

B R E V I O R A

Museum of Comparative Zoology

CAMBRIDGE, MASS. 29 JANUARY, 1971

NUMBER 368

STRUCTURAL HABITATS OF WEST INDIAN *ANOLIS* LIZARDS I. LOWLAND JAMAICA

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ABSTRACT. This paper reports differences in structural and climatic habitat among the commonest *Anolis* species of three lowland Jamaican localities. Three of the species studied, *grahami*, *opalinus*, and *valencienni*, occurred at all localities; two other species, *sagrei* and *lineatopus*, occurred at one (Whitehouse) and two (Port Antonio, Mona) localities, respectively, and thus were complementary.

With a few exceptions, the ordering of species by height, from highest to lowest, was *valencienni*, *grahami*, *opalinus*, and *lineatopus* or *sagrei*; the ordering by diameter, from thickest to thinnest, was *opalinus*, *grahami*, *lineatopus* or *sagrei*, and *valencienni*; the ordering by insolation, from sunniest to shadiest, was *sagrei*, *grahami*, *valencienni*, *lineatopus*, and *opalinus*; the ordering by size, from largest to smallest, was *valencienni*, *lineatopus*, *grahami*, *sagrei*, and *opalinus*. Within species, larger individuals tended to occur higher and on thicker perches, smaller individuals lower and on thinner perches.

The above orderings result in low interspecific spatial overlap of similarly sized individuals in two ways. First, a *direct* relationship between body size and perch diameter *within* species and an *inverse* one *between* species ensures that spatially abutting species will overlap most their respective individuals least alike in size. Second, a direct relationship within species between size and height also, except for *valencienni* and *grahami*, results in the greatest spatial overlap being between the most dissimilarly sized individuals.

Many statistically significant associations were found between the habitat and climatic variables; the most common was a tendency for thin perches to be more often occupied in the sun.

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This is the first of a series of papers describing in a standard way the structural habitat of some West Indian *Anolis* lizards. Its primary purpose is to document differences between the size and sex classes of all the *Anolis* species found within a particular, limited study area. Between-site comparisons will be drawn occasionally; however, because of the great intersite variation in vegetation structure and its effect on lizard habitat distributions, that aspect will be described and analyzed in detail in a larger work covering much of the western Caribbean.

The "structural habitat," a term first invented by Rand (1964) for *Anolis*, refers to the spatial niche of a species population described in terms of characteristics of the vegetation and other structures upon which these arboreal animals carry out their activities. The two such characteristics that Rand originally used and that have subsequently proven most useful in discriminating the various species or species-classes are perch height and perch diameter (Rand, *l.c.*, 1967a; Rand and Rand, 1966; Schoener, 1968; Schoener and Gorman, 1968; Laska, 1970), and these will be the ones used below. Other possible structural characteristics are perch texture, perch color, and the size and nature of the plant or other object to which the perch is attached.

Observations that combine to give an overall picture of the spatial dimensions of the niche must be summed over a given time period and over a particular set of individuals. The method chosen in this and succeeding studies is to lump together "first sightings" recorded continuously throughout the day or throughout the period of maximum activity from a population of several hundred animals for each of the the commonest species. Thus, ideally, the sites of the major activities—thermoregulation, searching for food, capturing and eating prey, and social interaction—are weighted when observations are combined according to that fraction of the day spent by the average individual in the particular activity.

There are several limitations and qualifications of the structural-habitat concept which must be mentioned at the outset.

First, it does not provide a true picture of the animals' daily perch distribution, because inconspicuous animals are more often missed. This means that the most visible activities, feeding or fighting, for example, are disproportionately weighted in the totals. Inconspicuousness is perhaps less of a problem for continuous observation of single individuals than for "first sightings."

Second, weighting activities in proportion to the amount of time they take will not necessarily produce the most meaningful measure of a species' spatial distribution, either for testing hypotheses of optimal individual behavior or of community composition. For example, it may be most useful to know the places where prey are captured in order to determine how similar species can be and still coexist, but this activity consumes a very small amount of time, and Andrews (1971) and Trivers (personal communication) have both shown that distributions of feeding sites can differ markedly from the overall structural habitat. However, taxonomic breakdown of the prey of the four Bimini *Anolis* has shown that the prey is qualitatively what would be predicted from the overall structural habitat (Schoener, 1968).

Third, consideration of structural habitat alone provides an incomplete picture of the total niche of a species. The most important other kind of property characterizing the space in which an anole lives is climatic; some measure of this is given below for certain situations. A second important way in which animals of the same structural habitat may differ is in the prey selected from the habitat.

Fourth, structural habitat as determined by first sightings is a static concept: it says nothing about how an animal gets from one part of its home range to another, nor indeed about how perches of various heights and diameters are actually connected together in the habitat. Knowledge of the movements of animals is essential for certain kinds of studies, for example, those on foraging strategies, and may provide some indication of the type of prey captured. This limitation for Jamaican *Anolis* is important: Trivers (personal communication) has shown that *valencienni* differs strikingly from some other Jamaican anoles (e.g., *lineatopus*) in its active but cautious manner of searching for prey. The limitation should be kept in mind when *valencienni* is compared to the other species below.

Despite these disadvantages, the structural habitat has proven a useful "summary statistic" in describing *Anolis* communities. It has the great advantage that large populations of animals can be sampled quickly, thus permitting several such populations to be studied in a season. More balanced and detailed intralocality studies of *Anolis* populations are better for many purposes but are impractical for the study of the geographic variation of the niche. Hopefully, as greater numbers of these detailed studies

become available, it will be possible to set up correspondences—e.g., animals which are often found on leaves take large numbers of aphids—between the many properties measured in the detailed studies and the few properties of the overall structural habitat. Then some supposition can be made concerning the geographic distribution of many more species characteristics than those explicitly given as the “structural habitat.”

FORMAT

The format for reporting the results in this and succeeding papers will begin with a description of the localities studied, including a list of the *Anolis* lizards seen. This will be followed by a verbal summary of the results for each locality, accompanied by tables depicting the structural habitat of the lizard classes considered, as well as by a table indicating the statistical significance of differences in the habitat variables between all possible pairs of the lizard classes. Finally, some relation will be made of the results to previous studies of the species in question and to studies of the habitats of species from other areas.

METHODS

Structural habitats were estimated by the “censusing” method first developed by Rand (1964). In a transect through the study area, each new lizard seen, unless obviously disturbed by the observers, is noted as to its perch height, diameter, and (sometimes) insolation. Rand (1964, 1967a) and Schoener (1968) have pointed out the possible errors in this technique, including the especially serious one of differential visibility of various portions of the habitat. Thus lizards, sitting, for instance, on the tops of leaves in the canopy, are often likely to escape detection. However, the *direction* of difference between lizard groups within a given site should not usually be affected by this kind of error. We did most of the observations as a pair, using binoculars, the two of us crisscrossing the habitat about 10 to 20 feet apart; this technique probably reduced considerably the chance of missing lizards. Study areas were often censused several times per day, but as a rule no part of the area was censused at intervals closer than one and a half hours; observation of lizard behavior in the interval indicates that this was ample time for the animals to “recover” from disturbance.

Data were cast into standard tables for easy intergroup comparison of structural habitat (Tables 1-4). For each lizard class for which microclimatic information was taken, observations of climatic categories—sun, shade, and clouds—were lumped into a single structural habitat table. Additionally, however, the percent occurrence in the three climatic categories were listed separately for each class (Table 5).

A powerful new technique of multivariate analysis was used to compute the statistical significance of habitat differences among the various groups of lizards. The technique utilizes the iterative procedure of Deming and Stephan (1940) and was recently expounded by Bishop (1969). It is designed to detect associations between variables—in our case perch diameter, perch height, lizard class, and insolation—of complex contingency tables; thus it can handle both nominal and ordinal variables. Because it also simultaneously considers associations between the habitat variables *per se*, this technique should largely eliminate any apparent difference in habitat among lizard classes caused entirely by the structure of the vegetation. For example, were relatively high perches always also relatively thin perches, a lizard class which occupied significantly higher perches, in the statistical sense, would not necessarily occupy significantly thinner perches, because of the strong height versus diameter interaction. Details of the application of the method to our data are given in the appendix (see also Schoener, 1970). The reader not familiar with these techniques should first consult the paper by Fienberg (1970), which is an exposition of the method written especially for ecologists.

THE SPECIES

There are seven species of *Anolis* described for Jamaica (Underwood and Williams, 1959).

Two of the species—*sagrei* and *grahami*—can be characterized as inhabiting strictly lower and middle elevations. *A. grahami* is very widespread, occurring abundantly throughout the lowlands. Typical *grahami* (subspecies *grahami*) are medium-sized (σ snout-vent length (SVL) = 65.5 mm; ϕ SVL = 44.0 mm)¹ green to

¹ Means are of the largest third of all specimens examined (see Schoener, 1969).

green-blue lizards occurring in all areas but the northeast, where they are replaced by *grahami aquarum*, a somewhat smaller (σ SVL = 61.8 mm; ϕ SVL = 45.1 mm), bright emerald green lizard. *A. sagrei*, a medium-small (σ SVL = 50.4 mm; ϕ SVL = 40.9 mm) brown species, is restricted in habitat on Jamaica, occurring only over the western portion of the island and there confined to the openest, sunniest areas. It is often associated with rocks. Apparently, *sagrei* has invaded Jamaica from Cuba and is in the process of spreading eastward (Underwood and Williams, 1959; Williams, 1970).

Another primarily low and middle elevation species is *lineatopus*. This medium-sized (σ SVL = 62.7 mm; ϕ SVL = 43.6 mm) lizard is perhaps the most varied in its coloration and pattern: four subspecies are recognized, some of which are found in dry open areas and others of which are restricted to the darkest forest (Underwood and Williams, 1959).

Two species have been recorded from the lowlands to c. 4500 feet. *A. opalinus*, slightly smaller than *sagrei* (σ SVL = 49.5 mm; ϕ SVL = 40.5 mm), comes in varying patterns and shades of brown and grey. There is scarcely a locality in Jamaica that does not have this species, though in the lowlands it is restricted to the shadiest areas and in the uplands is found in very open situations (Underwood and Williams, 1959; Rand, 1967; this paper). The grey-white, medium-large (σ SVL = 79.4 mm; ϕ SVL = 68.5 mm) *valencienni* seems not to reach the density that the aforementioned species sometimes do but is found throughout Jamaica, including some areas above 4000 feet. It appears to be commoner in open than in heavily shaded situations, but by no means is absent from the latter (see below).

The above five species are the ones which occurred commonly at one or more of the three localities studied, and which are therefore included in the comparisons to follow. A sixth species, the "green lizard" *garmani*, was seen at each of the three study sites, but rarely. It is the largest of the Jamaican anoles (σ SVL = 110.0 mm; ϕ SVL = 82.5 mm) and occurs throughout the island at all elevations (Underwood and Williams, 1959). However, it is most abundant relative to other *Anolis* species at middle elevations (e.g., Trivers, MS, and below), though it is also known to be common at certain lowland localities, such as the "ironshore" vegetation along the northwest coast. The seventh species, *reconditus*,

is restricted to middle and upland elevations and has only recently been discovered (Underwood and Williams, 1959; Lazell, 1966).

LOCALITIES

Three lowland localities were selected for study, representing a wet, a rather dry, and a mesic area.

The first, about ten acres in extent, was located east of the town of Port Antonio, on Jamaica's northeast coast. Specifically, it extended over the northwestern edge of a point of land supporting the ruins of an estate locally referred to as the "Folly." The vegetation was quite secondary: planted trees and shrubs, such as *Ficus*, limes, palms, and mango trees intermingled with native vegetation such as *Terminalia*. This locality had, however, become considerably overgrown, and there then existed, side-by-side, an area of almost continuous canopy and oftentimes sparse understory on the one hand, and an area of widely spaced trees and shrubs with much low, tangled herbaceous vegetation on the other. Both areas were studied and will be discussed separately as "Port Antonio Open" and "Port Antonio Closed."

The locality was worked 30 June–11 July 1967. Despite the fact that Jamaica was then undergoing one of its most intense droughts, rain fell fairly frequently though not protractedly; the area averages 131 inches of rain per annum (Handbook of Jamaica, 1966). The anoline species *grahami aquarum*, *lineatopus lineatopus* (or intermediates between *lineatopus* and *ahenobarbus*) and, to a lesser degree, *opalinus* and *valencienni* were abundant in the open area; the species *opalinus* and *lineatopus*, and to a much lesser degree *valencienni*, were common in the closed area.

The second study site, about four acres in extent, was located at Mona, near Kingston, in tall, open forest near the base of Long Mountain. It apparently was marginal to Rand's (1967) "Mona bush" study area, but differed in its much greater preponderance of *grahami*. Vegetation in this area consisted of large trees and smaller woody shrubs of typical tropical dry forest aspect: thorns, flattened canopies and small, numerous leaves. The understory, in addition to the shrubs, was mostly grass of about one to two feet in height, but certain patches were practically cleared while others had a more varied herbaceous vegetation. The latter appeared seriously affected by the drought. The site in general falls within Asprey and Robbins' (1953) "dry limestone scrub forest."

The area was studied 13-18 July 1967. Rainfall was almost non-existent during this period. The nearby Hope Gardens record 51 inches of rain per year (Handbook of Jamaica, 1966), though because of the extreme microgeographic variation in climate found on the Greater Antilles, this figure may not be the same as that for the study site itself. The anoline species *grahami grahami*, *lineatopus lineatopus* and *opalinus* abounded in the area. In addition, *valencienni* was not uncommon.

The third study area was located about one mile west of Whitehouse, near the southwest coast. It consisted of groups of trees and shrubs of mesic to xeric aspect, which remained after partial conversion into pastureland. The portion of this area closest to the coast was planted in limes and pimentos; further upland, patches of native trees merged gradually into unbroken forest. In places, considerable grassy and rocky areas showed effects of heavy grazing. The vegetation is labelled by Asprey and Robbins (1953) "cultivated pasture or second growth scrub," bordered by remnants of "dry limestone scrub forest," or by forest transitional between that and "wet limestone forest." The total area considered encompassed about 15 acres, though parts of it were not included in the censuses.

The area was studied 21-27 July 1967. Weather was regular and cyclical during that time, sunny mornings giving way to overcast or partly cloudy afternoons, accompanied sometimes by heavy downpours. A nearby town (Bluefields) logs 91 inches of rain per annum (Handbook of Jamaica, 1966). The form *grahami grahami* occurred throughout the study area. The other two common species, *sagrei* and *opalinus*, were restricted to open and closed areas respectively, and their horizontal ranges, though interdigitating, overlapped little at the same time of day. A fourth species, *valencienni*, was seen rarely. The investigation of the *opalinus-grahami* area has been partly reported in a different context (Schoener, 1970) but will be reiterated in entirety below so as to standardize its results.

RESULTS FOR LIZARD STRUCTURAL HABITATS

In the following discussion, all comparisons, unless stated otherwise, are statistically significant (Tables 6-9) as judged by the technique described in the appendix. Statements in the text to follow, such as lizards of species A "occurred higher" or "were

higher" than those of species B, should be interpreted as descriptive of the modal individual or the bulk of the population rather than of all individuals in the species' population. Large lizards could always be distinguished as adult males and will generally be referred to hereafter simply as "males." Smaller lizards included mostly adult or subadult females but also included some subadult males; they were all lumped into the class "female-sized lizards" because they could not usually be distinguished in the field. When sufficiently abundant, the smallest lizards—"juveniles"—are considered separately.

Mona (Tables 1, 6). At *Mona*, ten classes of lizards in four species were considered.

The highest lizard species observed was *valencienni*: males occurred higher than any other class, and female-sized *valencienni* were higher than all but *grahami* males. *A. grahami* was the next highest species: its males occurred higher than all classes of *lineatopus* and *opalinus*. The males of *opalinus* occurred higher than female-sized *grahami* and all *lineatopus*. Female-sized *grahami* were higher than all *lineatopus* and female-sized *opalinus*. Male *lineatopus* occurred higher than female-sized *opalinus* and *grahami* juveniles. Female-sized *opalinus* occurred higher than *grahami* juveniles and female-sized or juvenile *lineatopus*. Juveniles of *grahami* were higher than female-sized and juvenile *lineatopus*.

A. opalinus as a species was on perches of the greatest diameter; males of this species were on significantly thicker perches than all classes but male *grahami*, and only the latter occupied thicker perches than female-sized *opalinus*. Male *grahami* were also on thicker diameters than any other interspecific class. Female-sized *opalinus* and male *lineatopus* had about the same perch diameters but were on thicker perches than *valencienni* and female-sized or juvenile *grahami* and *lineatopus*. Female-sized *grahami*, *valencienni*, and *lineatopus* all occurred on thin perches of nonsignificantly different diameter. Juveniles of *lineatopus* and *grahami* occupied the smallest perches, the latter the smallest of all.

Intraspecifically, in all four species males perched higher than did female-sized individuals, and female-sized individuals in *grahami* and *lineatopus* occurred higher than did juveniles. In all but *valencienni*, males frequented thicker perches than did female-sized individuals, and in *grahami* and *lineatopus*, female-sized lizards were on thicker perches than juveniles.

Although climatic observations were not recorded at *Mona*, our impression is that the species tended to separate the way Rand (1967a) has described for a nearby area: *grahami* and *valencienni* were in the openest, sunniest situations; *lineatopus* was intermediate; and *opalinus* was in the shadiest areas. Relatively shady areas at *Mona* are associated with large-diametered trees, and the comparatively small *opalinus* preferred trees

whose diameters were bigger than those for any group but *grahami* males.

Port Antonio Open Area (Tables 2, 7). The classes studied in the open segment of the Port Antonio site were the same as those observed at Mona.

In relative height, the lizard classes were arranged in nearly identical fashion to those at Mona. Male *valencienni* were the highest, as before, followed by *grahami* males, which were here significantly higher than female-sized *valencienni*. Probably the greater number of low thin-branched shrubs in relation to trees in the open area at Port Antonio is responsible for this discrepancy with the Mona area. Next in height were male *opalinus*, higher than female-sized and juvenile *grahami* as well as all classes of *lineatopus*. Female-sized *grahami* and *opalinus* were distributed over similar heights and were higher than any class of *lineatopus*. Males of *lineatopus* were higher than juvenile *grahami*, but the latter were higher than female-sized or juvenile *lineatopus*.

In diameter, there was a major reversal from the pattern at Mona. Adult male *valencienni*, the largest of the four species, occurred on diameters not significantly thinner than those of *grahami* or *opalinus* males and significantly thicker than those of male *lineatopus*. Males of *opalinus* at Port Antonio were on thicker diameters than *grahami* males, and the latter showed no significant difference from female-sized *opalinus*. Female-sized *opalinus* were on thicker perches than female-sized or juvenile *grahami*, *lineatopus*, or *valencienni*. Males of *lineatopus* occurred on larger-diametered perches than did female-sized and juvenile *grahami* or female-sized *valencienni*. Female-sized *grahami* occupied thicker perches than did female-sized *valencienni* or female-sized and juvenile *lineatopus*. Female-sized *valencienni* occurred on thicker perches than did female-sized *lineatopus* or juveniles of *grahami* and *lineatopus*. Finally, female-sized *lineatopus* were on thicker perches than *grahami* juveniles.

Within the same species, males of *grahami*, *opalinus*, and *lineatopus* were found higher than smaller-sized individuals. In addition, female-sized anoles were higher than juveniles in *grahami* and *lineatopus*. For each species, classes whose individuals were of the largest size were found on thicker perches than all classes of smaller individuals.

Once again, *opalinus* and *grahami* segregated by shade and sun, respectively. And again, *opalinus*, a small species, occurred on bigger trunks and branches than did the larger species *grahami* or *lineatopus*. *A. opalinus* was also found close to the ground in shrubby, more tightly packed vegetation, where it was able to perch in the shade. In such areas, which were scattered in patches throughout the study site, *grahami* ranged higher, being found on leaves and more exposed branches. As at Mona, male *lineatopus*, similar in size to male *grahami*, were more often found on thinner perches.

Unlike the Mona situation where leaves were mostly small, the Port Antonio site contained many broad-leaved herbaceous plants. In such vegetation, particularly on leaves, it was common to see female and juvenile

grahami (Table 2). It is possible that *aquarum*, which is that form of *grahami* inhabiting the wettest lowland areas (including Port Antonio), is both smaller and of a brighter, more leafy green color because of its opportunity for occupying the more luxuriant green vegetation resulting from the heavy rainfall.

Port Antonio Closed Area (Tables 3, 8). In this more shaded site, so few *valencienni* were seen that they are all lumped into one category. Representatives of *grahami* were also very uncommon and are therefore not included. In addition, because of the much greater abundance of *opalinus*, female-sized individuals are treated separately from juveniles in that species.

In height, differences between all possible pairs of lizard classes were significant. The order of groups, from highest to lowest, was *valencienni*, *opalinus* males, *lineatopus* males, female-sized *opalinus*, *opalinus* juveniles, female-sized *lineatopus*, and *lineatopus* juveniles.

In diameter, *opalinus* males were on thicker perches than any other group. Female-sized *opalinus*, male *lineatopus*, and *valencienni* occurred on perches not significantly different in diameters, and all were on thicker perches than female-sized *lineatopus* or juveniles of *opalinus* and *lineatopus*. Female-sized *lineatopus* occurred on thicker perches than did juveniles of *opalinus*.

Intraspecific relations paralleled those for the other two areas: in *opalinus* and *lineatopus*, the larger the size of the lizard, the higher it occurred, and the thicker were its perches.

Whitehouse (Tables 4, 9). The study site near Whitehouse is identical in species composition to those near Mona and Port Antonio except that *sagrei* replaces *lineatopus*. The only form of *lineatopus* in the vicinity of the site is *neckeri*, an animal which seeks darker forest than *opalinus*. As stated above, climatic observations were recorded at Whitehouse in addition to those on structural habitat. Although reported in part elsewhere (Schoener, 1970), data treatment here differs in two major respects: the category "clouds" was added to those of "sun" and "shade" for the climatic variable, and "time" is not considered as an additional variable.

In this area again, *grahami* males and *valencienni* (all classes combined) were found at the greatest heights. They were followed by female-sized *grahami*, which occurred higher than any class of *sagrei* or *opalinus*. Juvenile *grahami* were found higher than *sagrei* and male *opalinus*. Both classes of *opalinus* perched at greater heights than did any class of *sagrei*.

Male *grahami*, male *opalinus*, and female-sized *opalinus* did not show significant differences in perch diameter, though the first were on the thickest perches. Male *grahami* were found on thicker diameters than male *sagrei*, but the latter did not differ significantly from either class of *opalinus*. Male *sagrei* occurred on thicker perches than did female-sized *grahami*, juvenile *grahami* and *valencienni*. Female-sized *sagrei*, juvenile *sagrei* and *valencienni* all had greater-diametered perches than did juvenile *grahami*. In addition, *sagrei* juveniles perched at greater diameters than did the combined *valencienni*.

Within the same species, adult males of *grahami*, *sagrei*, and *opalinus* perched higher than female-sized individuals. The latter in *sagrei* perched higher than juveniles, but in *grahami* the two classes were similar in height.

Once again, males of the three commonest species occurred on thicker perches than did smaller individuals, but the results were not significant for *opalinus*. Juveniles in *grahami* and *sagrei* were found on thinner perches than the other intraspecific classes.

Although there was an overall tendency for *sagrei* and *valencienni* to be found most often in the sun and *opalinus* most often in the shade or on cloudy days, this pattern varied by species class (Table 5). Males of *opalinus* were most consistently found in the shade: they were seen significantly more often during cloudy days or occurred more often on shady perches than male and juvenile *sagrei*, male and female-sized *grahami*, and *valencienni*. Juveniles of *sagrei*, in contrast, were very frequently seen in the sun: all classes of *grahami* and male *opalinus* were seen significantly more often in the shade or during cloudy weather than were juvenile *sagrei*. Only two other intraspecific comparisons were significant: female-sized *grahami* were most often seen in the sun or during cloudy days than male *sagrei*, and *valencienni* were most often seen in the sun or on cloudy days than male *grahami*. Thus there was no invariant tendency for that class recorded most often in the shade to be also the one recorded most often during cloudy weather.

Only a few intraspecific differences were significant: male *opalinus* were recorded more frequently in the shade or on cloudy days than smaller *opalinus*; female-sized *grahami* were more frequently seen in the sun or on cloudy days than male *grahami*, and female-sized *sagrei* were more frequently seen in the shade or during cloudy weather than juvenile *sagrei*. Thus there was some inclination for the smaller-sized lizards within a species to be on sunnier perches.

DIFFERENCES BETWEEN HABITAT VARIABLES

The statistical treatment of the structural-habitat data also detects significant interactions between the two perch variables, height and diameter, and when available, the climatic variable. Thus it answers the following kind of question: is there a significant association between thin perches and high perches for all perches combined of the two lizard classes being compared?

At Mona, for most comparisons among lizard classes, small perches occurred at greater heights than did large perches (Table 6). However, in the three of nine cases in which a significant height-diameter interaction was found (male *grahami* with female-sized *grahami*, male *valencienni*, or female-sized *valencienni*), the

reverse was true. In the Port Antonio open area, on the other hand, where trees were more widely scattered and there was much low second growth, all significant associations were of small-diametered perches with low heights. Whitehouse resembled the Mona area more than Port Antonio in its relation of perch height to perch diameter; low perches tended to be of larger diameter. This interaction again reflects the vegetation structure: at Whitehouse, there were few tall trees and little herbaceous understory—most large perches were therefore low, including the fenceposts especially preferred by *sagrei*. The only statistically significant exceptions to this pattern were for *sagrei* juveniles, the most terrestrial class of lizards on the site.

At Whitehouse, it was also possible to look for associations between the climatic categories and those of perch height and diameter (Table 9).

There were few significant interactions between perch height and insolation, probably because, in the patchy vegetation of the study site, the sun penetrated for the most part to vegetation of all heights. For intraspecific *sagrei* comparisons, higher perches tended to be relatively shady and lower perches relatively sunny. Individuals of *sagrei* were found more often than those of other species in areas away from the shade provided by large trees and shrubs: in such areas, most perches are both low and sunny. Lower perches in sun than during cloudy weather were found for the combined data of juvenile *grahami* and male *sagrei*. In contrast, the lowest perches were found in the shade or sun and the highest on cloudy days for female-sized *sagrei* lumped with *grahami* males. Why these were the only interspecific comparisons showing a significant height-insolation interaction is not apparent.

There were many more significant associations between perch diameter and insolation. All but one were of two sorts: the thinnest perches were occupied in the sun and the thickest in either shade or on cloudy days. (The exception was for female-sized and juvenile *grahami*: thinnest perches were shadiest, and thickest perches were utilized during cloudy weather.) In a previous study which also separated observations by time of day, a three-way interaction between diameter, insolation, and time was detected at Whitehouse (Schoener, 1970). Exterior perches tend to be thinner in all habitats, but in patchy ones such as that at Whitehouse, tend to be sunnier as well—thus the association may simply reflect the physiognomy of the vegetation. However, Jenssen (1970) found that

individuals of *Anolis nebulosus* climb into vegetation during mid-day and has attributed this behavior to a warming of the substrate. Perhaps a similar thermoregulatory function can explain the lizards' avoidance of sunny, large surfaces during most of the day at Whitehouse.

In several of the comparisons for each locality, the statistical procedure indicated that there might be significant three-way interactions between the variables (see appendix). Several are of interest. Two were interactions between perch diameter, insolation and lizard class. These were cases in which a low class, one of *sagrei*, was paired with a higher class, one of either *grahami* or *valencienni*. In *sagrei*, thick perches are more likely to be used in the shade on sunny days, whereas in the more arboreal forms, thick perches are more likely to be used on cloudy days. Another three-way interaction showed that *sagrei* males tended to seek out shady perches that were most often relatively high, whereas female-sized *sagrei* found their shady perches relatively lower. Both these results probably reflect differences in regard to relative availability of sunless perches between the habitats of the classes being compared.

As inspection of Tables 6-9 shows, there is a considerable number of significant interactions involving climatic and/or habitat variables alone; therefore the extended statistical treatment given the data of this paper is well justified. Most of these interactions reflect differences in the vegetational structure and its exposure to the sun. As mentioned, a few may indicate thermoregulatory behavior on the part of the lizards. However, the use of the climatic categories—sun, shade, and clouds—can only give a crude first approximation of the climatic preferences of these animals. Finer resolution would be gained were temperature, humidity, wind speed, and other variables measured at each perch.

DISCUSSION OF LIZARD STRUCTURAL HABITATS AND RELATION TO PREVIOUS STUDIES

The climatic and structural habitats of the lowland species can be summarized as follows.

1. *Climatic*. As first pointed out by Rand (1967a) for Kingston populations, in all localities *grahami* inhabited relatively open, sunny places and *opalinus* relatively closed, shaded places. At Mona and Port Antonio, *lineatopus* was intermediate in this regard. However, *sagrei*, its structural habitat counterpart at Whitehouse, occurred in sunnier, more exposed places than did *grahami*. In that

locality, *opalinus* occurred on lower perches than elsewhere and thus occupied in part perches where *lineatopus* would have been expected were it present.

2. *Structural*. In all four study areas, *valencienni* as a species was seen higher than its congeners (Figs. 1-4). Wherever found, *grahami* was next in height, followed usually quite closely by *opalinus*. However, at Port Antonio female-sized lizards of *grahami* *aquarum* were lower than either class of *opalinus*, reflecting their abundance in herbaceous vegetation at that site. *Lineatopus* and *sagrei* both occurred lowest in their respective sites though *sagrei* appeared relatively more terrestrial. The ranking of species by height at Mona was the same as that found by Rand in several localities near Kingston. As can be seen from the figures, no particular between-species relationship of species-size to height was evident. However, within species, smaller lizards always tended to occur lower than did larger ones.

The ordering of species with respect to perch diameter is slightly less consistent from locality to locality. At Mona, both male and female-sized lizards taken separately showed a perfect inverse relation of body size and perch diameter: the largest species, *valencienni*, occurred on the thinnest perches, followed by *lineatopus*, then *grahami*, and finally, the smallest species, *opalinus* (Fig. 1, Table 1). At Port Antonio Open, the situation was the same except that male *valencienni* occurred on thicker perches than all but male *opalinus*, and female-sized *lineatopus* occurred on thinner perches than female-sized *valencienni* (Fig. 2, Table 2). At Port Antonio Closed, where only two species were considered in detail, *opalinus* again took thicker perches than did *lineatopus* for both sexes (Fig. 3, Table 3). At Whitehouse, the ordering was essentially the same as at Mona, except that *sagrei* replaces *lineatopus* (Fig. 4, Table 4). However, *sagrei* is smaller than *grahami*, so there is not a perfect inverse relation of species-size and diameter at Whitehouse. Taken as a whole, the data are in almost total opposition to what would be expected if perch diameters were selected by species on the basis of body weight.¹ The inverse relation is made all the more interesting by the fact that within each

¹ It should be pointed out, however, that *garmani*, the largest species on Jamaica, was very rare and was therefore not considered in the study sites. What few data exist on the perch diameter of this species (Rand, 1967a, our unpublished data) indicate that *garmani* do not inhabit thinner perches than *valencienni* but rather are often found on large trees and therefore often perch on large branches.

species, all significant associations are of larger individuals with larger perches and vice-versa. Clearly some explanation other than a purely supportative one must be sought for species-specific differences in perch diameter.

A possible explanation is the following. Given that, within species, larger individuals are found on larger perches, an inverse relation between perch diameter and species size would be expected if species evolved so that that class of a given species overlapping in space the most with a class of another species was the one which differed the most in size from the latter class. In other words, a direct relationship between size and perch diameter *within* species and an inverse one *between* species is one way of ensuring that interspecific spatial overlap is between dissimilarly sized individuals. In fact, given the direct, within-species relationship, none of the 24 possible permutations of the species ordered by diameter results in less total difference in the sizes of the most closely overlapping interspecific pairs, though a few alternatives are about as good as the one discussed. Because anoline lizards of different sizes take differently sized foods (Rand, 1967a; Schoener, 1967, 1968; Schoener and Gorman, 1968), such staggering of sizes in space should alleviate resource competition (Rand, 1967b; Schoener, 1968).

Reversal of *both* the within- and between-species relationships is, of course, an alternative way of juxtaposing dissimilarly sized classes from different species. Why then does this second arrangement not occur instead? An answer can perhaps be found if we examine the probable course of faunal increase on Jamaica. It is highly unlikely that the four species evolved simultaneously and sympatrically. Therefore, while in isolation from other anoles, the first species to have evolved probably showed a *direct* within-species relationship between body size and perch diameter: not only is a direct relationship adaptive over the large range in body sizes spanned by the different age classes, but dominant individuals in *Anolis* are usually largest (Rand, 1967b; Trivers, in prep.; Schoener, in prep.) and would therefore appropriate the most suitable perches. Furthermore, all solitary species studied in heterogeneous vegetation showed such a direct relationship (Rand and Rand, 1966; Schoener, 1967; Schoener and Schoener, in prep.). Upon coming together, in order to achieve the second arrangement, the species would have to change their species-specific size and/or

perch diameters *as well as* the within-species relationship between size and perch diameter. Rather than that, it seems more feasible for species to shift their size and/or perch diameters in such a way as to preserve the intraspecific relationship and still avoid overlap of similarly sized individuals, *i.e.*, in accordance with the existing arrangement. The positioning of a relatively large species on perches of relatively small diameter could then be facilitated by morphological changes in body proportions, such as those in relative leg length. Indeed, some proportional differences do seem to exist in the Jamaican species: *valencienni*, the largest species considered, has relatively short limbs, particularly in femur. Similar changes in proportions would likely be more difficult to build into the ontogeny of single species, as would be necessary were the second arrangement adhered to.

Though there is no between-species relationship of perch height and size, the within-species tendency for smaller individuals to be found relatively low also results in minimal interspecific spatial overlap of similarly sized individuals, except for the *valencienni-grahami* combination, in which female-sized *valencienni* are about the same size as male *grahami*. However, those classes occur on quite different perch diameters (Figs. 1-2, Tables 1-4), and Trivers (personal communication) has evidence for major differences in searching for prey and, possibly, prey taxa between the two species. Rand (1967a) noted a tendency for *opalinus* and *lineatopus* to juxtapose dissimilar sizes according to height, in localities around Kingston, but he found the opposite for *grahami* and *lineatopus*. A further difference between Rand's and our study is that his data for small-sized *grahami* are bimodally clustered by height, one mode being below six feet and the other above ten feet. A likely reason for the discrepancy is difference in the structure of the available vegetation of the respective sites. Rand observed most of his *grahami* on the campus of the University of the West Indies where there is little high, shrubby understory surrounding the large trees. Thus the distribution of female-sized *grahami* may have paralleled differences in vegetational layers. The three localities we looked at were all more overgrown and vegetationally more heterogeneous. We also found a greater difference in perch height between male and female-sized *grahami* in all localities than did Rand. Possibly at Mona there were many more females on high branches than we were able to detect, but this is unlikely to be much of a factor at

either Port Antonio or Whitehouse, where the canopy is lower and more broken. Again, the lack of a viney, bushy understory in the "park-like" vegetation where Rand studied most of his *grahami* is probably responsible for the difference. A third possible reason for the difference is simply some effect associated with the smaller sample size Rand used, either one purely of sampling error, or one related to a smaller range of times of day or weather conditions than covered in our study.

ACKNOWLEDGMENTS

We thank T. A. Jenssen, A. S. Rand, R. L. Trivers, and E. E. Williams for critical comments on the manuscript and S. D. Fienberg for statistical advice. We also thank C. B. Lewis and T. Farr of the Jamaica Institute and I. Goodbody of the University of the West Indies for assistance in the field. Research was supported by NSF grants GB 3167 to the Committee on Evolutionary Biology, Harvard University, and NSF grants GB 6944 and B 019801X to E. E. Williams.

APPENDIX I

STATISTICAL APPENDIX

Data of the sort presented above are ideally treated in the form of a multiway contingency table, because variables are both ordinal (perch height and diameter) and nominal (lizard group, climatic category). In the case of nominal variables, there is no problem in selecting categories (referred to as "levels"): there are two lizard groups and three climatic categories (see above). However, for ordinal variables, a continuous set of quantitative data must be broken at one or more places in order to form categories. Because of the multiplicative increase in the total number of cells in a contingency table with increasing number of categories for a single variable, two categories each were chosen for perch height and perch diameter. That is to say, all observations less than or equal to some number were cast into one category, and all those greater than that number were cast into the other. The point at which the data were broken was chosen by computing that number which gave the maximum difference in cumulative frequency between the two distributions of observations belonging to the lizard groups being compared. Hence this procedure was designed to detect

maximum differences in height and diameter taken separately between the lizard classes, although because of interactions between variables, it will not necessarily produce a maximum difference in a combined model. The critical values were, of course, usually much removed from those required to give maximum interaction between the environmental variables themselves (e.g., perch height and insolation). The critical value so determined for height or diameter was generally different in different comparisons, and ranged from one-fourth inch to four inches for diameter and eleven inches to ten feet for height. An alternative procedure would have been to choose the same intervals for all comparisons, but given the great variation in lizard habitat preference, would have obscured most differences. What we have in effect done is to redefine "high" and "thick" for each comparison. There are statistical objections to this procedure, but at present appropriate alternative methods of grouping data are not available (Fienberg, 1970). The points at which the data were broken are listed here (Table 10) for two reasons: 1) Other researchers may wish to define "high" and "thick" differently and therefore can better compare their method with the one used here; and 2) It is of biological interest when comparing habitat distributions to know where the point of maximum difference lies, especially in case the observations were repeated later in the same or similar areas.

Once categories were chosen, the procedures diverged for three and four variable situations.

In the four-way case, a contingency model was first set up which contained all possible two-factor or pairwise interactions between the four variables; in this case there were $\binom{4}{2} = 6$ such interactions. Then an iterative procedure described elsewhere (Bishop, 1969; Mosteller, 1968; Fienberg, 1970; Schoener, 1970) was used to fit the data to the model, that is, to compute expected values for each cell of the contingency table. Two measures of goodness of fit, the standard chi-square and the log-likelihood chi-square (Kullback, 1959) were computed and degrees of freedom determined as described by Ku and Kullback (1968) and Fienberg (1970). It was then noted whether the model gave a fit satisfactory at the 5 per cent level. In most cases the two statistics were very similar, but where they allowed a different conclusion to be drawn about significance, the log-likelihood ratio chi-square was followed.

Next, each two-way interaction was individually dropped, giving six new models. For each of these, the difference between the new

model and the original model was evaluated for statistical significance by testing the difference in their log-likelihood ratio chi-squares, according to the partitioning technique expounded in Kullback (1959), Ku and Kullback (1968), and Fienberg (1970). If all new models were significantly different from the old model at the 5 per cent level the process was terminated. Otherwise, that new model was then chosen (and thereby the corresponding interaction removed) whose log-likelihood ratio chi-square was most similar to that of the original model. The procedure was then repeated, five new models each containing four two-way interactions being tested against the model containing five two-way interactions. Interactions were thus removed, one at a time, until all models with a smaller number of interactions were judged significantly different from the next most inclusive model, or until no interaction remained.

Because of space limitations, detailed results could not be reported as they were in a previous paper (Schoener, 1970). Instead, the results are summarized in Table 10. The six tiers of the table correspond to the six possible two-way interactions. For each lizard combination, these are given a number from zero to four. A "1" denotes that the interaction remained significant in the above sense every time it was tested in the removal procedure. A "2" denotes that the interaction was significant at least at the termination of the procedure. A "3" means that the interaction was significant when removed from the most inclusive model (with six interactions) but not at termination. A "4" indicates that the interaction was significant sometime during the procedure but not at the beginning or end. A "0" indicates that the interaction was never significant. Interestingly, in Table 10 most interactions could be labelled either "0" or "1", and in the simpler three-variable case, all interactions could be so labelled (Tables 7-9). In the discussion of the text, any interaction labelled 1-4 is considered significantly non-zero, but the tables should be checked for fine distinctions.

In the case of three-variable tables (perch height, perch diameter, and lizard group), there are $\binom{3}{2} = 3$ two-way interactions. The reduction procedure for these was similar to that described for four-way tables, but of course is much shorter: only three new models need be tested against the most inclusive model on the first round instead of six.

Rarely, a set of models was encountered which never gave a

chi-square value denoting a satisfactory fit of the model at the 5 per cent level, regardless of what interactions were removed. These are labelled in the tables. In such cases, differences between models were still computed in the usual way and the results listed in the tables. In addition, however, a search was programmed for significant three-way interactions, in order to see if an improved fit could be obtained. In the case of four variables, there are $\binom{4}{3} = 4$ three-way interactions. The procedure was to test each of four models corresponding to the addition of a different three-way interaction to the model with all two-way interactions. For the Whitehouse data, there was no tendency for any particular three-way interaction to predominate: each produced the best fit at least once. Some of these are discussed in the text. In no case was it necessary to consider more than one three-way interaction in order to produce a satisfactory fit. Once such a fit was obtained, the three two-way interactions able to be removed were deleted one at a time as before, and differences in chi-square with more inclusive models were tested. In most cases, the two-way interactions that could be removed without producing a significant difference between models were the same as some of those removed in the analysis of two-way interaction models only.

In the case of a model with three variables, there is but a single three-way interaction. Fitting this interaction would be a trivial exercise resulting in a perfect fit (within the limits of computational accuracy); therefore, three-way interactions could only be considered for tables with four variables.

In several cases it happened that margins (the total number of observations in a particular category of a variable or combination of such categories) were zero. For these cases, two procedures were tried. The first was to correct for the additional degrees of freedom lost in such a table according to the method of Bishop (unpublished thesis; Fienberg, personal communication). Once this was done, the removal procedure could be carried out as before. In no case in the present study was the recalculated number of degrees of freedom zero or negative, though if there are too many zeros this will happen. A second way to handle zero margins is to adjust the table slightly by shifting one (if possible) or more observations so that margins are no longer zero. This is best done conservatively, that is, so as to reduce the likelihood of achieving a significant difference to the variables of interest, in our case those

in structural habitat. For such tables, where there was a choice from several cells for selecting the observation to be moved, the cell with the most observations was chosen. While far less preferable than the first method, table adjustment had to be carried out for the three-variable case, because the initial $2 \times 2 \times 2$ model tested has, assuming no zero margins, but one degree of freedom; thus no further deletion is possible. Unless otherwise specified, values in the tables of significance for four-way comparisons are computed by the first method, though in only about 15 per cent of tables with zero margins so far examined did conclusions from the two methods differ at all.

APPENDIX II

REMARKS ON OTHER LOCALITIES

Jamaica, like the other Greater Antilles, is large and topographically diverse, yet it contains only seven species as compared to Puerto Rico's ten, Hispaniola's 24 and Cuba's 24. Jamaica's less diverse fauna is in part apparently associated with a great variation from locality to locality within Jamaica in regard to what species are found in certain segments of the vegetation. Brief visits which we made to other Jamaican localities give an inkling of this variability. Already shown is that in western Jamaica *sagrei* replaces *lineatopus* as the open-area trunk-ground lizard. In darker, mesic forests west of the Whitehouse locality (such as that near Ferris Cross), the trunk-ground species is *lineatopus neckeri*, an olive green-brown form somewhat smaller than the nominate subspecies. *A. opalinus* is also common in such forests, but inhabits less shady places and is more likely to be encountered marginally. *A. grahami* seems entirely absent from these dark forests, but *garmani* is present. More xeric forests two to five miles east of the Whitehouse study area contained no trunk-ground species *per se*. Instead, *opalinus* occurred often on low perches (though no measurements were made), and *garmani* seemed commoner than at any of our study areas.

Yet other species combinations are possible. In natural beach vegetation near Rose Hall on the northwest coast, we saw *grahami* and *sagrei* commonly. Where this vegetation met the xeric "iron-shore" limestone formation, these species were replaced by *lineatopus merope*, a rubiginous form well camouflaged on the rust-colored limestone, and *garmani*. In certain moist mid-elevation sites such as

can be found about Mandeville, *garmani* was the common arboreal species, and *opalinus* occurred in quite open, sunny places, including low woodpiles and fenceposts. In these localities we found *grahami* to be practically absent, while *lineatopus neckeri* was common in the blackest part of the forest. E. E. Williams and T. A. Jenssen (personal communication) have also observed *opalinus* in exposed situations at Mandeville; Williams, however, found *grahami* moderately common in certain of these situations. In montane forest (c. 4000 feet), such as that surrounding Green Hills, we frequently observed *opalinus* in extremely exposed places, including along roadsides as at least temporarily a terrestrial lizard. Other lizards in the area were *valencienni* in open situations and *garmani* in somewhat more enclosed places; we also saw several *reconditus* in relatively dark woodland.

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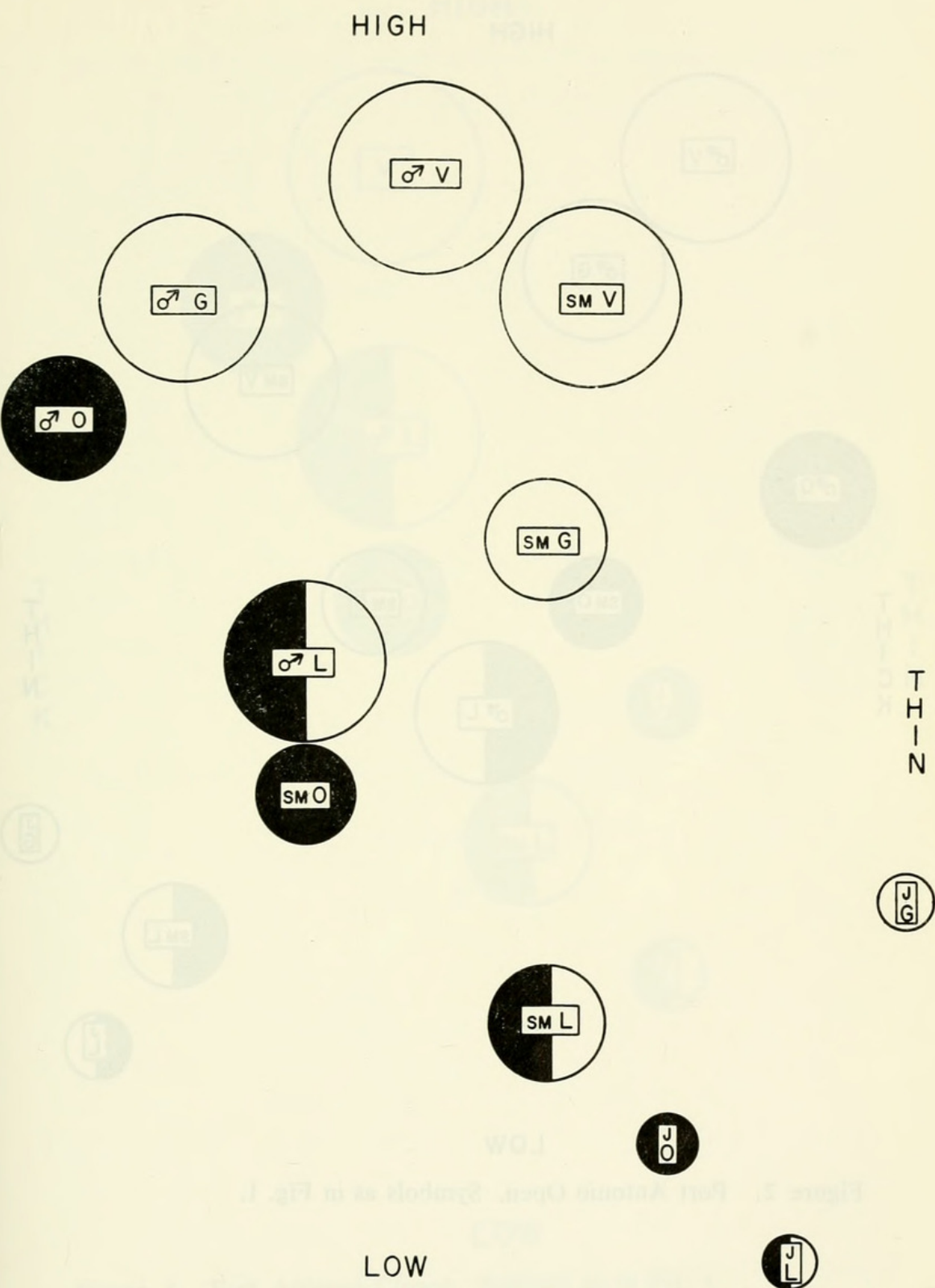


Figure 1. Mona. Species-classes are ranked by perch height and perch diameter; distances between species-classes are not representative of the magnitude of difference. Circles have diameters in proportion to the length of the individuals in the designated class. Clear circles are of classes found mostly in open, sunny areas; shaded circles are of classes in mostly closed, shady situations; intermediate classes are represented by half-shaded circles. V = *valencienni*, G = *grahami*, O = *opalinus*, L = *lineatopus*.

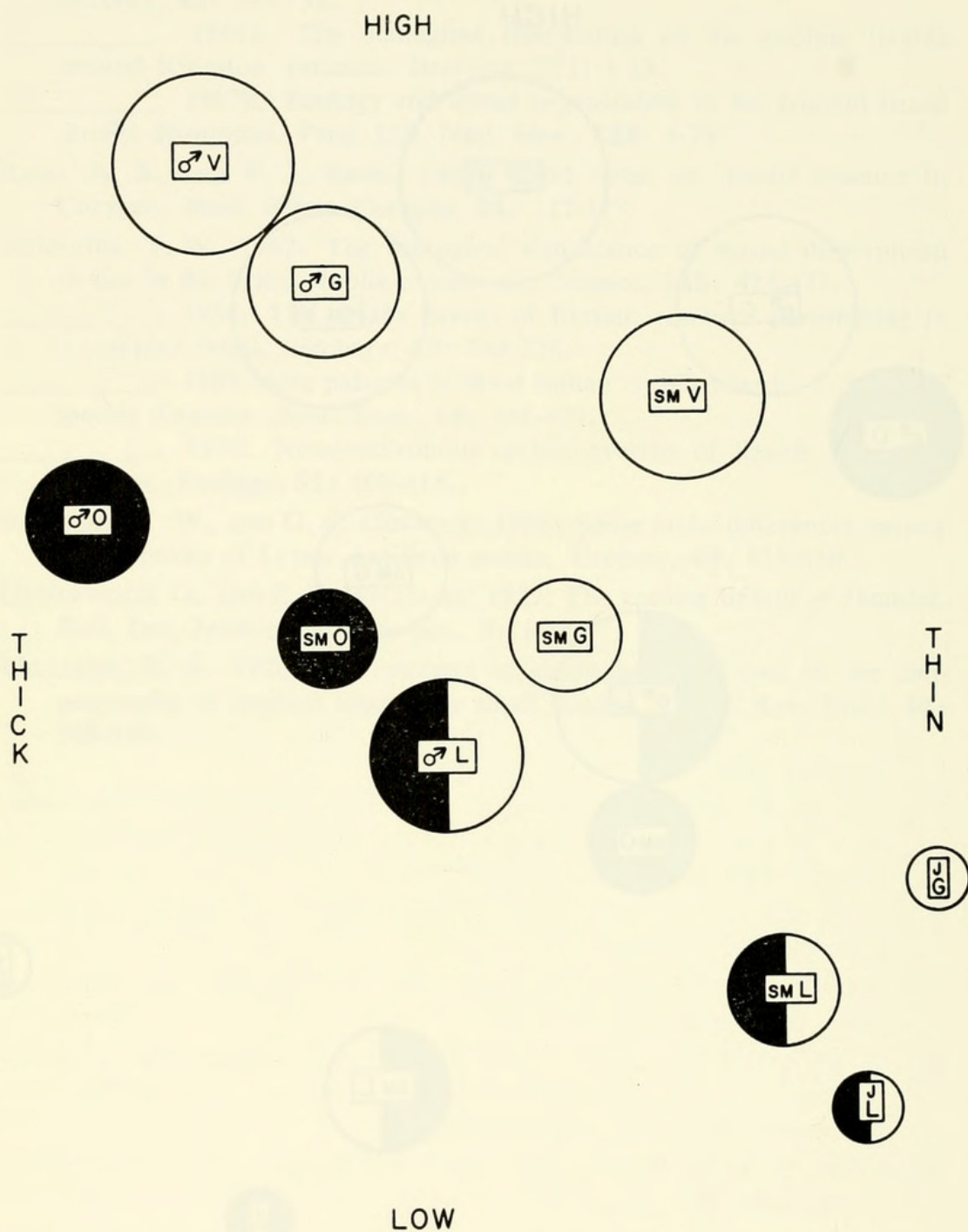


Figure 2. Port Antonio Open. Symbols as in Fig. 1.

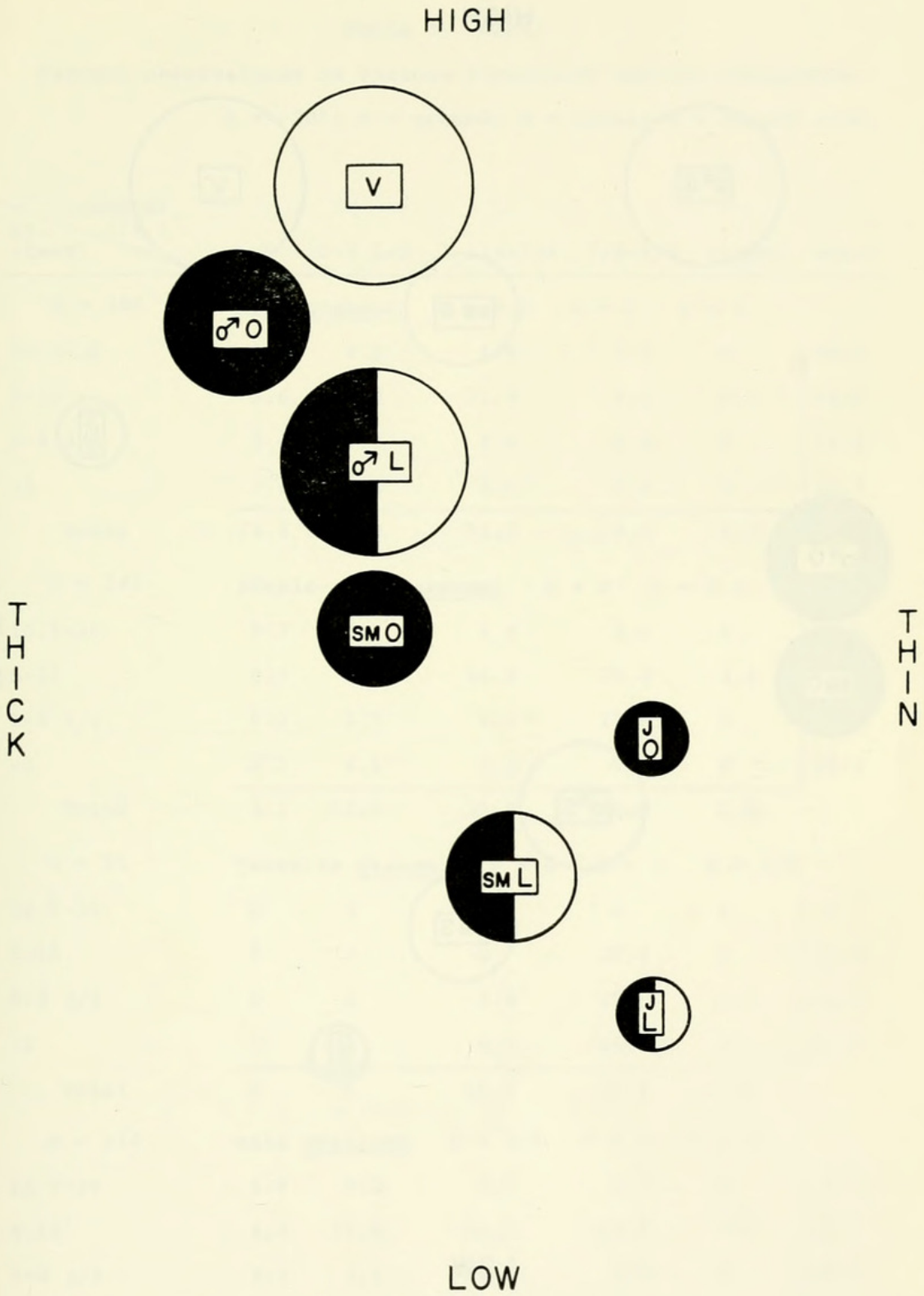


Figure 3. Port Antonio Closed. Symbols as in Fig. 1.

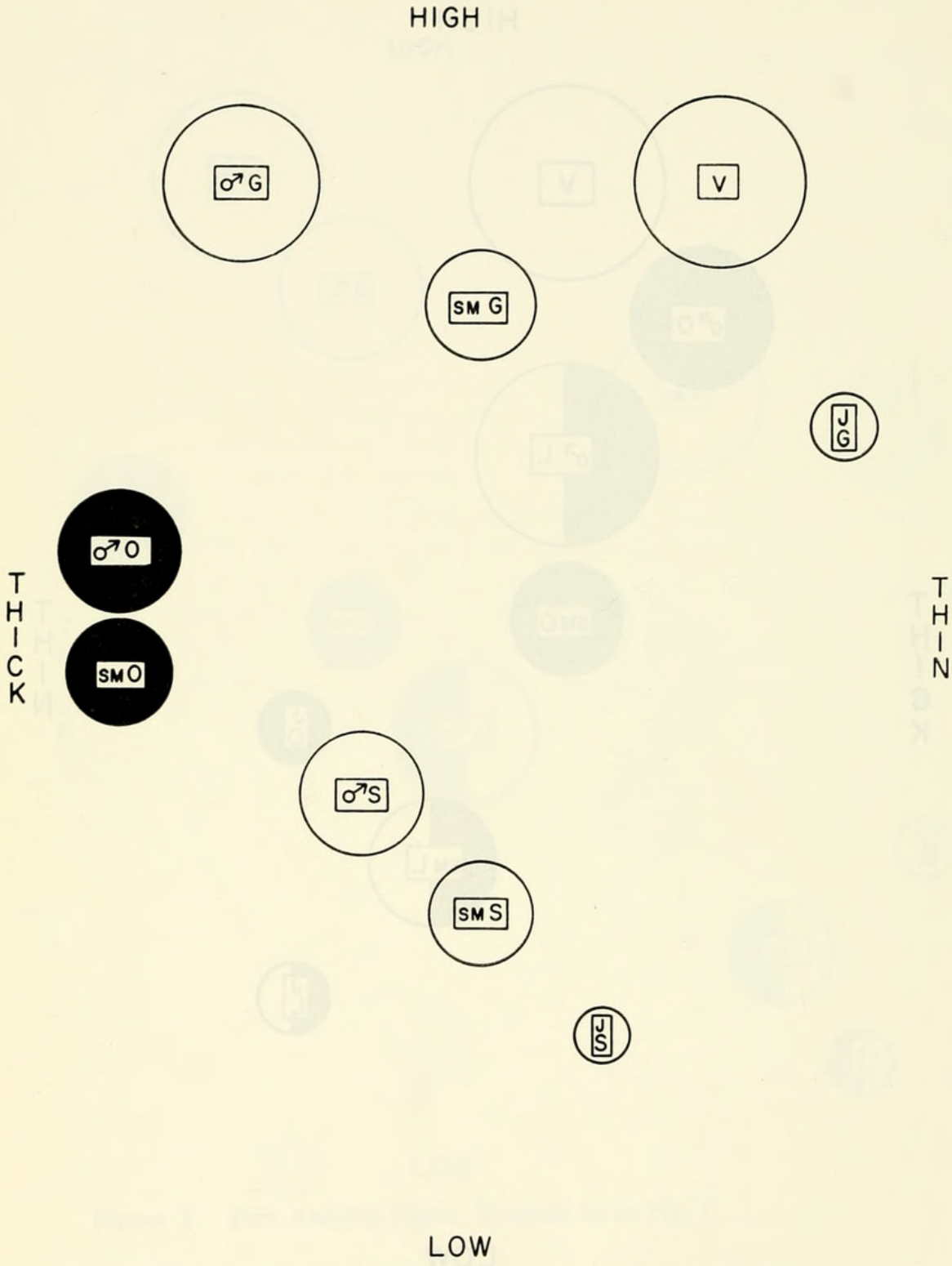


Figure 4. Whitehouse. Symbols as in Fig. 1. S = *sagrei*.

Table 1. Mona.

Percent observations in various structural habitat categories.

H = >20'; G = ground; R = rocks; N = sample size.

Diameter Ht. (in.) (feet)	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 385	male <u>grahami</u> H = 2.3 G = 0 R = 0					
10.5-20	3.6	8.1	6.6	3.8	0	22.1
5-10	3.6	13.8	21.4	9.5	0.3	48.9
3-4 3/4	3.6	5.5	4.6	3.5	0	16.2
<3	3.6	2.6	3.3	2.5	0	10.7
Total	12.4	30.0	35.9	19.3	0.3	
N = 246	female-sized <u>grahami</u> H = 0 G = 0.3 R = 0					
10.5-20	0.7	2.7	2.9	2.6	0	8.9
5-10	0.3	3.4	14.9	28.2	1.0	47.9
3-4 3/4	0.3	2.7	6.0	11.5	0	20.5
<3	2.7	4.1	7.2	8.4	0	22.4
Total	4.1	13.0	30.9	50.6	1.0	
N = 31	juvenile <u>grahami</u> H = 0 G = 0 R = 3.2					
10.5-20	0	0	0	0	0	0
5-10	0	0	0	25.8	0	25.8
3-4 3/4	0	0	4.8	37.1	3.2	45.1
<3	0	0	6.5	19.4	0	25.9
Total	0	0	11.3	82.3	3.2	
N = 214	male <u>opalinus</u> H = 0.4 G = 0 R = 0					
10.5-20	1.9	4.2	2.3	1.4	0	9.8
5-10	4.2	21.0	21.3	12.4	0.5	59.4
3-4 3/4	2.3	7.0	6.3	3.5	0	19.1
<3	1.9	5.6	3.3	0.5	0	11.3
Total	10.3	37.8	33.2	17.8	0.5	

Table 1. (cont'd).

<div> Diameter Ht. (in.) (feet) </div>	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 235	female-sized <u>opalinus</u>			H = 0	G = 0.9	R = 0
10.5-20	0.4	2.1	1.3	0.9	0	4.7
5-10	2.6	10.2	18.1	14.3	0	45.2
3-4 3/4	1.7	4.7	10.9	7.5	0	24.8
<3	3.4	8.1	8.3	4.9	0	24.7
Total	8.1	25.1	38.6	27.6	0	
N = 15	juvenile <u>opalinus</u>			H = 0	G = 0	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	0	0	22.2	0	22.2
3-4 3/4	0	0	0	11.1	0	11.1
<3	0	11.1	22.2	33.3	0	66.6
Total	0	11.1	22.2	66.6	0	
N = 838	male <u>lineatopus</u>			H = 0.2	G = 0.8	R = 0
10.5-20	0.4	1.1	1.8	0.1	0	3.4
5-10	2.6	13.4	22.6	13.0	0	51.6
3-4 3/4	2.1	7.2	14.1	9.5	0.1	33.0
<3	1.7	2.5	3.6	3.0	0	10.8
Total	6.8	24.2	42.1	25.6	0.1	
N = 436	female-sized <u>lineatopus</u>			H = 0	G = 4.4	R = 0
10.5-20	0	0	0	0	0	0
5-10	0.5	1.4	6.0	3.9	0.2	12.0
3-4 3/4	0.5	4.6	8.4	18.9	0	32.4
<3	1.4	8.3	16.3	24.8	0.7	51.5
Total	2.4	14.3	30.7	47.6	0.9	

Table 1. (cont'd).

<div> Diameter Ht. (in.) (feet) </div>	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 24	juvenile <u>lineatopus</u> H = 0 G = 12.5 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	0	0	0	0	0
3-4 3/4	0	4.2	0	8.8	0	12.5
<3	0	8.3	2.1	56.3	8.3	75.0
Total	0	12.5	2.1	64.6	8.3	
N = 15	male <u>valencienni</u> H = 6.7 G = 0 R = 0					
10.5-20	0	6.7	6.7	13.3	0	26.7
5-10	0	6.7	6.7	33.3	0	46.7
3-4 3/4	0	0	0	13.3	0	13.3
<3	0	0	0	6.7	0	6.7
Total	0	13.4	13.4	66.6	0	
N = 16	female-sized <u>valencienni</u> H = 6.3 G = 0 R = 0					
10.5-20	0	6.3	6.3	12.5	0	25.1
5-10	0	12.5	6.3	6.3	0	25.1
3-4 3/4	6.3	6.3	0	12.5	0	25.1
<3	0	0	0	18.8	0	18.8
Total	6.3	25.1	12.6	50.1	0	
N = 3	juvenile <u>valencienni</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	33.3	0	33.3
5-10	0	0	0	0	0	0
3-4 3/4	0	0	0	0	0	0
<3	0	0	0	66.7	0	66.7
Total	0	0	0	100.0	0	

Table 2. Port Antonio Open.

Percent observations in various structural habitat categories.

H = >20'; G = ground; R = rocks; N = sample size.

Diameter Ht. (in.) (feet)	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 146	male <u>grahami</u> H = 4.1 G = 1.4 R = 0					
10.5-20	2.7	6.9	2.7	0	0	12.3
5-10	5.5	7.5	12.3	11.0	0	36.3
3-4 3/4	5.5	3.4	1.7	9.9	0.7	21.2
<3	4.8	2.1	6.8	8.9	2.1	24.6
Total	18.5	19.9	23.6	29.8	2.7	
N = 163	female-sized <u>grahami</u> H = 0.6 G = 2.5 R = 0					
10.5-20	0.6	0.6	0.6	0	0	1.8
5-10	1.2	2.5	7.7	5.2	0	16.6
3-4 3/4	1.2	0	2.8	10.7	1.8	16.6
<3	3.7	2.5	4.6	34.7	16.6	62.0
Total	6.8	5.5	15.6	50.6	18.4	
N = 75	juvenile <u>grahami</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	0	0	0	0	0
3-4 3/4	0	0	0	10.7	0	10.7
<3	0	0	1.3	57.3	30.7	89.4
Total	0	0	1.3	68.0	30.7	
N = 176	male <u>opalinus</u> H = 1.1 G = 0 R = 0					
10.5-20	0.6	1.7	10.8	1.7	0	14.8
5-10	5.7	15.9	12.8	4.3	0	38.6
3-4 3/4	6.3	11.4	5.4	6.0	0	29.0
<3	4.6	7.4	0.6	3.4	0.6	16.5
Total	17.1	36.4	29.6	15.3	0.6	

Table 2. (cont'd).

<div> Diameter Ht. (in.) (feet) </div>	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 136	female-sized <u>opalinus</u> H = 0 G = 0 R = 0					
10.5-20	0	1.5	0	0	0	1.5
5-10	3.7	5.2	14.3	4.8	0.7	28.7
3-4 3/4	3.7	2.9	5.5	7.0	0.7	19.9
<3	2.9	6.6	11.0	27.9	1.5	50.0
Total	10.3	16.2	30.9	39.7	3.0	
N = 21	juvenile <u>opalinus</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	0	4.8	4.8	0	9.5
3-4 3/4	0	0	0	14.3	0	14.3
<3	0	0	9.5	66.7	0	76.2
Total	0	0	14.3	85.7	0	
N = 183	male <u>lineatopus</u> H = 0 G = 3.3 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	1.1	1.6	3.8	0	6.6
3-4 3/4	2.2	6.6	5.2	13.4	0.6	27.9
<3	3.8	7.7	12.0	37.7	1.1	62.3
Total	6.0	15.3	18.9	54.9	1.6	
N = 110	female-sized <u>lineatopus</u> H = 0 G = 11.8 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	0	0	0	0	0
3-4 3/4	0	0	0.5	5.0	0.9	6.4
<3	0	0.9	9.1	63.6	8.2	81.8
Total	0	0.9	9.5	68.6	9.1	

Table 2. (cont'd).

Diameter Ht. (in.) (feet)	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 23	juvenile <u>lineatopus</u>			H = 0	G = 26.1	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	0	0	0	0	0
3-4 3/4	0	0	0	0	0	0
<3	0	0	0	56.5	17.4	73.9
Total	0	0	0	56.5	17.4	
N = 25	male <u>valencienni</u>			H = 4.0	G = 0	R = 0
10.5-20	8.0	12.0	16.0	0	0	36.0
5-10	8.0	12.0	12.0	8.0	0	40.0
3-4 3/4	4.0	4.0	0	0	0	8.0
<3	0	0	4.0	8.0	0	12.0
Total	20.0	28.0	32.0	16.0	0	
N = 36	female-sized <u>valencienni</u>			H = 2.8	G = 0	R = 0
10.5-20	2.8	0	0	0	0	2.8
5-10	2.8	2.8	8.3	19.5	0	33.4
3-4 3/4	2.8	8.3	0	11.1	2.8	25.0
<3	2.8	0	0	33.3	0	36.1
Total	11.1	11.1	8.3	63.9	2.8	
N = 3	juvenile <u>valencienni</u>			H = 0	G = 0	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	0	0	33.3	0	33.3
3-4 3/4	0	0	0	0	0	0
<3	0	0	0	66.7	0	66.7
Total	0	0	0	100.0	0	

Table 3. Port Antonio Closed.

Percent observations in various structural habitat categories.

H = >20'; G = ground; R = rocks; N = sample size.

Diameter Ht. (in.) (feet)	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 185	male <u>opalinus</u> H = 1.6 G = 0.5 R = 0					
10.5-20	6.5	1.6	1.6	2.2	0	11.9
5-10	7.0	9.7	22.2	9.7	0	48.6
3-4 3/4	5.9	1.6	8.6	2.7	1.1	19.9
<3	1.6	2.7	9.2	3.2	0.5	17.2
Total	21.1	15.7	41.6	17.8	1.6	
N = 206	female-sized <u>opalinus</u> H = 1.0 G = 2.4 R = 0					
10.5-20	0.5	0.5	0.7	1.2	0	2.9
5-10	8.3	3.4	9.5	15.8	0	37.0
3-4 3/4	5.3	1.5	5.8	6.8	0.5	19.9
<3	6.3	3.9	9.5	15.8	1.5	37.0
Total	20.4	9.2	25.5	39.6	1.9	
N = 79	juvenile <u>opalinus</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	1.3	1.3	19.0	0	21.5
3-4 3/4	0	0	0	17.7	0	17.7
<3	0	0	9.5	50.0	1.3	60.8
Total	0	1.3	10.8	86.7	1.3	
N = 122	male <u>lineatopus</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	0	0	0
5-10	4.1	3.3	15.6	14.8	0	37.7
3-4 3/4	5.7	3.3	10.2	18.4	0.8	38.5
<3	4.1	3.3	9.0	7.4	0	23.8
Total	13.9	9.9	34.8	40.6	0.8	

Table 3. (concl'd).

Diameter Ht. (in.) (feet)	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 112	female-sized <u>lineatopus</u>			H = 0	G = 3.6	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	0.9	0.9	8.9	0	10.7
3-4 3/4	0	0.9	4.9	21.0	0.9	27.7
<3	2.7	1.8	16.5	30.8	6.3	58.0
Total	2.7	3.6	22.3	60.7	7.2	
N = 32	juvenile <u>lineatopus</u>			H = 0	G = 3.1	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	0	0	6.3	0	6.3
3-4 3/4	0	0	0	6.3	0	6.3
<3	0	3.1	9.4	53.1	18.8	84.4
Total	0	3.1	9.4	65.7	18.8	
N = 13	<u>valencienni</u>			H = 0	G = 0	R = 0
10.5-20	7.7	7.7	15.4	7.7	0	38.5
5-10	0	0	15.4	15.4	0	30.8
3-4 3/4	15.4	7.7	0	7.7	0	30.8
<3	0	0	0	0	0	0
Total	23.1	15.4	30.8	30.8	0	

Table 4. Whitehouse.

Percent observations in various structural habitat categories.

H = 20'; G = ground; R = rocks; N = sample size.

Diameter Ht. (in.) (feet)	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 219	male <u>grahami</u> H = 1.4 G = 0.5 R = 0					
10.5-20	1.8	1.8	2.3	1.4	0	7.3
5-10	2.7	9.6	21.5	9.1	2.3	45.2
3-4 3/4	0.5	7.3	10.1	4.1	0.5	22.5
<3	1.8	10.1	7.1	4.3	0	28.3
Total	6.8	28.8	41.0	18.9	2.8	
N = 284	female-sized <u>grahami</u> H = 0 G = 2.5 R = 0.4					
10.5-20	0	0	0.4	0.7	0	1.1
5-10	0.7	2.8	14.1	21.8	4.6	44.0
3-4 3/4	1.8	1.8	5.8	7.9	2.5	19.8
<3	1.4	9.9	12.3	7.7	1.1	32.4
Total	2.9	14.5	32.6	38.1	8.2	
N = 54	juvenile <u>grahami</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	0	0	0
5-10	0	0	3.7	38.9	0	42.6
3-4 3/4	0	1.9	1.9	31.5	0	35.3
<3	0	0	6.5	13.9	1.9	22.3
Total	0	1.9	12.1	84.3	1.9	
N = 88	male <u>opalinus</u> H = 0 G = 0 R = 0					
10.5-20	0	0	0	0	0	0
5-10	1.1	6.8	18.2	4.6	0	30.7
3-4 3/4	2.3	13.6	15.9	1.1	0	32.9
<3	1.1	20.5	9.1	4.6	1.1	36.4
Total	4.5	40.9	43.2	10.3	1.1	

Table 4. (cont'd).

<div> Diameter Ht. (in.) Ht. (feet) </div>	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 72	female-sized <u>opalinus</u>		H = 0		G = 2.8	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	5.6	7.0	1.4	0	14.0
3-4 3/4	2.8	4.2	16.7	1.4	0	25.1
<3	2.8	31.9	19.5	4.2	0	58.4
Total	5.6	41.7	43.2	7.0	0	
N = 10	juvenile <u>opalinus</u>		H = 0		G = 0	R = 0
10.5-20	0	0	0	0	0	0
5-10	0	0	10.0	20.0	0	30.0
3-4 3/4	0	10.0	10.0	20.0	0	40.0
<3	0	10.0	10.0	10.0	0	30.0
Total	0	20.0	30.0	50.0	0	
N = 263	male <u>sagrei</u>		H = 0		G = 6.5	R = 2.7
10.5-20	0	0	0	0	0	0
5-10	0	0.8	1.5	0	0	2.3
3-4 3/4	0	6.5	8.4	2.3	0	17.2
<3	2.3	30.0	27.8	11.4	0	71.5
Total	2.3	37.3	37.7	13.7	0	
N = 393	female-sized <u>sagrei</u>		H = 0		G = 13.2	R = 4.8
10.5-20	0	0	0	0	0	0
5-10	0	0	0.8	0.3	0	1.1
3-4 3/4	0	1.6	1.3	0.3	0	3.2
<3	2.5	31.8	22.5	21.0	0	77.8
Total	2.5	33.4	24.6	21.6	0	

Table 4. (concl'd).

<div> Diameter Ht. (in.) (feet) </div>	>5	5-2 1/2	2 1/4-7/8	7/8-1/8	leaves	Total
N = 251	juvenile <u>sagrei</u>		H = 0	G = 31.9	R = 4.0	
10.5-20	0	0	0	0	0	0
5-10	0	0	0.8	1.6	0	2.4
3-4 3/4	0	0.8	0.4	2.0	0	3.2
<3	2.0	17.8	12.6	25.6	0.4	58.4
Total	2.0	18.6	13.8	29.2	0.4	
N = 7	male <u>valencienni</u>		H = 0	G = 0	R = 0	
10.5-20	0	0	0	0	0	0
5-10	14.3	0	28.6	42.9	0	85.8
3-4 3/4	0	0	14.3	0	0	14.3
<3	0	0	0	0	0	0
Total	14.3	0	42.9	42.9	0	
N = 8	female-sized <u>valencienni</u>		H = 0	G = 0	R = 0	
10.5-20	0	0	0	0	0	0
5-10	0	0	0	25.0	0	25.0
3-4 3/4	0	0	37.5	0	0	37.5
<3	0	0	0	37.5	0	37.5
Total	0	0	37.5	62.5	0	
N = 7	juvenile <u>valencienni</u>		H = 0	G = 0	R = 0	
10.5-20	0	0	0	0	0	0
5-10	0	0	42.9	14.3	0	57.2
3-4 3/4	0	0	0	28.6	0	28.6
<3	0	0	14.3	0	0	14.3
Total	0	0	57.2	42.9	0	

Table 5. Percent observations for Whitehouse
species in climatic categories.

	Sun	Shade	Clouds
male <u>sagrei</u>	17.4	74.4	8.3
female-sized <u>sagrei</u>	15.9	73.8	10.2
juvenile <u>sagrei</u>	33.8	58.8	7.4
male <u>grahami</u>	12.4	74.6	12.9
female-sized <u>grahami</u>	20.5	61.4	18.1
juvenile <u>grahami</u>	15.7	66.7	17.6
male <u>opalinus</u>	3.5	72.1	24.4
small <u>opalinus</u>	14.5	66.3	19.3
<u>valencienni</u>	36.4	50.0	13.6

Table 6. Statistical significance for Mona comparisons ^a

group vs. height		group vs. diameter																			
grahami ♂	grahami ♀	female- sized grahami	grahami juvenile	lineatopus	female- sized lineatopus	lineatopus juvenile	opalinus ♂	small opalinus	valencienni	female- sized valencienni	grahami ♂	grahami ♀	female- sized grahami	grahami juvenile	lineatopus	female- sized lineatopus	lineatopus juvenile	opalinus ♂	small opalinus	valencienni	female- sized valencienni
grahami ♂		1	1	1	1	1	1	1	1	0	grahami ♂		1	1	1	1	1	1	1	1	0
female-sized grahami	1*		1	1	1	1	1*	1*	1*	1*	female-sized grahami		1*		1	1	1	1*	1*	1*	1*
grahami juvenile	1*	1*		1*	1	1	1*	1*	1*	1*	grahami juvenile	1*	1*		1	1	1	1*	1*	1*	1*
lineatopus ♂	1*	1	1		1	1	1*	1*	1*	1*	lineatopus ♂	1*	1	1		1	1	1*	1*	1*	1*
female-sized lineatopus	1*	0	1	1*		1	1*	1*	1*	1*	female-sized lineatopus	1*	0	1	1*		1	1*	1*	1*	1*
lineatopus juvenile	1*	1*	0	1*	1*		1*	1*	1*	1*	lineatopus juvenile	1*	1*	0	1*	1*		1*	1*	1*	1*
opalinus ♂	0	1	1	1	1	1		1	1	1	opalinus ♂	0	1	1	1	1	1	1*	1*	1*	1*
small opalinus	1*	1	1	0	1	1	1*			1	small opalinus	1*	1	1	0	1	1	1*	1*	1*	1*
valencienni ♂	1*	0	1	1*	0	0	1*	1*		1	valencienni ♂	1*	0	1	1*	0	0	1*	1*	1	1
female-sized valencienni	1*	0	1	1*	0	0	1*	1*		1	female-sized valencienni	1*	0	1	1*	0	0	1*	1*	1*	0

Table 6 (concl'd)

height vs. diameter	comments											
	grahami ♂	female- sized grahami	grahami juvenile	lineatopus ♂	female- sized lineatopus	lineatopus juvenile	opalinus ♂	small opalinus	valencienni ♂	female- sized valencienni		
<u>grahami ♂</u>			Z									
<u>female-sized grahami</u>	1 (A)		Z									
<u>grahami juvenile</u>	0	0		Z	Z	Z	Z	Z	Z	NS		
<u>lineatopus ♂</u>	0	1 (A)	0					NS				
<u>female-sized lineatopus</u>	0	0	0	1 (B)						NS		
<u>lineatopus juvenile</u>	0	0	0	0	0							
<u>opalinus ♂</u>	0	1 (B)	0	0	1 (B)	1 (B)						
<u>small opalinus</u>	0	0	0	1 (A)	0	0	0					
<u>valencienni ♂</u>	1 (A)	1 (B)	0	1 (B)	0	1 (B)	0	0				
<u>female-sized valencienni</u>	1 (A)	1 (B)	1 (B)	1 (B)	0	1 (B)	0	0	0			

^a NS = model never significant at 5% level; Z = has zero margins; * = species at top has larger value;
A = small diameters at low perches; B = small diameters at high perches; for interpretation of numbers, see
"Statistical appendix."

Table 7. Statistical significance for Port Antonio Open comparisons a

group vs. height	group vs. diameter					
	grahami ♀	female- sized grahami	grahami juvenile	lineatopus ♀	female- sized lineatopus	lineatopus juvenile
grahami ♂	1	1	1	1	1	1
female-sized grahami	1*		1	1	1	1
grahami juvenile	1*	1*		1*	1	1
lineatopus ♂	1*	1	1		1	1
female-sized lineatopus	1*	1*	1	1*		1
lineatopus juvenile	1*	1*	0	1*	1*	1*
opalinus ♂	1	1	1	1	1	1
small opalinus	0	1	1	0	1	1
valencienni ♂	0	0	1	1	1	1
small valencienni	1*	1*	1	1*	1	1

Table 7 (concl'd)

height vs. diameter	comments		grahami ♂		female-sized grahami		grahami juvenile		lineatopus ♂		female-sized lineatopus		lineatopus juvenile		opalinus ♂		small opalinus		valencienni ♂		small valencienni	
grahami ♂			1 (A)						NS				Z									
female-sized grahami			0		0														Z			
grahami juvenile			0		1 (A)		1 (A)										NS		NS			
lineatopus ♂			0		0		0		0										Z			
female-sized lineatopus			0		0		0		0						NS				Z			
lineatopus juvenile			0		0		0		0		0				Z				Z		Z	
opalinus ♂			1 (A)		1 (A)		0		1 (A)		1 (A)		1 (A)									
small opalinus			1 (A)		1 (A)		1 (A)		1 (A)		1 (A)		0		1 (A)							
valencienni ♂			1 (A)		1 (A)		0		0		0		0		0		0					
small valencienni			1 (A)		1 (A)		0		1 (A)		0		0		1 (A)		1 (A)		1 (A)		1 (A)	

a NS = model never significant at 5% level; Z = has zero margins; * = species at top has larger value; A = small diameters at low perches; for interpretation of numbers, see "Statistical appendix."

Table 8. Statistical significance for Port Antonio Closed comparisons ^a

group vs. height	group vs. diameter					
	opalinus ♂	female-sized opalinus	opalinus juvenile	lineatopus ♂	female-sized lineatopus	lineatopus juvenile
opalinus ♂	1	1	1	1	1	1*
female-sized opalinus	1*	1	1	1*	1	1*
opalinus juvenile	1*	1*	1	1*	1	1*
lineatopus ♂	1*	0	1	1	1	1*
female-sized lineatopus	1*	1*	1	1*	1	1*
lineatopus juvenile	1*	1*	0	1*	1*	1*
valencienni	1*	0	1	0	1	1

Table 8. (concl'd).

group vs. diameter	comments									
	opalinus ♂	female- sized opalinus	opalinus juvenile	lineatopus ♂	female- sized lineatopus	lineatopus juvenile	valencienni	lineatopus juvenile	valencienni	lineatopus juvenile
opalinus ♂										
female-sized opalinus	0									
opalinus juvenile	0	0								
lineatopus ♂	0	0	0							
female-sized lineatopus	0	0	0	1 (B)						
lineatopus juvenile	0	0	0	0	0					
valencienni	0	0	0	0	0	0				

^a Z = has zero margins; * = species at top has larger value; B = small diameters at high perches; for interpretation of numbers, see "Statistical appendix."

Table 9. Statistical significance for Whitehouse comparisons a

group vs. height		sagrei ♂	female- sized sagrei	sagrei juvenile	grahami ♂	female- sized grahami	grahami juvenile	Opalinus ♂	small Opalinus	valencienni
group vs. diameter		sagrei ♂	female-sized sagrei	sagrei juvenile	grahami ♂	female-sized grahami	grahami juvenile	Opalinus ♂	small Opalinus	valencienni
	sagrei ♂	1*	1+	1	1*	1*+	1*	1*	1*	1*+
	female-sized sagrei	1*		1	1*	1*+	1*	1*	1*	1*+
	sagrei juvenile	1*	1*		1*	1*	1*	1*	1*	1*+
	grahami ♂	1	1	1		1	1	1	1	0
	female-sized grahami	1*	0	0	1*		0	1*	1	0
	grahami juvenile	1*	1*	1*	1*	1*		2	0	0
	Opalinus ♂	0	1	1	0	1	1		1	2*
	small Opalinus	0	1	1	0	1	1	0		1*
	valencienni	1*	1*	2*	1*	1*	1	1*	1*	

group vs. insolation										
	height vs. diameter	sagrei ♂	female- sized sagrei	sagrei juvenile	grahami ♂	female-sized grahami	grahami juvenile	opalinus ♂	small opalinus	valencienni
<u>sagrei</u> ♂			0	0	0	0	1*(E)	0	1*(C)	0
female-sized <u>sagrei</u>		0		1(C)	0	2*(E)	0	1(D)	0	0
<u>sagrei</u> juvenile		1(A)	0		2*(C)	1*(C)	2*(C)	1*(C)	0	0
<u>grahami</u> ♂		0	0	0		1*(F)	0	1*(C)	0	2*(E)
female-sized <u>grahami</u>		1(B)	1(B)	1(A)	1(B)		0	1*(C)	0	0
<u>grahami</u> juvenile		0	0	0	0	1(B)	0	0	0	0
<u>opalinus</u> ♂		0	0	0	0	1(B)	0		1(C)	1(C)
small <u>opalinus</u>		0	0	3(A)	0	1(B)	1(B)	0		0
<u>valencienni</u>		0	0	0	0	1(B)	1(B)	0	0	0

Table 10. Points at which data were broken for perch height and diameter.

diameter (inches)	height (feet)	Mona										♂				female-sized valencienni
		grahami	female- sized grahami	grahami	grahami juvenile	lineatopus	female- sized lineatopus	lineatopus juvenile	♂	lineatopus juvenile	opalinus ♂	small opalinus	valencienni	opalinus	valencienni	
<u>grahami</u> ♂		7 1/4	7 1/4	5 3/4	6 3/4	4 1/4	4 1/4	3	7 1/4	7 1/4	7	6	5			
female-sized <u>grahami</u>	7/8			5 1/4	6	4 1/4	4 1/4	3	3	6 3/4	7 3/4	7 3/4	7 3/4			
<u>grahami</u> juvenile	1	1		4 3/4	2 1/4	2 1/4	4 1/4	2 1/4	4 1/4	5 1/4	6	7	7			
<u>lineatopus</u> ♂	3	7/8	7/8	1	4 3/4	3	4 3/4	3	6	2 1/2	6	7 3/4	7 3/4			
female-sized <u>lineatopus</u>	1 1/4	3/8	3/8	1	7/8	2 1/4	4	2 1/4	4	4 1/4	6	6 1/4	6 1/4			
<u>lineatopus</u> juvenile	5/8	5/8	5/8	1	5/8	5/8			3	3	3	3	3			
<u>opalinus</u> ♂	1 3/4	1 3/4	1 3/4	1	1 3/4	1 3/4	1 3/4	7/8	7/8	3 1/4	7 3/4	10	10			
<u>small opalinus</u>	2	1	1	1	1 1/2	1	5/8	1 3/4	5/8	1 3/4	7 3/4	7 3/4	7 3/4			
<u>valencienni</u> ♂	3/4	3/4	3/4	1/4	3/4	3/4	5/8	5/8	3/4	3/4	3/4	5	5			
female-sized <u>valencienni</u>	3/4	2 1/4	2 1/4	1	3/4	2 1/4	5/8	5/8	3/4	3/4	1 1/2	1 1/2	1 1/2			

Port Antonio Closed

height (feet)	diameter (inches)						
		Opalinus ♂	female- sized Opalinus	Opalinus juvenile	lineatopus ♂	female- sized lineatopus	lineatopus juvenile
	<u>Opalinus ♂</u>	3 3/4	3 1/2	6 3/4	4 1/4	2	10
	<u>female-sized Opalinus</u>	1	3 1/2	2 1/4	4 1/4	2	2 3/4
	<u>Opalinus juvenile</u>	7/8	3/4	2 1/4	6 1/4	1	3 1/2
	<u>lineatopus ♂</u>	1	2 3/4	3/4	3	2	8
	<u>female-sized lineatopus</u>	1	3/4	3/4	5/8	2	3
	<u>lineatopus juvenile</u>	5/8	5/8	5/8	5/8	5/8	2
	<u>valencienni</u>	3/8	1 3/4	7/8	3	1 3/4	5/8

Port Antonio Open

height (feet)											
diameter (inches)	°	female- sized grahami	grahami juvenile	lineatopus °	female- sized lineatopus	lineatopus juvenile	opalinus °	small opalinus	valencienni °	small valencienni	
grahami ♂		3 1/2	2 1/4	3 1/2	2 1/4	1 1/4	10	2	6 3/4	3	
female-sized grahami	3/4		1 1/2	5	1 3/4	1 1/4	3 1/4	3 3/4	5 3/4	5 3/4	
grahami juvenile	3/8	3/8		1 1/2	1	1	3	3 1/2	2 1/4	1 1/2	
lineatopus ♂	3/4	3/8	3/8		1 3/4	1 1/4	3	3 1/2	5	5	
female-sized lineatopus	5/8	3/8	1/4	3/8		1 1/4	2	1 3/4	2 1/4	1 1/2	
lineatopus juvenile	5/8	3/8	1/4	3/8	1/4		1 1/4	1 1/4	1 1/4	1 1/4	
opalinus ♂	1 1/2	7/8	3/8	1	1	5/8		2	6 3/4	3	
small opalinus	2	7/8	3/8	7/8	5/8	3/8	2		6 3/4	1 1/2	
valencienni ♂	1 1/4	7/8	5/8	7/8	7/8	5/8	4	2 1/4		6 3/4	
small valencienni	3/4	3/8	3/8	3/8	1 1/2	5/8	3/4	3/4	3/4	3/4	

Table 10 (concl'd)

height (feet) diameter (inches)		Whitehouse									
		sagrei ♂	female- sized sagrei	sagrei juvenile	grahami ♂	female- sized grahami	grahami juvenile	opalinus ♂	small opalinus	valencienni	
sagrei ♂		1 1/6	1 1/6	1 1/6	3 1/2	3 1/2	3 1/4	3 1/2	3 1/4	3 1/2	
female-sized sagrei	3/4		11/12		2 1/2	2 1/2	2 3/4	2	2	2 3/4	
sagrei juvenile	7/8	7/8			1 3/4	1 1/6	2	1 3/4	1 1/6	2	
grahami ♂	4	4	7/8			4 1/4	7	4 1/4	4	7 3/4	
female-sized grahami	1 3/4	1 3/4	2		3/4		3 1/4	5 1/4	4	3 1/4	
grahami juvenile	7/8	7/8	7/8		7/8	7/8		3 1/4	3 1/2	5 3/4	
opalinus ♂	1 1/4	1 1/4	7/8	7/8	1 1/4	1 1/2	7/8		3 3/4	3 1/4	
small opalinus	2 3/4	3/4	7/8	7/8	2 3/4	2	7/8	1 1/4		3 3/4	
valencienni	1 1/4	1 1/4	1 1/2	1 1/2	1 1/4	1 1/4	7/8	1 1/4	1		



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