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SUPPLEMENTARY MATERIAL

Bee diversity responses to forest and open areas in heterogeneous Atlantic Forest*

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Supplementary Material

Table S.1 - List of plants species sampled in forest fragments and open areas with their respective family.

Species	Family	Forest	Open areas
Acanthospermum australe	Asteraceae		x
Acisanthera variabilis	Melastomataceae		x
Adenostemma brasilianum	Asteraceae		x
Aeschynomene denticulata	Fabaceae		x
Ageratum conyzoides	Asteraceae		x
Alternanthera brasiliana	Amaranthaceae		x
Amaranthus deflexus	Amaranthaceae		x
Amaranthus retroflexus	Amaranthaceae		x
Aphelandra longiflora	Acanthaceae	x	
Asclepias curassavica	Apocynaceae		x
Aspidogyne hylibates	Orchidaceae	x	
Baccharis anomala	Asteraceae	x	
Baccharis cognata	Asteraceae		x
Baccharis dracunculifolia	Asteraceae		x
Baccharis punctulata	Asteraceae		x
Baccharis sp.1	Asteraceae		x
Baccharis trinervis	Asteraceae		x
Baccharis vulneraria	Asteraceae		x
Musa sp.	Musaceae		x
Bauhinia aff forficata	Fabaceae		x
Begonia cucullata	Begoniaceae		x
Begonia sp.1	Begoniaceae		x
Bidens pilosa	Asteraceae		x
Borreria sp.1	Asteraceae		x
Borreria sp.2	Rubiaceae		x
Borreria sp.3	Rubiaceae	x	x
Capsicum baccatum	Solanaceae		x
Chamaecrista flexuosa	Fabaceae		x
Chamaecrista rotundifolia	Fabaceae		x
Chaptalia sp.1	Asteraceae		x
Chromolaena maximilianii	Asteraceae		x
Chromolaena sp.	Asteraceae	x	
Chrysolaena cognata	Asteraceae		x
Cipura paludosa	Iridaceae		x
Cirsium vulgare	Asteraceae		x
Coccocypselum lanceolatum	Rubiaceae	x	
Commelina benghalensis	Commelinaceae		x
Commelina diffusa	Commelinaceae	x	x
Commelina erecta	Commelinaceae		x
Comparettia coccinea	Orchidaceae	x	
Convolvulaceae sp.1	Convolvulaceae		x
Convolvulaceae sp.2	Convolvulaceae		x
Convolvulaceae sp.3	Convolvulaceae		x
Corymborkis flava	Orchidaceae	x	
Costus spiralis	Costaceae		x
Croton lundianus	Euphorbiaceae		x
Cuphea racemosa	Lythraceae	x	x
Cyperus aggregatus	Cyperaceae		x
Cyperus friburguensis	Cyperaceae	x	x
Cyperus hermaphroditus	Cyperaceae		x
Cyperus luzalae	Cyperaceae		x
Desmodium incanum	Fabaceae		x
Desmodium uncinatum	Fabaceae		x
Dichorisandra pubescens	Commelinaceae	x	
Dichorisandra thyrsiflora	Commelinaceae	x	
Dicliptera cf squarrosa	Acanthaceae		x
Eclipta prostrata	Asteraceae		x
Elephantopus mollis	Asteraceae	x	x
Emilia fosbergii	Asteraceae		x
Emilia sonchifolia	Asteraceae		x

Species	Family	Forest	Open areas
Erechtites valerianifolius	Asteraceae		x
Euphorbia heterophylla	Euphorbiaceae		x
Fimbristylis dichotoma	Cyperaceae		x
Galeandra beyrichii	Orchidaceae	x	
Galinsoga parviflora	Asteraceae		x
Galinsoga quadriradiata	Asteraceae		x
Galinsoga sp.1	Asteraceae		x
Geonoma schottiana	Arecaceae	x	
Goeppertia cylindrica	Marantaceae	x	
Govenia utriculata	Orchidaceae	x	
Grazielia intermedia	Asteraceae		x
Habenaria johannensis	Orchidaceae		x
Habenaria parviflora	Orchidaceae	x	
Hapalorchis micranthus	Orchidaceae	x	
Hedychium gardnerianum	Zingiberaceae	x	
Hibiscus rosa-sinensis	Malvaceae		x
Hydrangea macrophylla	Hydrangeaceae		x
Hypoxis decumbens	Hypoxidaceae		x
Hyptis radicans	Lamiaceae		x
Impatiens walleriana	Balsaminaceae	x	x
Ipomoea cairica	Convolvulaceae		x
Jaegeria hirta	Asteraceae		x
Justicia sp.1	Acanthaceae	x	
Justicia sp.2	Acanthaceae		x
Justicia sp.3	Acanthaceae	x	
Lantana camara	Verbenaceae	x	x
Lantana sp.1	Verbenaceae		x
Lantana trifolia	Verbenaceae		x
Leandra amplexicaulis	Melastomataceae	x	
Leandra melastomoides	Melastomataceae	x	x
Leandra sericea	Melastomataceae	x	
Leandra sp.1	Melastomataceae	x	
Leandra sp.2	Melastomataceae	x	
Leandra variabilis	Melastomataceae	x	
Leandra xanthocoma	Melastomataceae	x	x
Leonurus japonicus	Lamiaceae		x
Lepidaploa cotoneaster	Asteraceae		x
Leptostelma maximum	Asteraceae		x
Lilium sp.	Liliaceae		x
Liparis nervosa	Orchidaceae	x	
Lippia sp.1	Verbenaceae	x	
Ludwigia elegans	Onagraceae		x
Ludwigia sericea	Onagraceae		x
Macroptilium atropurpureum	Fabaceae		x
Mandevilla sp.1	Apocynaceae	x	
Manettia gracilis	Rubiaceae	x	x
Marsypianthes chamaedrys	Lamiaceae		x
Mesadenella cuspidata	Orchidaceae	x	
Mesosphaerum sidifolium	Lamiaceae	x	x
Mesosphaerum suaveolens	Lamiaceae	x	x
Miconia latecrenata	Melastomataceae	x	
Miconia ligustroides	Melastomataceae		x
Miconia sp.	Melastomataceae	x	
Miconia valtheri	Melastomataceae	x	
Mimosa debilis	Fabaceae		x
Mimosa pudica	Fabaceae		x
Mimosa ramosissima	Fabaceae		x
Moquiniastrum polymorphum	Asteraceae		x
Myrtaceae sp.1	Myrtaceae	x	
Myrtaceae sp.2	Myrtaceae	x	
Neomarica caerulea	Iridaceae	x	x
Ocimum carnosum	Lamiaceae	x	
Oeceoclades maculata	Orchidaceae	x	
Olyra glaberrima	Poaceae	x	
Oplismenus hirtellus	Poaceae	x	
Orthopappus angustifolius	Asteraceae		x
Ossaea sanguinea	Melastomataceae	x	
Oxalis latifolia	Oxalidaceae	x	x
Palicourea forsteronioides	Rubiaceae	x	x
Palicourea marcgravii	Rubiaceae	x	
Palicourea sp.1	Rubiaceae	x	
Parodiolyra micrantha	Poaceae	x	
Paspalum notatum	Poaceae	x	x
Passiflora capsularis	Passifloraceae	x	x
Passiflora villosa	Passifloraceae	x	
Pavonia communis	Malvaceae	x	x
Peixotoa parviflora	Malpighiaceae		x
Peperomia velloziana	Piperaceae	x	
Phymatidium delicatulum	Orchidaceae	x	
Piper aduncum	Piperaceae	x	
Piper amalago	Piperaceae	x	
Piper gaudichaudianum	Piperaceae	x	
Piper lepturum	Piperaceae	x	
Piper richardiifolium	Piperaceae	x	
Piper sp.	Piperaceae	x	x
Piper umbellatum	Piperaceae	x	
Pleroma heteromallum	Melastomataceae		x
Pombalia atropurpurea	Violaceae	x	
Praxelis diffusa	Asteraceae		x
Prestonia sp.1	Apocynaceae		x
Psychotria aff. hoffmannseggiana	Rubiaceae	x	
Psychotria cf. leiocarpa	Rubiaceae	x	x
Psychotria ruelliifolia	Rubiaceae	x	
Psychotria sp.	Rubiaceae	x	
Psychotria sp.1	Rubiaceae	x	
Psychotria sp.2	Rubiaceae	x	

Species	Family	Forest	Open areas
Psychotria sp.3	Rubiaceae	x	
Psychotria sp.4	Rubiaceae	x	x
Psychotria sp.5	Rubiaceae	x	
Psychotria sp.6	Rubiaceae	x	
Psychotria sp.7	Rubiaceae	x	
Psychotria suterella	Rubiaceae	x	
Psychotria vellosiana	Rubiaceae	x	
Pterocaulon virgatum	Asteraceae		x
Renealmia petasites	Zingiberaceae	x	
Rhododendron simsii	Ericaceae		x
Rhynchanthera cordata	Melastomataceae		x
Rosa canina	Rosaceae		x
Rubus rosifolius	Rosaceae	x	x
Salvia splendens	Lamiaceae	x	
Scleria distans	Cyperaceae		x
Scleria panicoides	Cyperaceae	x	
Scleria sp.	Cyperaceae	x	
Senecio madagascariensis	Asteraceae		x
Sida glaziovii	Malvaceae		x
Sida planicaulis	Malvaceae	x	x
Sida rhombifolia	Malvaceae	x	x
Sida sp.	Malvaceae	x	
Sida tuberculata	Malvaceae		x
Sidastrum micranthum	Malvaceae		x
Sipania sp.1	Rubiaceae	x	
Siphocampylus macropodus	Campanulaceae	x	x
Solanum cf palinacanthum	Solanaceae		x
Solanum grandiflorum	Solanaceae		x
Solanum granulosoleprosum	Solanaceae		x
Solidago chilensis	Asteraceae		x
Sonchus oleraceus	Asteraceae		x
Sphagneticola trilobata	Asteraceae		x
Stachytarpheta cayennensis	Verbenaceae	x	x
Stachytarpheta sp.1	Verbenaceae		x
Stylosanthes guianensis	Fabaceae		x
Symphyopappus compressus	Asteraceae		x
Taraxacum officinale	Asteraceae		x
Thalia cf geniculata	Marantaceae	x	
Tibouchina cerastifolia	Melastomataceae		x
Tibouchina fothergillae	Melastomataceae		x
Tibouchina herbacea	Melastomataceae	x	x
Tibouchina pulchra	Melastomataceae	x	x
Tilesia baccata	Asteraceae	x	
Tillandsia stricta	Bromeliaceae		x
Tradescantia zebrina	Commelinaceae	x	
Tragia volubilis	Euphorbiaceae	x	
Trichogoniopsis adenantha	Asteraceae		x
Tripogandra diuretica	Commelinaceae	x	x
Triumfetta semitriloba	Malvaceae	x	
Turnera sp.1	Turneraceae		x
Varronia curassavica	Boraginaceae		x
Vernonanthura polyanthes	Asteraceae		x
Vernonanthura subverticillata	Asteraceae		x
Vernonia sp.5	Asteraceae		x
Vriesea ensiformes	Bromeliaceae		x
Zornia latifolia	Fabaceae		x

Table S.2 - Class descriptors used in the mapping process.

Classes	Classes descriptors
Water body	Lakes, rivers
Forest	Initial forest: more homogeneous in the image, without trees standing out in the canopy; Intermediate forest: presence of high trees, letting the images more rough
Agriculture	Annual and perennial agriculture
Shrubs	Initial process of ecological succession, with sparse trees; bushy pasture with herbaceous and shrub species
Silviculture	Forestry and tree hedgerows
Open Areas	Exposed ground, non-managed pastures and degraded areas
Swamps	Varzeas and river banks with herbaceous-shrub vegetation, varzea and river banks with initial stages of forest vegetation
Anthropic areas	Rural villages, urban areas, roads and highways
Clouds	Clouds hiding the image

Table S.3 - List of bee species sampled in open areas and forest with their respective family and abundance (from larger to smaller). In the end, number of total species and abundance.

Species	Family	Abundance		
		Open areas	Forest	Total
Apis mellifera	Apidae	519	29	548
Trigona spinipes		130	3	133
Trigona sp.		89	1	90
Trigona braueri		68	36	104
Trigona hyalinata		60	-	60
Trigona recursa		7	1	8
Trigona fuscipennis		2	2	4
Cephalotrigona capitata		-	1	1
Paratrigona subnuda		56	2	58
Paratrigona lineata		5	-	5
Geotrigona subterranea		1	-	1
Geotrigona sp.		24	-	24
Scaptotrigona sp.		4	-	4
Nannotrigona testaceicornis		2	-	2
Nannotrigona sp.		1	-	1
Scaptotrigona tubiba		2	-	2
Scaptotrigona depilis		1	-	1
Scaptotrigona xanthotricha		1	-	1
Leurotrigona muelleri		3	-	3
Tetragonisca angustula		27	3	30
Tetragona clavipes		12	2	14
Tetragona sp.		2	-	2
Melipona quadrifasciata		-	1	1
Melipona marginata		9	1	10
Melipona quadrifasciata anthidioides		1	-	1
Plebeia droryana		16	10	26
Plebeia recursa		-	1	1
Plebeia remota		-	1	1
Plebeia saiqui		1	-	1
Plebeia sp.		8	2	10
Plebeia sp.2		13	-	13
Schwarziana quadripunctata		5	-	5
Friesella schrottkyi		4	-	4
Frieseomelitta varia		1	-	1
Partamona sp.		3	-	3
Partamona helleri		1	-	1
Meliponini		17	2	19
Bombus morio		5	-	5
Bombus brasiliensis		3	23	26
Bombus sp.		3	-	3
Xylocopa1		4	1	5
Eufriesea violaceae		2	2	4
Eufriesea sp.		1	-	1
Eufriesea sp.(male)		1	-	1
Eufriesea sp.1		1	-	1
Euglossa sp.1		-	1	1
Ceratina sp.1		1	-	1
Ceratina sp.2		1	-	1
Ceratina sp.3		1	-	1
Ceratina sp.4		1	-	1
Ceratina sp.5		26	4	30
Ceratina sp.6		1	-	1
Ceratina sp.7		1	1	2
Ceratina sp.8		3	11	14
Ceratina sp.9		8	-	8
Ceratina sp.10		1	-	1
Ceratina sp.11		-	1	1
Ceratina sp.12		7	-	7
Tetrapedia diversipes		1	-	1
Tetrapedia diversipes (male)		1	-	1
Tetrapedia sp.		3	-	3
Tetrapedia sp.1		27	-	27
Tetrapedia sp.2 (male)		1	-	1
Tetrapedia sp.3		15	-	15
Tetrapedia sp.3(male)		2	-	2
Tetrapedia sp.4		1	-	1
Tetrapedia sp.5		1	-	1
Tetrapedia sp.5(male)		1	-	1
Tetrapedia sp.6		-	1	1
Tetrapedia sp.7		25	-	25
Tetrapedia sp.7(male)		1	-	*1*
Tetrapedia sp.8		1	-	1
Tetrapedia sp.9(male)		1	-	1
Tetrapedia sp.10		1	-	1
Tetrapedia sp.11		-	1	1
Tetrapedia sp.12		1	-	1
Paratetrapedia sp.		2	-	2
Paratetrapedia sp.1		6	-	6
Paratetrapedia sp.2		1	-	1
Tapinotaspidini morpho.1		60	4	64
Tapinotaspidini morpho.4		1	-	1
Tapinotaspidini morpho.8		1	-	1
Protosiris sp.1		-	1	1
Protosiris sp.2		1	1	2
Centris sp.1		1	-	1
Epicharis sp. (male)		1	-	1
Epicharis sp.1		-	2	2

Species	Family	Abundance		
		Open areas	Forest	Total
Epicharis sp.2		1	-	1
Centridini		4	-	4
Exomalopsis sp.		10	-	10
Exomalopsis sp. (male)		1	-	1
Exomalopsis sp.1		2	-	2
Exomalopsis sp.2		15	-	15
Melissoptila sp.		1	-	1
Anthophorini		12	-	12
Thygater sp.		3	-	3
Eucerini		3	-	3
Augochlora sp.	Halictidae	30	3	33
Pseudaugochlora sp.		16	4	20
Paroxystoglossa sp.		10	5	15
Augochlorella sp.		3	-	3
Augochloropsis sp.		4	3	7
Augochloropsis sp.1		-	1	1
Augochloropsis sp.2		2	-	2
Augochloropsis sp.3		1	1	2
Augochloropsis sp.4		1	-	1
Augochloropsis sp.5		2	-	2
Augochloropsis sp.6		2	-	2
Augochloropsis sp.7		1	-	1
Augochloropsis sp.9		1	-	1
Augochloropsis sp.10		1	-	1
Augochloropsis sp.11		1	-	1
Dialictus sp.		30	2	32
Dialictus sp.1		8	7	15
Augochlorini		20	3	23
Augochlorini1		35	5	40
Augochlorini morpho1-A		5	-	5
Augochlorini morpho1-B		1	-	1
Augochlorini morpho1-D		2	-	2
Augochlorini morpho1-F		1	-	1
Augochlorini morpho1-H		1	-	1
Augochlorini morpho1-I.1		1	-	1
Augochlorini morpho1-I.2		2	-	2
Augochlorini morpho1-I.3		1	-	1
Augochlorini morpho1-J		1	-	1
Augochlorini morpho1-K.1		1	-	1
Augochlorini morpho1-K.2		-	1	1
Augochlorini morpho1-P		1	-	1
Augochlorini morpho1-Q		1	-	1
Augochlorini morpho 2		12	1	13
Augochlorini morpho 2-A		16	-	16
Augochlorini morpho 2-B		10	-	10
Augochlorini morpho 2-D		7	1	8
Augochlorini morpho 2-E		-	1	1
Augochlorini morpho 2-F		2	-	2
Augochlorini 3		6	2	8
Augochlorini morpho 3-D		1	-	1
Augochlorini morpho 3-E		1	-	1
Augochlorini 4		1	-	1
Augochlorini morpho 4-A		1	-	1
Augochlorini morpho 4-B		1	-	1
Augochlorini morpho 4-C		2	-	2
Augochlorini morpho 4-D		1	-	1
Augochlorini morpho 4-E		2	-	2
Halictini morpho 1		63	5	68
Halictini morpho 2		1		1
Halictidae		65	2	67
Epanthidium sp.	Megachilidae	6	-	6
Epanthidium sp.(male)		1	-	1
Epanthidium sp.1		8	-	8
Epanthidium sp.1 (male)		2	-	2
Coelioxys sp.		1	-	1
Anthidiini sp.2 (male)		1	-	1
Anthidiini sp.2		14	-	14
Megachilidae		4	1	5
Megachilidae morpho1		1	-	1
Megachilidae morpho 1 (male)		-	1	1
Megachilidae morpho 2		30	1	31
Megachilidae morpho 2 (male)		1	-	1
Megachilidae morpho 3		10	-	10
Megachilidae morpho 3 (male)		1	-	1
Megachilidae morpho 6		1	-	1
Megachilidae morpho 6 (male)		1	-	1
Megachilidae morpho 7 (male)		1	-	1
Megachilidae morpho 9		2	-	2
Megachilidae morpho 11		1	-	1
Megachilidae morpho 12		1	-	1
Megachilidae morpho 13		1	-	1
Hylaeus sp1	Colletidae	19	1	20
Colletidae morpho 1		9	-	9
Colletidae morpho 2		-	2	2
Colletidae morpho 3		2	1	3
Colletidae morpho 4		1	-	1
Oxaea sp.	Andrenidae	1	-	1
Parapsaenythia sp.		1	-	1
Andrenidae		1	-	1
	Total	1875	206	2081
Common species	39			

Table S.4 - Linear regression results for bee richness, abundance and diversity (shannon index) inside the forest and in adjacent open areas. The table shows all models tested for the landscape scale selection for the proportion of Forest in the Landscape (F.Cover) and Landscape Heterogeneity (L.Heterogeneity) measured with the landscape shannon index. In bold only the models selected with the highest R2. Significant p values appear marked with *.

Forest Cover					
Modelos	**R²**	**p**	**Modelos**	**R²**	**p**
Shannon index in the forest			Shannon index in open areas		
~ F.Cover_250	0.00009017	0.9603	~ F.Cover_250	0.007459	0.6882
~ F.Cover_500	0.02804	0.3764	~ F.Cover_500	0.0359	0.3752
~ F.Cover_750	**0.05971**	**0.1931**	~ F.Cover_750	0.07889	0.1837
~ F.Cover_1000	0.05294	0.2213	**~ F.Cover_1000**	**0.0964**	**0.1398**
Richness in the forest			Richness in open areas		
~ F.Cover_250	0.007791	0.6428	~ F.Cover_250	0.001477	0.8585
~ F.Cover_500	0.005669	0.6925	~ F.Cover_500	0.05139	0.2868
~ F.Cover_750	**0.0252**	**0.4021**	~ F.Cover_750	0.1082	0.1166
~ F.Cover_1000	0.02054	0.4499	**~ F.Cover_1000**	**0.1326**	**0.08018**
Abundance in the forest			Abundance in open areas		
~ F.Cover_250	0.01628	0.5017	~ F.Cover_250	0.04919	0.2976
~ F.Cover_500	0.03214	0.3432	~ F.Cover_500	0.1543	0.05759
~ F.Cover_750	0.03219	0.3428	~ F.Cover_750	0.1773	0.04043
~ F.Cover_1000	**0.03959**	**0.2918**	**~ F.Cover_1000**	**0.1871**	**0.03476***

Landscape Heterogeneity					
Models	**R²**	**p**	**Models**	**R²**	**p**
Shannon index in the forest			Shannon index in open areas		
~ L.Heterogeneity_250	0.009468	0.609	~ L.Heterogeneity_250	0.0008847	0.8903
~ L.Heterogeneity_500	0.01853	0.4732	~ L.Heterogeneity_500	0.003681	0.7782
~ L.Heterogeneity_750	0.01952	0.4615	**~ L.Heterogeneity_750**	**0.01128**	**0.6213**
~ L.Heterogeneity_1000	**0.0217**	**0.4372**	~ L.Heterogeneity_1000	0.008445	0.6693
Richness in the forest			Richness in open areas		
~ L.Heterogeneity_250	0.0003915	0.9173	~ L.Heterogeneity_250	0.005574	0.7288
~ L.Heterogeneity_500	0.0002529	0.9335	~ L.Heterogeneity_500	0.008961	0.66
~ L.Heterogeneity_750	0.001487	0.8397	**~ L.Heterogeneity_750**	**0.01714**	**0.542**
~ L.Heterogeneity_1000	**0.002946**	**0.7758**	~ L.Heterogeneity_1000	0.009721	0.6467
Abundance in the forest			Abundance in open areas		
~ L.Heterogeneity_250	0.0003525	0.9216	~ L.Heterogeneity_250	0.02368	0.4728
~ L.Heterogeneity_500	0.03144	0.3486	**~ L.Heterogeneity_500**	**0.06063**	**0.2461**
~ L.Heterogeneity_750	**0.04273**	**0.2731**	~ L.Heterogeneity_750	0.01871	0.5239
~ L.Heterogeneity_1000	0.03407	0.3288	~ L.Heterogeneity_1000	0.006249	0.7135