Review Paper

Qualitative and quantitative analysis of hedgerows in urban areas

ABSTRACT

The research aimed to analyze the maintenance, composition, pruning, planting aspects and architectural elements on urban hedgerows. This study was carried out in an area of Imbiribeira, Recife, PE, Brazil, during six months. The survey was conducted in an area of 30 city blocks (37.024 hectares). The application of the questionnaire was directed to people residing, working, or owning real estate that contained hedgerows. Maintenance (person with the responsibility of pruning and maintenance of the hedge and types of maintenance performed on the hedges); Plant species aspects (species used were classified into groups of plant species: arboreal, shrub, herbaceous and climbing plants); Composition (Homogeneous or Heterogeneous); Pruning (Maintenance or Topiary); Planting aspects (planting alignment, spacing rhythm and dimensions of the hedge). In the study area, 30 blocks were sampled, where the presence of hedgerows was observed in 18 of them. The people responsible for the maintenance and management of hedgerows were mostly non-professional workers. The practice of watering hedgerows was found in 95.24 % of the visited properties. The use fertilizer was found in 28.57 % of the cases and only 4.76 % of the properties use pesticide products due to phytosanitary problems. Most of the hedgerows had a homogeneous composition. Topiary pruning is the most practiced treatment on the hedgerows, with a frequency of 82.28% in the study area. The quincux planting with no definite spacing rhythm was the most found. The most observed Planting Alignment in the study area was in line. The most observed Spacing Rhythm was the one with no rhythm of planting. Although hedgerows are widely used in urban and rural areas, studies on their maintenance, composition, structure, ecological importance and relevance to biodiversity conservation are scarce.

Keywords: Hedgerows, maintenance, pruning, green areas.

1. INTRODUCTION

The conversion of green areas into built areas is one of the major reasons for the destruction of natural habitats in urban cities around the world. According to Yamamoto et al.[1] no environment is more altered than the urban environment, due to the current models of buildings and land use that restrict the spaces that was once green areas. These restrictions limit the access to green areas in a urban environment.

According to Veras [2], the urban green area is characterized as one of the most important elements that compose the urban ecosystem. For the benefits that it produces, should be a permanent concern of any and all urban planning.

Plants influence climate as trees and other vegetables intercept, absorb and transmit solar radiation, improving air temperature in the urban environment. A single tree hardly affects its climate in a significant way, but being in groups or scattered, can be efficient in the microclimatic improvement and comfort sensation [3].

There is a growing recognition of the benefits caused by the access to green areas on the improvement on public well-being [4]. Several researches have provided scientific evidence on the benefits of urban green areas on population health, in their different ages and different uses [5,6,7,8].

Hedgerows such as lines of trees, shrubs or other plants are landscape elements used in many parts of the world. They are considered mainly by their cultural and ecological values. Hedgerows always have a human component that manages them to maintain control and prevent their expansion to adjacent areas. This human action is essential for the formation of hedges. Thus, the suggested definition would be a linear characteristic structure, composed of managed shrubs and / or trees [9].

Hedgerows constitute an important part of our landscape, and can be an ideal frontier for gardens. They have many benefits, such as: reduce noise; provide shelter and natural habitats for animals such as insects, birds and mammals; pest control because they provide habitat for natural predators; provide privacy; security, thorny species provide obstacles for anyone trying to overcome them; they are visually attractive, may present different physiognomy according to the time. They can also act as green corridors for the movement of insect populations and increase the connection between the different parts of the hedges [9,10].

In addition to providing a valuable food source, hedgerows provide an attractive habitat for invertebrates, as they have a suitable microclimate, an environment for landing and mating, and protection against predators, climatic extremes, and harmful agricultural operations [11]. Besides that, hedgerows provide a favorable environment for various birds such for nesting, shelters, feeding, shelter against predators and displacement.

In some European countries, the implantation of hedgerows is widely used as a strategy for the conservation and preservation of wild animals, aiming to make anthropic environments more accessible to animals [9].

Although the description and distribution of these elements have not yet been widely studied, hedgerows have a much wider distribution than can be perceived [12]. According to Montagnini [13], in human cultural development is the use of plants that form hedgerows, which stand out as a characteristic feature of rural landscapes in many tropical American countries, in arid, semi-arid or humid regions.

According to Nair [14], hedgerows are currently distributed in the humid, sub-humid, semi-arid and arid tropical regions of the world. It had been found in Latin America from prehispanic times, from Mexico to Peru. It is described as the most widely distributed agroforestry technology [15].

The study aimed to analyze the maintenance, composition, pruning, planting aspects and architectural elements on urban hedgerows.

2. MATERIAL AND METHODS

2.1 Study area

Located in the eastern portion of the Northeast, at 8° 04' 03"south latitude and 34° 55' 00" west longitude, the RMR (Metropolitan Region of Recife) is located in the coast of Pernambuco. In The City of Recife in in central part of the RMR. The city has an average altitude of 4 meters. Recife has an eminently urban profile, with small rural population and small farming activities. Rich and diversified environments in continuous process of urbanization and economic exploitation.

The climate of the city of Recife, according to the classification of Köppen is rainy tropical, type Ams'. It is characterized by two distinct periods: the first is a dry season, which runs from September to February (spring-summer) and the second is the rainy season from March to August (autumn-winter). It is considered a fairly humid climate, with an annual precipitation above 750mm, average temperature ranging from 25° C to 30° C and relative humidity ranging from 79.2% to 90.7% in the wetter months.

2.2 Sample area

This study was carried out in an area of Imbiribeira, Recife, PE, Brazil, during six months. 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 were registered. The application of the questionnaire was directed to people residing, working, or owning real estate that contained hedgerows.

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 Maintenance

The person with the responsibility of pruning and maintenance of the hedge has been classified as: Owner, individual possessing the property containing hedgerows; Non-professional worker, person who does not reside in the property that has hedgerows, but has some working relationship with the owner of the property, not having technical knowledge; Professional of the area, person with technical knowledge, able to perform the correct maintenance of the hedge; and owner of the property, with some technical knowledge.

The interviewee was questioned about the types of maintenance performed on the hedges (pruning, watering, fertilizer, defensive products or others).

2.5 Composition

The hedgerows were classified according to their function and composition in: Homogeneous, when the hedge was composed of only one plant species, independent of

the group of plant species; and Heterogeneous, when the hedge is composed of more than one plant species, independent of the group of plant species.

2.6 Plant species aspects

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.

2.7 Pruning

The treatment given to the individual members of the hedgerows was classified as: Maintenance, when only dry or diseased branches are eliminated through pruning, remaining the specific form of the species; and Topiary, when, in the presence of pruning, the shape of the canopy is changed for aesthetic purposes, creating hedgerows with carved aspect, modifying the natural form of the plants (generally in square or rectangular format).

2.8 Planting aspects

The planting alignment was characterized as: Line planting, when the planting was carried out in one or more lines with individuals opposing each other; and Quincunx planting, when the planting was carried out in two or more lines with individuals alternating each other.

The spacing rhythm was classified as: spacing with rhythm, when the hedge had a standard spacing throughout its length and; Spacing without rhythm when the hedgerow had no standard spacing along its length. In the classification of the hedgerows with rhythm, the spacing used was noted. In hedgerows without rhythm, the range of spacing used was noted.

2.9 Dimensions

The Height (H), Width (w), Extension (E) and Planting Spacing of the hedgerows were measured with the aid of a measuring tape. With such data, the occupied area or Area of Projection (AP) of the hedgerow was calculated, and also the Area of Maintenance of the hedge (AM), that is, the total area of the hedgerow where pruning is practiced.

The occupied area, or projection area (AP) of the hedge and the maintenance area (AM) were found according to the following equations:

$$AP = W \times E \qquad (1)$$

$$AM = 2 \times (H \times E) + 2 \times (H \times W) + (W \times E) \qquad (2)$$

The calculation of the maintenance area was adjusted according to the need of each hedge, due to the fact that some hedgerows have one or more of their sides facing walls, and no maintenance is performed on these faces.

2.10 Architectural elements on hedgerows

It was observed the absence or presence of architectural elements (walls, gratings, barbed wire, etc.) associated with the hedgerows as complementary materials to the structure of the hedgerows.

From the obtained data, the total number of the analyzed blocks, the total number of hedgerows found in the study area, the average number of hedgerows found per block and the average number of hedgerows per analyzed properties were determined. The data was computed as Frequency (%), which was the percentage that each variable presented in relation to the analyzed variable.

3. RESULTS AND DISCUSSION

3.1 Properties characterization

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

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

3.2 Maintenance

The people responsible for the maintenance and management of hedgerows in the study area in the Imbiribeira neighborhood were mostly non-professional workers. Non-professionals represented 61.54 % of the cases, followed by professionals with 23.08 % and owners of the properties with 15.38 % (Fig. 1). These results show that the majority of hedgerow maintenance is conducted by people who only have empirical training. It is also noted that few owners personally manage their hedgerows.

The lack of knowledge of the professionals that deal with the hedgerows can contribute to several damages to the hedges. According to Castro [16], bad pruning besides damaging the canopy, leaves the tree exposed to the attack of pests and diseases by the physiological stress imposed by this practice. The pruning period of the hedgerows should be evaluated according to the typology of the plant species. The duration and frequency of pruning is a variable that requires studies to quantify it, since it depends, among other factors, on the density of planting, type of pruning and quality of the work. The longer the interval between prunings, the thicker the pruned branches and the more disturbed the hedge will be. However, most plants are able to withstand this kind of damage. There are few plants that get sick or die for this reason. The gradual increase of pruning height and width will reduce the damages caused to the branches by pruning [17].

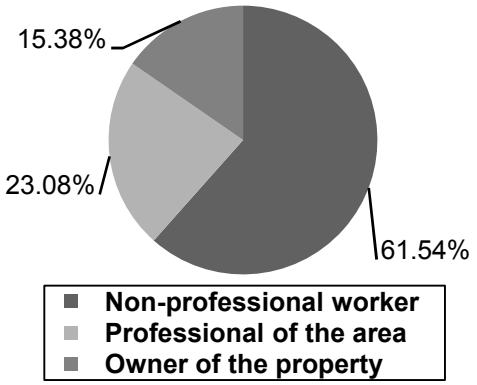

Fig. 1. Responsible for the maintenance and conduction of the hedgerows in the study area in the neighborhood of Imbiribeira, Recife, PE, Brazil

The practice of watering hedgerows was found in 95.24 % of the visited properties. The use fertilizer was found in 28.57 % of the cases and only 4.76 % of the properties use pesticide products due to phytosanitary problems (Fig. 2).

In a study about hedgerows, Britt et al. [18] found that over 40% of farmers have already used herbicides in weed control. More than half were always careful that herbicides did not come into contact with live fences, while 9% never used herbicides. This work also showed that selective herbicides can be valuable in the recovery of highly weed infested hedges. Treatments with herbicides also increase the diversity of bed bug species (Heteroptera) [19]. This can be beneficial from an ecological and agronomic point of view, although it is pointed out that other weeds can be beneficial to insects.

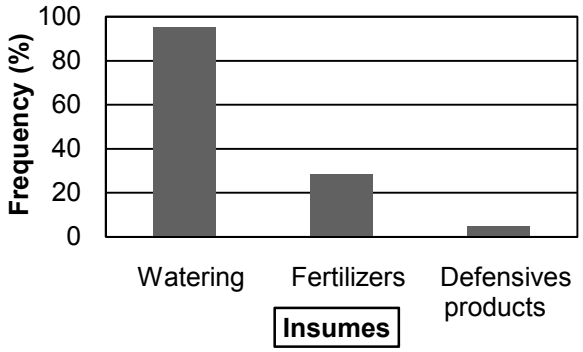

Fig. 2. Watering and Insumes used to maintain hedgerows in the study area in the neighborhood of Imbiribeira, Recife, PE, Brazil

3.3 Composition

Most of the hedgerows had a homogeneous composition, representing a frequency of 85.14% of the study area of the Imbiribeira neighborhood (Fig. 3). Hedgerows with heterogeneous composition presented a frequency of 14.86%.

In a study carried out in rural area of Abreu e Lima/ PE, a predominance of hedgerows with heterogeneous composition was observed [20]. The introduction of more species to increase diversity in the construction of hedgerows can be a tactic to reduce pest impacts.

Hedgerows composed by a larger diversity of species can provide more benefits to the wildlife than the ones composed by only one species [19,21,22]. Although heterogeneous hedgerows have a greater ecological importance in terms of plant species diversity and importance to fauna, the preference for hedgerows with homogeneous composition is higher in urban areas. The homogeneous composition of hedgerows, when subjected to proper maintenance, give the environment a pleasant and elegant visual appearance. This is why their adoption is predominant in urban areas.

In a study about the importance of hedgerows, composed by different plant species, in the density and diversity of spiders, Wu et al. [23], observed that spiders can present preferences for determinate plant species in different seasons, as well as preference for hedgerows instead of another agroforestry systems.

The plants diversity is one of the most important components of the urban ecosystem because it provides several ecological benefits and contributes directly to the quality of life and well-being of the population [24,25]. The diversity of species can contribute to conserve local biodiversity by preserving native tree species in urban environments and providing natural habitats for local animal species [26].

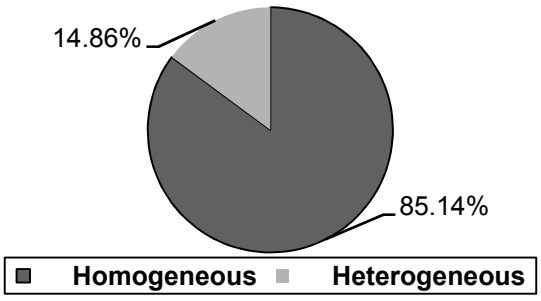

Fig. 3. Composition of hedgerows (homogeneous or heterogeneous) in the neighborhood of Imbiribeira, Recife, PE, Brazil

3.4 Pruning

Topiary pruning is the most practiced treatment on the hedgerows, with a frequency of 82.28% in the study area (Fig. 4). Hedgerows that exhibit uniformity have a more pleasant visual appearance, which is why most of the hedgerows are subjected to frequent topiary pruning aiming for uniform growth of the individuals that compose the hedgerow.

A research about hedgerows in the city of Abreu e Lima, in Pernambuco, reported that only one of the hedgerows evaluated was managed with maintenance pruning [20]. A lower frequency of hedgerows treated with maintenance pruning was found in the study area.

In the maintenance pruning of hedges, it is important to ensure that the lower part of the plant does not remain in the absence of light. This error is very common and its main consequence is the emergence of leafless bases, with flaws and dead or diseased branches. This problem happens mainly when the hedgerow has a square shape, because

the superior part will always grow more than the lower one, because it will receive more light [26]. Although this practice was not studied in this research, there was no hedgerows presenting the pruning suggested by the author.

The management of hedgerows controls its various structural parameters such as width, height, density and vegetation stratification, determining its value for invertebrates [11].

According to Marshall et al. [19] the effects of time and frequency of pruning are determinant for the presence of populations of some arthropods species. Some populations of insects show higher growth in hedgerows that are not pruned, while others are more abundant in pruned hedgerows. This fact can also happen when the period of the year in which pruning is performed is considered. Due to this fact, the authors recommend that not all individuals composing a hedgerow should be pruned at the same time.

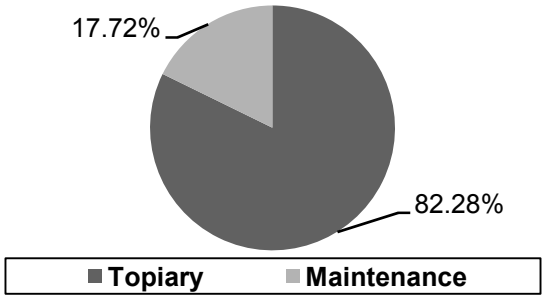

Fig. 4. Treatments given to hedgerows in the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

Hedgerows composed of climbing species receive mostly topiary pruning, with a frequency of 92.31% (Fig. 5). While in hedgerows composed of herbaceous species, only maintenance pruning was noted. This is due to the different aesthetics of the species, making pruning not necessary to modify the structure of the species.

Hedgerows with shrub species were subjected to both topiary and maintenance pruning in the study area with frequencies of 80.95% and 19.05%, respectively.

Hedgerows composed of tree species were submitted, in most cases, to topiary pruning in 100.00% of the cases in the Imbiribeira neighborhood.

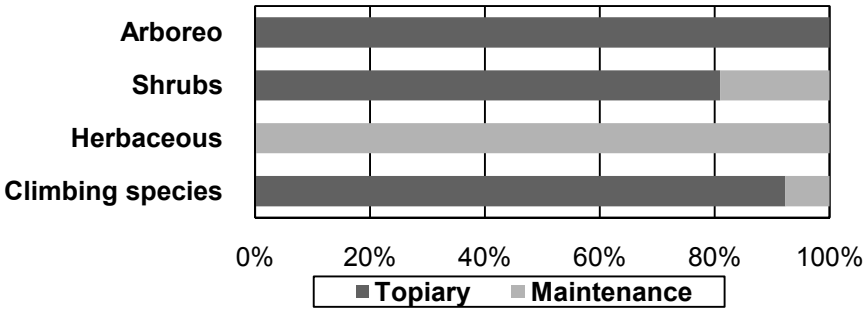

Fig. 5. Treatments given to hedgerows in the different groups of plant species in the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

3.5 Planting aspects

The quincux planting with no definite spacing rhythm was the most found in the study area with a frequency of 94.74% (Fig. 6). The rhythm of spacing most used in line plantings was with rhythm, with a 78.57% frequency.

Double row planting with intercalated pits (quincunx) can form wider hedgerows in a shorter time. Depending on the owner's purpose or preference, the width of the hedgerows may be influenced by the alignment chosen at the moment of implantation of the hedge. Larger hedgerows can be obtained through quincunx plantations and hedgerows of smaller widths can be obtained with plantings in rows. However, this type of planting eventually consumes more space in the garden. The single line can be formed by aligned grooves or holes and occupy less space.

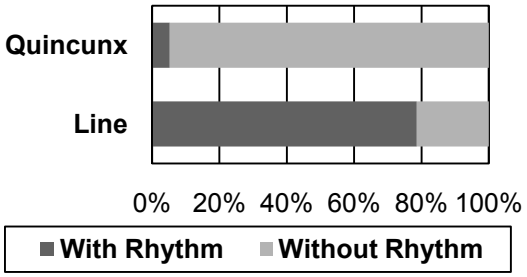

Fig. 6. Relation between Spacing Rhythm and the Planting Alignment used in the hedgerows of the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

The most observed Planting Alignment in the study area was in line, with a 65.58% frequency (Fig. 7). The quincunx alignment was observed in 34.48% of the cases. Even though the quincunx alignment is able to form wider hedgerows, the line alignment is the most common used.

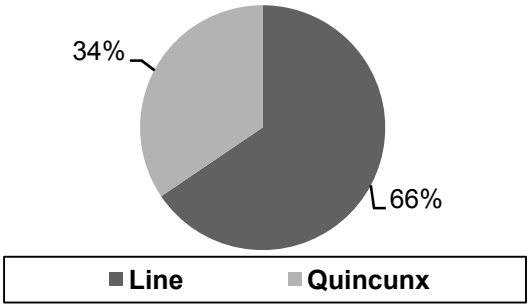

Fig. 7. Planting Alignment used in the hedgerows of the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

The most observed Spacing Rhythm was the one with no rhythm of planting, with a frequency of 54.17% (Fig. 8). This fact could be explained due to the death of individuals or new individuals added to the hedgerow. The spacing with rhythm was observed in 45.83% of the cases.

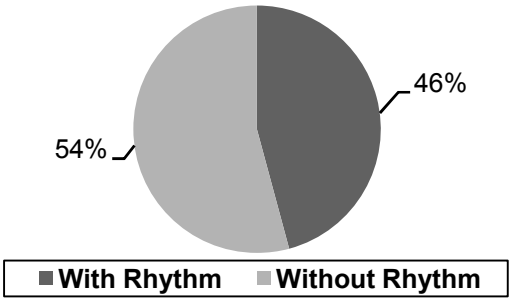

Fig. 8. Spacing Rhythm used in the hedgerows of the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

There is a difficulty in measuring the spacing and pace of spacing due to death of individuals or individuals entering the hedge. Due to the fact that the present research carried out the survey of the hedgerows in just one moment, the data exposed disregarded dead individuals, taking into account only the current arrangement.

The most used range of spacing in hedgerows composed of herbaceous plants in the study area was 0.00m to 0.20m and 0.21m to 0.40m, with a 50% frequency each (Fig. 9).

Hedgerows composed of shrub species had more frequent spacing in the range of 0.21m to 0.40m, presenting a frequency of 58.33%, followed by the range 0.00m to 0.20m, with a 29.17% frequency. This group was also found with other spacing range, but with a lower frequency.

Hedgerows composed of tree species presented the planting spacing only in the range from 0.81m to 1.00m.

In general, the most widely used spacing range in planting hedgerows was 0.21m to 0.4m with a frequency of 56.86% for the study area.

A common practice is to reduce the spacing between the seedlings in order to accelerate the formation of the hedgerow. Thus, the roots and branches will overlap, generating competition for light, water and nutrients and impairing the development and health of the plants. Instead, it is preferable to acquire more developed seedlings, respecting the recommended spacing for each species [27].

The appropriate spacing between the seedlings varies from species to species and should always be respected, otherwise the roots and branches will overlap, generating competition for sunlight, water and nutrients and impairing the development and health of the plants.

The range of spacing of the climbing plants were not possible to measure.

Fig. 9. Range of Spacing used in different groups of species that compose hedgerows in the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

3.6 Dimensions

It was possible to observe a greater height for the climbing species, according to Table 1, due to the fact that the plant has to be adequate in proportion to the height of the support, which are generally high walls. The dimensions of climbing species, in general, fit the dimensions (height, width and extension) of the support.

The average heights of hedgerows formed by herbaceous and shrubs were similar, with 0.95m and 0.98m respectively.

The width of hedgerows showed a tendency to increase according to the natural size of the group of species. The average widths found in hedgerows composed of herbaceous and shrubs species in the study area presented averages of 0.48m for herbaceous and 0.67m for shrubs. The average values of width found for hedgerows composed of trees were 1.50m.

The maintenance areas found presented an average of 45.37m² in climbing plants, 10.63m² in herbaceous plants, 12.13m² in shrubs, and 18.55m² in trees of the study area. These dimensions in conjunction with the extension and the projected area can be used to make a better plan of the hedgerows maintenance and pruning considering time and costs.

Table 1. Dimensions of hedgerows in the different groups of species in the study area in the Imbiribeira neighborhood, Recife, PE, Brazil

Average values	Group of Species			
	Climbing species	Herbaceous	Shrubs	Arboreal
Height (m)	2.60	0.95	0.98	1.85
Width (m)	0.15	0.48	0.67	1.50
Extension (m)	10.32	4.08	4.36	2.50
Area of Projection (m²)	2.34	1.92	2.67	3.75
Area of Maintenance (m²)	45.37	10.63	12.13	18.55

3.7 Architectural elements on hedgerows

Most of the hedgerows did not present complements in their structure or in their proximity (Fig. 10).

The presence of walls was verified in 35.62% of the hedgerows in the study area, representing the highest frequency among the verified elements.

The presence of hedgerows complementing fences of grids presented 16.44% of frequency in the studied hedgerows, and has as function the privacy to one or both sides of the hedge. The presence of low walls was found with the same frequency.

The use of barbed wire was not observed in hedgerows in the study area.

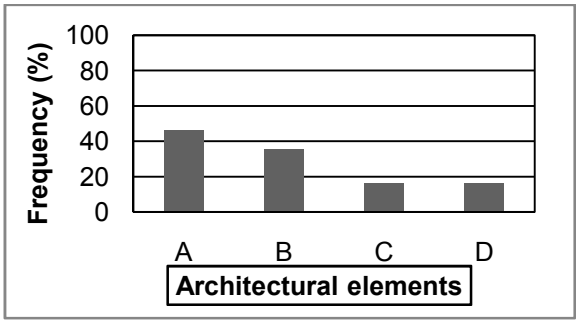

Fig. 10. Architectural elements associated with hedgerows in the study area in the Imbiribeira neighborhood, Recife, PE, Brazil. Where: A – No complements; B – Presence of high walls (above 0.5 m); C – Presence of low walls (under 0.5 m); D – Presence of grids

4. CONCLUSION

Throughout the study area a considerable amount of relatively well conserved hedgerows of varying sizes could be witnessed.

Although heterogeneous hedgerows have a greater ecological importance in terms of plant species diversity, there was a preference for hedgerows of homogeneous composition for providing pleasant and elegant aesthetics.

Hedgerows that have uniformity have a more pleasant visual appearance, which is why most of the hedgerows are subjected to frequent topiary pruning. This promotes uniform growth of the individuals that compose 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.

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