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Color intensity preference and its relation to differential territory defense in the field cricket, *Acheta pennsylvanica*, and the domestic cricket, *Acheta domesticas*

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Christine L. Hocke
Lycoming College
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Approved by:

Robert B. Augstadt

Edward J. Gabriel

Gene D. Gredrickson

Benton Baldwin

Abstract

Juvenile and adult crickets of the species Acheta pennsylvanica and Acheta domesticas were used in experiments to determine if crickets had a preference in hiding places based on their color or intensity. Paper cones were used as shelters. Both species were found to prefer dark colored objects to hide under. In the second phase of the study the favored black cone was pitted against the most unfavored white cone. It was hypothesized that a territorial male would defend the preferred black cone more aggressively than the white cone. The preference for black was found to have little relation to differential territory defense. Individuals of A. pennsylvanica were found to be less aggressive toward one another than individuals of A. domesticas. However, males of A. pennsylvanica may have been familiar with one another or related to some degree and could have been displaying an aspect of kin recognition. Also, since they were raised together, they may have had a previously established dominance hierarchy and therefor no need to demonstrate aggression.

Introduction

Visual perception and color preference has been studied in several animals including the chick. Polt (1971) used chicks that had imprinted on different colored balls. These chicks were then tested to see what colors they preferred by placing different colored circles in front of them and counting the number of times they pecked each spot.

The aim of this study was to examine visual perception and its relation to aggression in the field cricket Acheta pennsylvanica and the house cricket Acheta domesticas. Juvenile field crickets acquired from summer breedings were used in several experiments to determine if crickets had a preferred color or color intensity for their shelter. Juvenile and adult house crickets from a supply company were used in a similar experiment. James M. Polt (1971) explained an experiment using colored blocks and the crickets "impulse to climb" to observe these visual perceptions, and counted the number of crickets on the blocks to determine preference. In his paper he demonstrated that crickets prefer black objects over white objects to climb on. In this study colored paper cones were used, taking advantage of the crickets instinct to hide under things.

The second part of this study explored the relationship between visual perception and aggression in the field cricket Acheta pennsylvanica and the domestic cricket A. domesticas. Literature documents many behavioral differences between these two species. Price and Stokes (1968) report that A. domesticas is less aggressive than "field forms." Data gained in the first phase of this experiment prompted questioning into whether territorial males defend their territory differentially depending on the "color" or "brightness" of their habitat (cone). Would they defend a dark colored cone more aggressively, since it was preferred, than a light colored cone.

Methods

Juvenile field crickets from wild stock were used in five tests to determine "color" preference. The wild stock was caught in New Milford Township, Susquehanna County, Pennsylvania in early June 1989. All of the wild test crickets used resulted from the matings between these five female crickets and six males caged together in a ten gallon tank during the summer of 1989. In all preference tests ten crickets were placed in an eight by eleven inch cage. Cages contained sand, water dish, food, and three cones. The first cones used were the upturned cups of cardboard egg cartons. In later tests these were replaced with folded construction paper cones because of the lack of enough available egg cartons, and because the color intensity of construction paper is better. See figure 1 for cone positions.

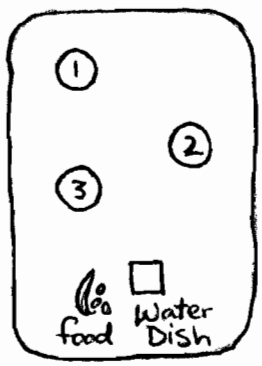

Figure 1. Positions of cones in test cages.

Readings were taken twice a day by lifting the cone and counting the number of crickets beneath each. Sums were taken for cone positions (1,2,3) and cone color (red, blue, yellow in color tests) or (black, gray, white in intensity tests). From these sums percentages were computed and the Chi-square test of fit was used to determine if a significant difference between positions or colors was present.

The aim in the second phase of the experiment was to see if a male cricket set up in a preferred colored cone would defend his territory more aggressively than a cricket in the unpreferred colored cone. This test was carried out over a one week period. One half of the crickets (males) were set up in the preferred black cone cages, the other half in the unpreferred white cone cages. After four and a half days a second cricket was added and the ensuing activities recorded. Each cage was observed for an hour in a staggering progression where two cages were watched together. Further activity of the two crickets was observed for two additional days. On the second week the groups were switched--black coned crickets getting white cones and vice-versa. The same crickets were paired during week two as were paired week one. This test was done with both field and domestic species. Comparisons were made within groups, between groups, between weeks, and between species. Alexander (1961) provides a five level scale of aggression and the pathways that aggressive action takes in field crickets. This was used to quantify the level of aggression between pairs of crickets.

Results

The data from the various preference tests are presented in Table I. The significance level used for the Chi-square tests was .05.

Test 1A' Position. Cages were set up with three cones of the same color. This test was done to see if the position a cone held in a cage gave it higher preference to other in that cage.

Position was found to be a significant factor using the Chi-square test, $X^2=26.96$ ($P<0.05$, d.f.=2). Therefore in all subsequent testing each different color was rotated through each of the three positions; R-B-Y, B-Y-R, Y-R-B, etc.

Test 1A Color and Position. Here blue, red, and yellow egg cartons were used. The cones were checked twice per day, and the number of crickets beneath each cone were counted and recorded. Blue cones were chosen 60.5% of the time over red at 29.9% and yellow at 9.6%. Position was still a significant factor, $X^2=13.25$ ($P<.05$, d.f.=2), although percent-wise it was less of a factor compared to test 1A'.

Test 1B Color and Position. In this test construction paper cones were used due to the lack of available egg cartons. To help cut down on position effects cones were changed twice during the test. Red was the darkest color and was chosen 81.6% over blue 17.7% and yellow 0.67%. Position was not found to be a significant factor, all positions were chosen equally, $X^2=4.94$ ($P>0.05$, d.f.=2).

Test 2A & 2B Intensity and Position. In this test brightness/intensity was the focus. Black, gray, and white construction paper cones were used. There was a significant difference between intensities; black 65.4%, gray 32%, and white 2.6%. Position was a significant factor in this test, $X^2=13.85$ ($P<.05$, d.f.=2). This basic test was repeated as test 2B changing the cones more often and moving the sand beneath the cones to disturb any chemical cues. Intensity was still significant; black 55.6%, gray 35%, white 9.4%, $X^2=175.51$ ($P<.05$,

d.f.=2). Position was still significant, X^2=7.94 (P<.05, d.f.=2), although the percentages were quite close; black 35.4%, gray 36.8%, and white 27.8%.

Test 2C Intensity and Position. This was the preference test for domestic crickets. Once again black, gray and white construction paper cones were used, and these were changed after each reading. The sand was also moved to disturb any chemical cues. Intensity/brightness was significant: black-47.50%, gray-41.25%,and white-11.25%, X^2=34.795 (P<.05, d.f.=2). The lower percentages may be due to a smaller sample size. Position was not a factor in this test, X^2=1.963 (P>.05, d.f.=2).

The compiled results of tests 1A, 1B, 2A, and 2B are found in Table II. Position was not a significant factor, X^2=5.92 (P>.05, d.f.=2) for the complied results. Color was significant with the darkest colors chosen 64.05%, middle range colors chosen 29.83%, and the lightest colors chosen only 6.12%. For color X^2=591.7 (P<.05, d.f.=2).

Table I Various tests for position, color, and intensity for two species of cricket. Significance level=.05 for all tests. (#=number of crickets, %=percent of total tested).

<1A'>Position-A. pennsylvanica

Position test with single colored egg carton cones.

Position:	#	%	X^2	
1	135	43.8	10.20	
2	111	36.0	0.69	
3	62	20.1	16.07	
	308		X^2=26.96	Position significant

<1A>Position and Color-A. pennsylvanica

Color test using different colored egg carton cones.

Position:	#	%	X^2	
1	91	29.0	1.77	
2	88	28.0	2.63	
3	135	43.0	8.85	
	314		X^2=13.25	Position significant

Color:	#	%	X^2	
Blue	190	60.5	69.700	
Yellow	30	9.6	1.074	
Red	94	29.9	53.200	
	314		X^2=123.970	Color is significant

<1B>Position & Color-A. pennsylvanica

Color test using different colored construction paper.

Position:	#	%	X^2	
1	105	35.0	0.29	
2	112	37.0	1.54	
3	82	27.0	3.11	
	299		X^2=4.94	Position **not** significant

Color:	#	%	X^2	
Red	244	81.60	209.4	
Blue	53	17.70	21.8	
Yellow	2	0.67	95.6	
	299		X^2=326.8	Color is significant

<2A>Position & Intensity-A. pennsylvanica

Intensity test using black, gray, and white construction paper cones.

Position:	#	%	X^2	
1	147	42.0	8.5300	
2	108	31.1	0.4996	
3	92	26.5	4.8200	
	347		X^2=13.8496	Position significant

Intensity:	#	%	X^2	
Black	227	65.4	107.400	
Gray	111	32.0	0.183	
White	9	2.6	98.300	
	347		X^2=205.883	Color significant

<2B>Position & Intensity-A. pennsylvanica

Rerun of intensity test 2A.

Position:	#	%	X^2	
1	193	35.4	0.71	
2	210	36.8	2.06	
3	151	27.8	5.17	
	545		X^2=7.94	Position significant

Intensity:	#	%	X^2	
Black	303	55.6	81.05	
Gray	191	35.0	0.48	
White	51	9.4	93.98	
	545		X^2=175.51	Color significant

<2C>Position & Intensity-A. domesticas

Intensity test using black, gray, and white construction paper for the domestic cricket.

Position:	#	%	X^2	
1	57	35.6	.253	
2	58	36.3	.409	
3	45	28.1	1.301	
	160		X^2=1.963	Position not significant

Intensity:	#	%	X^2	
Black	76	47.50	9.637	
Gray	66	41.25	1.753	
White	18	11.25	23.405	
	160		X^2=34.795	Color significant

Table II Compiled results for A.pennsylvanica

Position

TEST	1	2	3	TOTAL	
1A	91	88	135	314	
1B	105	112	82	299	
2A	147	108	92	347	
2B	193	201	151	545	
	536	509	460	1505	
%=	35.6	33.8	30.6		
X^2=	2.35 +	.11 +	3.46=	5.92	Position not significant

Color/Intensity

TEST	Dark	Mid	Light	TOTAL	
1A	190	94	30	314	
1B	244	53	2	299	
2A	227	111	9	347	
2B	303	191	51	545	
	964	449	92	1505	
%=	64.05	29.83	6.12		
X^2=	426.07 +	5.53 +	334.54 =	766.14	Color is significant

In the second phase of the study differential aggression was investigated. Using Alexander's (1961) five level aggression scale (Table III) the activities of each pair of crickets was recorded and ranked for each week. Two cages were watched in a staggering progression for one hour a piece. Rankings were given for the highest level aggression exhibited by the pair. For example, first level-1, second level-2, etc. These numbers were then summed for different groups.

Table III

Alexander's scale

"First Level-Contacts terminated without clear dominance, no apparent retreat, and no apparent aggression.
Second Level-Contacts terminated by retreat without apparent aggression.
Third Level-Contacts terminated by retreat after mild to moderate one-sided or mild reciprocal aggression.
Fourth Level-Contact terminated after moderate to intense reciprocal aggression.
Fifth Level-Contact terminated only after sustained combat." (1961)

A visual inspection revealed little difference between the level of aggression shown between weeks for either specie. The same level of aggression was often observed both weeks for each pair.

Within color groups for each specie only one group showed a wide range of behaviors. In A. domesticas' white group two pairs displayed level one aggression, one pair displayed level two, two pairs displayed level three, and one pair displayed level five aggression.

The non-parametric sign test showed no statistically significant difference ($P>.05$) in levels of aggression between color groups of each specie. The sign test was chosen because of the small sample size. A. pennsylvanica's black cone group had five level one cages and one level two. The white cone group had equal numbers of level one and level two. A. domesticas' black cone group also had equal numbers of level one and level two cages, while the white cone group had a wide range as previously mentioned.

Between species there were some differences observed. The range of levels was much greater for A. domesticas, an average deviation of 8.33×10^{-1}. A. pennsylvanica had an average deviation of 3.33×10^{-3}. The mean aggression level for A. pennsylvanica was 1.33, while the mean for A. domesticas was 2.00. A. pennsylvanica showed less aggression, and pairs were found resting together after two days more often than in A. domesticas. All of the more violent levels observed were between pairs of the domestic cricket. This difference in aggression level was found to be statistically significant ($P<.05$). The non-parametric sign test was chosen because of the small sample size and the large differences in variances. This difference in aggression between these two species is contrary to what Price and Stokes (1968) reported for domestic crickets.

Table IV-Differential Aggression (B=black cone, W= white cone, sequence is by week.)

Acheta pennsylvanica			Acheta domesticas		
cage #1	B	1	cage #1	B	2
	W	1		W	1
cage #2	W	1	cage #2	W	3
	B	2		B	1
cage #3	B	1	cage #3	B	1
	W	2		W	3
cage #4	W	2	cage #4	W	5
	B	1		B	2
cage #5	B	1	cage #5	B	2
	W	2		W	2
cage #6	W	1	cage #6	W	1
	B	1		B	1

A. pennsylvanica
Sums of rank-black=9
-white=9
-total=24
Average of rank=1.33
Average deviation=8.33×10^{-1}

A. domesticas
Sums of rank-black=7
-white=15
-total=16
Average of rank=2
Average deviation=3.33×10^{-8}

Discussion

The results of the first phase of this study show that crickets prefer to hide under dark objects where, perhaps, they will be hard to see. There also seems to be a preference to return to the hiding place (position) previously used. This position effect was significantly lowered when cones were changed often and the sand beneath them was moved. Some type of pheromone or other odor may be a cue for them to find their cone (or in the wild-burrow) after leaving to forage for food.

The second phase of this study showed that there was no aggressional difference between color groups. Any relation between color preference and aggression seems to be over ridden or masked by the crickets' territorial instinct. One possible explanation for the differences found between the two species in the second phase is that the A. pennsylvanica males were raised together. This previous familarity may have subdued any aggression because their dominance hierarchy may have already been established. Another possibility is that the wild type males used may have been related, either siblings or paternal half brothers. Simmons (1989) researched kin recognition and its influence on mating behavior in the spanish field cricket, Gryllus bimaculatus (de Geer). Simmons found that crickets have the ability to recognize kin, and that mating behavior between related males and females is different than between unrelated couples. Females took two times longer to mate with half sibling males than with non-kin males and three times longer to mate with

full sibling males. Females evaded full siblings more often than half and non-kin. Males too behaved differently towards related females. They tended to pause more often and for longer intervals when with full sibling females than with half or non-kin. The evolutionary significance of this is that crickets seem to be able to avoid inbreeding. Simmons (1989) also indicates that cuticular pheromones may be the recognition cue that crickets use.

The significance of this to the project is that the wild type males used in this study may have been related since all went through their final molt within a few days of one another, and their parents were caged together. Therefore they may have not been aggressive toward one another because of their degree of relatedness. Being at least 25-50% genetically related, it may not have been beneficial to be territorially aggressive toward one another.

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