

3
4 **Use and Characterization of plant species in the**
5 **composition of urban hedgerows**
6

7
8
9
10
11
12 **ABSTRACT**
13

The aim of the study was to conduct a qualitative and quantitative survey of hedgerows in a study area in the Imbiribeira neighborhood, Recife-PE, Brazil. After the delimitation of the study area, the number of properties with hedgerows was registered. The application of the questionnaire was directed to people residing, working or owning real estate that contained hedgerows with the following functions: embellishment, privacy, delimitation and coating. The number of blocks sampled, blocks with hedgerows, sampled hedgerows, hedgerows by block, properties with hedgerows, hedgerows by property and private companies and residences with hedgerows were noted. The interviewee was questioned about reasons for implantation and difficulties faced, presence of animals, reasons of plant selection, composition of plant species and phytosanitary conditions. In the study area 30 blocks were sampled, the presence of hedgerows was observed in 18 of them. Of these 18 blocks 73 hedgerows were surveyed, with an average of 2.43 hedgerows per block. The presence of hedgerows in 27 properties was verified. Landscape beautification is one of the main reasons for implantation and maintenance of the hedgerows. Of those interviewed, 30.77% stated that the work required for implantation and maintenance was a negative aspect of planting hedgerows. The presence of arthropods was verified in all studied hedgerows. General aesthetics was the reason the majority of interviewees chose their particular plant species. Seventeen plant species and 11 families were observed. The species *Ixora coccinea* L. var. *compacta* Hort. was the most commonly found species. Hedgerows for the purpose of embellishment represent 83.56% of the hedges found. The phytosanitary status and the presence of flaws in the hedgerows in the study area presented a certain relation. Although hedgerows are widely used in urban and rural areas, studies on their composition, structure, ecological importance and relevance to biodiversity conservation are scarce.

14
15 *Keywords: Hedgerows, Urban forests, Landscaping, Phytosanitary, Ecological benefits.*
16

17
18 **1. INTRODUCTION**
19

20 Most Brazilian people live in urban and semi-urban areas, where houses are surrounded by
21 brick walls, iron grids, or electric fences with almost no free terrain. It is possible to take
22 advantage of the walls structure and fences by transforming them into green fences (fences
23 that are formed by plants). Increasing greenery improves well-being and makes the
24 environment more natural and enjoyable.

25 The conversion of green area into developed area is one of the major reasons for
26 destruction of natural habitats in urban cities around the world. There is no environment
27 more altered than the urban environment due to subsequent construction that paves over
28 and dissects green spaces. Development limits access to green areas in the urban
29 environment.

30

31 Urban forest corresponds to all vegetation covered public or a private space located in the
32 urban perimeter. Urban trees and green spaces can be classified as urban forest [1]. Urban
33 forests are important for human sustainability, not only in environmental, economic, and
34 industrial terms, but also spiritually, historically, and aesthetically because of their direct and
35 indirect provided benefits [2]. Urban forests provide biophysical, physical, psychic,
36 ecological, political, and social-economic benefits. These benefits include adding aesthetic
37 value and recreational opportunities that improve health and well-being and raises property
38 values in the neighborhoods [3].

39

40 The plants that compose the urban forests not only embellish the landscape, but play an
41 important role in reducing the environmental impact of urban settlements. Several ecological
42 benefits can be obtained from urban forests, such as micro-climatic improvement, humidity,
43 reduction of insulation, mitigation of atmospheric and acoustic pollution, and protection of
44 soil and fauna [3].

45

46 The improvement of the climate is due to the provided shade and modification of the airflow
47 by evapotranspiration. Shade reduces the amount of radiant energy absorbed, stored and
48 radiated by concrete surfaces. Urban forests can also serve as a community attraction [4].

49

50 There are many reasons to plant hedgerows. How hedgerows are handled and the diversity
51 and types of plant species present will result in hedgerows with different functions and can
52 affect the diversity of fauna species that can be found in these hedgerows, as well as in their
53 phytosanitary conditions.

54

55 Hedgerows constitute an important part of our landscape, and can be an ideal border for
56 gardens. They have many benefits: such as reducing noise; providing shelter, food supply
57 and natural habitats for animals such as insects, birds and mammals; pest control because
58 they provide habitat for natural predators; provide privacy; security, thorny species provide
59 obstacles for anyone trying to overcome them, and they are visually attractive. Hedgerows
60 also act as green corridors for the movement of insect populations and increase the
61 connection between the different parts of the hedges [5,6]. Hedgerows provide a favorable
62 environment for various birds for nesting, providing shelter against predators, and homes for
63 insect food sources.

64

65 In some European countries, the implantation of hedgerows is widely used as a strategy for
66 the conservation and preservation of wild animals, aiming to make anthropic environments
67 more accessible to animals [6].

68

69 Hedgerows can play an important role in the moth diversity and conservation in productive
70 areas, where their benefits are influenced by their number of individuals, richness of species
71 and management [7].

72

73 Hedgerows with a rich diversity of species can reduce their susceptibility to pests and
74 diseases. Plant diversity is one of the most important components of the urban ecosystem
75 because it provides several ecological benefits and contributes directly to the quality of life
76 and well-being of the population [8]. The diversity of species can contribute to the
77 conservation of local biodiversity by preserving native species in urban environments and

78 providing natural habitats for local animal species [9]. One way to achieve a greater diversity
79 of invertebrates in hedgerows is to increase the floristic diversity, this increases potential
80 hosts for a variety of invertebrates. A rich diversity of trees and shrubs species may also
81 provide a longer flowering period. This is particularly beneficial for animals that eat pollen
82 and nectar and for the animals that use pollinators as a food source.

83
84 The types and functions of hedgerows can generally be determined according to the
85 predominant plant species. The distribution of hedgerow types depends on a combination of
86 environmental and cultural factors. In an urban environment, hedgerows have the primary
87 function of embellishment, privacy, delimitation, and coating. Hedgerow species most
88 commonly planted for embellishment often have ornate or uniquely aromatic flowers,
89 beautiful aesthetics, or unique coloring.

90
91 Species that form a crown or a dense vegetative part can be characterized as delimitation or
92 privacy hedgerows. Hedgerows used to delimitate areas usually have the purpose of
93 providing privacy to one side of the hedgerow, or both.

94
95 The delimitation function (green fence) can be both physical and symbolic. A physical barrier
96 could completely prevent or make it difficult to overpass the hedgerow.

97
98 The symbolic limit or barrier, such as a row of small shrubs around a garden, may not exert
99 any major impediment to overtake. A symbolic limit can serve primarily as a walking guide,
100 encouraging people to stay in the pedestrian area. These types of hedgerows are generally
101 small and have ornamental appearance.

102
103 The presence of climbing species generally indicates hedgerows of the coating type, since
104 they alone would not exert the function of a hedge. Hedgerows consisting of climbing plant
105 species always use an underlying support to form the structure. Some of the advantages of
106 the green-walls (hedgerows with coating species) are the thermal insulation and reduction of
107 solar rays directly on the constructions providing reduction of energy expenses for cooling of
108 the environment, aside from psychological and aesthetic benefits [10].

109
110 The aim of this work was to conduct a qualitative and quantitative survey of urban
111 hedgerows in a study area in the Imbiribeira neighborhood, located in the city of Recife-PE,
112 Brazil. The study used a survey evaluating the properties containing hedgerows. The goal
113 of the survey was to record the rationale for selecting the species, the relevance of the
114 hedgerows to the local fauna, the plant species found and the group of species the belong,
115 the types of hedgerows mentioned (Coating, Embellishment, Privacy and Delimitation) and
116 the phytosanitary conditions of the hedgerows.

117 118 **2. MATERIAL AND METHODS**

119 120 **2.1 Study area**

121
122 The coast of Pernambuco is generally flat and low, in several places lower than sea level. It
123 is considered a "green region" because of the variety of ecosystems, such as the Atlantic
124 Rain Forest, Restingas, Estuaries with extensive Mangroves, Coral Reefs, Islands, and
125 plains covered by coconut trees.

126
127 The city of Recife has an approximate area of 218,435 km² and a population of 1,537,704
128 inhabitants. The city represents about 7.2% of the metropolitan area and concentrates 42%
129 of the inhabitants of the region. Its urban area extends throughout the municipal territory and
130 its population grows beyond the limits of the municipality.

131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182

2.2 Sample area

This study was carried out in an area of Imbiribeira, Recife, PE, Brazil. The neighborhood of Imbiribeira has 0.14km² of predominantly residential area, with commerce in its main streets. It presents a landscape characterized by the Atlantic Forest Biome, tropical climate, and average annual temperature of 21° C, with an average rainfall of 1400mm/year.

2.3 Survey

The survey was conducted in an area of 30 city blocks (37.024 hectares) consisting mostly of residential properties and a small park.

After the delimitation of the study area, the number of properties with hedgerows was registered. The application of the questionnaire was directed to people residing, working, or owning real estate that contained hedgerows with the following functions: embellishment, privacy, delimitation and coating.

The method for conducting the interview was based on qualitative and quantitative research with a semi-structured questionnaire, which combined open and closed questions, where the person inquired has the possibility to discuss the proposed topic.

2.4 Properties characterization

The number of blocks sampled, blocks with hedgerows, sampled hedgerows, hedgerows by block, properties with hedgerows, hedgerows by property and private companies and residences with hedgerows were noted.

2.5 Potentialities and limitations

In order to understand the reasons that led people to opt for a hedgerow instead of other types of fences or construction materials, the interviewees were asked the reasoning for hedgerow implantation on the property, and of any problems or difficulties encountered getting the plants established.

2.6 Local Fauna relevance

To assess the relevance of the hedgerows to the local fauna, the interviewees were asked which taxonomic groups (mammals, birds, amphibians, reptiles and arthropods) are frequently found in the hedgerows, regardless of the purpose (food, shelter, pollination, nesting, breeding, rest, etc.).

2.7 Plant species aspects

The plant species that compose the hedgerows were registered and the interviewees were asked the reasons why they chose the species to compose it.

The species that comprised the hedgerows were classified according to their origin in: native and exotic. The species used were classified into groups of plant species: arboreal, shrub, herbaceous and climbing plants. From the survey of the species, the frequency of observation was observed.

183 **2.8 Types of Hedgerows**

184

185 The hedgerows were classified according to their function in four types: Coating, when it
186 covered another type of fence to give a more ecological connotation (grid, wall, etc.);
187 Embellishment, species with showy flowers or with differentiated aesthetic aiming an
188 ornamental and aesthetic beauty of the environment; Privacy, when it is intended to prevent
189 the display of one or both sides of the hedgerow; Delimitation, when it has the function of
190 guiding people's path, delimiting gardens, or of hindering or preventing the passage through
191 them.

192

193 **2.9 Phytosanitary conditions**

194

195 A phytosanitary evaluation was performed by the analysis of the visual aspect of the hedge,
196 classifying them in: healthy plants; and sick plants. The sick plants were classified according
197 to their sickness level as: low, medium and high.

198

199 Regarding the integrity, the hedgerows were classified as: with flaws, when the hedgerow
200 presented discontinuities along its extension caused by flaws in its structure and; without
201 flaws, when the hedgerow had no discontinuities along its length.

202

203 **3. RESULTS AND DISCUSSION**

204

205 **3.1 Properties characterization**

206

207 In the study area of the neighborhood of Imbiribeira, 30 blocks were sampled, where the
208 presence of hedgerows was observed in 18 of them (Table 1). In these, 73 hedgerows were
209 surveyed with an average of 2.43 hedgerows per block. The presence of hedgerows was
210 verified in 27 properties, with an average of 2.70 hedgerows per property, of which 18 (66.67
211 %) are residential and 9 (33.33 %) belong to private companies.

212

213 Although, considering the low number of properties with hedgerows, the number of
214 hedgerows surveyed in the area was above the expectations. Opening the possibility to
215 consider that this system is valued in the area.

216

217 **Table 1. Hedgerows found in the study area in the neighborhood of Imbiribeira,**
218 **Recife, PE, Brazil**

219

Analyzed variables	Data
Sampled blocks	30
Blocks with hedgerows	18
Blocks without hedgerows	12
Sampled hedgerows	73
Hedgerows by blocks	2.43
Properties with hedgerows	27
Hedgerows by property	2.7
Private companies with hedgerows	9
Residences with hedgerows	18

220

221 **3.2 Potentialities and limitations**

222

223 All the interviewees stated that landscape beauty is one of the main reasons for the
224 implantation and maintenance of the hedgerows (Fig. 1).

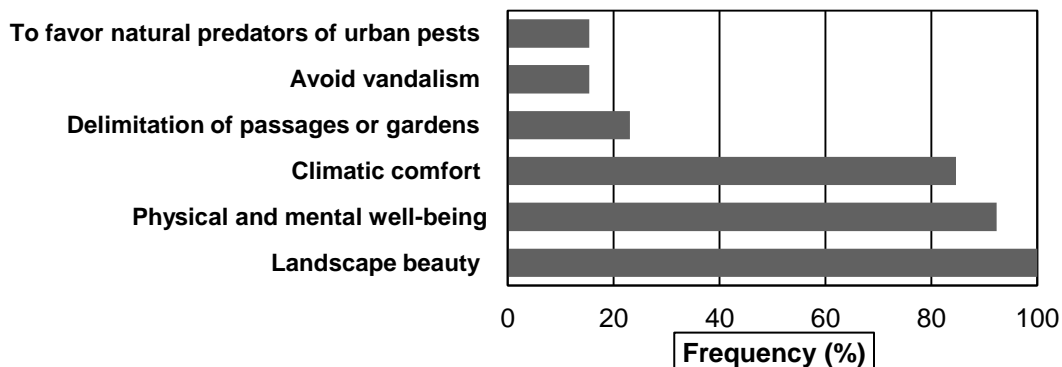
225

226 Another reason for their implantation was the physical and mental well-being, indicated by
227 92.31 % of the interviewees of the study area. There is growing recognition access to green
228 areas has a beneficial effect on public well-being [11]. Several researches have provided
229 scientific evidence showing the benefits urban green areas have on resident's health [12].
230

231 The climatic comfort generated due to the presence of the hedgerows was constantly
232 mentioned by the interviewees as one of the main reasons, being indicated by 84.62 % of
233 them.
234

235 The other reasons stated by the interviewees were the delimitation of passages or gardens
236 (23.08 %), avoiding graffiti on walls (vandalism) (15.38 %) and to favor natural predators of
237 urban pests such as lizards and spiders (15.38 %).
238

239 Hedgerows provide a number of benefits to the environment around them, but they can
240 become an issue when not properly maintained and can present many problems.
241
242



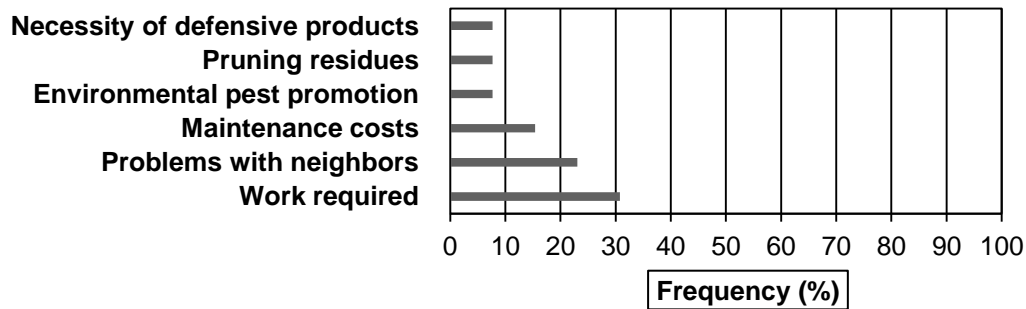
243
244

245 **Fig. 1. Reasons for implantation and maintenance of hedgerows in urban areas**

246

247 Although there are difficulties in the maintenance of hedgerows, these were not pointed out
248 by the majority of the interviewees. Among the difficulties encountered in the use of
249 hedgerows is the work required in implantation and maintenance, indicated by 30.77 % of
250 the interviewees in the study area (Fig. 2). Other problem such as issues with encroachment
251 on neighboring properties was reported by 23.08% of the interviewees. Also, high
252 maintenance costs were pointed out by 15.38%. The environmental pest promotion,
253 generation of pruning residues and necessity of defensive products to control phytosanitary
254 problems were pointed equally by 7.69 % of them.
255

256 A small percentage of interviewees mentioned difficulties maintaining their hedgerows. Of
257 those who mentioned difficulties none stated the challenges were enough to force them to
258 remove their hedgerows.
259
260



261
 262
 263
 264
 265
 266
 267
 268
 269
 270
 271
 272
 273
 274
 275
 276
 277
 278
 279
 280
 281
 282
 283
 284
 285
 286
 287
 288
 289
 290
 291
 292
 293
 294
 295
 296
 297
 298
 299
 300
 301
 302
 303

Fig. 2. Difficulties faced in the use of hedgerows in urban areas

3.3 Local Fauna relevance

As for the presence of fauna, it was verified the presence of arthropods in all studied hedgerows (Fig. 3). Insects such as ants, bees, ladybugs, butterflies, and moths were the most mentioned by the interviewees as being the main residents of their hedgerows. Spiders were also mentioned by all the interviewees in the study area.

The effects of time and frequency of pruning can determine the presence of populations of some arthropod species [13]. Some populations of insects can show a higher growth in hedgerows that are not pruned, while others can be more abundant in pruned hedgerows. Arthropod population can also be affected depending on the season pruning is performed. Due to this fact, the authors recommend that not all individual plants composing a hedgerow should be pruned at the same time.

A study about the importance of hedgerows, composed by different plant species, in the density and diversity of spiders showed that spiders can present preferences for specific plant species in different seasons, as well as preference for hedgerows instead of another agroforestry system [14].

Most studies about the presence of invertebrate populations in hedgerows have focused on Coleoptera and Lepdoptera [15,16] and Lepdoptera [17]. However, studies on the presence of insect populations of various orders, such as Hymenoptera [15], Homoptera [15], Heteroptera [15,18,19] and Diptera [15] and arthropods such as molluscan [18] and spiders' species can also be observed [20]. Other studies have also reported the presence of amphibians such as frogs and salamanders, reptiles [21] and mammals such as bats and hedgehogs among others. Hedgerows with species that bloom all year round are potentially favorable to pollinating species such as bees.

The presence of birds was recorded by 88.24 % of the interviewees from the study area. Birds were the most mentioned by the interviewees. It was also mentioned the presence of nests in some hedgerows studied. Many birds make use of hedgerows by nesting in them, using them as a food source, and as a shelter. The usefulness of the hedgerow to the birds depends on the floristic composition. Homogeneous hedgerows have lower bird diversity than heterogeneous hedgerows because they present more diversity of flowers and fruits.

Reptiles were mentioned by 76.47 % of the interviewee. Lizards were the only kind of reptiles mentioned by the interviewees frequenting or residing in the hedgerows of the study area.

304 The mammals mentioned in the study area were mice and opossums which used the
305 hedgerows for feeding and rest.

306

307 Amphibians and mollusks were both mentioned by only 18.18 % of the interviewees in the
308 study area, and they were not considered as frequent fauna in their hedgerows.

309

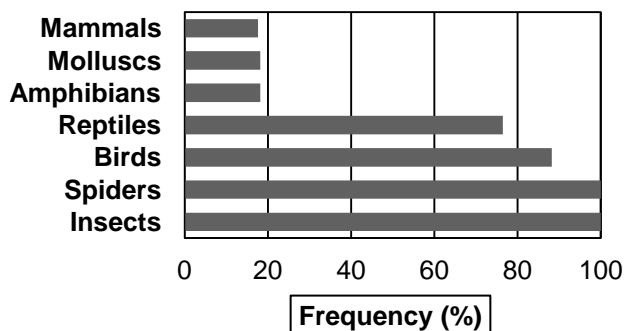
310 A study carried out in Abreu e Lima/PE, Brazil, reported the importance of hedgerows for the
311 local fauna. Several species of animals use the resources of hedgerows as a source of food
312 (flowers and fruits). Among the animals found in the study are wild rabbits, sloths, agoutis,
313 armadillos, capybaras, marmosets and anteaters [22].

314

315 The frequency and diversity of the animals found show that hedgerows help support local
316 wildlife. Hedgerows are being used as a source of food, refuge, nesting, reproduction, and
317 fallow creating an important habitat for wildlife.

318

319



320

321

322 **Fig. 3. Main faunistic groups observed by the interviewees in the hedgerows in urban**
323 **areas**

324

325 **3.4 Plant species aspects**

326

327 **3.4.1 Species choices reasons**

328

329 In the study area general aesthetics were pointed out by the majority of the interviewees as
330 the main reason for choosing the plant species composing the hedgerows. 100% of arboreal
331 and herbaceous types, 40% of shrubs, and 33.3% of climbing species were chosen for this
332 reason (Fig. 4).

333

334 The aesthetic characteristics, pointed out by the majority of the interviewees as the main
335 reason for choosing the plant species composing the hedgerows, can be analyzed from the
336 particularities of the parts of a certain species (leaves, flowers, bark, trunk and fruits) and the
337 species as a whole.

338

339 The interviewees who chose to plant hedgerows consisting of herbaceous varieties, did so
340 for general plant aesthetics. Those who chose hedgerows consisting of flowering varieties
341 did so for the coloring of the flowers and contrast with the environment.

342

343 The presence of flowers was mentioned as one of the main reasons for the plant species
344 selection. The shrubs were the most representative group, with 43.08 % of frequency.
345 Climbing species had a low frequency of choice for this reason. This reason was not pointed
346 out for choosing the arboreal species. This, due to the fact that the only species found

347 belonging to this group was *Ficus Benjamina*, which has no noticeable flowers and has no
 348 ornamental value.

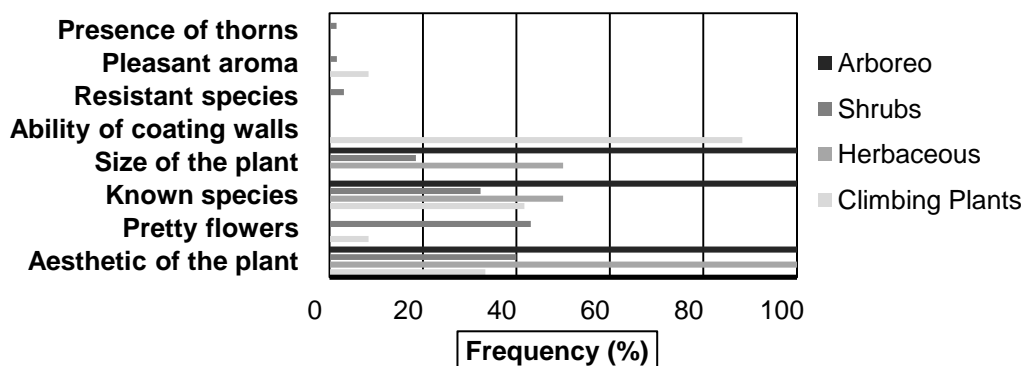
349
 350 The prior knowledge of the species was mentioned as the reason for choosing 100 % of the
 351 arboreal species. This option was almost equally pointed out by interviewees who had
 352 herbaceous and climbing species, with 50.00% and 41.67%, respectively. Due to the bigger
 353 variety of shrubs, this option was pointed out by only 32.31%. Interviewees who had
 354 hedgerows composed by the *Ixora* gender, *Duranta repens* var. *aurea* Hort. and climbing fig
 355 (*Ficus pumila* L.) were the ones who pointed out this reason the most.

356
 357 Plant size was mentioned as the reason for choosing 100% of the arboreal species. Whilst,
 358 in hedgerows composed of climbing plants, the size was not considered by the interviewees
 359 due to their ability to adjust to the size of the support. The plant size refers to the height
 360 preference of desired by the owner, which may be high to prevent visibility of one or both
 361 sides of the hedge, or, low height to allow the visualization of one or both sides of the hedge.

362
 363 The capacity to cover walls was mentioned as a reason for the selection 88.33 % of the
 364 climbing plants, where, this characteristic is more present.

365
 366 Other less mentioned reasons for choosing species, with lower frequency, were plants with
 367 pleasant aroma, in hedgerows with shrubs and climbing species, resilient plants, and
 368 hedgerows with shrubs.

369
 370



371
 372

373 **Fig. 4. Motifs of choice of plant species by group of plant species found composing**
 374 **hedgerows in urban areas**

375
 376

3.4.2 Plant species

377
 378

379 Seventeen plant species and eleven families were observed. The species *Ixora coccinea* L.
 380 var. *compacta* Hort. was the most found species in the study area in the Imbiribeira
 381 neighborhood, representing a frequency of 48.78% of the found species (Tab. 2).

382
 383

384 The *ixora*, the most found species in the study area, is a shrub species, dense, multi –
 385 branched evergreen, which height can reach more than 3m. It has attractive flowering, it is
 386 widely used in landscaping, especially in tropical gardens. There are different varieties with
 387 inflorescences in shades of red, orange, yellow and pink. It is widely cultivated for
 ornamental purposes.

388 The species *Ficus pumila* L. represented the second highest frequency of found species in
 389 the study area, with 14.62% of frequency. This species is one of the climbing species most
 390 used in landscaping. The climbing fig is a species of climbing plant with leaves in branches
 391 with adventitious roots that get attached to walls. The species has the ability to coat supports
 392 like walls, which makes it ideal for hiding construction defects or avoiding constant paintings.
 393 A study about green walls in residential real estate observed that most were composed by
 394 *Ficus pumila* [10].
 395

396 The species *Duranta repens* var. *aurea* Hort. presented a frequency of 6.10% among found
 397 species in the study area. The species is also widely used in the formation of hedgerows in
 398 urban environments, as well as species of the genus *Ixora*. The *Duranta repens* species is a
 399 fast growing shrub, which can reach a height up to 3 m. It is a popular ornamental plant used
 400 in hedges in tropical and subtropical parts of the world because of its showy flowers and
 401 fruits. Its dense lateral branches allow the formation of wide and dense hedges. Its young
 402 leaves have a golden-yellow color, which gives it good characteristics for its use as an
 403 ornamental plant.
 404

405 Other species were also found with smaller frequencies: *Sansevieria trifasciata* var. *laurentii*
 406 (De Wild.), *Cantharantus roseus* (L.) G. Don, *Tabernaemontana laeta* Mart. With a 2.44%
 407 frequency and *Euphorbia milii* var. *splendens* Des Moulins, *Ficus benjamina* L., *Jasminum*
 408 *officinale* L., *Podocarpus macrophyllus* (Thunb.) Sweet, *Heliconia bihai* L., *Polyscias*
 409 *guilfoylei* Bailey, *Jasminum sambac* (L.) Aiton and *Plumbago auriculata* Lam. with a 1.22%
 410 frequency.
 411

412 A study of the potential of shrub species, selected some species with ornamental potential in
 413 the Brazilian semi-arid region, among them *Rosa sinensis* L., *Ixora coccinea*, *Ixora*
 414 *chinensis*, *Tabernaemontana laeta* and *Duranta repens* [23].
 415

416 The two families with the highest numbers of individuals found in the study area was
 417 Rubiaceae, representing 62.20% of the species, all belonging to the *Ixora* genus, and
 418 Moraceae with 15.84%.
 419

420 The Rubiaceae family was also the one with the highest number of species, represented by
 421 four species, followed by the Moraceae, Apocynaceae and Oleaceae families, being all
 422 represented by two species. The two species of the Moraceae family were represented by
 423 the *Ficus* genus and the Oleaceae family was represented by two species of the *Jasminum*
 424 genus.
 425

426 An interesting aspect is the relationship between native and exotic species. The frequency of
 427 exotic species found in the study area corresponded to 90.24% (represented by 14 species),
 428 while only 9.76% (represented by 3 species) were native to the area. More than 80% of plant
 429 species in Brazilian cities are exotic flora. This is due to the lack of knowledge of native
 430 species and the colonial origin of Brazil which introduced several species from other
 431 countries to plant our streets and squares since the beginning of colonization. This
 432 predominance of exotic origin species over species of native origin was also reported in a
 433 study about ornamental species in the Brazilian semi-arid region [23]. The preference for
 434 exotic species in the urban forest composition, both due to rapid growth and aesthetic
 435 reasons, is one of the main consequences of urbanization and may increase biotic
 436 homogenization in urban cities.
 437

438 **Table 2. Species that compose hedgerows in the study area in the neighborhood of**
 439 **Imbiribeira, Recife, PE, Brazil**

Scientific Name	Family	Origin	Group of	F (%)
-----------------	--------	--------	----------	-------

			Species	
<i>Ixora coccínea</i> L. var. <i>compacta</i> Hort.	Rubiaceae	Exotic	Shrubs	48.78
<i>Ficus pumila</i> L.	Moraceae	Exotic	Climbing Plant	14.62
<i>Ixora coccínea</i> var. <i>lutea</i> (Hutch.) Corner	Rubiaceae	Exotic	Shrubs	10.98
<i>Duranta repens</i> var. <i>aurea</i> Hort.	Verbenaceae	Native	Shrubs	6.10
<i>Sansevieria trifasciata</i> var. <i>laurentii</i> (De Wild.)	Asparagaceae	Exotic	Herbaceous	2.44
<i>Cantharantus roseus</i> (L.) G. Don	Apocynaceae	Exotic	Shrubs	2.44
<i>Tabernaemontana laeta</i> Mart.	Apocynaceae	Native	Shrubs	2.44
<i>Euphorbia milii</i> var. <i>splendens</i> Des Moulins	Euphorbiaceae	Exotic	Shrubs	1.22
<i>Ficus benjamina</i> L.	Moraceae	Exotic	Arboreal	1.22
<i>Jasminum officinale</i> L.	Oleaceae	Exotic	Climbing Plant	1.22
<i>Podocarpus macrophyllus</i> (Thunb.) Sweet	Podocarpaceae	Exotic	Shrubs	1.22
<i>Heliconia bihai</i> L.	Heliconiaceae	Native	Shrubs	1.22
<i>Polyscias guilfoylei</i> L. H. Bailey	Araliaceae	Exotic	Shrubs	1.22
<i>Ixora macrothyrsa</i> Teijsm. & Binn.	Rubiaceae	Exotic	Shrubs	1.22
<i>Ixora chinensis</i> Lam.	Rubiaceae	Exotic	Shrubs	1.22
<i>Jasminum sambac</i> (L.) Aiton	Oleaceae	Exotic	Shrubs	1.22
<i>Plumbago auriculata</i> Lam.	Plumbaginaceae	Exotic	Shrubs	1.22

440

441

442

443

444

445

446

447

448

449

450

451

452

453

454

455

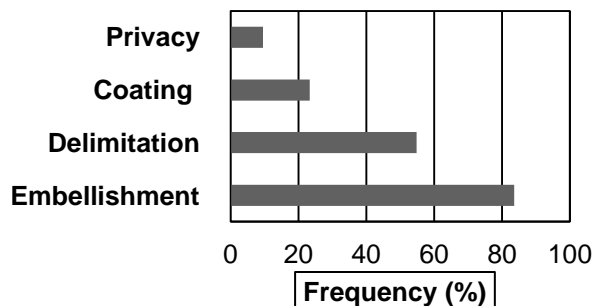
456

3.5 Types of Hedgerows

Hedgerows of embellishment were the most found, representing 83.56% of the hedges of the study area (Fig. 5). Delimitation hedgerows were the second most found, representing 54.79% of them. Coating and privacy hedgerows were found in 23.29% and 9.59% respectively of the cases in the Imbiribeira neighborhood.

Coating hedgerows composed of both shrub and tree species consist of the implantation of hedgerows near walls and grates, also known as green walls, with the function of covering these materials even if these plants do not use them as support. This implantation is mainly done to beautify the environment and hide construction defects.

It can be inferred that many of the hedgerows in urban areas can represent more than one type or function, and that embellishment is their primary purpose.



457

458

459

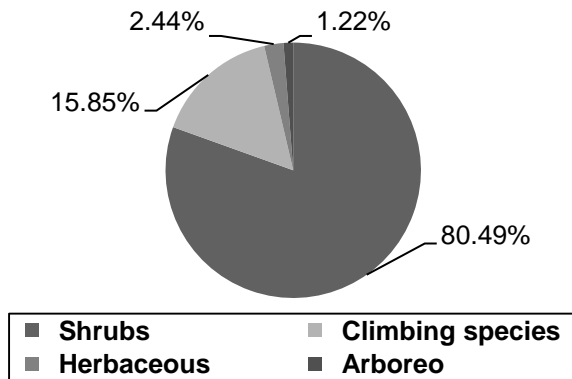
Fig. 5. Frequency of the different types of hedgerows in urban areas

460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477

The shrub species represented the higher frequency in the composition of hedgerows, with a frequency of 80.49% (Fig. 6). These species were the only ones composing all types of hedges in the study area of the neighborhood of Imbiribeira.

The peculiar shape of shrubs, with their different branches appearing at the ground, allows the formation of vegetation groups where the plants lose their individuality, forming associations, which can be very useful in the formation of hedgerows. This group of plants has great plasticity with regard to different colors, shapes, and volumes, some resembling small trees.

Climbing plants represented 15.89% of the hedgerows, followed by herbaceous and tree species, with 2.44% and 1.22%, respectively. The tree species presented a lower frequency among the vegetation groups in the study area of the Imbiribeira neighborhood. In all cases of tree species hedgerows, the same purpose was found, which is to embellish, delimit, and generate privacy to one or both sides of the hedgerow.



478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500

Fig. 6. Frequency of the groups of plants composing hedgerows in urban areas

The hedgerows with the privacy function had more representatives from the shrubs group, with a 75% frequency (Fig.7) and equal representatives from the arboreal and climbing species.

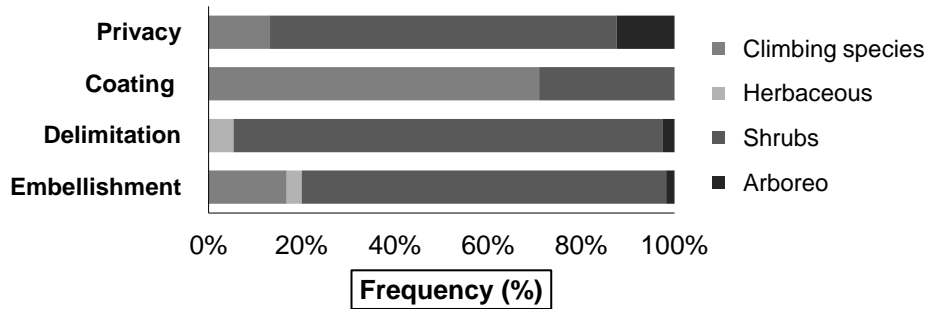
Coating hedgerows were most represented by the climbing species, as expected. Shrubs were also found to share this kind of function.

Hedgerows with delimitation function were mostly composed by shrubs, with a frequency of 92.50%. Another group found with this function, but with a lower frequency, was the herbaceous and arboreal. This is probably because the shrub plants can grow wider and denser hedgerows than herbaceous ones, making the ultrapassation harder to happen. Hedgerows composed by arboreal species can grow wider than the desired size.

Embellishment hedgerows were represented mostly by shrub species, with a 78.69% frequency, followed by climbing species (16.39%), herbaceous (3.28%), and arboreal (1.64%).

In general, the preference for shrub plants in most of the types of hedgerows, could be observed.

501
502



503
504
505
506
507

Fig. 7. Representation of each group of plants within the different types of hedgerows in urban areas

508 Analyzing the relationship between the plant groups and the hedgerow types, it was possible
509 to observe that the climbing species, in their totality, had the coating function (Fig. 8). Most
510 of the interviewees also pointed out the use of this group to beautify the environment
511 (83.33%) and a few to provide privacy (8.33%). Due to the necessity of support, this group
512 was not found for delimitation purposes.

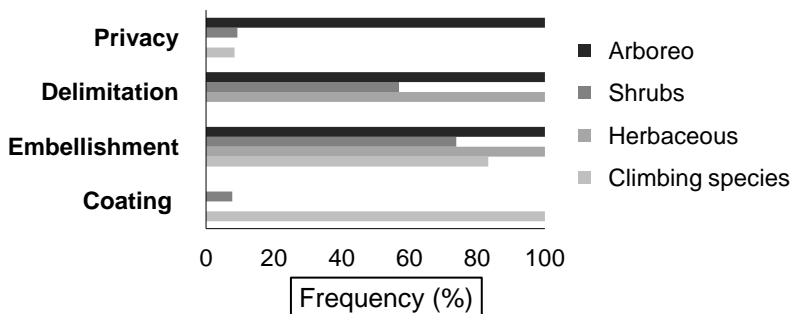
513
514
515
516
517

Hedgerows composed of herbaceous species were used to equally delimit and beautify the environment in all cases of the study area. This group was not found coating or exercising the privacy function.

518 Most of the shrubs were found exercising the embellishment function, with a 73.85%
519 frequency, followed by the delimitation function (56.92%). This, due to the wide diversity of
520 flowers and shapes of this group and its capacity to grow wider hedgerows. The functions
521 less mentioned by the interviewee were privacy and coating, with 9.23% and 7.69%,
522 respectively.

523
524
525
526
527

Arboreal species were equally mentioned exercising the embellishment, delimitation and privacy functions.



528
529
530
531
532
533

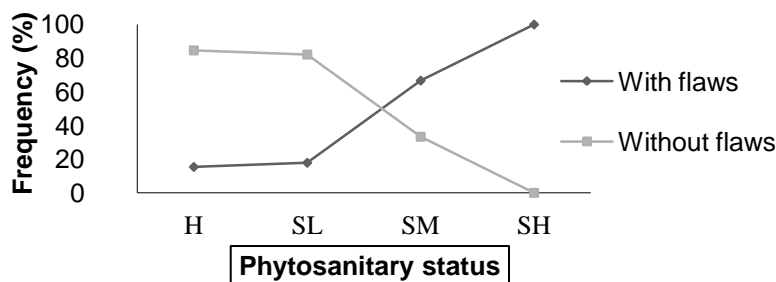
Fig. 8. Frequency of the plant groups that composed the different types of hedgerows in urban areas

3.6 Phytosanitary conditions

534
535
536
537
538
539
540
541
542
543
544
545
546
547
548

The phytosanitary status and the presence of flaws in the hedgerows of the study area presented a certain relation. According to the data, the presence of flaws intensified as the phytosanitary quality of hedgerows decreased. Only 15.38% of the hedgerows considered healthy presented flaws in their structure (Fig. 9). While, flaws were found in 100% of hedgerows with low phytosanitary quality (SH).

The uniformity of the plants composing the hedgerow is of great importance. Since a single dead plant or a plant with flaws in its structure can impair the hedgerows objective such as privacy (making it possible the visualization of one or both sides of the hedgerow) or security (making it possible to someone overpass the hedgerow that was meant for protection) or take away from the visual beauty.



549
550
551
552
553
554
555
556

Fig. 9. Relation between phytosanitary status and the integrity of hedgerows urban areas. Where: H corresponds to healthy plants; SL corresponds to sick plants of low intensity; SM, sick plants of medium intensity; and SH, sick plants with high intensity

4. CONCLUSION

557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575

A considerable amount of relatively well conserved hedgerows of varying sizes could be witnessed. Landscape beauty is the main reason considered for the implantation and the conduction of hedgerows. Although there are difficulties in the management of hedgerows, most of the interviewees do not consider maintenance enough of a problem for them to consider taking out the plants. According to the majority of the interviewees general aesthetics of the species and the presence of flowers were the main reasons for choosing the species of hedgerows. The most found species comprising hedgerows in the present study were the *Ixora coccinea* L. var. *compact* Hort., *Ficus pumila* L., *Ixora coccinea* var. *lutea* (Hutch.) Corner and *Duranta repens* var. *aurea* Hort. The variety of shapes, flowers, and colors of shrub species and their ability to form beautiful hedgerows can be considered the main reasons why they are used in the composition of hedgerows. Uniformity of the plants composing the hedgerow is of great importance, since a flaw in a single plant can impair the objective and the visual aspect of the hedgerow. Although hedgerows are widely used in urban and rural areas, studies on their composition, structure, ecological importance and relevance to biodiversity conservation are scarce.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

576

577

578

579

580

581

582

583

584

585

586

587

588

589

590

591

592

593

594

595

596

597

598

599

600

601

602

603

604

605

606

607

608

609

610

611

612

613

614

615

616

617

618

619

620

621

622

623

624

625

626

REFERENCES

1. Biondi D. Floresta urbana: conceitos e terminologias. Curitiba:2015.
2. Seth MK. 2004. Trees and their economic importance. *Bot Rev.* 2004;69(4):321-376.
3. Biondi D, Althaus M. Árvores de rua Curitiba: cultivo e manejo. Curitiba: FUPEF; 2005.
4. McPherson EG, Simpson GR. A comparison of municipal forest benefits and costs in Modesto and Santa Monica. *Urban For Urban Gree.* 2002;1:61-74.
5. Burel F. 1996. Hedgerows and their role in agricultural landscapes. *Cr Rev Plant Sci.* 1996;15:169-190.
6. Baudry J, Bunce RGH, Burel F. Hedgerows: An international perspective on their origin, function and management. *J Environ Manage.* 2000;60:7-22.
7. Tobar LDE, Ibrahim M. ¿Las cercas vivas ayudan a la conservación de la diversidad de mariposas en paisajes agropecuarios? *Rev Biol Trop.* 2010;58(1):447-463. Spanish.
8. Scopelliti M, Carrus G, Adinolfi C, Suarez G, Colangelo G, Laforteza R, et al. Staying in touch with nature and well-being in different income groups: the experience of urban parks in Bogotá. *Landscape Urban Plan.* 2016;148:139-148.
9. Ikin K, Le Roux DS, Rayner L, Villaseñor NR, Eyles K, Gibbons P, et al. Key lessons for achieving biodiversity-sensitive cities and towns. *Ecol Manag Restor.* 2015;16:206-214.
10. Valesan M, Fedrizzi B, Sattler MA. Vantagens e desvantagens da utilização de peles-verdes em edificações residenciais em Porto Alegre segundo seus moradores. *Ambiente Construído.* 2010;10(3):55-67. Portuguese.
11. Laforteza R, Davies C, Sanesi G, Konijnendijk CC. Green Infrastructure as a tool to support spatial planning in European urban regions. *iForest.* 2013;6:102-108.
12. Song C, Ikei H, Kokayashi M, Miura T, Li Q, Kagawa T, et al. Effects of viewing forest landscape on middle-aged hypertensive men. *Urban For Urban Gree.* 2017;21:247-252.
13. Marshall EJP, Maudsley MJ, West TM, Rowcliffe HR. Effects of management on the biodiversity of English hedgerows. In: Barr CJ, Petit, editors. *Hedgerows of the World: Their Ecological Functions in Different Landscapes.* Iale: International Association of Landscape Ecology; 2001.
14. Wu Y, Cai Q, Lin C, Chen Y, Li Y, Cheng X. Responses of ground-dwelling spiders to four hedgerow species on sloped agricultural fields in Southwest China. *Prog Nat Sci.* 2009;19(3):337-346.
15. Joyce KA, Jepson PC, Doncaster CP, Holland JM. Arthropod distribution patterns and dispersal processes within the hedgerow. In: Cooper A, Power J, editors. *Species Dispersal and Land Use Processes.* Coleraine: International Association for Landscape Ecology; 1997.
16. Alvarez T, Frampton GK, Goulson D. The role of hedgerows in the recolonisation of arable fields by epigeal Collembola. *Pedobiologia.* 2000;44(3-4):516-526.
17. Ouin A, Burel F. Influence of herbaceous elements on butterfly diversity in hedgerow agricultural landscapes. *Agr Ecosyst Environ.* 2002;93:45-53.
18. Maudsley MJ. 2000. A review of the ecology and conservation of hedgerow invertebrates in Britain. *J Environ Manage.* 2000;60:65-76.
19. Moreby SJ, Southway S. The importance of hedgerow field boundaries to densities of beneficial invertebrates in cereals. In: Barr C, Petit S, editors. *Hedgerows of the World: Their ecological functions in different landscapes.* Iale: International Association of Landscape Ecology; 2001.
20. Maudsley MJ, Seeley B, Lewis O. Spatial distribution patterns of predatory arthropods within an English hedgerow in early winter in relation to habitat variables. *Agr Ecosyst Environ.* 2002;89:77-89.
21. Reading CJ, Jofré GM. Habitat selection and range size of grass snakes *Natrix natrix* in an agricultural landscape in southern England. *Amphibia-Reptilia.* 2009;30:379-388.

- 627 22. Lima MSC. Potencial de Uso das Espécies que Compõem Cercas Vivas na Comunidade
628 Rural de Pitanga, Município de Abreu e Lima, Pernambuco. Mestrado em Biologia Vegetal
629 Departamento de Biologia. Recife: Universidade Federal de Pernambuco; 2008.
630 23. Menezes HEA. Seleção de espécies arbustivas potenciais para o paisagismo no semi-
631 árido brasileiro. Monografia, Centro de Saúde e Tecnologia Rural. Patos: Universidade
632 Federal de Campina Grande; 2009.

UNDER PEER REVIEW