

Investigation and Evaluation of Summer Vegetation in Guangzhou Baiyun International Airport

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Abstract: The bird ecological chain can be broken by the ecological environment management of the airport and its surrounding areas; it is an effective method for bird strike control. Based on a comprehensive survey of plant populations in Baiyun Airport, it can be seen that there are 68 dominant plant species that are more attractive to birds inside and outside Baiyun Airport. The K-means clustering algorithm is used to cluster the 68 plants in MATLAB. The analysis results show that these 68 plants can be divided into three categories according to their comprehensive attraction to birds. The airport authorities can invest different management resources and adopt different management methods for the three types of plants with different risk, so as to minimize the arrival of birds at the airport.

Keywords: Airport Plant Survey; K-means Clustering; Bird Attraction; Bird Strike Control.

1. Introduction

In recent years, airport bird strike not only poses a great threat to China's civil aviation safety, but also brings great losses to civil aviation transportation enterprises [1]. Many plants in the airport and its surrounding areas are the main attraction for birds and small animals [2], it is not only the habitat of many birds and small animals, but also produces fruits, grass seeds, roots and leaves that birds, small animals and even various insects like to eat. Therefore, it brings hidden dangers to the flight safety of the airport and increases the bird driving workload of the airport authorities. By clustering plants with K-means clustering algorithm [3], we can better find out the plants that are attractive to birds, and provide reference and basis for airport ecological environment management.

2. Overview of Baiyun Airport

Guangzhou Baiyun Airport is located in Renhe Town, Huadu District, northeast of Guangzhou, 28km away from the city center. It is located in the subtropical zone and belongs to the subtropical monsoon climate. The climate here is characterized by high temperature, more precipitation, less frost days, more sunshine and low wind speed. The annual average temperature of the airport is 21.9°C, and the annual average rainfall is about 1696.5mm. The rainy season of the airport is mainly from April to September, and it is relatively dry in winter. The airport is located on the edge of the tropics. Its climate is hot and rainy, and summer lasts for half a year. From the characteristics of plant growth, it is a potential zone where tropical and subtropical plants extend each other. Plants with a wide variety and rich resources provide rich food sources and ideal habitats for birds and other animals.

In order to understand the summer flora and fauna of Baiyun Airport, the author's team conducted three airport ecological surveys from April 1 to November 30, 2019. Through recording, collecting specimens, sorting and identification, the types of wild and artificially planted vegetation in summer around the airport are basically clarified, and the relationship between vegetation and birds and the degree of impact on bird strike at the airport are clarified.

3. Plants Survey

3.1. Investigation Method

The systematic sampling design method was adopted in this survey. Firstly, the boundaries of the airport and surrounding areas on the topographic map are marked, then the total area is determined, and finally the number of sample plots is calculated by Formula (1).

$$n' = \frac{t_a^2 C^2}{E^2} \quad (1)$$

In formula (1), t_a represents the reliability index, when the reliability is 95%, $t_{0.05}$ is equal to 1.96; C is the coefficient of variation, generally taken as 120%; E is the relative error limit, if the predetermined accuracy of this survey is 70%, e is equal to 30%.

According to the formula, the number of sample plots n is 61, and if the safety factor is increased by 20%, then n is 73, and 76 sample plots were set up in the actual survey. Calculate the sample plot distance with formula $D = \sqrt{A \times 10000 / n}$, in this formula, A represents the total area of the airport and surrounding areas, and then the sample plot distance D is 890m. Then, the points are arranged on the map. Set tree and shrub sample plots with size of 15×20m² at the determined sample plot position, all species, plant number, plant height, frequency and coverage in the sample plot were investigated. Five shrub and herb quadrats with size 2×2m² are set in the four corners of the sample plot, the species, quantity, average height, distribution and characteristics of shrubs and herbs in the quadrat were investigated by layers. A total of 202 quadrats were set.

3.2. Plant Population Survey Results

The team conducted systematic investigation and Research on plant species, distribution and growth, and collected more than 300 samples. After sorting and identification, it is preliminarily clarified that the summer wild plants in this area are 290 species, 183 genera and 77 families.

Table 1. Dominant plants and attraction to birds' index

Number	Genus of plants	Latin name	Edible universality	Population density (Quantity/m ²)	Average plant height (cm)	Plant community distribution
1	Alternanthera Forssk.	<i>Alternanthera philoxeroides</i> (Mart.) G.	5	55	80	1
2		<i>Alternanthera sessilis</i> (Linn.) DC.1	10	20	30	10
3		<i>Alternanthera dentata</i> 'Rubiginosa'	5	35	15	1
4		<i>Amaranthus tricolor</i> Linn.	5	10	110	5
5	<i>Cynanchum</i> Linn.	<i>Cynanchum auriculatum</i> Royle ex Wight	1	8	45	10
6	<i>Chenopodium</i> L.	<i>Chenopodium album</i> L.	5	12	90	10
7	<i>Acroptilon</i> Cass	<i>Acroptilon repens</i> (Linn.) DC.	10	43	50	1
8	Ixeris Cass.	<i>Ixeris chinensis</i> (Thunb.) Nakai3	5	22	20	10
9		<i>Ixeris japonica</i> (Burm. f.) Nakai	5	6	20	1
10		<i>Ixeris dentata</i> (Thunb.) Nakai	10	13	35	5
11		<i>Ixeris sonchifolia</i> Hance	10	25	50	10
12		<i>Ixeris gracilis</i> Stebb.	10	19	40	1
13		<i>Ixeris polycephala</i> Cass.	5	42	20	10
14	<i>Lactuca</i>	<i>Lactuca indica</i> Linn.	10	8	90	5
15	<i>Mikania</i>	<i>Mikania cordata</i> (Burm. F.) B. L. Robinson	5	21	28	10
16	Sonchus L.	<i>Sonchus brachyotus</i> D.C.	10	12	90	5
17		<i>Sonchus oleraceus</i> Linn.	5	24	85	10
18	<i>Tridax</i>	<i>Tridax procumbens</i> Linn.	10	32	65	5
19	<i>Wedelia</i>	<i>Wedelia chinensis</i> (Osb.) Merr.	5	36	35	1
20	<i>Xanthium</i> L.	<i>Xanthium sibiricum</i> Patrín ex Widder	1	9	55	1
21	<i>Aniseia Choisy</i>	<i>Aniseia biflora</i> (Linn.) Choisy	5	11	40	5
22	Calystegia R. Br.	<i>Calystegia dahurica</i> (Herb.) Choisy	5	7	15	5
23		<i>Calystegia hederacea</i> Wall.	5	13	20	10
24		<i>Calystegia pellita</i> (Ledeb.) G. Don.	10	9	15	10
25	<i>Batatas Choisy</i>	<i>Ipomoea obscura</i> (Linn.) Ker Gawl.	1	5	35	1
26	<i>Jacquemontia Choisy</i>	<i>Jacquemontia paniculata</i> (Burm.f.) Hallier f	10	6	15	5
27	<i>Pharbitis</i>	<i>Pharbitis purpurea</i> (Linn.) Voigt.	10	10	30	5
28	<i>Sedum</i> L.	<i>Sedum morrisonense</i> Hayata	10	47	15	1
29	<i>Brassica</i> L.	<i>Brassica juncea</i> Coss. var. <i>foliosa</i> Bailey	10	3	90	1
30	<i>Coronopus</i> J. G. Zinn nom. cons.	<i>Coronopus didymus</i> (Linn.) J. E. Smith	5	11	20	10
31	<i>Lepidium</i> L.	<i>Lepidium virginicum</i> Linn.	10	32	35	5
32	<i>Rorippa</i> Scop.	<i>Rorippa indica</i> (Linn.) Hiern	5	8	30	1
33	<i>Cuscuta</i> L.	<i>Cuscuta australis</i> R. Br.	5	14	5	5
34	<i>Bergia</i> Linn.	<i>Bergia ammannioides</i> Roxb. ex Roth.	5	17	19	10
35	<i>Acalypha</i> L.	<i>Acalypha australis</i> Linn.	5	21	35	5
36	<i>Euphorbia</i> L.	<i>Euphorbia hirta</i> Linn.	10	12	40	1
37	<i>Parthenocissus</i> Planch.	<i>Parthenocissus tricuspidata</i> (Siebet Zucc.) Planch	5	3	25	5
38	<i>Gonocarpus</i> Thunb.	<i>Myriophyllum verticillatum</i> Linn.	5	53	30	1
39	<i>Elsholtzia</i>	<i>Mosla chinensis</i> Maxim.	10	26	40	10
40	<i>Leonurus</i> L.	<i>Leonurus heterophyllum</i> Sweet.	10	12	80	1
41	Senna Mill.	<i>Cassia occidentalis</i> Linn.	5	2	115	5
42		<i>Cassia obtusifolia</i> Linn.	10	4	150	1
43	<i>Crotalaria</i> Linn.	<i>Crotalaria pallida</i> Ait.	1	18	38	5
44	<i>Desmodium</i> Desv.	<i>Desmodium gangeticum</i> (Linn.) DC.	1	15	80	5
45	<i>Kummerowia</i> Schindl.	<i>Acalypha brachystachya</i> Hornem	10	36	35	10
46	<i>Melilotus</i>	<i>Melilotus officinalis</i> (Linn.) Desr.	10	12	70	5
47	<i>Mimosa</i> Linn.	<i>Mimosa pudica</i> Linn.	5	22	50	5
48	<i>Sesbania</i> Scop.	<i>Sesbania cannabina</i> Pers.	10	3	300	5
49	Rotala Linn.	<i>Rotala rosea</i> Poir.	1	46	24	1
50		<i>Rotala tundifolia</i> (Buch.-Ham.ex Roxb.) Koehne	10	54	20	1
51	<i>Malva</i> Linn.	<i>Malva rotundifolia</i> Linn.	5	8	40	5
52	Oxalis L.	<i>Oxalis corymbosa</i> DC.	5	6	35	10
53		<i>Oxalis acetosella</i> Linn.	5	31	9	5
54	<i>Plantago</i> L.	<i>Plantago depressa</i> Willd.	5	9	10	10
55	Polygonum L.	<i>Polygonum aviculare</i> Linn.	5	7	25	5
56		<i>Polygonum hydropiper</i> Linn.	5	40	55	1
57		<i>Polygonum hydropiper</i> Linn. var. <i>flaccidum</i>	1	42	55	1
58		<i>Polygonum lapathifolium</i> Linn.	5	15	65	5
59		<i>Polygonum amphibium</i>	5	23	50	1
60	<i>Rumex</i> L.	<i>Rumex japonicus</i> Houtt.	5	5	75	5
61	<i>Portulaca</i> L.	<i>Portulaca oleracea</i> Linn.	10	9	13	10
62	<i>Anagallis</i> L.	<i>Anagallis arvensis</i> Linn. f. <i>coerulea</i> (Schreb.) Baumg	1	12	20	5
63	<i>Anemone</i> L.	<i>Anemone hupehensis</i> Lem.	1	25	75	5
64	Hedyotis Linn.	<i>Hedyotis chrysostricha</i> (Palib.) Merr.	5	48	30	5
65		<i>Hedyotis diffusa</i> Willd.	5	10	35	10
66	<i>Linnophila</i> R. Br	<i>Linnophila heterophylla</i> (Roxb.) Benth.	1	32	60	1
67	<i>Lindernia</i>	<i>Lindernia anagallis</i> (Burm. F.) Pennell	5	23	25	5
68	<i>Mazus</i> Lour.	<i>Mazus japonicus</i> (Thunb.) O. Kuntze.	10	7	18	5

At the same time, 156 species of cultivated plants are common in the airport and surrounding areas, of which woody plants account for 86%, shrubs and vines account for 9% and herbs account for 5%. According to the analysis of survey data, there are 242 dominant plant species in the airport and surrounding areas, of which 68 species are closely related to birds. The specific results are shown in Table 1.

4. K-means Clustering Algorithm Theory

K-means algorithm is an unsupervised clustering algorithm, which is relatively simple to implement. Assuming that the data cluster is divided into (D_1, D_2, \dots, D_k) , the goal is to minimize the square error E [4], then E can be obtained according to formula (2):

$$E = \sum_{i=1}^k \sum_{x \in D_i} \|x - \mu_i\|_2^2 \quad (2)$$

In formula (2), μ_i represents the mean vector of cluster D_i , and the calculation process of μ_i is shown in formula (3):

$$\mu_i = \frac{1}{|D_i|} \sum_{x \in D_i} x \quad (3)$$

K-means clustering algorithm randomly selects K from N data as the initial clustering centers, and then calculates the similarity between the remaining objects and the initial clustering centers for clustering division. Calculate the new cluster center again, and calculate the similarity between the remaining data and the new cluster center to achieve the purpose of cluster division [5]. Through repeated iterations, the cluster center of the data is changed to minimize the square error, which separates the clusters as far as possible and makes the cluster itself as compact as possible. The calculation flow of the clustering algorithm is shown in Figure 1.

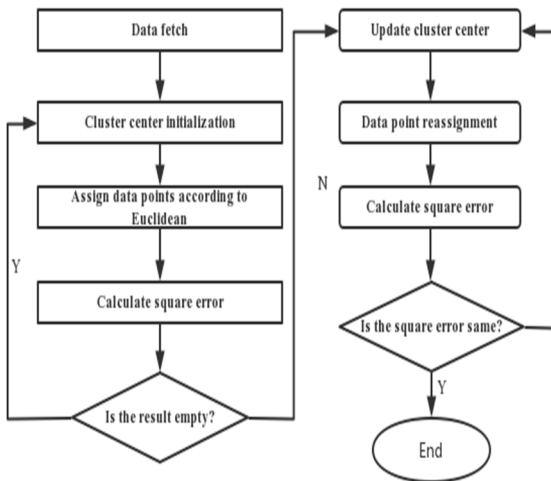


Fig 1. Calculation program of K-means clustering algorithm

It can be seen from Figure 1 that for K-means clustering of data, the clustering center must be initialized, and a k value needs to be given to determine the number of clusters. In the actual application process, it is difficult to determine the k value, which is often selected in combination with experience. The selection of k value has a great impact on the results of K-means cluster analysis. If it is not appropriate, it will lead to the low accuracy of cluster analysis [6]. Based on this, in the process of using K-means clustering algorithm, we should set the appropriate number of clusters to make the number of clusters close to the best as far as possible, so as to improve the clustering accuracy.

5. Cluster Analysis of Plant Attractiveness in Baiyun Airport

5.1. Selection of Attraction Factors of Plants to Birds

In order to objectively reflect the attraction of each airport dominant plant to birds, it is necessary to quantitatively and comprehensively select plants to comprehensively analyze the attraction factors of birds, so as to make the clustering level and results more accurate. Therefore, together with experts from relevant schools and enterprises, we have determined four bird attraction factors: edible universality, number of plant communities per unit area, average height of plants and community distribution.

5.2. Determination of Scoring Criteria

Among the above four bird attraction factors, food universality and community distribution are qualitative indicators, which need to be quantified. Score these two qualitative indicators, a high score indicates that it is more attractive to birds. In order to highlight the difference, score according to three grades: 1, 5 and 10. The scoring criteria are shown in Table 2. Finally, through animal and plant investigation and expert scoring, the data of four bird attraction factors corresponding to each dominant plant population in Baiyun Airport are shown in Table 1.

Table 2. Scoring criteria of bird attraction factor

Attraction factor	Scoring criteria		
	1	5	10
Edible universality	Eaten by some small animals	Eaten by some insects or some birds	Eaten by some small animals, insects and birds
Plant community distribution	Rare	Common in many places inside and outside the airport	Common both inside and outside the airport

5.3. Analysis of Simulation Results

The 68 row and 4 column data matrix are imported into Matlab, and then make the matrix 'x', and then enter the command 'x = zscore (x)' to standardize the data. The 10th, 36th and 62nd sample data are preliminarily selected as the initial clustering points, and then enter the command 'startdata = x ([10, 32, 62],:)' . After executing the above command, enter 'idx=kmeans (X,3,'Start',startdata)' for k-means clustering, so that 68 plants can be divided into 3 groups. Finally, enter the command '[S, H] = silhouette(X,idx)' to get the clustering contour map (as shown in Figure 2). It can be seen that each contour map is positive, which shows that it is very appropriate to divide 68 data into three categories.

In MATLAB, enter the commands 'name(idx==1), name(idx==2)', name(idx==3)' to call the clustering result, you can see that *Alternanthera sessilis* (Linn.) DC., *Ixeris dentata* (Thunb.) Nakai, *Ixeris sonchifolia* Hance, *Ixeris gracilis* Stebb. And other 21 species of plants belong to class 1. *Alternanthera philoxeroides* (Mart.) G., *Alternanthera dentata* 'Rubiginosa', *Acroptilon repens* (Linn.) DC. and other 14 species of plants belong to the second category. And 33 kinds of plants such as *Ixeris chinensis* (Thunb.) Nakai, *Amaranthus tricolor* Linn., *Cynanchum auriculatum* Royle ex Wight belong to the third category. The clustering results

show that the second type of plant population has the greatest attraction to birds, the first type is the second, and the third type is the smallest. In the ecological management, the flight area management department of Baiyun Airport should give priority to the regulation of class 2 plant population, so as to quickly remove the elements attracting birds, so as to greatly reduce the number of incoming birds.

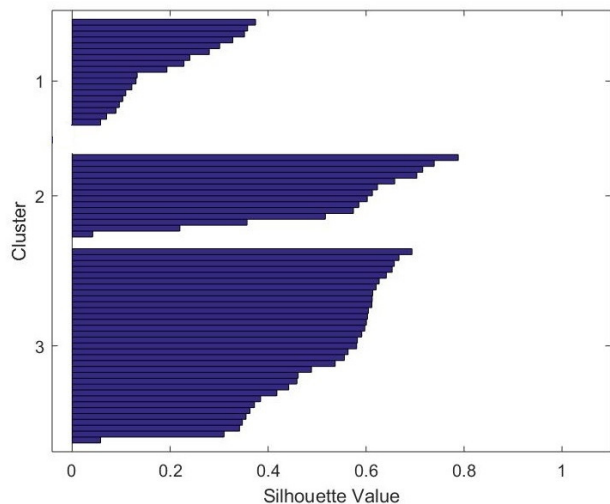


Fig 2. K-means clustering contour of 68 plants in Baiyun Airport

6. Conclusion

K-means clustering algorithm is an analysis method to classify data according to the distance between data points and the center of their class. The simulation results of plant

population in Baiyun Airport show that ideal clustering results can be obtained when the appropriate number of classifications is selected. The clustering results show that targeted management of plant populations with great attraction to birds can quickly reduce the incidence of bird strikes at the airport.

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