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环青海湖地区草地生境的蝗虫潜在发生可能性评价

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摘要：环青海湖地区是青海省草地蝗虫最集中的区域，主要有 10 种，它们对草地造成了很大危害。草地蝗虫的发生与由植被、地形、土壤等组成的生境类型存在密切的关系。论述了草地蝗虫生境类型划分的原则，并提出了生境分类方案。在此基础上，提出了各类生境针对草地蝗虫潜在发生可能性的评价原理、方法和评价指标体系，并据其对野外实地调查样点进行了评价。结果表明，草地蝗虫潜在发生可能性指数与草地蝗虫密度之间的相关系数高达 0.90。研究区受草地蝗虫严重危害或较严重危害的生境类型是芨芨草草原、克氏针茅草原及紫花针茅草原，高寒草甸属一般危害，高寒灌丛草甸则不发生危害。

关键词：草地蝗虫；生境；评价；青海湖

Assessment of Grassland Habitats on Potential Occurrence of Grasshoppers in the Region Around Qinghai Lake

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Abstract: Grasshopper (Orthoptern: acrididae) belongs to the pest insects seriously harmful to China's grassland. In China grasshoppers appear mainly in the livestock farming regions of the provinces of Xinjiang, Inner-Mongolia and Qinghai. In Qinghai Province, for example, there are more than a half million hectares of grassland suffering from grasshopper infestation. These grasslands are mostly distributed in the region around Qinghai Lake.

The region around Qinghai Lake, With total area of 16 730 square kilometers, is located on the northwestern Qinghai-Tibet Plateau. Its elevation ranges from 3 193 meters above sea level at the water surface of Qinghai Lake to more than 4 000 meters above sea level in the mountains surrounding the lake. The local climate is characteristic of drought, frigidness and strong wind, especially in winter and early spring seasons. High-warmer steppe, high-cold steppe, high-cold meadow, and high-cold meadow with shrubs are dominated vegetation types and they are distributed in order from lower area to upper area of the region. In this region ten grasshopper species appear most frequently and have most serious impact to the grasslands. These species are *Myrmeleotettix palpalis* Zub., *Chorthippus dubius* Zub., *Chothippus fallax* Zub., *Angaracris barabensis* Pall., *Angaracris rhodopa* F. W., *Gomphocerus licenti* Chang, *Dasyhippus barbipes* F. W., *Calliptamus abbreviatus* Ikom, *Bryodema luctuosum luctuosum* Stoll, and *Bryodemella tuberculatum dilutum* Stoll. Among them, three species, i. e. *Myrmeleotettix palpalis* Zub., *Chorthippus dubius* Zub. and *Chothippus fallax* Zub., consist of 90 percentages or more of the total grasshopper number in the region.

The study shown that in the region around Qinghai Lake a close relation exists between grasshoppers

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and their habitats. All these habitats are formed through the interaction between climate, vegetation, topography and soil. Therefore, the grasshopper habitat types in the region were firstly recognized and classified using the data collected in field in 1997, 1998 and 1999, and the Landsat TM image data in the same period. As a result, seven grasshopper habitat types were recognized, classified and mapped. They are *Acinatherum splendens* dominated steppe, *Stipa krylovii* dominated steppe, *Stipa purpurea* dominated steppe, marsh meadow, high-cold meadow, high-cold meadow with shrubs, and abandoned farmland. All these types of habitat have their own unique features in terms of vegetation component, grasshopper population and dominant species.

At the second stage of this study, the assessment on the classified types of grasshopper habitat was conducted against the potential occurrence of grasshoppers. Firstly, an index system used for the assessment was established. This system is consisted of a number of factors, namely, those of vegetation such as dominant species, total coverage and NDVI (vegetation index calculated using TM image data), those of topography such as elevation and slope aspect, and those of soil such as soil type, soil texture of surface layer and moisture content in surface layer. Following this step, each of the factors was divided into four classes which correspond to the levels of damage to grasslands by grasshoppers, i. e. severe damage, rather severe damage, moderate damage and no damage, respectively.

Secondly, the indices of potential occurrence of grasshoppers in the study area were developed. In the mean time, these indices were added to each of four grades of potential occurrence of grasshoppers. Thus, grade Ⅰ, Ⅱ, Ⅲ and Ⅳ have their grade values of >70, 70～50, 50～30 and <30, respectively.

Finally, based on these indices and grade values and using the grasshopper density data collected in the field in 1997 and 1999 the grasshopper habitats at twelve sampling sites in the study area were assessed against potential occurrence of grasshoppers. The result shown that, of these sampling sites eight sites indicate a strong correlation between the index of potential occurrence of grasshoppers and the grasshopper density observed in field. The correlation coefficient is as high as 0.90. However, the performance of the remaining sites is not so good as the above-mentioned sites. Among them there are three sites where grasshopper density is lower than the density observed in field, which may result from the grasshopper concrol conducted in the previous year at these sites. On the contrary, one site has its grasshopper density higher than the density observed in field. Its reason remains to study in future.

The study shown that, in the region around Qinghai Lake, the grasslands suffering severely or rather severely from grasshoppers are *Achnatherum splendens* dominated steppe, *Stipa krylovi* dominated steppe and *Stipa purpurea* dominated steppe. The high-cold meadow is on moderate level in terms of the damage, and nearly no damage exists in high-cold meadow with shrubs.

Key words: grasshopper; habitat; assessment; Qinghai Lake

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草地蝗虫是我国草地的主要害虫，主要分布在新疆、内蒙古、青海、甘肃、四川等牧区[1]。在青海省，受蝗虫危害的草地面积超过 $53.3\times10^4hm^2$，环青海湖地区是该省草地蝗虫最集中的区域。草地蝗虫的发生与草地生境类型及其组成因素如气候、植被、土壤、地形等直接有关。前人对我国内蒙古[2~5]、甘肃[6]等省区的草地蝗虫的分布、扩散等与草地植被的关系已有很多研究，但环青海湖地区在这方面尚属空白。本文根据1997～1999 年间在环青海湖地区的实地调查资料，就本区草地生境的蝗虫潜在发生可能性做一初步评价，以便为本区草地蝗虫的防治提供科学依据。

1 研究区概况

环青海湖地区地处青藏高原东北隅(99°36′～100°47′E 和 36°32′～37°15′N)，总面积约 16730km²。地形上为一湖泊盆地，青海湖湖面海拔为 3193m，北、东、南侧山地海拔在 4200m 以上。高原大陆性气候以干旱、

寒冷、多风为主要特征。山地温性草原、高寒草原、高寒草甸及高寒灌丛草甸为本区主要植被类型,它们自低至高依次分布[7,8]。

据不完全统计,本区的草地蝗虫主要有10种,即宽须蚁蝗(*Myrmeleotettix palpalis*(Zub))、狭翅雏蝗(*Chorthippus dubius*(Zub.))、小翅雏蝗(*C. fallax*(Zub.))、鼓翅皱膝蝗(*Angaracris barabensis*(Pall.))、红翅皱膝蝗(*A. rhodopa*(F. W.))、李槌角蝗(*Gomphocerus licenti*(Chang))、毛足棒角蝗(*Dasyhippus barbipes*(F. W.))、短星翅蝗(*Calliptamus abbreviatus* (Ikonn.))、白边痂蝗(*Bryodema luctuosum luctuosum*(Stoll))及轮纹异痂蝗(*Bryodemella tuberculatum dilutum* (Stoll))。其中,宽须蚁蝗、狭翅雏蝗和小翅雏蝗最为常见,它们的数量占研究区蝗虫总数的90%以上。这些蝗虫在当地俗称"土蝗",因为几乎无迁飞能力[9]。

2 草地蝗虫生境分类的原则与分类方案

2.1 生境分类的原则 草地蝗虫生境(或称栖境),是指草地蝗虫个体、种群或群落能在其中完成生命过程的空间[10]。草地蝗虫生境类型,是根据一定原则和指标对草地蝗虫生境的类群归并。(1)综合分析与主异因素相结合的原则 草地蝗虫生境类型的划分需要考虑多方面的要素,因此生境分类时应通过对各类因素的综合分析,从中提取出主导因素,即影响蝗虫发生的主导因子,据此对生境作出划分和归类。(2)适度划分原则 针对草地蝗虫的生态特性,对某些不常见发生蝗虫的生境类型采取粗分办法,即划分为面积较大的生境类型;对那些常发生蝗虫灾害的生境类型采用细分的方法,以尽量反映出生境类型之间的差异。

2.2 生境分类方案 根据以上原则,建立了研究区草地蝗虫生境分类方案(表1)。

表1 环青海湖地区草地蝗虫生境分类方案

Table 1 The habitat classification scheme in the region around Qinghai Lake

生境类型* Habitat type	生境特点 Habitat characteristics	蝗虫群落组成** Grasshopper community composition	蝗虫优势种** Predominant species
克氏针茅草原 SK Steppe	优势种为克氏针茅。伴生种为早熟禾、 草、紫花针茅、赖草、乳白香青、冷蒿、异叶青兰、马先蒿、芨芨草、紫苑、茵陈蒿、紫花苜蓿等。分布海拔高度为3200～3400m,总盖度约75%～90%,零星分布着斑块状裸地	CD,MP,CF,BLL,AB 等	CD,MP
芨芨草草原 AS steppe	优势种为芨芨草。伴生种为克氏针茅、紫苑、萎陵菜、扁穗冰草、兰花葱、早熟禾、黄芪、异叶青兰、赖草、茵陈蒿、细叶苔草、狼毒、披针叶黄华等。优势种芨芨草成朵状丛生分布,其中分布有许多斑块状裸地。分布海拔高度3200～3400m	CD,MP,CF,BLL,AB 等	CD,MP
紫花针茅草原 SP steppe	优势种为紫花针茅。伴生种为狼毒、萎陵菜、火绒草、小嵩草、矮嵩草、 草、早熟禾、黄芪、阿尔泰紫苑等	CD,MP,BLL,AR 等	CD
沼泽化草甸 Marsh meadow	优势种为华扁穗草。伴生种为萎陵菜、碱茅、麦冰草、蒲公英等。	—	—
高寒草甸 High-cold meadow	优势种为矮嵩草和线叶蒿草。伴生种为紫花针茅、珠芽蓼、黄华棘豆、泥湖菜、秦艽、石竹、萎陵菜、蒲公英、园穗蓼、早熟禾、黄芪等	CF,CD,MP 等	CF,CD
高寒灌丛草甸 High-cold shrub meadow	优势种为高山柳、嵩草、金露梅、珠芽蓼、高山锦鸡儿。伴生种为披碱草、萎陵菜、双叉细柄茅、柴胡、党参、 草、乳白香青、独活等	CF,CD,MP 等	CF,CD
撂荒地 Abandoned farmland	优势种为披碱草、萎陵菜、冷蒿。伴生种为蒲公英、紫苑、兰花葱、异叶青兰、柴胡等	CD,MP,AB,BLL 等	CD,MP

* AS steppe(Steppe dominated by *Achnatherum splendens*);SK steppe(Steppe domi. by *Stipa krylovii*);SP steppe(Steppe domi. by *Stipa pupurea*) ** AB(*Angaracris barabensis* Pall.);AR(*Angaracris rhodopa* F. W.);BLL(*Bryodema luctuosum luctuosum* Stoll);CD(*Chorthippus dubius* Zub.);CF(*Chorthippus fallax* Zub.);MP(*Myrmeleotettix palpalis* Zub.)

3 草地蝗虫生境评价因子选择的原则

(1)**主导因素原则** 所选生境评价因子与草地蝗虫的发生密切相关,如牧草的优势种与总盖度,海拔高度、坡度、坡向及土壤的类型、质地和含水量等。

(2)**相对独立性原则** 所选生境评价因子之间具有相对独立性,即相关性小,以免对生境因子评价重复考虑。

(3)**稳定性原则** 所选生境评价因子能反映各生境类型蝗虫潜在发生可能性的本底状况,故这类因子

应具有相对稳定性，即一般不随时间而变。

4 草地蝗虫生境评价的原理与方法

4.1 生境评价的原理 依据与草地蝗虫产卵、孵化、成虫活动等密切有关的生境因子，就草地蝗虫潜在发生的可能性和程度对各类生境作出等级评定，即通过分析草地蝗虫各生境因子对草地蝗虫的可能影响，评定其潜在发生的可能性等级。评价的前提，是必须对草地蝗害的发生机理进行深入研究，即深入分析各种生境因子与蝗虫发生之间的关系。

4.2 生境评价的方法 由于草地蝗虫生境受时间、空间因子的制约，而且这些制约因子的作用还难以用精确的数字表达。草地蝗虫生境对蝗虫发生的可能性只能以“严重”或“较严重”之类的量纲表示，它们之间无截然界限，即具有模糊性。因此，尝试利用模糊综合评判方法[11]，进行研究区草地蝗虫生境的评价。

5 草地蝗虫生境评价指标体系

研究区草地蝗虫生境的蝗虫潜在发生可能性评价因子指标体系见表 2。

表 2 环青海湖地区草地蝗虫生境评价因子指标体系

Table 2 The index system for habitat assessment in the region around Qinghai Lake

生境因子 Habitat element		严重危害 Serious damage (Ⅰ)	较严重危害 Rather serious damage(Ⅱ)	一般危害 Normal damage (Ⅲ)	不发生危害 No damage (Ⅳ)
植被 Vegetation	植被指数(F_1)* NDVI	0.24～0.38	0.18～0.24 0.38～0.45	0.12～0.18 或 0.45～0.50	<0.12 或>0.50
	优势种(F_2) Predominant species	克氏针茅或芨芨草 *Stipa krylovii* or *Achnatherum splendens*	紫花针茅 *Stipa purpurea*	紫花针茅与嵩草 *Stipa purpurea* & *Kobresia* sp.	嵩草或藏嵩草 *Kobresia* sp. or *K. tibetica*
	总盖度(F_3) Total coverage	<60%	60%～75%	75%～85%	>85%
地形 Topography	海拔高度(F_4) Elevation	3200～3300m	3300～3400m	3400～3500m	>3500m
	坡向(F_5) Aspect	南 S	东南或西南 SE or SW	东北或西北 NE or NW	北 N
土壤 Soil	土壤类型(F_6) Type	淡栗钙土 Light chestnut soil	栗钙土 Chestnut soil	暗栗钙土 Dark chestnut soil	沼泽土或高寒草甸土 Marsh soil or high-cold meadow soil
	表土质地(F_7) Texture of surface layer	壤土 Loam	沙质壤土 Sandy loam	粘壤土 Clay loam	沙土 Sandy soil
	表土含水量(F_8) Moisture of surface layer	15%～25%	<15%	25%～35%	<15%或>35%

* NDVI(F_1)：由 Landsat TM 数据计算获得

6 评价结果及其分析

6.1 评价结果 首先，确定研究区草地蝗虫潜在发生可能性指数 F（表 3）。然后，拟定研究区草地蝗虫生境评价标准和蝗虫潜在发生可能性指数对照表（表 4）。利用表 4 所列评价标准和蝗虫潜在发生可能性指数的对应关系，对研究区各类生境作出评价。表 5 是对 1997、1999 年部分样点的评价结果。

表 3 环青海湖地区草地蝗虫潜在发生可能性指数表

Table 3 The probable occurrence indices of grasshoppers in the region around Qinghai Lake

草地蝗虫潜在发生可能性等级 Grade of grasshopper probable occurrence	生境评价因子 Factors used for habitat assessment F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	分级标准 Grade value (F)
Ⅰ	16	12	16	8	8	8	5.6	6.4	>70
Ⅱ	12	9	12	6	6	6	4.2	4.8	50～70
Ⅲ	8	6	8	4	4	4	2.8	3.2	30～50
Ⅳ	4	3	4	2	2	2	1.4	1.6	<30

6.2 评价结果分析 由表 5 可见，在参与统计的 12 个样点中，有 8 个样点的草地蝗虫潜在发生可能性指数值与在野外实测的草地蝗虫密度（每个样地上捕获到的多种蝗虫的平均密度）之间有很好的相关性，这说明本研究提出的评价方法是基本可行的。然而，第 4、31 和 34 号样点实测蝗虫密度比应有的密

表 4　环青海湖地区草地蝗虫生境评价标准与蝗虫潜在发生可能性指数对照表

Table 4　The comparison table between habitat assessment standard and grasshopper probable occurrence indices in the region around Qinghai Lake

生境因子 Habitat element		严重危害 Severe damage (Ⅰ)	较严重危害 Rather severe damage (Ⅱ)	一般危害 Moderate damage (Ⅲ)	不发生危害 No damage (Ⅳ)
植被 Vegetation	F1	0.24～0.38 16.0	0.18～0.24, 0.38～0.45 12.0	0.12～0.18, 0.45～0.50 8.0	＜0.12,＞0.50 4.0
	F2	克氏针茅或芨芨草 *Stipa krylovii* or *Achnatherum splendens* 12	紫花针茅 *Stipa purpurea* 9	紫花针茅和嵩草 *Stipa purpurea* & *Kobresia* sp. 6	嵩草或藏嵩草 *Kobresia* sp. or *K. tibetica* 3
地形 Topography	F3	＜60% 16	60%～75% 12	75%～85% 8	＞85% 4
	F4	3200～3300m 8	3300～3400 6	3400～3500m 4	＞3500m 2
	F5	南 S 8	东南或西南 SE or SW 6	东北或西北 NE or NW 4	北 N 2
土壤 Soil	F6	淡栗钙土 Light chestnut soil 8	栗钙土 Chestnut soil 6	暗栗钙土 Dark chestnut soil 4	沼泽土或高寒草甸土 Marsh soil or high-cold meadow soil 2
	F7	壤土 Loam 5.6	沙质壤土 Sandy loam 4.2	粘壤土 Clay loam 2.8	沙土 Sandy soil 1.4
	F8	15%～25% 6.4	＜15% 4.8	25%～35% 3.2	＜15%或(or)＞35% 1.6

表 5　环青海湖地区草地蝗虫生境潜在发生可能性评价结果表

Table 5　The result of the assessment of habitats on grasshopper probable occurrence in the region around Qinghai Lake

样点编号 Site No.	生境类型* Habitat type	生境评价因子 Factors used for habitat assessment								$\sum_{i=1}^{8} F_i$	实测蝗虫密度 Grasshopper density (grasshoppers/m^2)	等级 Grade
		F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8			
1	克氏针茅草原①	16	12	12	8	8	8	5.6	6.4	76.0	50	Ⅰ
2	克氏针茅草原②	16	12	8	8	6	8	5.6	4.8	68.4	23	Ⅱ
3	高寒灌丛草甸③	4	3	4	4	2	2	2.8	1.6	23.3	6	Ⅳ
4	克氏针茅草原④	12	12	4	8	4	8	5.6	4.8	58.4	13	Ⅱ
5	紫花针茅草原⑤	12	9	12	6	8	6	5.6	3.2	61.8	35	Ⅱ
6	芨芨草草原⑥	16	12	8	8	6	8	5.6	6.4	70.0	16	Ⅰ
11	高寒草甸⑦	4	6	12	2	6	2	2.8	1.6	36.4	4	Ⅲ
13	克氏针茅草原⑧	16	12	12	8	8	8	5.6	6.4	76.0	50	Ⅰ
30	紫花针茅草原⑨	12	9	12	6	8	6	5.6	3.2	61.8	30	Ⅱ
31	芨芨草草原⑩	16	12	16	8	8	8	5.6	6.4	80.0	52	Ⅰ
32	紫花针茅草原⑪	12	9	16	6	8	6	5.6	4.8	67.4	55	Ⅱ
34	芨芨草草原⑫	16	12	12	8	6	8	5.6	4.8	72.4	30	Ⅰ

①SK steppe;②SK steppe;③High-coil shrub meadow;④SK steppe;⑤SP steppe;⑥AS steppe;⑦High-cold meadow;⑧SK steppe;⑨SP steppe;⑩AS steppe;⑪SP steppe;⑫AS steppe

度有所偏低,其主要原因,是这些样点在进行蝗虫密度测定的前一年曾进行过蝗虫治理。第 32 号样点的情况与上述 3 个样点正好相反,即实测蝗虫密度比应有的密度有所偏高,其原因有待进一步研究。从表 5 还可见,研究区受草地蝗虫严重或较严重危害的生境类型,是位于海拔较低、热量条件较好地段的芨芨草草原、克氏针茅草原及紫花针茅草原;高寒草甸因所处海拔较高、热量条件较差,属一般危害,在通常情况下不会出现明显的危害;而高寒灌丛草甸所处海拔虽与高寒草甸相近,但因其一般分布在山地阴坡或沟谷,热量条件更差,因此属于无危害类型。

为了更直观地阐明草地蝗虫潜在发生可能性指数值与实测蝗虫密度之间的关系,又根据表 5 数据绘制了拟合曲线图(图 1)。由图 1 可见,从总体上说,草地蝗虫潜在发生可能性指数值与实测蝗虫密度之间存

在较好的相关关系,经计算,两者间的相关系数达0.90,置信度为85%。从图1还可看出,凡是指数值大于60的样点,其蝗虫密度大多已超过当地所确定的蝗虫防治标准(25头/m²);而指数值大于80的样点,其蝗虫密度已在50头/m²以上,即大大超过了防治标准。

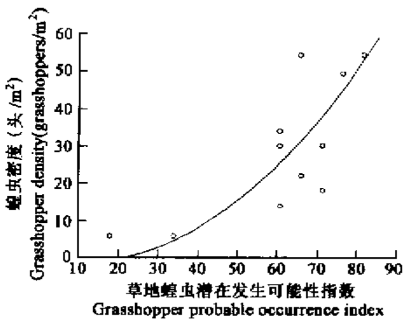

图1 环青海湖地区草地蝗虫潜在发生可能性指数与实测蝗虫密度相关曲线

Fig.1 Correlation curve between grasshopper probable occurrence index and grasshopper density

7 结论

(1)草地蝗虫种群的分布和动态变化等受许多因素的影响,其中既有属于非生物的环境因素,也有生物本身的因素。对草地蝗虫而言,这些因素不是孤立起作用的,而是紧密联系、综合施加影响的。同时,无论哪一种草地蝗虫,它们的栖息和活动都与一定的生境类型相联系。由此可以认为,从生境类型的研究入手对草地蝗虫的可能发生进行研究,虽为间接方法,但目前仍不失为一种可行和较好的方法。

(2)从生境类型入手研究草地蝗虫的可能发生状况,即针对草地蝗虫发生的可能性对各类生境作出科学评价,其关键问题,一是要恰当地划分生境类型,使所划分的生境类型确实与草地蝗虫的发生有紧密的联系。二是要选准生境评价因子,建立科学、适用的评价因子指标体系,特别要注意选择那些重要和较重要的评价因子。三是要正确地确定草地蝗虫潜在发生可能性指数,进行指数的恰当分级,以及将此指数分级与草地蝗虫生境评价标准相结合。在这些环节上把握得越好,草地蝗虫发生可能性评价的成果将越可靠。

(3)环青海湖地区12个样点的研究表明,从总体上看,草地蝗虫潜在发生可能性指数与实测的草地蝗虫密度之间存在很好的相关性。少数样点实测蝗虫密度比应有密度有所偏低,这可能与前一年曾进行过治理有关。个别样点的实测蝗虫密度比应有密度有所偏高,其原因有待进一步研究。

(4)评价结果表明,环青海湖地区受草地蝗虫严重或较严重危害的生境类型是芨芨草草原、克氏针茅草原及紫花针茅草原,高寒草甸属一般危害,而高寒灌丛草甸属不发生危害类型。

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