

Supplementary Information

Filling the gap: a new ant-butterfly symbiosis in the forest canopy

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Table S1. Published myrmecophilous associations in riordinid butterflies, including tending ants, ant subfamilies, caterpillar feeding habits, notes on type and degree of myrmecophily, localities and references. When possible, records were reassessed based on additional information (L. A. Kaminski, unpubl. data). Records where the ants were not identified were not included. Taxonomic arrangement for Riordinidae follows the phylogenetic hypothesis proposed by Seraphim et al. (2018) and nomenclature of Riordinidae is updated following Seraphim (2019). *: Specialized predacious caterpillars on honeydew-producing hemipterans; **: possible cases of social parasites found inside ant nests.

Riordinidae taxon	Tending ants	Ant subfamilies	Caterpillar feeding habits / type and degree of myrmecophily	Locality	References
Eurybiini: Eurybiina * <i>Alesa amesis</i> (Cramer 1777)	<i>Camponotus femoratus</i>	Formicinae	Exudates and predation on honeydew-producing hemipterans (HPHs) / trophobiotic, obligate association with parabiotic ants	Peru, Ecuador, Brazil	1, 2, 3
** <i>Alesa rothschildi</i> (Seitz, 1913)	<i>Cephalotes atratus</i>	Myrmicinae	Unknown / possibly social parasite, caterpillars with specialized morphology found inside the ant-nest in the canopy	Peru	4

<i>Eurybia elvina elvina</i> Stichel, 1910	<i>Neoponera villosa</i> , <i>Camponotus</i> sp., <i>Brachymyrmex musculus</i> , <i>Paratrechina</i> sp., <i>Pheidole</i> sp., <i>Ph. gouldi</i> , <i>Crematogaster</i> sp., <i>Cr. sumichrasti</i> , <i>Solenopsis</i> (<i>diplorhoptrum</i> group), <i>S. geminata</i> , <i>Wasmannia auropunctata</i> , <i>Ectatomma ruidum</i> , <i>E. tuberculatum</i>	Ponerinae Formicinae, Myrmicinae, Ectatomminae	Phytophagous on plants / trophobiotic, facultative, including <i>N. villosa</i>	Mexico, Costa Rica, Panama	5, 6, 7, 8
<i>Eurybia lycisca</i> Westwood, 1851	<i>Neoponera villosa</i> , <i>Camponotus</i> spp., <i>Paratrechina</i> sp., <i>Crematogaster</i> sp., <i>Cr. brevispinosa</i> , <i>Aphaenogaster araneoides</i> , <i>Pheidole</i> sp., <i>Ph. biconstricta</i> , <i>Ph. nr. biconstricta</i> , <i>Wasmannia auropunctata</i> , <i>Solenopsis</i> sp., <i>S. (diplorhoptrum</i> group), <i>Megalomyrmex foreli</i> , <i>Ectatomma</i>	Ponerinae Formicinae, Myrmicinae	Phytophagous on plants / trophobiotic, facultative, including <i>N. villosa</i>	Costa Rica, Panama	6, 7

<i>Eurybia patrona persona</i> Staudinger, 1876	<i>ruidum</i> , <i>E. tuberculatum</i> <i>Neoponera villosa</i> , <i>Camponotus</i> sp., <i>Paratrechina</i> sp., <i>Crematogaster</i> sp., <i>Pheidole</i> sp., <i>Wasmannia auropunctata</i> , <i>Solenopsis</i> sp.	Ponerinae Formicinae, Myrmicinae,	Phytophagous on plants / trophobiotic, facultative, including <i>N. villosa</i>	Costa Rica	6, 7
Eurybiini: Mesosemiina <i>Hyphilaria thasus</i> (Stoll, 1780)	<i>Camponotus</i> spp.	Formicinae	Phytophagous on plants / non-trophobiotic, caterpillars may be living in places with ants, but do not establish stable associations	Costa Rica, Trinidad, Colombia, Brazil	1, 9, 10
Nymphidiini: Zabuellina <i>Zabuella paucipuncta</i> (Spitz, 1930)	<i>Crematogaster</i> sp.	Myrmicinae	Phytophagous on plant / trophobiotic, obligate	Brazil	11, 12
Nymphidiini: Stalachtina <i>Protonymphidia senta</i> (Hewitson, 1853)	<i>Pheidole biconstricta</i> complex, <i>Ph. gertrudae</i>	Myrmicinae	Phytophagous on plant / trophobiotic, specialized on <i>Pheidole-Bauhinia</i> association	Ecuador, Brazil	1, 6, 13, 14
<i>Stalachtis phlegia</i> (Cramer, 1779)	<i>Camponotus</i> spp., <i>Crematogaster</i> sp., <i>Cephalotes</i> sp., <i>Ectatomma</i> sp.	Formicinae, Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Brazil	1, 15

Nymphidiini: Pachytheonina

* <i>Pachythone gigas</i> Godman & Salvin, 1878	<i>Azteca</i> sp.	Dolichoderinae	Exudates and predation on HPHs / non-trophobiotic, obligate	Costa Rica	16
* <i>Pachythone xanthe</i> Bates 1868	<i>Azteca</i> cf. <i>chartifex</i>	Dolichoderinae	Predation on HPHs / non- trophobiotic, obligate	Brazil	17
** <i>Pseudonymphidia</i> <i>agave</i> (Godman & Salvin, 1886)	<i>Neoponera villosa</i>	Ponerinae	Unknown / possibly social parasite, caterpillars with specialized morphology found inside the ant-nest with the brood	Mexico	This study
<i>Minstrellus grandis</i> (Callaghan, 1999)	<i>Pseudomyrmex</i> <i>triplarinus</i> group	Pseudomyrmecinae	Unknown / ant-mediated oviposition, immatures unknown	Brazil	18
Nymphidiini: Theopina					
<i>Theope archimedes</i> <i>zyzyxoxys</i> D'Abbrera, 1994	<i>Dolichoderus</i> <i>bispinosus</i>	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Panama	6
<i>Theope bacenis</i> Schaus, 1890	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Costa Rica	6, 7
<i>Theope eudocia</i> Westwood, 1851	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Brazil	14, 19, 20, 21
<i>Theope guillaumei</i> <i>cecropia</i> DeVries & Hall, 1996	<i>Solenopsis</i> (<i>diploporum</i> group)	Myrmicinae	Phytophagous on plant / trophobiotic, probably facultative	Costa Rica	6, 7, 22, 23
<i>Theope leucanthe</i> Bates, 1868	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Brazil	14
<i>Theope lycaenina</i> Bates, 1868	<i>Azteca chartifex</i> , <i>Azteca</i> spp.	Dolichoderinae	Phytophagous, pupation inside ant-built shelters on plants / trophobiotic, obligate	Panama, Costa Rica, Brazil	6, 7, 14, 24

<i>Theope phaeo</i> Prittitz, 1865	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Costa Rica	19
<i>Theope pieridoides</i> Felder & Felder, 1865	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Brazil	14
<i>Theope publius</i> <i>publius</i> Felder & Felder, 1861	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Costa Rica	7, 19
<i>Theope terambus</i> (Godart, 1824)	<i>Azteca</i> sp., <i>Pheidole</i> sp.	Dolichoderinae, Myrmicinae	Phytophagous, pupation inside ant-built shelters on plants / trophobiotic, obligate	Brazil	14, 25
<i>Theope thestias</i> Hewitson, 1860	<i>Camponotus</i> <i>blandus</i> , <i>Ca.</i> <i>crassus</i> , <i>Ca.</i> <i>melanoticus</i> , <i>Ca.</i> <i>mus</i> , <i>Ca. rufipes</i> , <i>Ca.</i> <i>sericeiventris</i> , <i>Cephalotes pusillus</i>	Formicinae, Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Brazil	14
<i>Theope virgilius</i> (Fabricius, 1793)	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Costa Rica, Panama	6, 7
Nymphidiini: Nymphidiina					
<i>Catocyclotis adelina</i> (Butler, 1872)	<i>Crematogaster</i> sp.	Myrmicinae	Phytophagous on plant / trophobiotic, degree unknown	Costa Rica	26
<i>Catocyclotis</i> <i>densemaculata</i> (Hewitson, 1870)	<i>Crematogaster</i> sp.	Myrmicinae	Phytophagous on plant / trophobiotic, degree unknown	Peru	27
<i>Nymphidium a.</i> <i>azanoides</i> Butler, 1867	<i>Pheidole</i> sp., <i>Ph.</i> <i>biconstricta</i> , <i>Wasmannia</i> sp.	Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Costa Rica, Panama, Brazil	1, 6, 7
<i>Nymphidium cachrus</i> (Fabricius, 1787)	<i>Paratrechina</i> sp., <i>Crematogaster</i> sp., <i>Pheidole</i> sp.,	Formicinae, Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Costa Rica, Panama, Ecuador	6, 7, 28

<i>Nymphidium caricae</i> (Linnaeus, 1758)	<i>Megalomyrmex foreli</i> , <i>Solenopsis</i> sp., <i>CreMATogaster</i> sp., <i>Pheidole</i> sp., <i>Ph. nr. biconstricta</i> , <i>Megalomyrmex foreli</i> , <i>Ectatomma tuberculatum</i>	Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Ecuador, Brazil, French Guiana	1, 6, 28, 29
<i>Nymphidium haematostictum</i> Godman & Salvin, 1878	<i>CreMATogaster</i> sp.	Myrmicinae	Phytophagous on plant / trophobiotic, degree unknown	Costa Rica, Panama	6, 7
<i>Nymphidium leucosia</i> (Hübner, 1806)	<i>Brachymyrmex</i> sp., <i>Camponotus</i> sp., <i>CreMATogaster</i> sp., <i>Ochetomyrmex</i> sp., <i>Gnamptogenys</i> sp.	Formicinae, Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Ecuador, Brazil	1, 6
<i>Nymphidium lisimon</i> (Stoll, 1790)	<i>Wasmannia auropunctata</i>	Myrmicinae	Phytophagous on plant / trophobiotic, obligate	Colombia, Ecuador, Brazil	1, 30
<i>Nymphidium mantus</i> (Cramer, 1775)	<i>Azteca</i> sp.	Dolichoderinae	Phytophagous on plant / trophobiotic, probably obligate	Costa Rica, Panama, Guyana	6, 7, 28
<i>Nymphidium minuta</i> H. Druce, 1904	<i>CreMATogaster</i> sp.	Myrmicinae	Phytophagous on plant, facultative carnivory on ant-tended treehoppers / trophobiotic, probably obligate	Ecuador, Guyana, Brazil	28
<i>Nymphidium onaeum</i> Hewitson, 1869	<i>Pheidole</i> sp., <i>Solenopsis</i> sp.	Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Costa Rica, Panama	6, 7, 19

<i>Nymphidium velatum</i> Stichel, 1914 (referred to as <i>N. nr derufata</i>)	<i>Megalomyrmex foreli</i>	Myrmicinae	Phytophagous on plant / trophobiotic, degree unknown	Ecuador	6
Nymphidiini: Pandemina					
<i>Parvospila cilissa</i> (Hewitson, 1863)	<i>Tapinoma</i> sp., <i>Wasmannia auropunctata</i> , <i>Crematogaster</i> sp., <i>Cr. brevispina</i> , <i>Ectatomma ruidum</i>	Dolichoderinae, Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Costa Rica	6, 7, 28
<i>Parvospila emylius</i> (Cramer, 1775)	<i>Crematogaster</i> sp., <i>Solenopsis</i> sp., <i>Ectatomma tuberculatum</i>	Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Ecuador, Guyana, Brazil	1, 6, 28
* <i>Setabis lagus jansonii</i> (Butler, 1870)	<i>Pheidole</i> sp., <i>Ph. biconstricta</i> , <i>Azteca</i> sp.	Dolichoderinae, Myrmicinae	Predation on HPHs, caterpillar and pupation inside ant-built shelters on plants / non- trophobiotic, obligate	Costa Rica	6, 7, 28
* <i>Setabis lagus lagus</i> (Cramer, 1777)	<i>Pheidole biconstricta</i>	Myrmicinae	Predation on HPHs, myrmecophagy in laboratory conditions, and extrafloral secretions, caterpillars inside ant-built shelters on plants / non-trophobiotic, obligate	Brazil	28, 31
Nymphidiini: Lemoniadina					
<i>Annulata annulifera</i> (Godman, 1903)	<i>Pheidole</i> sp., <i>Megalomyrmex balzani</i> , <i>Paraponera clavata</i> , <i>Ectatomma tuberculatum</i>	Myrmicinae, Paraponerinae, Ectatomminae	Bamboo extrafloral secretions, adults observed stealing nectar from the mandibles of <i>E. tuberculatum</i> / trophobiotic, facultative	Peru	32

<i>Periplacis felsina</i> (Hewitson, 1863)	<i>Camponotus crassus</i>	Formicinae	Phytophagous on plant / trophobiotic, facultative	Brazil	33
<i>Periplacis menander</i> (Stoll, 1780)	<i>Camponotus</i> sp., <i>Crematogaster</i> sp.	Formicinae, Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Costa Rica, Panama, Ecuador	6, 7
<i>Periplacis pretus</i> (Cramer, 1777)	<i>Azteca</i> sp., <i>Camponotus</i> sp., <i>Crematogaster</i> sp.	Dolichoderinae, Formicinae, Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Costa Rica	6, 7, 34
<i>Synargis abaris</i> (Cramer, 1776)	<i>Camponotus</i> <i>femoratus</i> , <i>Pheidole</i> nr. <i>biconstricta</i> , <i>Ectatomma</i> <i>tuberculatum</i>	Formicinae, Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Brazil, Ecuador	1, 6
<i>Synargis calyce</i> (Felder & Felder, 1862)	<i>Azteca</i> sp., <i>Camponotus</i> <i>blandus</i> , <i>C. crassus</i> , <i>C. rufipes</i> , <i>C.</i> <i>sericeiventris</i> , <i>C.</i> <i>melanoticus</i> , <i>Cephalotes pusillus</i> , <i>Ectatomma</i> <i>tuberculatum</i>	Dolichoderinae, Formicinae, Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Brazil	1, 35, 36
<i>Synargis galena</i> (Bates, 1868)	<i>E. brunneum</i> , <i>E.</i> <i>tuberculatum</i>	Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Brazil	1, 37
<i>Synargis gela</i> (Hewitson, 1853)	<i>Ectatomma</i> <i>tuberculatum</i>	Ectatomminae	Phytophagous on plant / trophobiotic, obligate	Ecuador, Brazil	1, 6
<i>Synargis mycone</i> (Hewitson, 1865)	<i>Ectatomma ruidum</i> , <i>E. tuberculatum</i> , <i>Camponotus</i> <i>sericeiventris</i> , <i>Cephalotes atratus</i> , <i>Wasmannia</i> sp.	Ectatomminae, Formicinae, Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Costa Rica	6, 7

<i>Synargis palaeste</i> (Hewitson, 1870)	<i>Camponotus sericeiventris</i>	Formicinae	Unknown / Unknown, prepupae found at the nest entrance	Costa Rica	7
<i>Juditha caucana</i> (Stichel, 1911)	<i>Dolichoderus bispinosus</i> , <i>Camponotus</i> sp. (need confirmation)	Dolichoderinae, Formicinae	Phytophagous on plant / trophobiotic, obligate	Belize, Costa Rica, Panama, Colombia	6, 7, 19, 22, 38, 39
<i>Juditha dorilis</i> (Bates, 1866)	<i>Dolichoderus validus</i>	Dolichoderinae	Unknown / Ant-hemipteran oviposition	Costa Rica	6, 7
<i>Juditha molpe</i> (Hübner, 1808)	<i>Dolichoderus bispinosus</i>	Dolichoderinae	Phytophagous on plant / trophobiotic, obligate	Trinidad, Brazil	1, 6, 20
<i>Juditha odites praeclarum</i> (Bates 1866)	<i>Dolichoderus bispinosus</i>	Dolichoderinae	Aphytophagy indicated / Ant-hemipteran oviposition	Panama	6, 7
<i>Thisbe irenea</i> (Stoll, 1780)	<i>Dolichoderus</i> sp., <i>Camponotus</i> sp., <i>Ca. sericeiventris</i> , <i>Paratrechina</i> sp., <i>Aphaenogaster araneoides</i> , <i>Pheidole</i> sp., <i>Solenopsis (diplorhoptrum group)</i> , <i>S. geminata</i> , <i>Ectatomma ruidum</i> , <i>E. tuberculatum</i>	Dolichoderinae, Formicinae, Myrmicinae, Ectatomminae	Phytophagous on plant / trophobiotic, facultative	Belize, Costa Rica, Panama, Ecuador, Brazil	1, 6, 7
<i>Thisbe silvestre</i> Kaminski, Iserhard & Freitas 2015	<i>Camponotus</i> sp., <i>Ca. rufipes</i> , <i>Procryptocerus</i> sp., <i>Pheidole</i> sp.	Formicinae, Myrmicinae	Phytophagous on plant / trophobiotic, facultative	Brazil	40
<i>Lemonias caliginea</i> (Butler, 1867)	<i>Camponotus atriceps</i>	Formicinae	Phytophagous on plant / trophobiotic, facultative,	Mexico	41

<i>Lemonias egaensis</i> (Butler, 1867)	<i>Camponotus distinguendus</i> , <i>Camponotus</i> sp.	Formicinae	pupation in ant-built shelters at the base of host plant Phytophagous on plant / trophobiotic, facultative	Ecuador, Brazil	1, 6
<i>Lemonias zygia</i> (Hübner, 1807)	<i>Camponotus blandus</i> , <i>Ca.</i> <i>crassus</i> , <i>Ca.</i> <i>melanoticus</i> , <i>Ca.</i> <i>rufipes</i>	Formicinae	Phytophagous on plant / trophobiotic, facultative	Brazil	1, 42
** <i>Aricoris arenarum</i> (Schneider, 1937)	<i>Camponotus punctulatus</i>	Formicinae	Hemiptera honeydew and ant trophallaxis / Social parasite within ant shelters	Argentina, Brazil, Uruguay	6, 43, 44
<i>Aricoris chilensis</i> (C. Felder & R. Felder, 1865)	<i>Camponotus punctulatus</i> , <i>C. mus</i>	Formicinae	Phytophagous on plant / trophobiotic, ant-mediated oviposition, rest in underground shelter built by ants	Argentina	1, 43, 45, 46, 47
<i>Aricoris domina</i> (Bates, 1865)	<i>Ectatomma tuberculatum</i> , <i>Ectatomma</i> sp.	Ectatomminae	Unknown / oviposition near ant-tended hemipterans	Panama	48
<i>Aricoris erostratus</i> (Westwood, 1851)	<i>Camponotus</i> spp., <i>Paratrechina longicornis</i>	Formicinae	Phytophagous on plant / trophobiotic, ant-mediated oviposition, rest in underground shelter built by ants	Colombia	1, 49
<i>Aricoris notialis</i> (Stichel, 1910)	<i>C. punctulatus</i>	Formicinae	Phytophagous on plant / trophobiotic, ant-mediated oviposition, rest in underground shelter built by ants	Argentina, Brazil, Uruguay	1, 43

<i>Aricoris propitia</i> (Stichel, 1910)	<i>Solenopsis</i> <i>saevissima</i> complex	Myrmicinae	Phytophagous on plant / trophobiotic, ant-mediated oviposition, rest in underground shelter built by ants	Brazil	50
<i>Aricoris signata</i> (Stichel, 1910)	<i>Solenopsis</i> <i>saevissima richteri</i>	Myrmicinae	Phytophagous on plant / trophobiotic, ant-mediated oviposition, rest in underground shelter built by ants	Argentina	51
**Unidentified Nymphidiini	<i>Azteca</i> sp.	Dolichoderinae	Unknown / Photo taken in the ant nest	Costa Rica	52

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Table S2. Sample information of relevant taxa.

ID	Species	Sample location	Previously published by	Barcode accession number
JH03R005	<i>Pixus corculum</i>	El Durango, Ecuador	1	KT286472
BLU826	<i>Pachythone xanthe</i>	Alta Floresta - MT, Brazil	2	
KP849182	<i>Pachythone gigas</i>	Barro Colorado Island, Panama	3	KP849182
NS0362	<i>Roeberella lencates</i>	Recife - PE, Brazil	4	MG607921
LLM517	<i>Archaeonympha</i> sp.	Alta Floresta - MT, Brazil	5	
JH03R008	<i>Pseudonymphidia agave</i>	El Durango, Ecuador	1	KT286306
MAL-05053	<i>Pseudonymphidia agave</i>	Mexico	6	GU657881
MAL-05054	<i>Pseudonymphidia agave</i>	Mexico	6	GU657874
CH0000657-A01	<i>Pseudonymphidia agave</i> - larva		5 – target sequence	

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5. Unpubl. data.
6. C. Pozo *et al.*, unpubl. data.

Table S3. Number of specimens in data bases of collections housing *Pseudonymphidia agave* specimens from Mexico.

Entomological Collection source	Nb. of specimens
AMNH Entomology Collection (New York, NY, USA)	8
CMNH Arthropods Collection (Cleveland, OH, USA)	1
CNIN Colección Nacional de Insectos (Instituto de Biología, UNAM) (Mexico, DF, Mexico)	15
ECO-CH-L Colección Lepidopterológica (Chetumal, QRoo, Mexico)	3
FSMC Collection of Entomology (Gainesville, FL, USA)	2
MGCL-FLMNH Entomological Collection (Gainesville, FL, USA)	13
MZFC Colección Lepidopterológica (Facultad de Ciencias UNAM) (Mexico, DF, Mexico)	1
USNM National Entomological Collection (Washington, DC, USA)	5
Reports without collecting information	4
Total	52

Table S4. Number of specimens and Mexican states where *Pseudonymphidia agave* individuals have been collected.

State	Nb. of specimens
Campeche	2
Chiapas	3
Colima	1
Oaxaca	4
Puebla	2
Quintana Roo	2
San Luis Potosí	1
Veracruz	37
Total	52

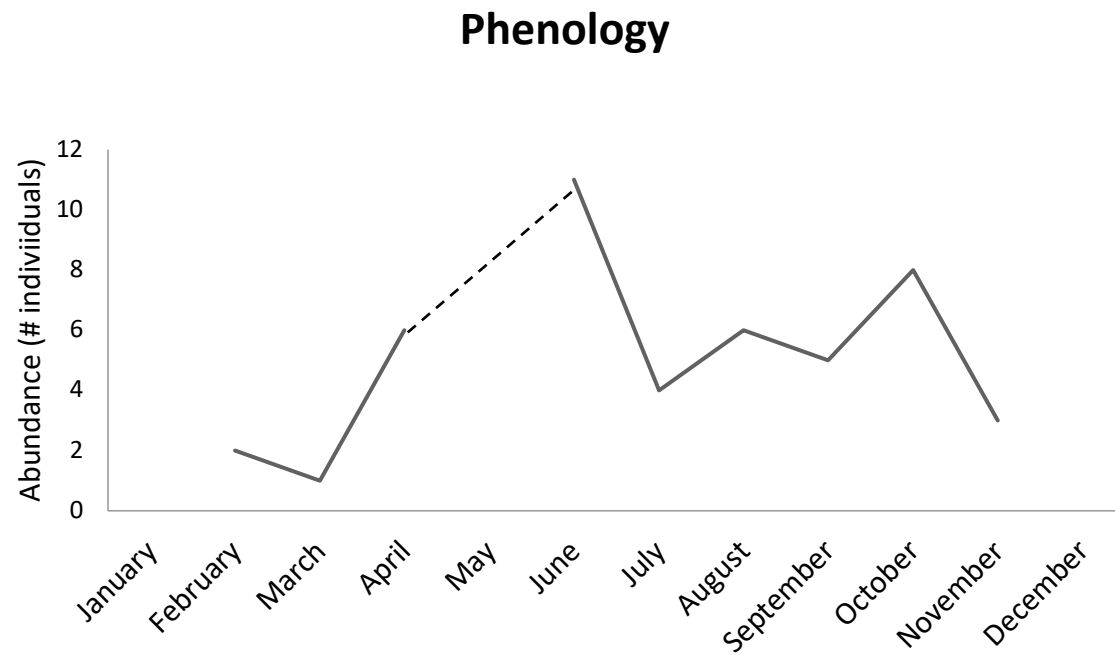


Fig. S1. Flight activity according to records of Mexican specimens in Museums.