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长江口杭州湾鸻形目鸟类群落季节变化和生境选择

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摘要:在长江口南岸杭州湾北岸滨海滩涂进行了鸻形目鸟类的资源调查,以及鸟类栖息地选择模式分析,2004 年 3 月至 2005 年 1 月共统计到鸟类 25 种,春季优势种为大滨鹬(*Calidris tenuirostris*)、尖尾滨鹬(*Calidris alpine*)和红颈滨鹬(*Calidris ruficollis*);夏季为环颈鸻(*Charadrius alexandrinus*)、青脚鹬(*Tringa nebularia*)和蒙古沙鸻(*Charadrius mongolus*),秋季为环颈鸻、红颈滨鹬和青脚鹬,冬季为黑腹滨鹬(*Calidris alpina*)、环颈鸻和泽鹬(*Tringa stagnatilis*),鸟类总体数量呈春季 > 秋季 > 冬季 > 夏季,海堤外(自然滩涂)和堤内(人工湿地)鸟类种数四季大致相等,但鸟类平均密度季节差异显著。通过对样点内鸟类与环境因子进行多元分析,初步总结出堤外滩宽和光滩宽是影响鸟类栖息的最关键因子,海三棱藨草(*Scirpus* × *mariquete*)覆盖比例和潮上坪宽度的影响程度次之。堤内浅水塘比例和裸地比例是影响鸻形目鸟类分布的关键因子,海三棱藨草覆盖比例也起正向作用。而人类干扰大、芦苇(*Phragmites communis*)/ 互花米草(*Spartina alterniflora*)密植和高水位的区域不利于鸟类利用。

关键词:鸻形目鸟类;季节变化;多元分析;生境选择

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Seasonal change and habitat selection of shorebird community at the south Yangtze River Mouth and north Hangzhou Bay

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Abstract: Coastal regions are important habitats for migratory shorebirds. The aim of the study is to understand the habitat use by the migratory shorebird and to develop a conservation strategy in sustainable-use of wetland and the migrants. From March 2004 to January 2005, we conducted seasonal shorebirds censuses in ten coastal habitats along the south Yangtze River mouth and North Hangzhou Bay, examining the relative seasonal abundance of shorebirds and their spatial distribution simultaneously.

A total of 25 species were identified, the seasonal dominant species were Great Knot (*Calidris tenuirostris*), Sharp-tailed Sandpiper (*Calidris alpine*) and Red-necked Stint (*Calidris ruficollis*) in spring; Kentish Plover (*Charadrius alexandrinus*), Common Greenshank (*Tringa nebularia*) and Lesser Sand Plover (*Charadrius mongolus*) in summer; Kentish Plover, Red-necked Stint and Common Greenshank in autumn; Dunlin (*Calidris alpine*), Kentish Plover and Marsh Sandpiper (Tringa stagnatilis) in winter. These species accounted for more than 85% of all shorebirds counted. The numbers of shorebirds counted were highest in spring and then in autumn, winter and summer consequently. Among the four seasons, there were little significant differences of bird species abundance between the sites outside seawall (natural mudflat) and the sites inside seawall (artificial wetland), but the average density of shorebirds had obvious difference.

The habitat-selection analysis of the environmental-factor (outside and inside the seawall) impacting on the shorebird

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community was made in the ten study sites with Canonical Correspondence Analysis. The study results indicated that: (1) Outside the seawall, total intertidal the widths of intertidal mudflat and bare mudflat were the key factors affecting the shorebirds; the proportion of bulrush (*Scirpus* × *riqueter*) covering and supertidal mudflat width had the positive correlation with the bird abundance, the human disturbance and the proportion of reed (*Phragmites communis*)/smooth cord-grass (*Spartina alterniflora*) covering had the negative impacts on the bird contribution; (2) Inside the seawall, mudflat with sallow water and the proportion of mudflat were the key factors to increase the bird abundance; the proportion of bulrush covering should benefit to the shorebird appearance. The habitats with heavy human disturbance, dense reed and smooth cord-grass bed or high water table were not good to be used by shorebirds.

Key words: shorebirds; seasonal change; multi-analysis; habitat selection

鸻形目鸟类繁殖于北半球高纬度,越冬于低纬度及南半球的大洋州地区,多数是长途迁徙物种,长江口南岸杭州湾北岸滩涂处于"东亚-澳大利亚"迁飞路线的中点,是候鸟停歇、补充能量的驿站和良好的越冬地[1-3]。鸻形目鸟类的消长和分布,对指示维持生态系统的稳定性以及监测湿地生态系统的变化均起着重要作用[4]。栖息地的环境异质性是影响鸟类群落的重要因素,水鸟的迁徙性及对湿地的依赖性,决定了它们对栖息地景观的敏感程度[5,6],然而这一点在湿地鸟类群落的研究中容易被忽视。

长江每年携带大量泥沙在长江口杭州湾沉积,滩涂淤涨后湿地资源丰富[7-9],但由于经济发展和土地需要等原因,此区域的滩涂均进行了不同程度的围垦,城市化趋势明显,造成自然滩涂萎缩及破碎化[7],影响了鸟类对栖息地的利用。本研究拟通过湿地水鸟群落及环境因子的调查分析,确定其主要影响因子,可为降低围涂工程对鸟类的负面效应和湿地生态恢复提供科学依据。

1　研究区域

1.1　样地选取

长江口南岸杭州湾北岸位于上海市滨海(30°~32°E, 120°~122°N),年平均气温在16~17℃之间,年平均降雨量为1100mm。属于正规半日潮区,平均潮差2.5~3.4m,最大潮差达7.5m。本研究从250余公里的海岸带上选取10个调查点(图1)。长江口南岸的五好闸、朝阳农场、东海农场、庙港、芦潮港和杭州湾北岸的星海农场、柘林、漕径、金山嘴、金山卫等区域生境差异明显,均为上海市野生动植物资源普查以及水鸟栖息地优劣评价工作的重点区域[10-13]。该区域由于经济发展和土地需要等原因,近年来进行了不同程度的围垦,围垦区内土地利用包括农田、城市化建设、工业建设等,也有部分属于鱼、蟹塘和待开发的荒滩等人工次生湿地,受堤外潮汐环境影响较弱。样点的面积、植被类型、堤外滩宽与堤内人工湿地宽度,以及堤内滩涂的使用状况见表1。

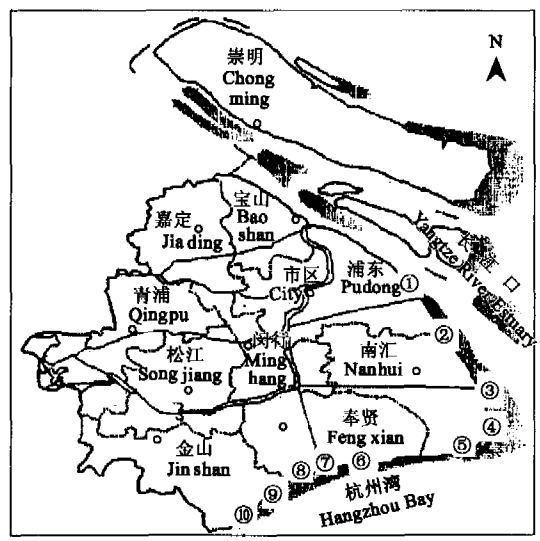

图1　长江口南杭州北部以及所取样点

Fig.1　The study sites of the South Yangtze river mouth & North Hangzhou bay

1. 五好闸 WHZ;2. 朝阳农场 CYF;3. 东海农场 DFF;4. 庙港 MG;5. 芦潮港 LCG;6. 星海农场 XHF;7. 柘林 ZL;8. 漕径 CJ;9. 金山嘴 JSZ;10. 金山卫 JSW;下同 the same below

2　研究方法

2.1　鸟类调查

在各个样点分别在沿海大堤外部的自然滩涂和内部人工次生湿地两部分,堤外和堤内调查面积基本控制在较合理的25hm^{2}左右[14],根据实际情况,有些样点实际面积小于25hm^{2}的,按实际面积调查,按照鸻形目鸟类迁徙方式,以3~5月份为春季,6~8月份为夏季,9~11月份为秋季,12~翌年1月份为冬季。春秋季是鸻

形目鸟类迁徙高峰期[12, 15]，种类数量变化幅度大，所以每月调查1次，而夏冬季鸻形目鸟类丰富度较小且较稳定[15~18]，所以每季调查1次。器械为双筒望远镜(8倍)两台、单筒望远镜(16~52倍)1台、GPS 1台、测距仪1台和鸟类野外鉴定手册等。调查在低潮期开始(根据国家海洋局潮位表)，平均调查约4h，调查时充分考虑堤内、外鸟类可利用滩地的优劣(初步以表1所示滩宽为标准)进行时间分配。统计在样方内堤外和堤内栖息或下落的水鸟数量，高空飞过的鸟类不计算在内，同时对各个样方的环境参数进行记录。采用最大值保留法[4]，即从数次调查的同种鸟类统计数值中保留最大值代表该鸟类的数量。

2.2 生境环境参数

由于围垦堤坝内外环境有很大差异，堤外滩涂受潮汐运动影响，堤内不受潮汐影响，而且土地利用方式不一，生境类型多样，根据现有工作基础[19~21]，对堤内和堤外分别选择潜在环境因子进行测算和评估，所考察的生境参数见(表2)。

表1 样点的调查面积、植被类型和堤内滩涂的使用状况

Table 1 The area, vegetation type and land utilization status of the study sites

样点* Samples	堤外 Outside Seawall			堤内 Inside Seawall			
	面积 Area (hm^2)	滩宽 Width (m)	植被类型 Vegetation type	面积 Area (hm^2)	滩宽 Width (m)	植被类型 Vegetation type	使用情况 Utility status
1. WHZ	15	150	海三棱藨草①	20	50	海三棱藨草，芦苇	滞留**
2. CYF	25	100	海三棱藨草，芦苇	10	400	杂草④	鱼塘
3. DHF	25	30	无②	25	800	海三棱藨草，芦苇，互花米草，碱蓬	滞留
4. MG	25	20	芦苇③	25	500	芦苇，互花米草⑤，碱蓬⑥	滞留
5. LCG	25	20	无	15	200	海三棱藨草，芦苇	滞留
6. XHF	25	50	芦苇	25	0	无	民房
7. ZL	25	600	海三棱藨草，芦苇，互花米草	25	80	杂草	鱼塘
8. CJ	25	20	芦苇	25	0	无	工厂
9. JSZ	25	80	无	25	0	杂草	民房
10. JSW	25	100	海三棱藨草，芦苇	25	0	无	工厂

* 样点说明见图1 Samples' names refers to fig.1; ** 指围垦后还未开发的荒地 The land reclaimed but not been used; ① *Scirpus* × *mariguetir*, ② Bare land, ③ *Phragmites community*, ④ Weed, ⑤ *Spartina* spp., ⑥ *Suaeda glauca*

表2 生境参数

Table 2 Habitat variables

	代号 Symbol	生境参数 Habitat variable	说明 Description
堤外	TW	滩宽 Total mudflat width (m)	低潮时整个滩涂宽度①
Outside Seawall	MW	光滩宽 Bare *mudflat width* (*m*)	低潮时光滩的宽度②
	PB	海三棱藨草覆盖比例 (%) Proportion of bulrush covering	海三棱藨草等低矮植被面积占滩涂比例③
	PRS	芦苇/互花米草覆盖比例 Proportion of reed/smooth cord-grass (%)	芦苇，互花米草，碱蓬等高植被比例④
	SMW	潮上坪宽 Supertidal mudflat width (m)	高潮时水位以上的滩涂宽度⑤
	HN	人数 human number(person)	滩涂上的人员数量，5人为一个单位⑥
堤内	PM	裸地比例 Proportion of bare mudflat (%)	无植被裸地面积占样地的比例⑦
Inside Seawall	PMSW	浅水塘比例 Proportion of mudflat with shallow water (%)	< 5cm 的水塘面积占样地的比例⑧
	PMDW	深水塘比例 Proportion of mudflat with deep water(%)	> 5cm 的水塘面积占样地的比例⑨
	PB	海三棱藨草覆盖比例 Proportion of bulrush covering (%)	海三棱藨草等低矮植被面积占样地比例⑩
	PRS	芦苇/互花米草覆盖比例 Proportion of reed/Smooth cord-grass (%)	芦苇，互花米草，碱蓬等高植被比例⑪
	HN	人数 Human number (person)	样地内的人员数量，5人为一个单位⑫

①The width of total mudflat when low tide, ②The width of bare mudflat when low tide, ③The area of bulrush covering/total mudflat area, ④The area of high vegetation (reed or smooth cord-grass)/total mudflat area, ⑤The width of mudflat over water when high tide, ⑥The human number on the mudflat (5 person as a unit), ⑦The area of bare land/total survey area, ⑧The area of Shallow water (< 5cm)/total survey area, ⑨The area of deep water (> 5cm)/total survey area, ⑩The area of bulrush covering/total survey area, ⑪The area of high vegetation (reed or smooth cord-grass)/total survey area, ⑫The human number in the study area (5 person as a unit)

2.3 生境选择模式分析

运用典范相关分析(Canonical Correspondence Analysis,CCA)对长江口南岸杭州湾北岸的鸻形目鸟类种类和密度与所处生境环境因子进行排序及多元回归分析,得出鸻形目鸟类在区域内的生境选择模式[22-24],以找出影响鸟类栖息的关键环境因子。统计分析工作在 SPSS11.0 和 PCORD4.0 软件包上完成。

3 结果与分析

3.1 鸻形目鸟类群落季节变化

2004 年 3 月至 2005 年 1 月,在长江口南岸杭州湾北岸堤内外近 500ha 的调查区域共观察到鸻形目鸟类 25 种,数量见表 3。其中春季 14 种,夏季 9 种,秋季 17 种,冬季 6 种。环颈鸻(*Charadrius alexanadrinus*)、红颈滨鹬(*Calidris ruficollis*)、尖尾滨鹬(*Calidris acuminate*)、黑腹滨鹬(*Calidris alpina*)、细嘴滨鹬(*Calidris tenuirostris*)、青脚鹬(*Tringa nebularia*)和泽鹬(*Tringa stagnatilis*)等 7 种为优势种,占总体数量的 90.65%,春季优势种为红颈滨鹬、尖尾滨鹬和细嘴滨鹬;夏季为环颈鸻、青脚鹬和蒙古沙鸻(*Charadrius mongolus*);秋季为环颈鸻、红颈滨鹬和青脚鹬;冬季为环颈鸻、黑腹滨鹬和泽鹬,其数量均超过各季节总数的 80%。四季鸟类群落数量比为 8:1:5:3,春秋季为迁徙高峰期,数量最多;夏季为繁殖期,在中转站能观察到的数量最少;冬季有一定量的越冬鸟类。

表 3 鸻形目鸟类数量调查结果(春秋季以平均数 ± 标准差表示)

Table 3 The shorebirds counted in study sites(The data of spring and autumn presented as Mean ± SD)

种类 Species	春季 Spr.	夏季 Sum.	秋季 Aut.	冬季 Win.	年比例 Proportion(%)
环颈鸻 *Charadrius alexanadrinus*	—	60*	377.67 ± 311.50*	134*	22.30%
红颈滨鹬 *Calidris ruficollis*	310.33 ± 125.50*	15	221.33 ± 121.50*	—	21.29
尖尾滨鹬 *Calidris acuminate*	478.33 ± 332.50*	—	—	—	18.64
黑腹滨鹬 *Calidris alpina*	45.67 ± 33.48	—	2.33 ± 4.04	203*	9.75
细嘴滨鹬 *Calidris tenuirostris*	244.67 ± 151.46*	—	—	—	9.55
青脚鹬 *Tringa nebularia*	7.33 ± 7.51	25*	84.0 ± 24.0*	33	5.81
泽鹬 *Tringa stagnatilis*	25.33 ± 14.50	—	4.33 ± 5.13	56*	3.31
黑尾塍鹬 *Limosa limosa*	47.33 ± 16.74	—	12.67 ± 3.51	—	2.34
蒙古沙鸻 *Charadrius mongolus*	3.0 ± 3.0	40*	7.33 ± 2.52	—	1.95
鹤鹬 *Tringa erythropus*	1.0 ± 1.73	—	—	26	1.05
中杓鹬 *Numenius phaeopus*	25.33 ± 14.50	—	—	—	0.97
红腰杓鹬 *Numenius madagascariensis*	3.0 ± 3.0	2	13.33 ± 13.50	—	0.70
金眶鸻 *Charadrius dubius*	—	5	12.0 ± 12.0	—	0.66
弯嘴滨鹬 *Calidris ferruginea*	—	—	8.33 ± 14.33	—	0.31
翘嘴鹬 *Xenus cinerea*	6.33 ± 6.51	—	1.33 ± 1.53	—	0.27
黑翅长脚鹬 *Himantopus himantopus*	—	4	2.0 ± 3.46	—	0.23
红脚鹬 *Tringa totanus*	2.0 ± 1.0	3	—	—	0.19
矶鹬 *Tringa hypoleucos*	—	—	—	4	0.16
灰斑鸻 *Pluvialis squatarola*	—	—	3.0 ± 5.19	—	0.12
灰头麦鸡 *Vanellus cinereus*	—	2	—	—	0.08
剑鸻 *Charadrius hiaticula*	—	—	2.33 ± 0.58	—	0.08
斑尾塍鹬 *Limosa lapponica*	1.67 ± 2.89	—	—	—	0.08
扇尾沙锥 *Gallinago gallinago*	—	—	2.33 ± 4.04	—	0.08
灰鹬 *Tringa incana*	—	—	1.0 ± 1.73	—	0.04
金斑鸻 *Pluvialis dominica*	—	—	0.67 ± 1.15	—	0.04
鸟类总数 *Sum*	1199.33 ± 266.24	156	754.67 ± 91.1	456	

* 各季节的优势种,其数量之和占 80%以上 Black font means that the shorebirds species whose number percent occupied more than 80% of the total were the dominant species in the respective season; — 样点内没有观察到此鸟类 Means the species not been observed in the study sites

3.2 堤内外鸟类比例季节差异

长江口杭州湾的鸻形目鸟类在围垦堤外滩涂和堤内可利用的区域都有分布。由(图 2a)可知,堤内外鸟类物种数量大致相等,差异不明显($F = 0.38$, $p = 0.58$)。但各季节鸟类平均密度差异显著($F = 6.80$, $p = 0.04$) (图 2b),春夏季大部分鸻形目鸟类分布在堤内,而秋冬季节堤内鸟类减少,堤外数量大幅增加。

3.3 生境选择模式分析

由于春秋季是鸻形目鸟类的迁徙高峰期,数量种类较丰富,因此以堤外生境参数结合春秋季生境中的鸟类群落特征参数排序整合成 CCA 散点图(图 3),箭头线段表示鸻形目鸟类群落矢量化特征,生境参数分布点对线段的投影距离和方向代表了环境变量和鸟类群落的相对关系。由(图 3a,因子信息量 Axis 1 = 39.4%, Axis 2 = 33.7%)可知,堤外滩宽(TW)和光滩宽(MW)在矢量线段上的投影距离相对较短,而且落在正方向,说明对丰富鸟类种类和密度的增加起关键作用。海三棱藨草覆盖比例(PB)对鸟类密度影响较大,潮上坪宽度(SMW)对鸟类种类数的增加有一定作用。滩上人数(HN)的投影点落在矢量线段的负方向。芦苇(*Phragmites communis*)/ 互花米草(*Spartina alterniflora*)覆盖比例(PRS)对鸻形目鸟类群落作用不大。

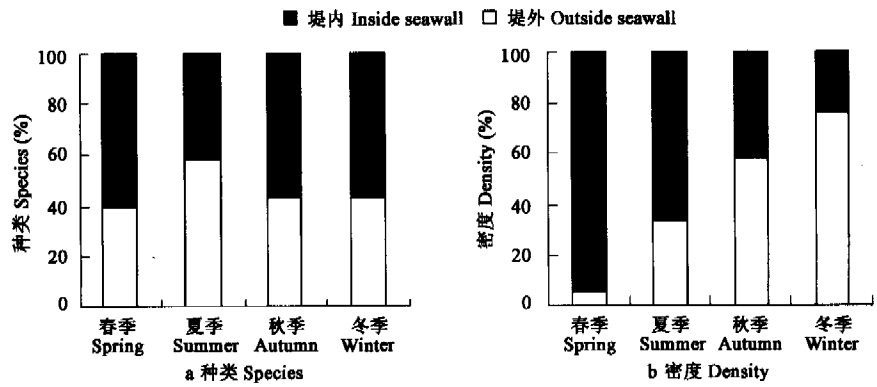

图 2 堤内外鸻形目鸟类比例季节差异

Fig.2 The difference of shorebirds percent outside and inside seawall

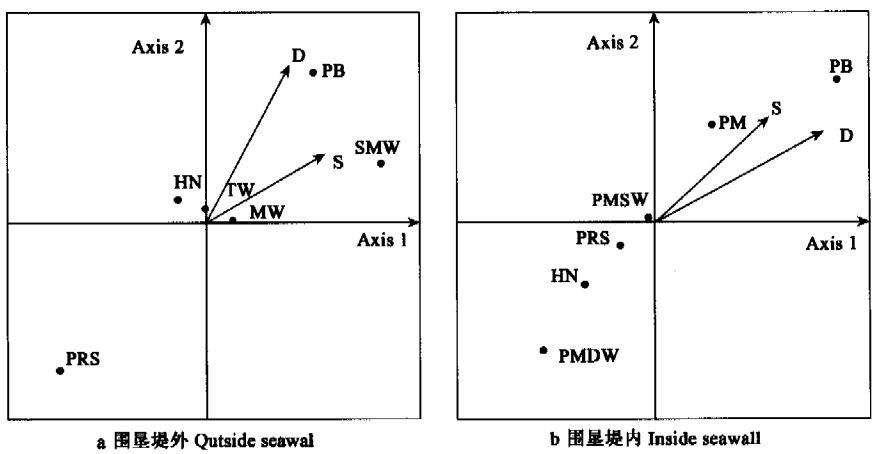

图 3 调查点鸻形目鸟类生境选择模式

Fig.3 The habitat selection model of the shorebirds in the study sites

S 种类 Species; D 密度 Density; 生境参数参见表 2 Habitat variables refer to table 2

部分围垦堤内样点类型为民居或工厂(表 1),四季皆没有观察到鸻形目鸟类,分析时为避免干扰总体模型而归为无效样点,以分析有效样点内鸟类群落的生境选择为主。由(图 3b,因子信息量 Axis 1 = 59.3%, Axis 2 = 16.8%)可知,堤内浅水塘比例(PMSW)和裸地比例(PM)在矢量线段上的投影距离较短,而且落在正方向,

对丰富鸟类种类和密度的增加起关键性作用。海三棱藨草覆盖比例(PB)也对鸟类群落有利,影响稍弱,对鸟类密度影响较大。芦苇/互花米草覆盖比例(PRS)、滩上人数(HN)和深水塘比例(PMDW)投影点落在矢量线段的负方向,不利于鸟类栖息。

4 讨论

4.1 鸻形目鸟类群落季节变化

长江口杭州湾是鸻形目鸟类在迁徙路线上的中转站,由本次调查的结果可知,春秋季为主要迁徙期,鸟类数量比例较大,细嘴滨鹬、尖尾滨鹬及红颈滨鹬等为优势种,这与澳大利亚统计到的迁飞鸟类群落数量比例相近[25-28]。由于春季北迁高峰期在5月底结束,因此,夏季鸟类组成较为简单,大多为短途间歇迁徙型群落和零散个体,数量最少。鸻形目鸟类夏季在北半球繁殖结束后,秋季向南半球的越冬地迁飞,故可以在长江口杭州湾观察到。但有研究表明,与春季不同,部分长距离迁徙鸟类可以越过本研究区域直接到达目的地[29-31],这可能是造成调查中鸟类群落组成变化以及数量上减少的原因。相关研究结果表明冬季有一定数量的鸻形目鸟类在长江口杭州湾滩涂越冬[15,16],本次调查中也得出相同的结论,鸟类数量较夏季多,但种类丰富度不高,可能是由于鸟类本身受冬季环境气候条件限制,种类数较少。

4.2 堤内外鸻形目鸟类分布与生境选择

由相关滨海滩涂调查可知,湿地的变化主要是由围垦造成的,过大的围垦强度使沿海滩涂大幅度萎缩,堤外自然滩涂不断变窄,使得高潮期潮水将淹没滩涂和潮上坪[7,13],而行为形态学研究发现由于鸻形目鸟类形态特征和生活习性决定了其不能在过深的水域取食和栖息[32,33],所以在高潮期将被迫迁至附近堤内次生湿地,如鱼塘、农田和部分滞留未使用滩地,有些鸟类迁至较近的可利用滩涂[34,35],此次调查中也可以发现部分样点堤外滩涂虽然较窄,但如具备堤内有效滩地生境,则仍可支持一定种类数量的鸻形目鸟类觅食和栖息。

围垦堤外滩涂生境的滩地性质、植被群落和潮水等环境参数变化较有规律,是鸻形目鸟类典型的利用生境[12],由(图3a)可知,在低潮期鸟类偏向选择滩宽和光滩较宽,低矮植被如海三棱藨草等植被较丰富的滩涂活动。而高植被如芦苇、互花米草等植被区域,鸻形目鸟类一般不利用。潮上坪宽度在早期的研究中对鸟类群落起决定性作用[12],但由于地貌的改变,由表1可知,调查中没有堤内外均为有效滩地(即较宽滩涂)的样点,部分样点由于深水围垦几乎没有潮上坪,故鸟类一般在堤内有效生境活动,这与相关研究结果一致[34,35],所以此因子在堤外生境选择模型中没有决定性作用。

在围垦堤内次生湿地区域,人类活动较多样化,滩地性质、植被群落格局和水文性质受人为控制,规律性低,即时生境选择模型可以总结出(图3b),堤内浅水滩塘和裸地比例对鸻形目鸟类群落起决定性作用,一些样地具有大面积的薄水层(2~5cm的水膜)和一定面积的裸地,比如在春季东海农场堤内的滞留滩地和冬季的朝阳农场鱼塘,鸟类比例可以达到10只/hm^2以上的程度。但调查中发现,秋季东海农场堤内水床干涸,底栖动物匮乏,栖息于此的鸟类也开始减少。春季因渔业需要,朝阳农场和柘林等地鱼塘内水位被人为放高,由于鸻形目鸟类不能在过深的水域取食和栖息[32,33],导致鸟类数量大大减少,甚至没有观察到。低矮植被可以起到隐蔽作用,所以也有利于鸟类利用。但堤内人类活动干扰性较堤外大,为经济目朝阳农场内密植了大面积的芦苇,因此涉禽的有效栖息地面积有所下降,并受惊扰的现象时有发生。

长江口杭州湾区域社会经济特点决定了强度较大的人类活动,对沿海滩涂的围垦开发利用、旅游、捕获海产品和猎杀鸟类等因素都可能干扰鸻形目鸟类的取食和栖息[36,37],影响了鸟类对栖息地的利用,所以寻得一个自然与经济和谐可持续发展的平衡点是重中之重。

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