NON-SPECIFIC STRESS IN JUVENILE LIZARDS,
SCELOPORUS UNDULATUS GARMANI

by

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ACKNOWLEDGEMENTS

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INTRODUCTION

A current emphasis in ecology concerns population regulation. The direct density-dependent effects of predation (including parasites and disease), competition, and to a lesser extent "social force" have been investigated. Darling (1937), Green and Larson (1938), Clarke (1955), Barnett (1958), Chitty (1959), Christian (1961), Krebs (1964), and others have studied stress in mammalian populations; Allen (1934), Wynne-Edwards (1959), Watson (1964), Lack (1954, 1966), etc., in avian species. These two classes have been studied due to their spectacular, short-term changes in numbers and proximal relationships to man, who seeks technology to regulate his own numbers.

Mammals are possibly more suited to physiological studies but, populations of iguanid lizards are more observeable and manageable for detailed life-stage studies of a species (Blair, 1960; Tinkle, 1967; Ferguson, unpublished). They are found on more open terrain rather than in tress, as are most birds; or underground, as are most rodents studied to date. The spiny lizard, Sceloporus, and its relatives especially can be readily captured, measured, and marked. They adapt well to experimental environments and are easily reared (Crenshaw, 1955; Carpenter, 1960; Tubbs and Ferguson, unpublished).
This paper reports an experimental investigation into the role of aggression as a regulator of juvenile lizard density. It is part of an overall study of population regulation in iguanid lizards at Kansas State University.

METHODS

Gravid Northern Prairie Swifts, *Sceloporus undulatus garmani* (Smith, 1956; Stebbins, 1966), were collected approximately five miles west of Hutchinson, Kansas in May, 1971. They were displaced to outdoor enclosures near Manhattan, Kansas. These were standard stock tanks approximately 5 x 2 1/2 x 2 1/2 feet (henceforth referred to as tubs) filled with 4-6" of sand and dirt, covered with chicken wire to prevent predation by birds, supplied with basking sites in the form of logs and limestone rock, and placed in parallel north-south lines. None were shaded. Groups of 2, 3, or 4 females were randomly put in each of eight tubs. All tubs had a single male. Clutches were gathered as laid and placed in baby food jars partially filled with sand, then capped with aerated lids and buried in another tub filled with 1 1/2 feet of sand, which served as an incubator. Data were collected on egg deposition, fecundity, incubation period and incubation temperature. Some second clutch hatchlings (31 August/1 September) were then used for the following experiment.

Juveniles from three clutches were marked by toe-clipping (Tinkle, 1967), sexed, and placed in tubs (as above) in the following numbers:
Tub A--one individual from clutch 4-7-14; Tub B--one individual from clutch 4-9-19 and six individuals from clutch 4-9-13; Tub C--one individual from clutch 4-9-13. They were fed one net sweep of insects per lizard 3 times per week. A "net sweep" was obtained by driving through a grassy field at 20 mph with the insect net out the window for approximately one minute. For example, Tub B would receive a total of 21 net sweeps per week. In all tubs this feeding schedule appeared to provide a superabundance of food as there were always many obtainable insects of various species in the tubs at the time of subsequent feedings. All environmental factors were assumed equal with the variable being space per individual. From 3 September to 19 October, 1971, each tub was observed for 15 minutes per day in the late afternoon, the time of greatest social activity in at least some iguanids (Irwin, 1965). The number of moves (other than to feed), feeds, stereotyped pushup displays (Carpenter and Grubitz, 1960) and overt encounters were tallied for each tub. Daily substrate temperatures were kept. Growth and mortality information was also recorded in an attempt to note any density dependent effects. Pushup and survivorship data collected by G. W. Ferguson (30 August--10 October, 1970) using the same techniques for five isolates and four groups of *Sceloporus undulatus garmani* were included in the analyses.

**RESULTS**

**Overt Encounters**

No overt attacks or chases were observed in Tub B. Although overt
encounters have been observed in *garmani* (Carpenter, 1965; Ferguson, unpublished), it is usually among adult males and observations would lead one to believe this does not play an important role in juvenile social regulation.

**Stereotyped Pushup Displays**

The seven isolated juveniles (Tubs A, C, and the 1970 isolates) displayed an average of .428 times/individual over the total observation period. The seven grouped individuals (Tub B) displayed an average of 2.42 times/individual. Twenty pushups were observed during 44 observation periods in all groups versus three pushups over 48 periods for the seven isolates. This difference was highly significant. ($p < .001$, chi-square = 16.2, df = 1)

**Feeds**

The isolates fed an average of .58 times (31.5%) more per observation than the crowded group. The enclosure of seven juveniles fed 1.84 times/observation/lizard as compared to 2.42 feeds/observation/individual for the two isolated juveniles. These differences were large but not statistically significant.

**Moves**

The isolates moved (other than to feed) an average of 2.70 times (80.5%) more per observation than the crowded group. The tub of seven juveniles moved 3.35 times/observation/lizard as compared to 6.05 moves/observation/individual for the two isolated juveniles. These differences
again were large but not statistically significant.

**Growth**

There was no significant difference in growth rates as measured by snout-vent (s-v) length. (Table 1)

**Temperature**

Substrate temperature varied less than one degree among the three experimental enclosures. Below 20° C all activity ceased and data from three such days were not included in the analysis.

**Survivorship**

Fourteen of the 37 individuals (37.8%) in five groups during the 1970 and 1971 observation periods survived to termination of the experiment. (The groups consisted of 7, 7, 9, and 11 hatchlings in 1970.) Six of the seven isolates (85.7%) from both years survived. This difference is significant at the .05 level (chi-square = 3.85, df = 1). No significant relationship between sex and survivorship was found in the juvenile groups from 1970 and 1971.

**DISCUSSION**

Selye (1946) first identified stress as an important factor influencing the ups and downs of mammalian populations and postulated a "General Adaptation Syndrome" (G.A.S.) for the physiological responses of a mammal
in a stressful situation. The manifestations of the syndrome become observable in a highly crowded or aggressive population. Certain changes in behavior have been identified (Clarke, 1953; Christian, 1963; Morrison and Thatcher, 1969; Chitty, 1970). Some are increased aggressiveness, decreased emotionality and feeding, and emigration or death if emigration is physically prevented. Stress may be of a specific or non-specific causality (Wynne-Edwards, 1962). The former is physically inflicted, usually by superiors (Darling, 1937; Guhl, 1953; Clarke, 1955) unless the social order has broken down as happens in some microtine rodents, and results in visible external injuries. The latter is inflicted psychologically and more subtly and results in internal disturbances (Selye, 1950; Clarke, 1953; Strecker and Emlen, 1953; Dawson, 1958; Christian, 1959). Both types of stress induce the G.A.S. response with its associated physiological and behavioral changes and eventual death if the source of stress persists.

In groups of juvenile lizards aggression (stereotyped pushup displays) appears to promote stress in at least part of the population. Positive indications of a stressed condition were more displays and less activity. Active aggression (specific stress), as occurs between adult lizards of the same sex, was not observed in the juveniles (overt encounters), however, the results are consistent with the interpretation that the stereotyped pushup displays are a form of passive aggression (non-specific stress) highly correlated with density. There were more displays, less feeds, and less locomotor moves in the crowded lizards. Allen (1934) observed an analogous
situation in ruffed grouse. Certain individuals could be completely subdued by an intimidation display and reduced their activity to the point of death from what he termed "shock disease."

Growth rates of crowded and isolated lizards were not statistically different. Although the crowded individuals fed less they moved less also so the energy available for growth should have been about the same. Growth rates for non-survivors were not available, of course, and group survivors may have all been dominants and thus relatively free of major stress effects. However, the smallest initial hatchling (A), an isolate, attained the greatest length, while the largest initial hatchling (B₃) housed in a group grew the least. (Table 1)

Sex and displays were not compared. Carpenter (1965) did observe, though, that aggressive gestures in hatchlings unlike those of adults were not correlated with single sex encounters in this species.

Stress resulting from aggression increased mortality among crowded lizards even in an unlimited food situation. In enclosures isolates suffered only 14.3% mortality as compared to 62.2% die-off for the groups. Survivorship in juvenile lizards was density-dependent and interestingly 18 of the 27 individuals that died in a group did so within the first 10 days of the 46 day study, while the only non-surviving isolate (C) died on the 12th day. My non-quantitative impression was that those that died became sluggish and reclusive two or three days before death--a condition similar to that of grouse (Allen, 1934). Wild snowshoe hares brought into captivity underwent
convulsions, coma, and death within an average of 4.2 days (Green and Larson, 1938). All had symptoms of the G.A.S. Isolated adult toads are capable of living for years in captivity. Elkan (1960) found that crowded toads, however, actually starved in the presence of an abundance of food. Victims lacked fat reserves, a symptom of non-specific stress also found in house mice (Strecka and Emlen, 1953). Southwick (1955) noted that young mice exhibit a high mortality in an unlimited nutritional environment. The author states this also seemed to relate to population pressure and space per individual.

In a natural environment a stressed juvenile would be most likely to migrate as an alternative to death at the crowded hatch site. However, as a hatchling ventures from the point of origin its chances of predation may be proportionately increased. (See Tinkle, 1967, for the advantages of area familiarity and the need for gradual, i.e. unforced, exploration.) Increased social strife and movement are thought to increase predation among subordinates in other vertebrate species (Errington, 1943; Blair, 1951; Lockley, 1961; Myktowycz, 1961). So an aggression-induced stress which forces emigration may still indirectly contribute to the death of the individual. Ferguson and Bohlen (unpublished) have observed a density-dependent migration of juveniles in *S. u. gormanii*. All high density hatch areas subsequently became low density areas, while initially low density areas remained low or became higher in density. The vulnerability of young age groups to social pressure in an over-populated habitat, forcing them to
emigrate or colonize and consequently suffer high death rates is well documented (Lack, 1954; Wynne-Edwards, 1962). Carrick (1963) and Kluyver (1951) have recorded parallels in Australian magpies and great tits respectively. They both believed the forcing out of juvenile birds was not due to available food but rather to an individual space requirement.

Stress reflects a mutual intolerance exemplified by passive aggression in juvenile lizards which could be selected for. (See also Chitty, 1970.) The adaptive role of aggression in partitioning a habitat into territories is well known. Stress may be adaptive because it forces dispersion of the aggressed. (See also Christian and Davis, 1964.) When migration is impossible as in the crowded tubs, stress results in extermination of the least fit and therefore is unadaptive for them. Physiological disorders and death in wild hares (Green and Larson, 1938) were thought to function in nature (two recordings) and to be responsible for the periodic fluctuation of hare numbers (i.e., there was a crash after the population achieved a high density.) This may be another example of the phenomenon. High mortality rates among the young of snowshoe hares and field voles known to occur after a peak in numbers of the species may be related (Elton, et. al., 1935; Godfrey, 1955; Hoffmann, 1958; Chitty, 1970).

CONCLUSION

Crowding in an experimental environment with superabundant food
resulted in a low survivorship among juvenile lizards, *S. u. garmani*. This may reflect a G.A.S. due to adaptive social intolerance and inability to emigrate to low density areas. Positive indications of stress in the groups were increased displays, decreased moves and feeds, and a low survivorship. Growth rates (snout-vent length) were not correlated with density.

Future studies should include sampling of intermediate density ranges (i.e., between 1 and 7), increasing the replicates of all sample sizes, using juveniles from qualitatively equal clutches (egg weights), measuring growth by weight, autopsing for fat body comparisons, and balancing sex ratios.
Table 1: Growth rates (snout-vent length in mm) of crowded vs. isolated lizards

<table>
<thead>
<tr>
<th>Hatchling</th>
<th>1 September</th>
<th>16 September</th>
<th>19 October</th>
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<tbody>
<tr>
<td>A</td>
<td>21</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>B₁</td>
<td>23</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td>B₂</td>
<td>23</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>B₃</td>
<td>24</td>
<td>27</td>
<td>30</td>
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Note: Growth measurements were taken in 1971 only. Hatchlings C and B₄ thru B₇ expired before 16 September.
LITERATURE CITED


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Lizards are well suited for population regulation studies. The role of aggression and stress as a regulator of juvenile lizard density is investigated.

Juvenile *S. u. grahami* were placed in experimental enclosures at varying densities. All other environmental factors were equal. Behaviors, growth, temperature, and survivorship were recorded. Isolated individuals fed and moved more, gave fewer stereotyped pushup displays, and exhibited a much higher survivorship than the crowded lizards. Survivorship was density-dependent and apparently related to space per individual. Growth rates were not significantly different. Sex and temperature played no observeable role.

In groups of juvenile lizards passive aggression appeared to promote stress through a G.A.S. response. Stress resulting from aggression increased mortality among crowded lizards when food was unlimited. In a natural environment stress would increase emigration. Stress may reflect a mutual intolerance exemplified by passive aggression in juvenile lizards which could be selected for. Aggression is adaptive in forcing dispersion which in turn benefits the individual.