varied daily and, at the first three days, one particular wasp species predominated in number of visits; the number of visits per day also varied in both plant species (Fig. 2). These observations confirm the uncertain and variable character of wasps as pollinators (Faegri & van der Pijl, 1976). Each visit per plant was, generally, of one wasp, which took nectar from several flowers, remaining at the plant until 30 min. The increase of available flower number does not seem to affect the number of insect visits (Fig. 2). Heithaus (1979) observed that the increase of wasp rate of visitation in plants of 26 different families was positively correlated with the abundance of flowers. He called these plants as "opportunists", since they attract many other floral visitors: bees, beetles, butterflies and flies. *O. appendiculatum* and *O. banksii* subsp. *banksii* do not show themselves as opportunists, maybe due to their complex floral features and their complex pollination mechanism, when compared to the plants mentioned by Heithaus (1979). The low number of wasp visits to the flowers of *Oxypetalum* species (Fig. 2) may have a relation with the flowering of other plants with opportunist characteristics. The visit of *Polybia ignobilis* to flowers of *Borreria* sp. (Rubiaceae) near plants of *O. banksii* subsp. *banksii* was noted, without any visit to the many (over 100) flowers of the latter species. The tendency was that the flowers of *O. appendiculatum* were visited mainly by *P. ignobilis*, while *O. banksii* subsp. *banksii* was visited mainly by *Brachygastra lecheguana* (Fig. 2). However, *P. ignobilis*, as well as *P. sericea*, were visitors of the two species flowers (Fig. 2). These data indicate that both species may share the same pollinators, as observed by Kephart (1983) in *Asclepias* species. Manual interspecific pollinations between *O. appendiculatum* and *O. banksii* subsp. *banksii* done by Vieira (1998) result in seeds viable and fertile F_1 hybrid, a hybrid not yet found in nature (Fontella-Pereira, *pers. comm*.).

Species of the group 2 are pollinated by small bees of the families Anthophoridae, Apidae and Halictidae (Table 2). Heithaus (1979) mentions that only 25.8% of the flowers with short corolla and green, yellow-green, or white flowers, characteristic of group 2 plants, are visited by bees.

Flowers of *O. subriparium* were pollinated by bees of the Apidae family (Table 2). These bees are social, have perennial colonies and visit several floral types, belonging to different families (Roubik, 1989). Although generalist, these bees seem to play an important role in *O. subriparium* reproduction. The bees *Augochloropsis* (*Paraugochloropsis*) *electra* (Halictidae) and *Apis mellifera* (Apidae) were the pollinators of *O. jacobinae* (Table 2). The introduced *A. mellifera* is commonly seen pollinating flowers of other Asclepiadaceae (e.g. Frost, 1965; Macior, 1965; Willson *et al*., 1979; Kephart, 1983; Morse, 1985; Liede & Whitehead, 1991). *Ceratina* sp. (Anthophoridae, Table 2) was the only captured bee carrying pollinarium of *O. mexiae* after 48 hours of field observations. The visits of this bee to the *O. mexiae* flowers must be rare (pollinia removal and insertion rates are very low, according to Vieira, 1998), which indicates that this species may be presenting reproductive limitations. Bee's visit behavior in *O. subriparium* and *O. jacobinae* flowers was similar to wasps behavior in *O. appendiculatum*; also the behavior of *Ceratina* sp. in *O. mexiae* was similar to that of wasps that visit flowers of *O. banksii* subsp. *banksii* (*O. mexiae* flowers present reflexed corolla and corona elements partially exposed outside the corolla tube).

All the mentioned bees were carrying up to two pollinaria and were able to present accumulated translator apparatus, but without the formation of pollinaria chain.

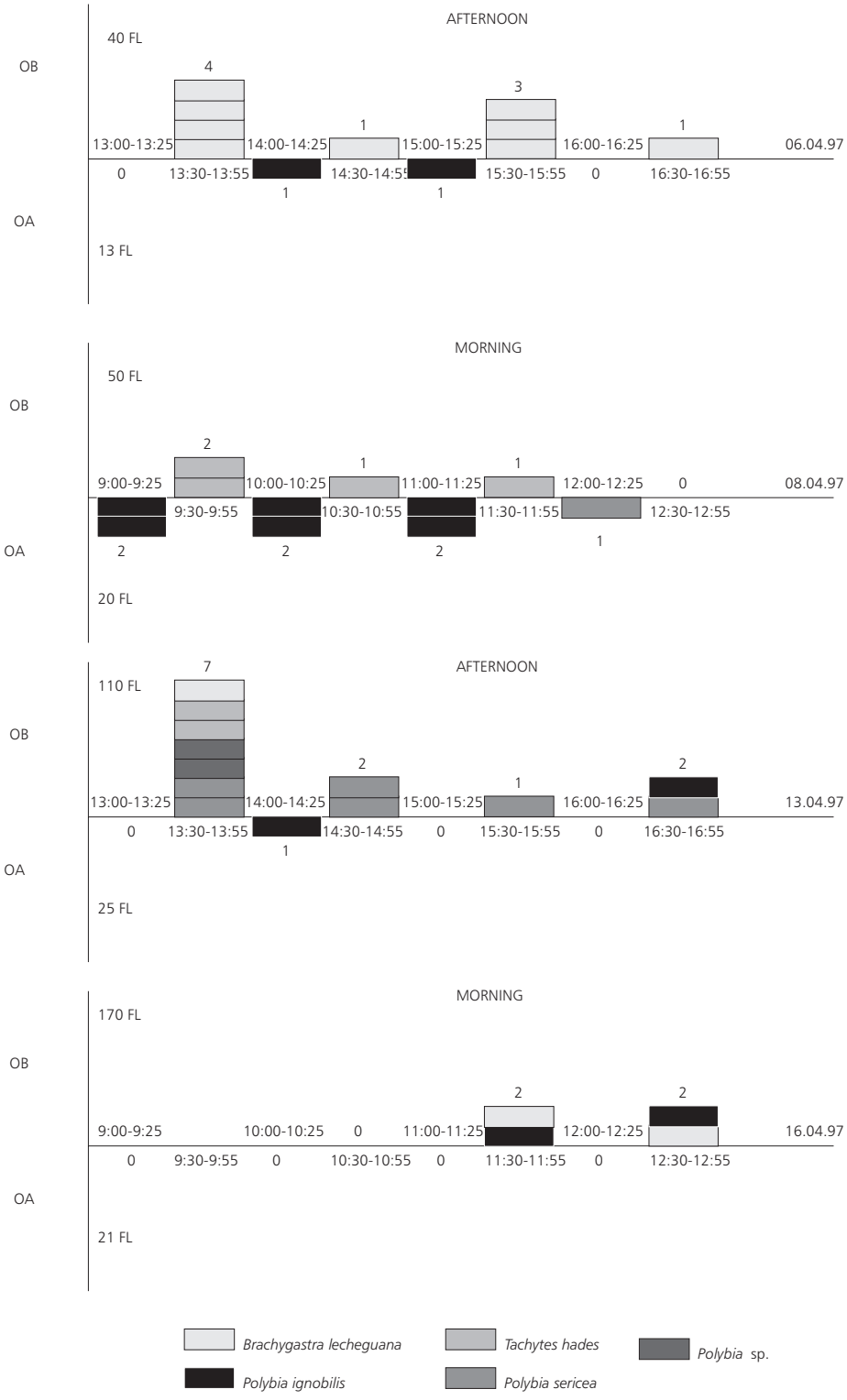

Fig. 2 — Number of registered visits to flowers (FL) of *Oxypetalum appendiculatum* (OA) and *O. banksii* subsp. *banksii* (OB), during four consecutive hours (25 minutes alternated for each species), in four different days.

Among group 2 species, there was an overlap of floral visitors in *O. subriparium* and *O. jacobinae*, both of which being visited by *A. mellifera* (Table 2). Although these plants can be seen in the same site (Table 1), morphological differences of their flowers, including pollinaria, appear to maintain their identity.

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REFERENCES

BERTIN, R. I. & WILLSON, M. F., 1980, Effectiveness of diurnal and nocturnal pollination of two milkweeds. *Can. J. Bot*., *58*: 1744-1746.

BOOKMAN, S. S., 1981, The floral morphology of *Asclepias speciosa* (Asclepiadaceae) in relation to pollination and a clarification in terminology for the genus. *Amer. J. Bot*., *68*: 675-679.

CHATURVEDI, S. K., 1993, Significance of light windows in the pollination of some Indian ceropegias (Asclepiadaceae). *Cactus Succul. J*., *65*: 148-151.

EISIKOWITCH, D., 1986, Morpho-ecological aspects on the pollination of *Calotropis procera* (Asclepiadaceae) in Israel. *Pl. Syst. Evol*., *152*: 185-194.

FAEGRI, K. & VAN DER PIJL, L., 1976, *The principles of pollination ecology*. PERGAMON PRESS, Oxford, 291p.

FONTELLA-PEREIRA, J. & SCHWARZ, E. DE A., 1984, Estudos em Asclepiadaceae, XIX. Uma nova espécie de *Gonolobus* Mich e novas combinações em *Oxypetalum* R. Br. *Bol. Mus. Bot. Munc. de Curitiba* (61): 1-8.

FONTELLA-PEREIRA, J., VALENTE, M. DA C. & ALENCASTRO, F. M. M. R. DE, 1971, Contribuição ao estudo das Asclepiadaceae brasileiras, V. Estudo taxonômico e anatômico de *Oxypetalum Banksii* Roem. et Schult. *Rodriguésia* (38): 261-281.

FONTELLA-PEREIRA, J., VALENTE, M. DA C. & SCHWARZ, E. DE A., 1984, Contribuição ao estudo das Asclepiadaceae brasileiras, XXI. Asclepiadaceae do município de Ouro Preto, Estado de Minas Gerais – Uma sinopse. *Bol. Mus. Bot. Kuhlmann* (2): 63-127.

FORSTER, P. I., 1989, Pollination of *Marsdenia fraseri* (Asclepiadaceae) by *Metriorrhynchus lateralis* (Coeloptera: Lycidae). *Coleopts. Bull*., *43*: 311-312.

FORSTER, P. I., 1992a, Insects associated with the flowers of *Marsdenia cymulosa* Benth. (Asclepiadaceae) and their possible role in pollination. *Aust. ent. Mag*., *19*: 45-47.

FORSTER, P. I., 1992b, Pollination of *Hoya australis* (Asclepiadaceae) by *Ocybadistes walkeri sothis* (Lepidoptera: Hesperidae). *Aust. ent. Mag*., *19*: 39-43.

FORSTER, P. I., 1994, Diurnal insects associated with the flowers of *Gomphocarpus physocarpus* E. Mey. (Asclepiadaceae), an introduced weed in Australia. *Biotropica*, *26*: 214-217.

FROST, S. W., 1965, Insects and pollinia. *Ecology*, *46*: 556-558.

GRANT, V. & WILKEN, D. H., 1988, Natural hybridization between *Ipomopsis aggregata* and *I. tenuituba* (Polemoniaceae). *Bot. Gaz.*, *149*: 213-221.

HEITHAUS, E. R., 1979, Flower visitation records and resource overlap of bees and wasps in northwest Costa Rica. *Brenesia*, *16*: 9-52.

JENNERSTEN, O. & MORSE, D. H., 1991, The quality of pollination by diurnal and nocturnal insects visiting common milkweed, *Asclepias syriaca. Amer. Midl. Nat*., *125*: 18-28.

KEPHART, S. R., 1983, The partitioning of pollinators among three species of *Asclepias. Ecology, 64*: 120-133.

KUNZE, H., 1991, Structure and function in asclepiad pollination. *Pl. Syst. Evol*., *176*: 227-253.

KUNZE, H. & LIEDE, S., 1991, Observations on pollination in *Sarcostemma* (Asclepiadaceae). *Pl. Syst. Evol*., *178*: 95-105.

LIEDE, S. & WHITEHEAD, V., 1991, Studies in the pollination biology of *Sarcostemma viminale* R. Br. *sensu lato. South Afr. J. Bot*., *57*: 115-122.

LUMER, C. & YOST, S. E., 1995, The reproductive biology of *Vincetoxicum nigrum* (L.) Moench (Asclepiadaceae), a Mediterranean weed in New York State. *Bull. Torrey Bot. Club*, *122*: 15-23.

MACIOR, L. W., 1965, Insect adaptation and behavior in *Asclepias* pollination. *Bull. Torrey Bot. Club*, *92*: 114-126.

MEVE, U. & LIEDE, S., 1994, Floral biology and pollination in stapeliads – new results and a literature review. *Pl. Syst. Evol., 192*: 99-116.

MORSE, D. H., 1985, Milkweeds and their visitors. *Sci. Am*., *253*: 90-96C.

MORSE, D. H. & FRITZ, R. S., 1983, Contributions of diurnal and nocturnal insects to the pollination of common milkweed (*Asclepias syriaca* L.) in a pollen-limited system. *Oecologia*, *60*: 190-197.

OCCHIONI, P., 1953, Notas sôbre o gênero *Oxypetalum* – II (As espécies do Estado do Rio de Janeiro). *Dusenia*, *4*: 251-271.

OCCHIONI, P., 1956, Contribuição ao estudo do gênero *Oxypetalum*, com especial referência às spp. da Serra do Itatiaia e Serra dos Órgãos. *Arq. Jard. Bot*., *14*: 37-210.

PANT, D. D., NAUTIYAL, D. D. & CHATURVEDI, S. K., 1982, Pollination ecology of some Indian asclepiads. *Phytomorphology, 32*: 302-313.

PROCTOR, M., YEO, P. & LACK, A., 1996, *The natural history of pollination*. TIMBER PRESS, Portland, 479p.

ROUBIK, D. W., 1989, *Ecology and natural history of tropical bees*. CAMBRIDGE UNIV., Cambridge, 514p.

TOMLINSON, P. B., BUNT, J. S., PRIMACK, R. B. & DUKE, N. C., 1978, *Lumnitzera rosea* (Combretaceae) – its status and floral morphology. *J. Arnold Arbor*., *59*: 342-351.

VIEIRA, M. F., 1998, *Biologia reprodutiva de espécies de* Oxypetalum (*Asclepiadaceae*), *na região de Viçosa, MG, sudeste brasileiro*. Tese de Doutorado, UNICAMP, Campinas, Brasil, 141p.

VIEIRA, M. F. & SHEPHERD, G. J., 1995, Polinização de *Oxypetalum* spp. (Asclepiadaceae). *In*: XLVI Congresso Nacional de Botânica. Ribeirão Preto, São Paulo, p. 147 (Resumos).

WANNTORP, H.-E., 1974, *Calotropis gigantea* (Asclepiadaceae) and *Xylocopa tenuiscapa* (Hymenoptera, Apidae). *Sven. Bot. Tidskr*., *68*: 25-32.

WILLSON, M. F. & BERTIN, R. I., 1979, Flower-visitors, nectar production, and inflorescence size of *Asclepias syriaca*. *Can. J. Bot*., *57*: 1380-1388.

WILLSON, M. F., BERTIN, R. I. & PRICE, P. W., 1979, Nectar production and flower visitors of *Asclepias verticillata*. *Amer. Midl. Nat*., *102*: 23-35.