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ARTICLE

Phytoseiidae (Acari: Mesostigmata) from the Atlantic Forest in Rio de Janeiro, Brazil, with complementary description of *Amblyseius impeltatus* Denmark & Muma

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Abstract. Phytoseiid mites (Acari: Phytoseiidae) have been largely used for the biological control of arthropod pests. However, information on the phytoseiid fauna associated with plants of the Rio de Janeiro State, Brazil is still scanty. Surveys were carried out in two areas of Atlantic Forest in Rio de Janeiro State – Jaguanum island and Paraty. We report 11 species of seven genera from all three subfamilies. A complementary re-description is provided for *Amblyseius impeltatus* Denmark & Muma, 1973 and measurements are provided for ten other species.

Keywords. Coast; Island; Predator; Survey; Parasitiformes.

INTRODUCTION

The Atlantic Forest occupies mainly the East coast of Brazil, but also parts of Argentina and Paraguay. In Brazil, it covers more than 1 million km^2 (MMA, 2015). Due to the high degree of endemism and the exceptional loss of original habitat, the Atlantic Forest is considered a hotspot and a world priority conservation area (Myers *et al.,* 2000; Rezende *et al.,* 2018). About 900 mite (Acari) species have been registered in this biome, belonging to 124 families of both Acariformes and Parasitiformes (Giupponi *et al.,* 2017).

Phytoseiid mites (Parasitifomes: Phytoseiidae) are used as biological control agents in several regions of the world (Gerson *et al.,* 2003; McMurtry *et al.*, 2013; Knapp *et al.,* 2018). Therefore, it is one of the most studied mite families, with more than 2,700 described species worldwide; in Brazil, about 220 species have been reported (Demite *et al.,* 2014, 2021).

More than 150 phytoseiid species have been recorded from the Atlantic Forest (Giupponi *et al.,* 2017), which represents about 60% of the species of this family registered in Brazil. However, several areas of this biome have been poorly or not yet investigated. The majority of species was reported from São Paulo state, where most samplings have been conducted (*e.g.,* Karg, 1983; Feres & Moraes, 1998; Gondim-Jr. & Moraes, 2001; Zacarias & Moraes, 2002; Feres *et al.,* 2005, 2007; Buosi *et al.,* 2006; Castro & Moraes, 2007, 2010; Demite *et al.,* 2011; Moraes *et al.,* 2013). Only two studies reported phytoseiids from natural areas of Rio de Janeiro state, both from the same municipality – Itatiaia (El-Banhawy, 1984; Kreiter & Tixier, 2010), and a third study focused on mites of *Carica papaya* L. (Caricaceae) orchards (Collier *et al.,* 2004).

The aim of this study was to survey the phytoseiid fauna associated with some native and cultivated plants from Rio de Janeiro state.

MATERIAL AND METHODS

This study was conducted in two areas of the Atlantic Forest in the state of Rio de Janeiro, Brazil: Jaguanum Island (22°59′28″S, 43°55′25″W) and Paraty (23°13′30″S, 44°46′35″W). In each area, native and cultivated plants were sampled, in April

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of 2007 (Jaguanum Island) and July of 2008 (Paraty). Specimens were mounted in Hoyer's medium; under "Material examined", we list the locality, specimens collected, host plant and collection date. The illustrations were accomplished using a drawing tube attached to an optic microscope equipped with phase contrast (Leica DM 2500). All measurements are given in micrometres (µm); each measurement corresponds to the mean for the stated number of individuals, followed by the respective range (min-max) in parentheses. The setal nomenclature adopted were those of Lindquist & Evans (1965) and Lindquist (1994), as adapted for Phytoseiidae by Rowell *et al.* (1978) for the dorsum; and by Chant & Yoshida-Shaul (1991) for the venter. Numbers of teeth on the fixed and movable cheliceral digits do not include the respective apical teeth.

Voucher specimens were deposited in the Acari Collection of Departamento de Ciências Biológicas (DZSJRP-Acari), Universidade Estadual Paulista (UNESP), São José do Rio Preto, São Paulo, Brazil (http://splink.cria.org.br). Holotype micrographs of *Amblyseius impeltatus* deposited at the collection of Florida Department of Agriculture and Consumer Service, Gainesville, FL, USA, were also examined.

RESULTS AND DISCUSSION

Eleven phytoseiid species belonging to seven genera from three subfamilies were found. A complementary redescription for *Amblyseius impeltatus* Denmark & Muma, 1973 is provided. Morphological information for the other species is given in Table 1.

Family Phytoseiidae Berlese

Subfamily Amblyseiinae Muma

Amblyseius impeltatus Denmark & Muma (Figs. 1-8)

Amblyseius impeltatus Denmark & Muma, 1973: 241; Moraes *et al.,* 1986: 16; 2004: 30; Chant & McMurtry, 2004: 199; 2007: 78.

Amblyseius (*Multiseius*) *impeltatus* – Denmark & Muma, 1989: 91.

Material examined: Paraty: 8 females and 2 males on *Cupania* sp. (Sapindaceae), 27-VIII-2008.

Female (n = 5)

Dorsum (Fig. 1): Dorsal shield smooth, with 6 pairs gland pores (*gd1, gd2, gd4, gd5, gd8* and *gd9*) and 12 pairs of lyrifissures (*id1, id2, id4, idx, idm2, idm3, idm4, idm6, is1, idl2, idl3* and *idl4*) visible, 388 (380-395) long and 250 (237-270) wide; with 17 pairs of setae on dorsal shield; setae *r3* and *R1* inserted in the unsclerotized cuticle. Setae *j1* 20 (19-20), *j3* 22 (22-23), *j4* 9 (8-10), *j5* 9 (7-10), *j6* 11 (9-12), *J2* 14 (14-15), *J5* 8 (7-9), *z2* 15 (13-16), *z4* 11 (10-12), *z5* 12 (10-14), *Z1* 13 (12-14), *Z4* 37 (34-41), *Z5* 134 (120-140), *s4* 41 (39-43), *S2* 14 (13-15), *S4* 13 (12-14), *S5* 13 (11-14), *r3* 12 (11-13), *R1* 13 (12-14). All dorsal setae smooth, except *Z5* serrate.

Peritreme: Extending forward to level of *j1*.

Venter (Fig. 2): Sternal shield smooth, except for some lateral striation in the anterior region; with three pairs of setae (*st1, st2* and *st3*) and two pairs of lyrifissures (*iv1* and *iv2*); distances between *st1-st3* 53 (52-55), *st2-st2* 70 (68-73). Seta *st4* and lyrifissure *iv3* on metasternal plate. Genital shield smooth, *st5-st5* 84 (82-87). With two pairs of metapodal plate. Ventrianal shield pentagonal, smooth; 97 (95-99) long, 85 (82-89) wide at level of *ZV2* and 77 (72-80) wide at anus level; with three pairs of preanal setae (*JV1, JV2* and *ZV2*) and a pair of spheric pores (*gv3*) posteromesad to *JV2*. Four pairs of opisthogastric setae on unsclerotized cuticle (*JV4, JV5, ZV1* and *ZV3*). *JV5* 61 (59-67). All ventral setae smooth.

Spermatheca (Figs. 3 and 8): Calyx bell-shaped 7 (7-9) long. Atrium indistinct, only noticeable by the presence of a ring surrounding embolus (lips) and minor duct.

Chelicera (Fig. 4): Movable cheliceral digit 27 (26-27) long, with three teeth; fixed cheliceral digit 27 (26-28) long, with 8-10 teeth.

Legs (Fig. 5): Leg macrosetae smooth and pointed: *SgeI* 30 (31-33), *SgeII* 34 (32-35), *SgeIII* 43 (42-45), *StilII* 30 (27-31), *SgeIV* 69 (68-71), *StilV* 52 (51-54), *StIV* 56 (54-58). Chaetotactic formula of genu II: 2-2/0-2/0-1 and genu III: 1-2/1-2/0-1.

Male (n = 2)

Dorsum: Dorsal shield smooth; 270 long and 215 wide. Setae *j1* 13, *j3* 30, *j4* 3, *j5* 5-7, *j6* 5-6, *J2* 10-11, *J5* 6-7, *z2* 11-13, *z4* 10, *z5* 10, *Z1* 10, *Z4* 33-34, *Z5* 115-119, *s4* 36-37, *S2* 12, *S4* 10-11, *S5* 7-8, *r3* 11-13, *R1* 11. Setae *r3* and *R1* on dorsal shield. All dorsal setae smooth, except *Z5* serrate.

Peritreme: Extending forward to the level of *j1*.

Venter (Fig. 6): Sternogenital shield smooth; ventrianal shield subtriangular, with striation anteriorly to pores (*gv3*); 104 long, 142-145 wide at anterior corners. *JV5* 40-44. All ventral setae smooth.

Spermatodactyl (Fig. 7): Shaft of spermatodactyl 20-22 long.

Legs: Leg macrosetae smooth: *SgeI* 28-29, *SgeII* 28-29, *SgeIII* 31-32, *StilII* 26-27, *SgeIV* 47-48, *StilV* 42, *StIV* 47-49. Chaetotactic formula of genu II and genu III as female.

Remarks: The cervix of the spermatheca of *A. impeltatus* was originally depicted in a narrow and elongated shape,

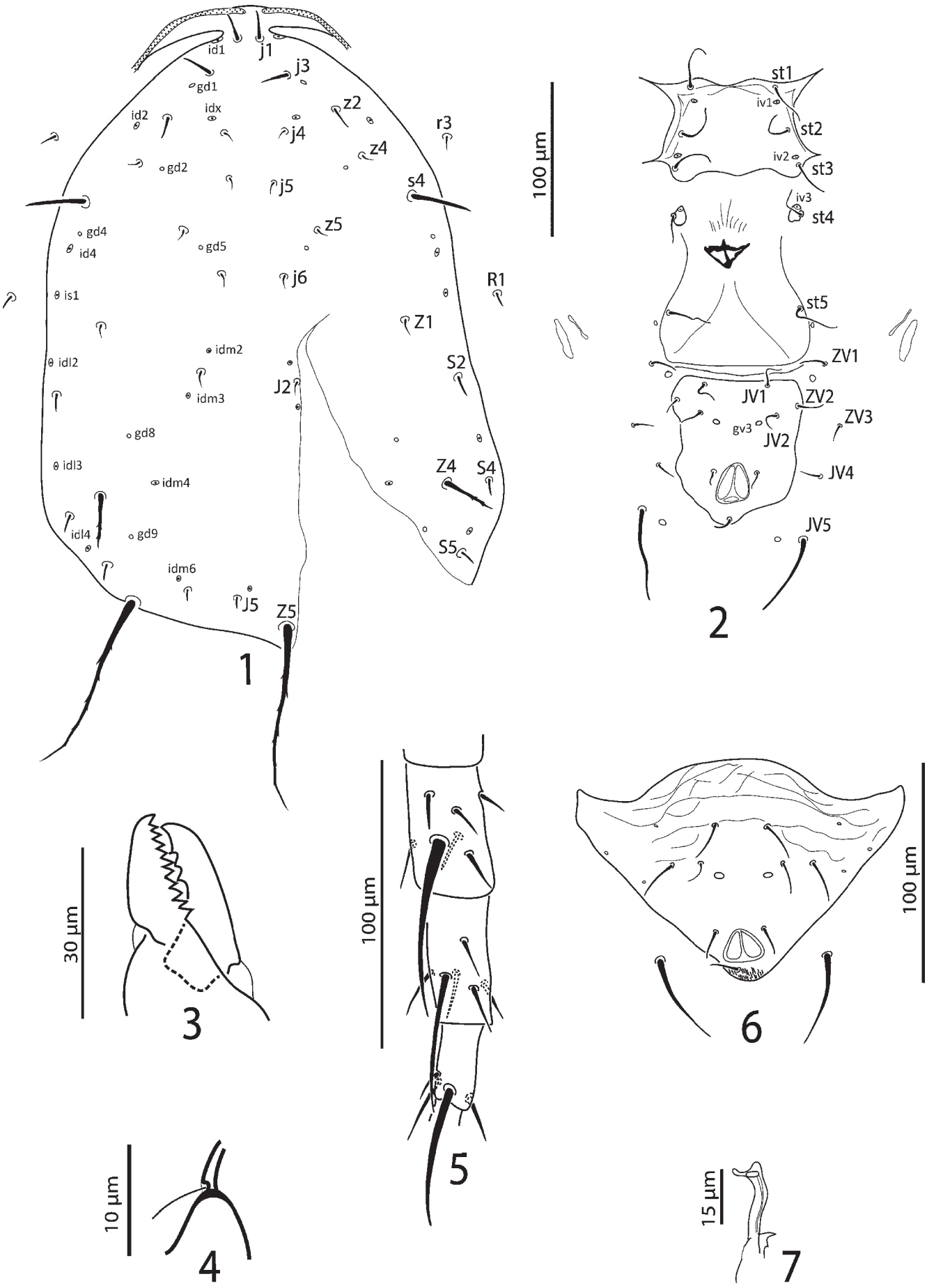
Table 1. Measures (mean and range) of eight species of Phytoseiidae of two areas of Atlantic Forest in Rio de Janeiro State (Jaguanum island and Paraty), Brazil.

Character	Amblyseiinae							Phytoseiinae		Typhlodrominae
	Amblyseius largoensis ♀ (n = 2)	*Amblyseius operculatus* ♀ (n = 5)	*Euseius alatus* ♀ (n = 3)	*Euseius mesembrinus* ♀ (n = 5)	*Iphiseiodes zuluagai* ♀ (n = 1)	*Proprioseiopsis dominigos* ♀ (n = 1)	*Typhlodromips cananeiensis* ♀ (n = 1)	*Phytoseius marumbus* ♀ (n = 1)	*Phytoseius woodburyi* ♀ (n = 5)	*Leonseius regularis* ♀ (n = 3)
DSL	350-387	409 (385-425)	304 (295-312)	315	350	505	320	280	300 (295-305)	378 (365-388)
DSW	232-235	286 (262-300)	225	206 (200-212)	315	380	210	155	155 (150-157)	280 (275-288)
j1	35-41	41 (40-43)	28 (25-30)	29 (29-30)	32	25	20	20	32 (31-34)	30 (29-30)
j3	51-52	58 (55-61)	20 (20-21)	19 (17-21)	35	112	20	24	39 (37-42)	42 (41-45)
j4	7	10 (9-11)	15	9 (8-10)	3	4	18	13	5 (4-6)	5
j5	7	7 (6-7)	15 (14-15)	9 (9-10)	3	3	11	7	6 (5-6)	5
j6	8	10 (8-11)	17 (14-18)	10 (10-11)	3	2	14	7	7 (6-7)	5
J2	10-13	11 (10-12)	18 (16-19)	12 (11-13),	3	—	14	7	—	7 (6-7)
J5	10	9 (8-10)	8 (7-9)	6 (5-6)	4	5	9	7	7 (7-8)	7 (6-8)
z2	10-13	16 (13-17)	17 (17-18)	14 (13-15)	2	16	17	7	15 (14-17)	5 (4-6)
z3	—	—	—	—	—	—	—	43	36 (34-38)	11 (10-11)
z4	9-10	15 (12-17)	16 (16-17)	15 (14-16)	2	40	16	6	15 (14-16)	7 (6-7)
z5	7	8 (7-9)	15 (15-16)	9 (9-10)	2	4	14	10	6 (5-6)	5 (4-5)
Z1	8-14	12 (11-12)	18 (17-19)	12 (12-13)	3	6	17	—	—	—
Z4	95-100	139 (132-152)	18 (18-19)	12	4	150	28	53	97 (92-100)	95 (88-100)
Z5	262-300	297 (285-307)	57 (55-60)	57 (54-59)	117	145	69	68	84 (81-90)	301 (292-315)
s4	92-102	111 (104-116)	22 (21-23)	22 (20-23)	116	137	20	55	129 (121-140)	90 (85-96)
s6	—	—	—	—	—	—	—	65	89 (87-90)	8 (7-8)
S2	12-19	14 (12-15)	20 (19-21)	15 (14-16)	3	6	20	—	—	—
S4	12-13	14 (12-16)	20 (20-21)	17 (16-19)	4	6	17	—	—	—
S5	12-13	14 (12-16)	24 (21-26)	18 (17-20)	5	4	17	—	—	6 (6-7)
r3	14-16	16 (15-17)	15 (15-16)	16	7	10	15	42	48 (45-51)	10 (10-11)
R1	12-14	15 (11-19)	15 (14-15)	13 (12-13)	6	lost/broken	15	15	—	10 (9-10)
st1-st3	65-68	74 (70-77)	52 (50-53)	56 (54-57)	50	60	58	62	60 (57-65)	63 (62-64)
st2-st2	63-67	80 (77-85)	69 (68-70)	68 (67-71)	82	77	66	65	62 (62-63)	71 (69-73)
st5-st5	52-75	77 (74-82)	73	71 (67-75)	119	120	62	55	63 (62-64)	77 (76-78)
VSL	105-115	139 (130-147)	94 (92-96)	96 (93-101)	120	118	110	86	98 (95-101)	118 (116-119)
VSWant	52-53	86 (82-89)	55 (53-57)	54 (50-57)	124	135	101	46	40 (37-43)	66 (64-68)
VSWpost	73-71	92 (85-97)	66 (63-70)	67 (65-69)	110	125	80	49	46 (45-47)	78 (73-82)
JV5	68-70	84 (80-88)	33 (30-35)	31 (30-33)	37	57	48	45	53 (49-56)	62 (59-65)
calyxL	24-37	8 (7-9)	17 (16-18)	16 (16-17)	6	23	7	10	8-10	11 (10-12)
MDL	27-30	36 (34-37)	22 (21-23)	23	27	35	28	22	21 (20-22)	25 (20-29)
MD teeth	3	4-5	1	1	1	2	2	1	1	3
FDL	30-35	38 (35-40)	24 (24-26)	25 (24-25)	32	37	28	22	23 (22-25)	(24-30)
FD teeth	11	13-17	6-7	5	12	4	11	3	3-4	11
SgeI	32-43	47 (39-52)	21 (20-22)	23 (22-24)	46	20	—	—	—	51 (50-53)
SgeII	38-40	46 (39-50)	19 (18-19)	23 (23-24)	33	21	—	—	—	43 (40-50)
SgeIII	50-55	40 (38-42)	26 (25-26)	26 (26-27)	45	26	19	—	—	53 (50-55)
StiIII	38-42	40 (38-42)	20	23	27	26	—	—	—	35 (35-36)
SgeIV	122-136	130 (125-140)	37 (36-38)	34 (33-37)	85	68	27	22	—	128 (123-132)
StiIV	98-104	93 (80-103)	25 (23-27)	30 (27-32)	52	48	18	24	51 (50-54)	79 (76-82)
StIV	65-72	84 (80-88)	44 (43-45)	51 (49-54)	35	65	38	25	26 (25-27)	59 (58-60)

DSL: Dorsal Shield Length; DSW: Dorsal Shield Width; VSL: Ventrianal Shield Long; VSWant: Ventrianal Shield Wide at level of *ZV2;* VSWpost: Ventrianal Shield widht at anus level; calyxL: calyx of spermatheca length; MDL: Movable Digit Length; FDL: Fixed Digit Length.

not showing a distinct atrium and both major and minor ducts (Denmark & Muma, 1973, fig. 15). Subsequently, in a revision of genus *Amblyseius,* the spermatheca was modified to a stockier shape, with both ducts represented, but with a distinct nodular atrium (Denmark & Muma, 1989, fig. 477). In our specimens, however, the spermatheca had a bell-shaped calyx and an indistinct atrium, indistinguishable from the major duct (Figs. 4, 8). Micrograph examination of the holotype species (Fig. 8) has revealed the shape of spermatheca matches with the structure described above in our specimens, and do not correspond the previous two illustrations. In addition, all setae on leg IV are herein illustrated on genu (7), tibia (6) and basitarsus (4), while some of the ventral setae were not represented in those previous works.

It is also noteworthy mentioning that despite both papers (Denmark & Muma, 1973, 1989) stated the holotype is deposited at ESALQ Collection in Piracicaba, Brazil, it is actually deposited at the collection of Florida Department of Agriculture and Consumer Service, Gainesville, FL, USA.



Figures 1-7. *Amblyseius impeltatus* Denmark & Muma, 1973. Female (1-5): (1) Dorsal shield; (2) Ventral idiosoma; (3) Chelicera; (4) Spermatheca; (5) Genu, tibia and basitarsus of leg IV. Male (6-7): (6) Ventrianal shield; (7) Spermatodactyl.

***Amblyseius largoensis* (Muma)**

Material examined: Jaguanum Island: 2 females on *Couroupita guianensis* (Lecythidaceae), 20-IV-2007.

***Amblyseius operculatus* De Leon**

Material examined: Jaguanum Island: 3 females on unidentified plant, 19-IV-2007; 2 females on *Persea americana* (Lauraceae), 20-IV-2008; 1 female on *C. guianensis,* 20-IV-2007; Paraty: 5 females on *Cupania* sp., 27-VII-2008.

***Euseius alatus* De Leon**

Material examined: Jaguanum Island: 3 females on unidentified plant, 19-IV-2007.

***Euseius mesembrinus* (Dean)**

Material examined: Jaguanum Island: 13 females and 4 males on unidentified plant, 19-IV-2007, 5 females and 3 males, 20-IV-2007, 5 females and 1 male, 21-IV-2007; 7 females and 3 males on undetermined Leguminosae, 19-IV-2007; 2 females and 1 male on *Hibiscus* sp. (Malvaceae), 19-IV-2007.

***Iphiseiodes zuluagai* Denmark & Muma**

Material examined: Jaguanum Island: 1 female on unidentified plant, 19-IV-2007.

***Proprioseiopsis dominigos* (El-Banhawy)**

Material examined: Paraty: 1 female on *Cupania* sp., 27-VII-2008.

***Typhlodromips cananeiensis* Gondim-Jr. & Moraes**

Material examined: Paraty: 1 female on *Cupania* sp., 27-VII-2008.

Subfamily Phytoseiinae Berlese

***Phytoseius marumbus* El-Banhawy**

Material examined: Jaguanum Island: 1 female on unidentified plant, 19-IV-2007.

***Phytoseius woodburyi* De Leon**

Material examined: Jaguanum Island: 2 females on unidentified plant, 19-IV-2007, 11 females and 1 male, 20-IV-2007; 1 female on unidentified Leguminosae, 19-IV-2007.

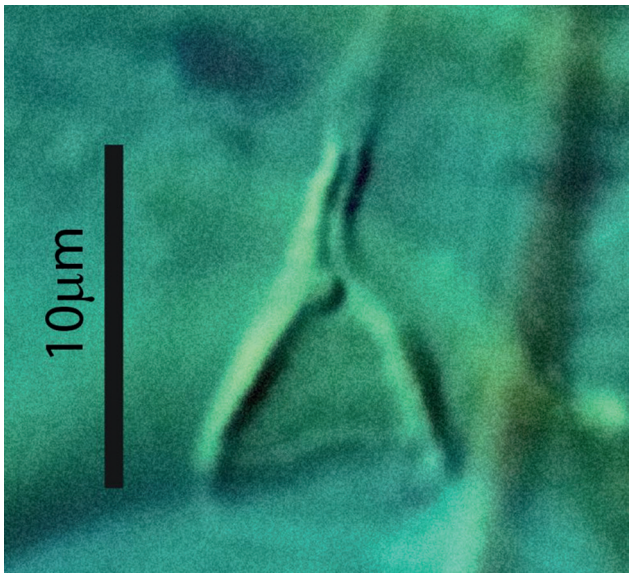


Figure 8. *Amblyseius impeltatus* Denmark & Muma. Holotype spermatheca (Photo: Samuel Bolton).

Subfamily Typhlodrominae Wainstein

***Leonseius regularis* (De Leon)**

Material examined: Paraty: 3 females on *P. americana,* 20-IV-2007; 4 females on *Cupania* sp., 27-VII-2008.

All species found here had previously been reported in the Atlantic Forest in South coast of São Paulo State (Gondim-Jr. & Moraes, 2001; Moraes *et al.,* 2013; Zacarias & Moraes, 2002), distant about 400 km from both areas sampled in this study. This suggests a similarity among phytoseiid mite communities from different areas of Atlantic Forest.

Two species found in this study, *T. cananeiensis* and *P. marumbus,* have been found only in the Atlantic Forest so far, suggesting they might be endemic to this biome. Others, like *Amblyseius largoensis, Euseius alatus, Iphiseiodes zuluagai,* and *Proprioseiopsis dominigos,* all reported herein, are also frequently registered in several agricultural crops in other localities and biomes in Brazil, indicating phytoseiids from the Atlantic Forest may also migrate to nearby crops and act as natural enemies of pest mites. This reinforces the idea of the native vegetation working as reservoirs of phytoseiids as suggested by previous authors (Tixier *et al.,* 2000; Demite & Feres, 2005, 2008; Lofego & Moraes, 2006; Castro & Moraes, 2007, 2010; Demite *et al.,* 2013; Rezende *et al.,* 2014). Phytoseiids have a major role in ecosystems, regulating phytophagous mite populations in natural environments and agroecosystems (Demite *et al.,* 2013; Lofego & Moraes, 2006). Surveying natural vegetation areas provides a clearer picture of the real diversity of these organisms, also contributing to understand the structure of mite communities and the species turnover between natural vegetation and adjacent crops.

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AUTHORS' CONTRIBUTIONS

Conceived the study: A.C.C.C., P.R.D., A.C.L., F.A.H. Material sampling: P.R.D., A.C.L., F.A.H. Species identification and analysis: A.C.C.C., P.R.D., A.C.L. Illustration: A.C.C.C., P.R.D. Writing, review and editing: A.C.C., P.R.D., A.C.L., F.A.H.

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