Braz. J. Bot (2014) 37(3):329–337
DOI 10.1007/s40415-014-0078-x

Checklist, conservation status, and sampling effort analysis of Malpighiaceae in Espírito Santo State, Brazil

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Received: 11 August 2013 / Accepted: 2 June 2014 / Published online: 28 June 2014

Abstract Espírito Santo is one of the Brazilian States most threatened within the Atlantic Forest, but still one of the most diverse with a great number of endemic taxa in many groups of animals and plants. Malpighiaceae were previously represented by 59 species in this state, but after examining field and herbaria collections, we recorded 119 species widely distributed within the rain forest, Semideciduous dry forest, lowland forest, Restinga and Inselbergs vegetation types. About 80 % of species were classified as threatened following IUCN standards. Three municipalities scored the highest numbers of specimen records, reflecting the "botanist effect" of research centers in the surrounding areas. Another 16 municipalities within the Semideciduous dry forest lacked any record of Malpighiaceae, reflecting its poor collection sampling. A call for an extensive sampling effort of Malpighiaceae in Espírito Santo State is made.

Keywords Atlantic forest · Conservation · Taxonomy

Introduction

Malpighiaceae is one of the most diverse families of tropical and subtropical lianas and shrubs worldwide (Davis and Anderson 2010). It is easily recognized by the presence of malpighiaceous hairs (unicellular hairs bearing a foot and two branches), by a pair of oil secreting glands at the base of each sepal, called elaiophores, and by unguiculate petals with a very conspicuous claw (Anderson 1981). The family comprises about 77 genera and 1,300 pantropical species, predominantly distributed within the Neotropical region, which holds 85 % of the family diversity (Davis and Anderson 2010). In Brazil it is represented by 45 genera and 529 species distributed through all Brazilian biomes, but especially diverse within the biodiversity conservation hotspots of the Cerrado and the Atlantic forest (Mittermeier et al. 2005; Mamede et al. 2013).

The Atlantic Forest is the most fragmented and threatened hotspot in Brazil, with just 7 % of its original extent (Martini et al. 2007). The forest remnants within Espírito Santo and Bahia States constitute an important biodiversity corridor (Atlantic forest Central Corridor), which holds the world record for tree diversity per hectare (Thomaz and Monteiro 1997; Thomas et al. 1998; Martini et al. 2007), and a high number of endemics in different taxa of birds (Silva et al. 2004), mammals (Costa et al. 2000; Passamani 2000), butterflies (Tyler et al. 1994; Brown Jr and Freitas 2000), bamboos (Soderstrom et al. 1988), and woody plants (Prance 1982).

According to Mamede et al. (2013), Malpighiaceae is currently represented by 59 species in Espírito Santo. On the other hand, the data available on *speciesLink* (SpeciesLink 2013), a website that integrates databases from the Brazilian network of herbaria, indicate the occurrence of about 100 species, mostly determined by experts on Malpighiaceae. These collections are the primary sources for spatial and temporal records of plant species occurrences, reflecting the sampling efforts of local botanical communities within a region (Cotterill 1995; Geri et al. 2013).

We conjectured that a detailed analysis of Malpighiaceae collections in Brazilian herbaria from Espírito Santo might reveal a new scenario for the family diversity in this state. Thus, the goal of this study was to (1) prepare an

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updated checklist of Malpighiaceae species from Espírito Santo State, Brazil; (2) determine the conservation status of all Malpighiaceae species recorded from Espírito Santo; (3) analyze the sampling effort of Malpighiaceae species using herbarium collections made in Espírito Santo State.

Methods

Area of study

The study area is located southeastern Brazil, occupying 45,597 km^2 within the Atlantic Forest domain. Its maximum length from north to south is 374 km, bordered to the east by the Atlantic Ocean, and its width varies from 130 to 150 km, with altitudes increasing from sea level, in the east, to 2,897 m in Caparaó Mountains in the west. Espírito Santo is bordered by the States of Bahia (north), Minas Gerais (west), and Rio de Janeiro (south) (IPEMA 2005).

There are two main geological zones: the Barreiras formation and the mountain zone (Amorim 1984). The Barreiras formation extends over a narrow coastal stretch in the south becoming broader in the north, and was originally covered by a lowland forest with a 30 m canopy; the mountain zone is located inland, and is characterized by the presence of dense rain forests, with a mean 25-m canopy (IPEMA 2005).

The state encompasses different vegetation physiognomies such as Altitudinal Grassland, Semideciduous dry forest, rain forest, lowland forest (regionally known as "Tabuleiro" forest), "Restinga" vegetation, Mangrove, and various granitic rock outcrops (known as Inselbergs) within which islands of xeric-like vegetation occur within the rain forest (Fig. 1) (Simonelli and Fraga 2007).

Taxonomic analysis

We studied field collections from two field expeditions carried out between October 2011 and January 2012, and the collections from CESJ, CEPEC, CVRD, ESA, FUEL, GUA, IAC, HB, HUEFS, MBM, MBML, PMSP, R, RB, SP, SPF, SPSF, UEC, UPCB, VIES herbaria (acronyms according to Thiers 2013). All the collections were studied with the aid of a stereomicroscope, specialized literature on the family and the consultation of type specimens (or images) for all species, whenever possible. A total of 2,557 specimens (38 field collections and 2,519 herbarium collections) were analyzed and identified to species level, and a voucher was selected and presented for each species in Table 1. The categorization of vegetation types follows Simonelli and Fraga (2007). Conservation Status categories for Malpighiaceae species followed IUCN (2012) and Simonelli and Fraga (2007).

Sampling effort analysis

The maps were elaborated using GIS software (ESRI 2009), and shape files were obtained from Ministério do Meio Ambiente website (2013). The geolocalization of the herbarium specimens posed several problems due to the varying level of precision or the lack of the geographical information given in the specimen labels. Because of this, we opted to georeference herbarium specimens by the coordinates of the municipality. We built a matrix containing the total number of herbarium records by municipality and inserted them as point records in the GIS software, using Spatial Joint analysis and selecting the join one-to-one parameter.

Results

A total of 23 genera and 119 species of Malpighiaceae were recorded for Espírito Santo (Table 1), representing an addition of 64 new records (>53 %) to the previous number of species cited for this state (Mamede et al. 2013). Field collections performed for this work represented 38 collections assigned to eight genera and 23 species, which *Byrsonima chrysophylla* Kunth, *Hiraea cuneata* Griseb., *Niedenzuella multiglandulosa* (A.Juss.) W.R.Anderson, *Niedenzuella poeppigiana* (A.Juss.) W.R.Anderson, and *Stigmaphyllon angustilobum* A.Juss. figured among the new records for the state. The MBML, RB, and VIES herbaria hold most of the recently determined collections regarding the flora of Espírito Santo.

The most diverse genera were *Heteropterys* (35 species), *Byrsonima* (21 species), and *Stigmaphyllon* (15 species), while *Alicia*, *Heladena*, *Janusia*, *Lophopterys*, *Mezia*, and *Thryallis* accounted for just a single species each. *Bunchosia glandulifera* (Jacq.) H.B.K., *Lophanthera lactescens* Ducke, *Malpighia glabra* L., and *Malpighia emarginata* DC. were not cited, due to their ornamental and horticultural usage.

A total of 101 species were added to the Red List of threatened species in Espírito Santo: two species are presumably extinct in the state, 24 species are critically endangered, 54 species are endangered, and 22 species are vulnerable.

The most diverse vegetation types were the rain forest with 79 species, followed by Semideciduous dry forest with 70 species and lowland forest with 66 species (Fig. 2). The Brazilian Atlantic forest holds 165 records of Malpighiaceae species (Mamede et al. 2013), which 101 can be

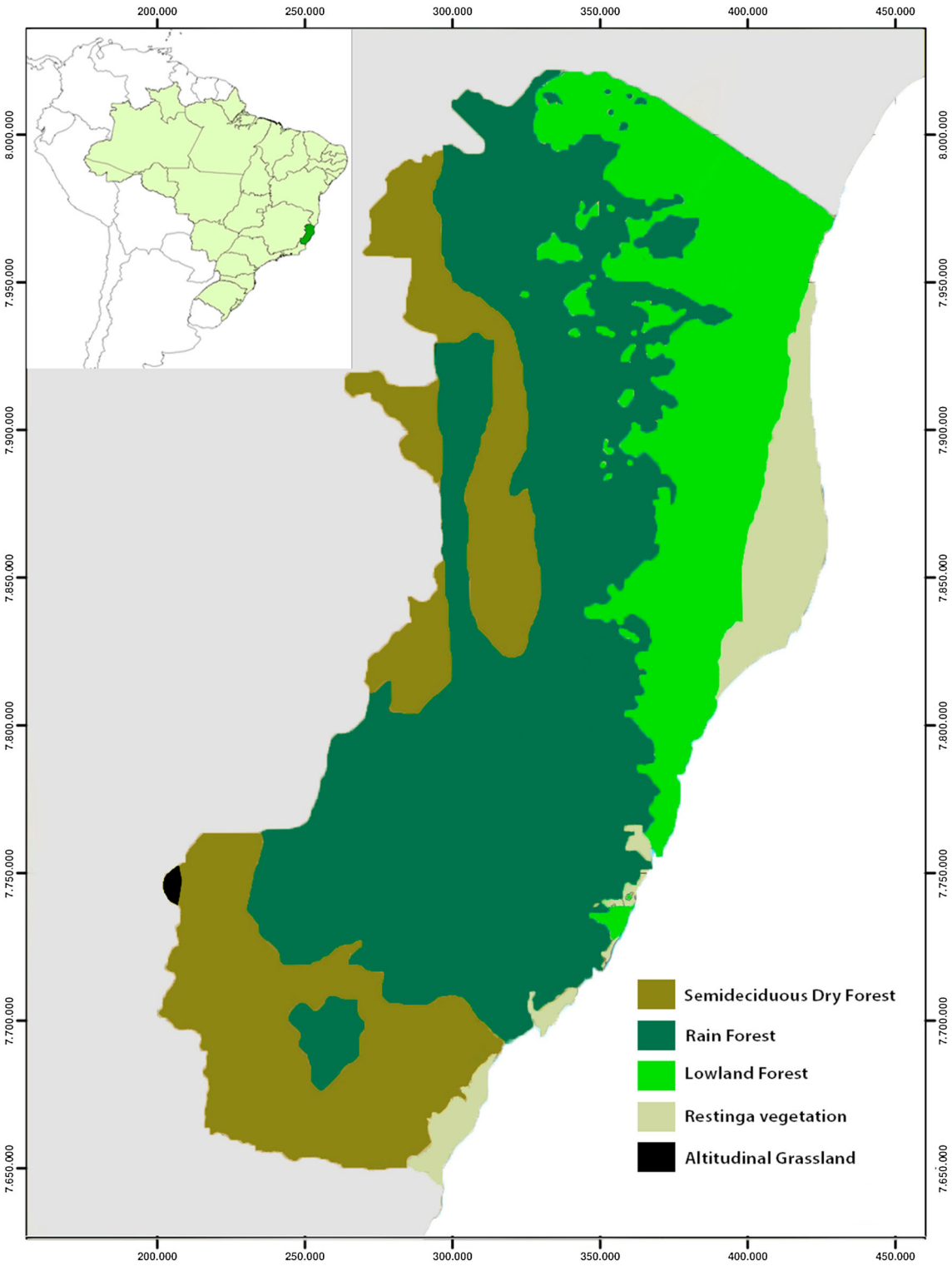

Fig. 1 Vegetation types of Espírito Santo State according to Simonelli and Fraga (2007) (modified from Ministério do Meio Ambiente 2007)

found in Espírito Santo according to our results, besides 20 new records for this biome.

Municipalities with the highest numbers of collected Malpighiaceae specimens were Santa Teresa (552 specimens), Linhares (551), and Guarapari (155) (Fig. 3). Some municipalities as Apiaca, Alto Rio Novo, Baixo Guandu, Bom Jesus do Norte, Brejetuba, Ecoporanga, Guaçuí, Irupi, Jerônimo Monteiro, João Neiva, Laranja da

Table 1 Malpighiaceae checklist from Espírito Santo State, Brazil

Species	Voucher	Phytophysiognomies	Redlist
Alicia anisopetala (A.Juss.) W.R.Anderson	Demuner 4566 (MBML)	RF, SDF, I	EP
Amorimia maritima (A.Juss.) W.R.Anderson*	Amorim 7426 (RB)	RF, I, LF	LR
Amorimia rigida (A.Juss.) W.R.Anderson*	Groppo Jr. 983 (SP)	RF, SDF, I, LF	VU
Banisteriopsis adenopoda (A.Juss.) B.Gates	Forzza 5806 (RB)	SDF	CR
Banisteriopsis membranifolia (A.Juss.) B.Gates*	Assis 1646 (VIES)	RF, SDF, I, LF, R	LR
Banisteriopsis multifoliolata (A.Juss.) B.Gates	Demuner 3440 (MBML)	RF, SDF, I	EP
Banisteriopsis muricata (Cav.) Cuatrec.*	Hatschbach 52739 (MBM)	RF, SDF, LF	VU
Banisteriopsis nummifera (A.Juss.) B.Gates*	Folli 1215 (CRVD)	RF, LF, R	EP
Banisteriopsis salicifolia (DC.) B.Gates	Bausen 145 (CEPEC)	RF, SDF	EP
Banisteriopsis scutellata (Griseb.) B.Gates	Kollmann 2511 (CEPEC)	RF	EP
Banisteriopsis sellowiana (A.Juss.) B.Gates	Pereira 339 (SP)	LF, R	EP*
Barnebya dispar (Griseb.) W.R.Anderson & B.Gates	Thomaz 1043 (VIES)	RF	CR*
Bronwenia ferruginea (Cav.) W.R.Anderson & C.C.Davis	Assis 1146 (MBML)	RF, SDF, LF	VU
Bunchosia acuminata Dobson	Paciencia 2355 (ESA)	RF, LF	EP*
Bunchosia macilenta Dobson	Amorim 7174 (RB)	RF, SDF, I, LF	LR*
Bunchosia maritima (Vell.) J.F.Macbr.*	Sobral 4703 (SP)	RF, SDF	VU
Byrsonima alvimii W.R.Anderson*	Vervloet 1682 (MBML)	RF	LR*
Byrsonima bahiana W.R.Anderson	Gomes 1463	R	CR*
Byrsonima cacaophila W.R.Anderson	Folli 5019 (CRVD)	LF, R	VU
Byrsonima chrysophilla Kunth	Almeida 516 (SP)	RF, SDF, LF, R	LR
Byrsonima coccolobifolia H.B.K.	Pereira 3200 (CEPEC)	LF	DD
Byrsonima crassifolia (L.) H.B.K.	Folli 5361 (CRVD)	SDF, LF, R	EP
Byrsonima crispa A.Juss.*	Assis 1642 (MBML)	SDF	EP
Byrsonima duckeana W.R.Anderson	Maielo-Silva 116 (RB)	LF, R	EP
Byrsonima gardneriana A.Juss.	Kollmann 5562 (MBML)	RF	CR
Byrsonima laevigata (Poir.) DC.	Vervloet 461 (MBML)	RF, SDF	EP*
Byrsonima laxiflora Griseb.	Hatschbach 51336 (UPCB)	SDF	CR
Byrsonima ligustrifolia A.Juss.*	Kollmann 1867 (MBML)	RF, SDF	EP
Byrsonima myricifolia Griseb.	Hatschbach 71483 (MBM)	RF, SDF	DD
Byrsonima niedenzuiana Skottsb.	Martinelli 10947 (RB)	RF	DD
Byrsonima nitidifolia A.Juss.	Fontana 5769 (MBML)	RF, SDF, I	EP
Byrsonima perseifolia Griseb.	Hatschbach 61600 (MBM)	SDF, LF	DD
Byrsonima sericea DC.*	Araujo 10036 (GUA)	RF, R, LF	LR
Byrsonima stipulacea A.Juss.*	Amorim 3355 (SP)	RF, LF	LR
Byrsonima verbascifolia (L.) DC.	Vinha 1422 (VIES)	R	DD
Byrsonima vernicosa Nied.	Simonelli 1363 (MBML)	RF, I	EP
Callaeum psilophyllum (A.Juss.) D.MJohnson	Mansano 91 (FUEL)	SDF	CR
Carolus chasei (W.R.Anderson) W.R.Anderson	Kollmann 7334 (MBML)	RF, I	EP
Carolus chlorocarpus (A.Juss.) W.R.Anderson	Fontana 5342 (MBML)	RF, SDF, LF	VU*
Dicella bracteosa (A.Juss.) Griseb.	Demuner 210 (MBML)	RF, LF	EP
Dicella macroptera A.Juss.	Fiaschi 3476 (RB)	LF, R	EP
Diplopterys carvalhoi W.R.Anderson & C.C.Davis	Britto 32 (MBML)	RF	CR
Diplopterys lutea (Griseb.) W.R.Anderson & C.C.Davis	Fontana 706 (MBML)	RF, SDF	EP
Diploterys patula (B.Gates) W.R.Anderson & C.C.Davis*	Vervloet 2759 (MBML)	SDF, LF	EP
Diploterys pubipetala (A.Juss.) W.R.Anderson & C.C.Davis	Folli 5011 (CRVD)	RF, SDF, LF	EP
Heladena multiflora (Hook. & Arn.) Nied.	Kollmann 1215 (MBML)	RF, LF	EP*
Heteropterys admirabilis Amorim*	Amorim 3316 (SP)	RF, SDF	VU*
Heteropterys alternifolia A.Juss.	Pereira 2753 (VIES)	LF, R	VU*

Table 1 continued

Species	Voucher	Phytophysiognomies	Redlist
Heteropterys bahiensis Nied.*	Almeida 522 (SP)	LF	EP*
Heteropterys bankisiifolia Griseb.	Demuner 1995 (MBML)	SDF, LF	EP
Heteropterys bicolor A.Juss.*	Fraga 2294 (RB)	RF, LF, R	VU
Heteropterys brunnea Sebastiani & Mamede	Kollmann 4799 (CEPEC)	RF	EP
Heteropterys capixaba Amorim*	Amorim 3317 (SP)	RF	EP*
Heteropterys chrysophylla (Lam.) DC.*	Almeida 540 (SP)	LF, R	LR
Heteropterys coleoptera A.Juss.*	Vervloet 1616 (CEPEC)	RF, SDF, LF, R	LR
Heteropterys crenulata A.Juss.	Brade 18437 (RB)	RF	EP
Heteropterys dumetorum A.Juss.	Leoni 3044 (SP)	R	CR
Heteropterys eglandulosa A.Juss.	Fraga 1958 (RB)	RF, SDF	EP
Heteropterys escallonifolia A.Juss.	Magnago 1390 (MBML)	RF, LF	EP
Heteropterys fluminensis (Griseb.) W.R.Anderson*	Amorim 4309 (CEPEC)	RF, SDF, LV, R	VU
Heteropterys glazioviana Nied.*	Kollmann 7737 (MBML)	RF, I	CR
Heteropterys intermedia (A.Juss.) Griseb.*	Almeida 505 (SP)	RF, SDF	LR
Heteropterys leschenaultiana A.Juss.*	Fraga 2365 (UPCB)	RF, SDF, LF, R	LR
Heteropterys lindleyana A.Juss.*	Kollmann 9738 (MBML)	RF	EP
Heteropterys macrostachya A.Juss.*	Magnago 1684 (MBML)	SDF, LF	EP
Heteropterys megaptera A.Juss.*	Sucre 8437 (RB)	LF	CR*
Heteropterys nervosa A.Juss.	Brade 18263 (SP)	RF	CR
Heteropterys nitida (Lam.) DC.*	Pinheiro 2329 (SPF)	RF, SDF, LF	LR
Heteropterys nordestina Amorim*	Amorim 7268 (RB)	RF, SDF, LF, R	VU
Heteropterys oberdanii Amorim*	Sebastiani 360 (CRVD)	LF, R	EP*
Heteropterys pauciflora A.Juss.	Thomaz 990 (CEPEC)	RF	EP
Heteropterys perplexa W.R.Anderson*	Fontana 1546 (MBML)	RF, I	EP*
Heteropterys rhopalifolia A.Juss.	Kollmann 7765 (MBML)	RF	CR
Heteropterys rufula A.Juss.*	Hoffmann 181 (MBML)	RF, SDF, LF, R	VU
Heteropterys sericea (Cav.) A.Juss.*	Fernandes 2654 (MBML)	RF, SDF, R	LR
Heteropterys syringifolia Griseb.	Vimercat 274 (RB)	RF	CR
Heteropterys trigoniifolia A.Juss.	Fraga 2004 (RB)	RF, SDF	EP*
Heteropterys umbellata A.Juss.	Demuner 4240 (MBML)	SDF, I	DD
Heteropterys wiedeana A.Juss.*	Amorim 3352 (SP)	LF	CR
Hiraea bullata W.R.Anderson	Pereira 4249 (VIES)	LF, R	EP*
Hiraea cuneata Griseb.	Almeida 518 (SP)	LF, R	EP
Hiraea fagifolia (DC.) A.Juss.*	Kollmann 10385 (MBML)	RF, SDF, LF	VU
Janusia hexandra (Vell.) W.R.Anderson*	Romão 1265 (ESA)	LF	CR
Lophopterys floribunda W.R.Anderson & C.C.Davis*	Amorim 7412 (RB)	RF, SDF, LF, I	VU*
Mascagnia bierosa (A.Juss.) W.R.Anderson	Kollmann 1213 (MBML)	RF, SDF, LF	EP
Mascagnia cordifolia (A.Juss.) Griseb.*	Almeida 534 (SP)	RF	EP
Mascagnia sepium (A.Juss.) Griseb.*	Demuner 4581 (MBML)	RF, SDF, R, I	VU
Mascagnia velutina C.E.Anderson*	Hatschbach 49939 (MBM)	SDF	CR
Mezia araujoi Schwacke*	Demuner 4700 (MBML)	SDF, LF	EP*
Niedenzuella acutifolia (Cav.) W.R.Anderson*	Almeida 519 (SP)	RF, SDF, LF, R, I	LR
Niedenzuella glabra (Spreng.) W.R.Anderson*	Pirani 2386 (SPF)	SDF, LF, R	VU
Niedenzuella leucosepala (Griseb.) W.R.Anderson	Kollmann 3330 (MBML)	SDF, LF	EP
Niedenzuella lucida (A.Juss.) W.R.Anderson*	Assis 1132 (MBML)	RF, SDF, LF, I	VU
Niedenzuella multiglandulosa (A.Juss.) W.R.Anderson	Almeida 523 (SP)	RF, SDF, LF	EP
Niedenzuella poeppigiana (A.Juss.) W.R.Anderson	Almeida 508 (SP)	RF, SDF, LF	LR*
Niedenzuella sericea (A.Juss.) W.R.Anderson	Amorim 3338 (SP)	RF, SDF, R	VU

Table 1 continued

Species	Voucher	Phytophysiognomies	Redlist
Peixota hispidula A.Juss.*	Almeida 515 (SP)	RF, SDF, LF, R	LR
Peixotoa reticulata Griseb.	Delistoianov s.n. (IAC)	SDF	EX
Stigmaphyllon acuminatum A.Juss.	Kollmann 11936 (MBML)	RF, SDF, LF	EP
Stigmaphyllon alternifolium A.Juss.*	Almeida 501 (SP)	RF, SDF, I	VU
Stigmaphyllon angustilobum A.Juss.	Almeida 503 (SP)	SDF, I	CR
Stigmaphyllon auriculatum A.Juss.	Fontana 658 (MBML)	RF, SDF, I	EP
Stigmaphyllon blanchetii C.E.Anderson*	Almeida 537 (SP)	RF, SDF, LF, R	LR
Stigmaphyllon ciliatum (Lam.) A.Juss.*	Almeida 541 (SP)	LF, R	LR
Stigmaphyllon crenatum C.E.Anderson*	Magnago 1348 (MBML)	RF, SDF, I	VU
Stigmaphyllon gayanum A.Juss.	Almeida 500 (SP)	SDF, I	EP
Stigmaphyllon glabrum C.E.Anderson*	Hatschbach 65269 (MBM)	SDF	CR
Stigmaphyllon lalandianum A.Juss.*	Fiaschi 3122 (SPF)	RF, SDF, R, I	LR
Stigmaphyllon lanceolatum C.E.Anderson	Bausen 35 (MBML)	RF	CR
Stigmaphyllon paralias A.Juss.*	Fontana 5071 (MBML)	RF, SDF, LF, R, I	LR
Stigmaphyllon salzmannii A.Juss.*	Almeida 526 (SP)	RF, SDF, LF, I	VU
Stigmaphyllon saxicola C.E.Anderson*	Hatschbach 49397 (MBM)	SDF, I	EP
Stigmaphyllon tomentosum A.Juss.*	Assis 1538 (MBML)	SDF, I	EP
Tetrapterys anisoptera A.Juss.	Amorim 7139 (RB)	RF, LF	EP
Tetrapterys crispa A.Juss.	Forzza 5522 (RB)	RF, LF, I	EP
Tetrapterys mucronata Cav.*	Almeida 517 (SP)	RF, SDF, LF	LR
Tetrapterys phlomoides (Spreng.) Nied.*	Couto 804 (MBML)	RF, SDF, LF, R, I	LR
Tetrapterys ramiflora A.Juss.	Fontana 965 (CEPEC)	RF, SDF, LF, I	EP
Thryallis brachystachys Lindl.*	Brade 18083 (RB)	LF	EX

Species marked with an asterisk (*) refers to species cited in Mamede et al. (2013). Records in the Redlist marked with an (*) refers to endangered species cited in Simonelli and Fraga (2007)

R Restinga, *LF* lowland forest, *I* Inselbergs (outcrop vegetation), *SDF* Semideciduous dry forest, *RF* rain forest. Redlist categories—*DD* deficient data, *LR* low risk, *VU* vulnerable, *EP* endangered, *CR* critically endangered, *EX* presumably extint in the state

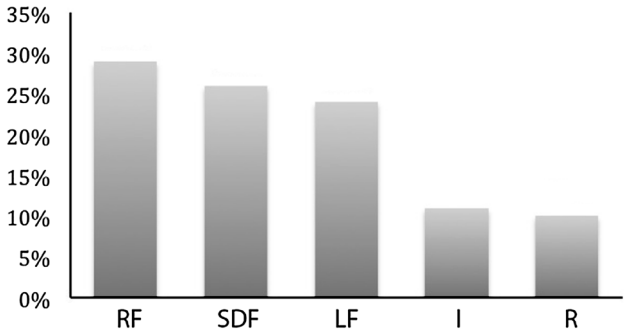

Fig. 2 Percentage of Malpighiaceae species occurring within the different vegetation types in Espírito Santo State: rain forest (RF); Semideciduous dry forest (SDF); lowland forest (LF); Inselbergs (I); Restinga (R)

Terra, Mantenópolis, Mucurici, Muqui, Ponto Belo, Rio Novo do Sul, São José dos Calçados, Vargem Alta, and Vila Valério do not have any records of Malpighiaceae specimens in visited or consulted herbaria.

Discussion

A high number of species for *Byrsonima*, *Heteropterys*, and *Stigmaphyllon* were expected since they are the most diverse Malpighiaceae genera within the Atlantic Forest, with 46, 16, and 28 species, respectively (Anderson 1997; Amorim 2003; Sebastiani and Mamede 2010; Mamede et al. 2013). *Alicia anisopetala* (A.Juss.) W.R.Anderson and *Heladena multiflora* (Hook. & Arn.) Nied. were also expected to account for a single species each, since the first includes just another species [*A. macrodisca* (Triana & Planch.) W.R.Anderson] occurring in the Amazon Forest, and the latter is a monospecific genus widespread in Brazil, Paraguay, and Argentina (Anderson et al. 2006; Mamede et al. 2013). *Lophopterys* and *Mezia* were also expected to account for a single species each, since both have diversified within the Amazon Basin, and single species of each reached the Atlantic forest (Anderson and Davis 2001; Anderson et al. 2006; Mamede et al. 2013). *Thryallis brachystachys* Lindl. was also expected to occur

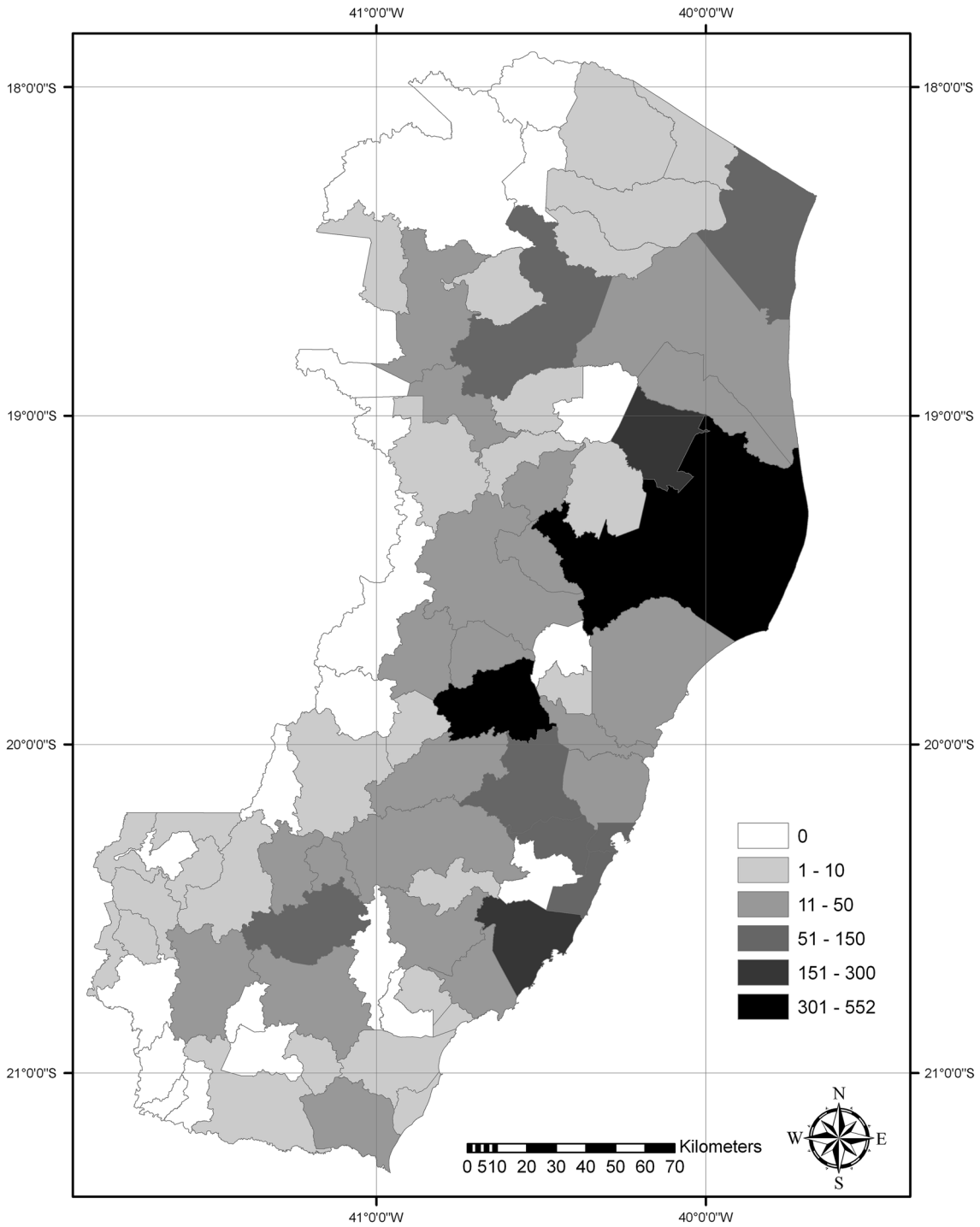

Fig. 3 Sampling effort analysis of Malpighiaceae specimens in Espírito Santo State: color chart represents number of collected specimens in each municipality

in the State, since it is a widespread species in the Atlantic Forest (Anderson 1995). However, this species might be extinct in the State due the lack of modern collections and presumably due the long-term and intensive human impact in the restinga vegetation of Espírito Santo (Pereira 2008).

The high number of threatened species of Malpighiaceae added to the Red List of Espírito Santo State might be explained by the few collections recorded in herbaria for most species listed here. This scenario might be a reflection of the poor sampling effort in the state and a bias of the methodology applied to categorize the threat level, since it

takes into account the number of records by locality (Simonelli and Fraga 2007; IUCN 2012). All collections were classified in the category 2a from Simonelli and Fraga (2007), which states that species found in no more than ten localities should be regarded as vulnerable, in no more than five localities as endangered, and in just a single locality as critically endangered. The concept of locality applied was related to ecological localities (fragments of the same habitat near each other, e.g., fragments of Montane Rain Forest in the surroundings of Santa Teresa municipality), rather than political geographical localities, as municipalities and districts.

A large number of collections are recorded for a few municipalities and in at least 16 municipalities, there is not a single collection of Malpighiaceae. Most of the unsampled municipalities are located within the Semideciduous dry forest domain, one of the most diverse vegetation types for Malpighiaceae in the state, and also within the Neotropics (Anderson 1981), and therefore liable to produce new records of the family if the sampling effort is increased.

One of the main problems associated with the analysis of herbarium data is the potential bias that exists in the spatial patterns of sampling effort and in the spatial autocorrelation among specimens (Ponder et al. 2001), together with a correlation between the number of species recorded and the number of herbarium specimens available (Moerman and Estabrook 2006; Pautasso and McKinney 2007; Ahrends et al. 2011). Some studies demonstrated values of higher species richness in sites in areas near universities or research centers, due to the better collection rates (Hijmans et al. 2000). Therefore, it is essential to detect such biases in order to make the appropriate corrections during the analysis.

The number of species detected in an area is largely dependent on the number of collected specimens. This is an "accepted fact" among botanists due to the highly heterogeneous distribution of herbarium collections being a reflection of the uneven distribution of research centers, taxonomists, and their scientific interests (Palmer 1995; Palmer et al. 2002). In Espirito Santo State, it is clear that the most investigated areas are those which have been considered very attractive to botanists, e.g., the Montane Forest of Santa Teresa municipality near the Mello Leitão Museum, the Lowland Forest of the Sooretama region near the Vale do Rio Doce Company Nature Reserve, and the Restinga vegetation of Guarapari municipality near the Federal University of Espírito Santo (Fig. 3).

Several studies have suggested that biologists tend to mainly explore the same localities or the same vegetation types (Sastre and Lobo 2009). This phenomenon, known as the "botanist effect," states that there is a strong relationship between the recorded number of species found and number of botanists working in an area (Palmer 1995; Palmer et al. 2002; Pautasso and McKinney 2007). For example, Moerman and Estabrook (2006) showed that there were more species reported in university counties than in their neighbors, because botanists paid more attention to sampling sites close to their workplaces. In Espírito Santo State the most relevant botanical institutions, Professor Mello Leitão Biological Museum, Vale do Rio Doce Company Nature Reserve, and the Federal University of Espírito Santo are located within the three municipalities with the highest numbers of collections. In this way, our data on the mapping of herbarium specimens showed a large difference between botanical collections in the different areas of the State, apparently confirming the existence of the pattern predicted by the botanist effect (Fig. 3).

Despite the existing bias, our data show that 65 % of Malpighiaceae species from the Atlantic Forest domain can be found in Espírito Santo State, evidencing their fundamental contribution to the biodiversity of the Central Biodiversity Corridor of the Atlantic Forest. Most species are already regarded as threatened while other municipalities in the State lack records of the family. Consequently, a call for an extensive sampling effort of Malpighiaceae species in Espírito Santo State is imperative before a more comprehensive taxonomic treatment is made in the future.

Acknowledgments We thank the curators of all visited herbaria for the loan and/or donation of Malpighiaceae specimens. The first author thanks CNPq for the fellowship granted. This work was supported by a CNPq grant, ProTax 562136/2010-0.

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