NICHE RELATIONSHIPS IN SHORE BUGS OF THE GENUS *Valleriola*

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Portion of BS thesis in Biology (Insect Ecology) conducted by the author in UP at Los Baños.

ABSTRACT

Valleriola buenoi **(Usinger) and ' *Valleriola mindorana* ι Drake were found to "coexist" on the same rock surfaces in the same area at the same time in Molawin Creek, Los Baños, Laguna. A closer examination of their niche relationships revealed varying degrees of habitat specialization in favorable areas. Differences in dispersion, behavioral patterns and microclimatic factors influencing fluctuation in their populations reveal a well-defined degree of niche divergence which explains their coexistence. Elevation, rock size and vegetation cover strongly determine their presence in streams. Observed mating preference for members of the same species demonstrates distinctness of V. buenoi and V. mindorana.**

Ann. Trop. Res. 2:232-249

INTRODUCTION

Studies on ecological relationships among closely related species with similar niches have shed light on problems concerning competitive displacement and coexistence principles. Such investigations may also lead to understanding the possible pathways leading to speciation in insects (De Bach, 1963, 1965). Of paramount interest is whether niche divergence – allowing for coexistence – as an evolutionary event, occurred during the period of sympatry or after the period of temporary allopatry (geographical isolation) and a return to sympatry. Most findings show that speciation may have been enhanced by geographical isolation where different prevailing environmental conditions allow for niche divergence of the isolated population from its parental population (Mayr, 1969, 1970), and that further niche divergence in time may have led to the formation of a new species. An eventual contact between the new species and its parental species may now have allowed coexistence to prevail.

In applied entomology, the niche concept has become important in recognizing differences among closely related pest species. Many biological control agents, (e.g., parasitoid insects) are known to exhibit a high degree of specificity to certain host species such that the success of control requires a full understanding of their niche breadths.

This study involves two closely related species of predatory semi-aquatic "shore bugs" of the genus *Valleriola* Distant (Hemiptera: Leptopodidae) which have been observed to occur together on rock surfaces along Molawin Creek, Los Baños, Laguna. Since *V. buenoi* and *V. mindorana* were frequently found on the same rocks in the same area at the same time, attempts were made to (a) show whether *V. buenoi* and *V. mindorana* are distinct species or are conspecific; (b) determine whether competition or coexistence of some kind exists between them; and (c) discover the mechanisms or factors responsible for either of these phenomena.

MATERIALS AND METHODS

Density and Distribution Patterns. — Individuals of both species were collected for five sampling periods from February to August, 1977 at Molawin Creek and its tributaries. The expanse of sampling covered the "Flatrocks" area down to the area near the UPLBCA Experiment Station. Aside from the regular sampling, intermittent trips to the creek were made to observe the behavioral patterns of the species during rainy days when the creek was flooded and the rocks were submerged.

Each sampling "plot" of rock surfaces was delimited by an imaginary circular area measuring 4 m. During each sampling, the plots were randomly established along the creek at an interval of 150-200 m.

The sampling plots were designated on a topographic map of the study area (Fig. 1). Plots were numbered consecutively and marked with bamboo pegs during each sampling period to avoid using the same in succeeding samplings. Fig. 1 shows that some plots were closely situated to previous sampling plots, and that the distance between them was not regular.

A total of 85 "plots" were sampled. The first sampling which consisted of 25 sample plots started from the "Flatrocks" area down to the area opposite the College COOP. From these sample plots, the starting point of the succeeding collections was determined based on the presence of the two species and the availability of suitable rock surfaces as possible refuge areas of the leptopodids. The succeeding sampling began on the area below the U.P. College of Forestry (UPCF) tennis court near the site where both species were recorded to be present (Plot No. 10, Fig. 1). This reduced the number of sampling plots to 15 but also extended the sampling area up to the vicinity of

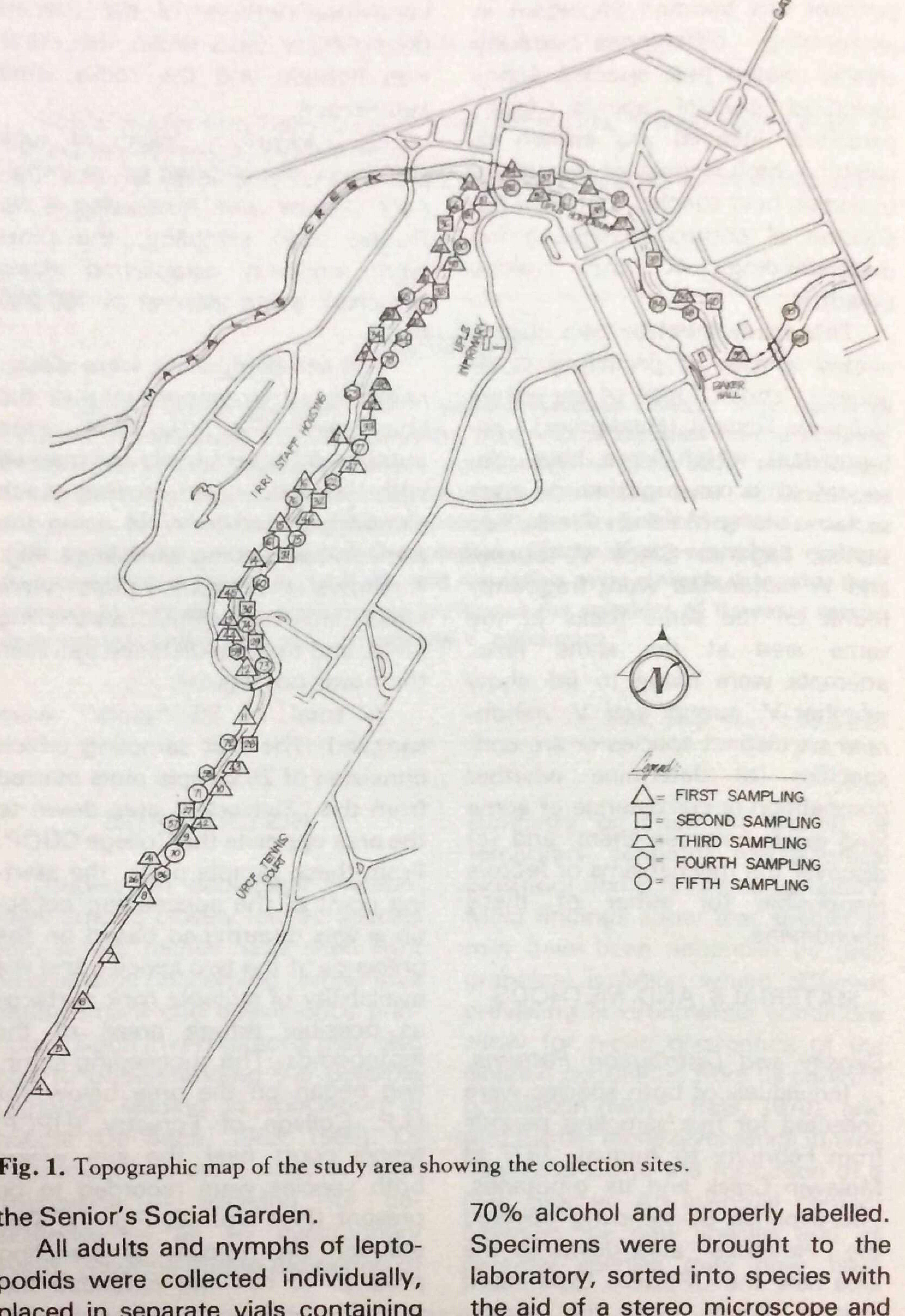

Fig. 1. Topographic map of the study area showing the collection sites.

the Senior's Social Garden.

All adults and nymphs of leptopodids were collected individually, placed in separate vials containing 70% alcohol and properly labelled. Specimens were brought to the laboratory, sorted into species with the aid of a stereo microscope and counts of each species per plot were recorded before they were preserved in ethyl alcohol for further studies.

Population densities of both species were plotted against sample plots to determine their density patterns and degree of distribution overlap. Average population densities were likewise plotted against sampling dates to show population trends within the seven-month period. The male-female ratio for both species was also determined, analyzed and interpreted in relation to population trends. Elevation was considered as a factor in determining distribution pattern for both leptopodids. Thus, the sampling area was divided into three general categories as follows: (1) high elevation, includes plots situated from the "Flatrocks" area down to the Makiling Botanical Gardens; (2) moderately high elevation, includes plots below the IRRI Staff Housing to the area below the UPLB Infirmary; and (3) low elevation, includes plots situated on the UPLB Hortorium area up to the Senior's Social Garden.

The index of dispersion was determined using Morisita's index (1959, 1962, 1964) as shown by the formula:

$$I = \frac{N \sum_{i=1}^{N} ni\,(ni-1)}{\Sigma x\,(\Sigma x - 1)} = \frac{N\Sigma x_2 - \Sigma x}{(\Sigma x)_2 - \Sigma x}$$

where N = total samples, ni = numbers in the ith sample and x = the sum of the number of individuals found in all the samples.

Niche-Breadth Relationships. — The ecological niches of the 2 species were determined by studying their habitat (spatial niche component), functional role in the community, position in environmental gradients of temperature, moisture, degree of shading, feeding habits, and reproductive behavior.

Densities of individuals during each sampling period were related with conditions prevailing in each sampling plot. Parameters like densities of shore bugs as affected by degree of shading, average rock size and nature of rock surface were used to delineate possible differences in habitat requirements for the two species using the following indices:

1. Degree of shading
   - A - completely shaded with trees and other vegetation
   - B - moderately shaded with tall trees
   - C - completely exposed to sunlight
2. Average rock size
   - A - large rocks, greater than 90 cm in diameter
   - B - moderately large rocks, greater than 45 cm or equal to 90 cm in diameter
   - C - small rocks, less than or equal to 45 cm in diameter

The nature of rock surface was described as either rough or smooth. The presence of lichens, mosses and ferns was also considered in differentiating rock surfaces.

Live specimens of both species

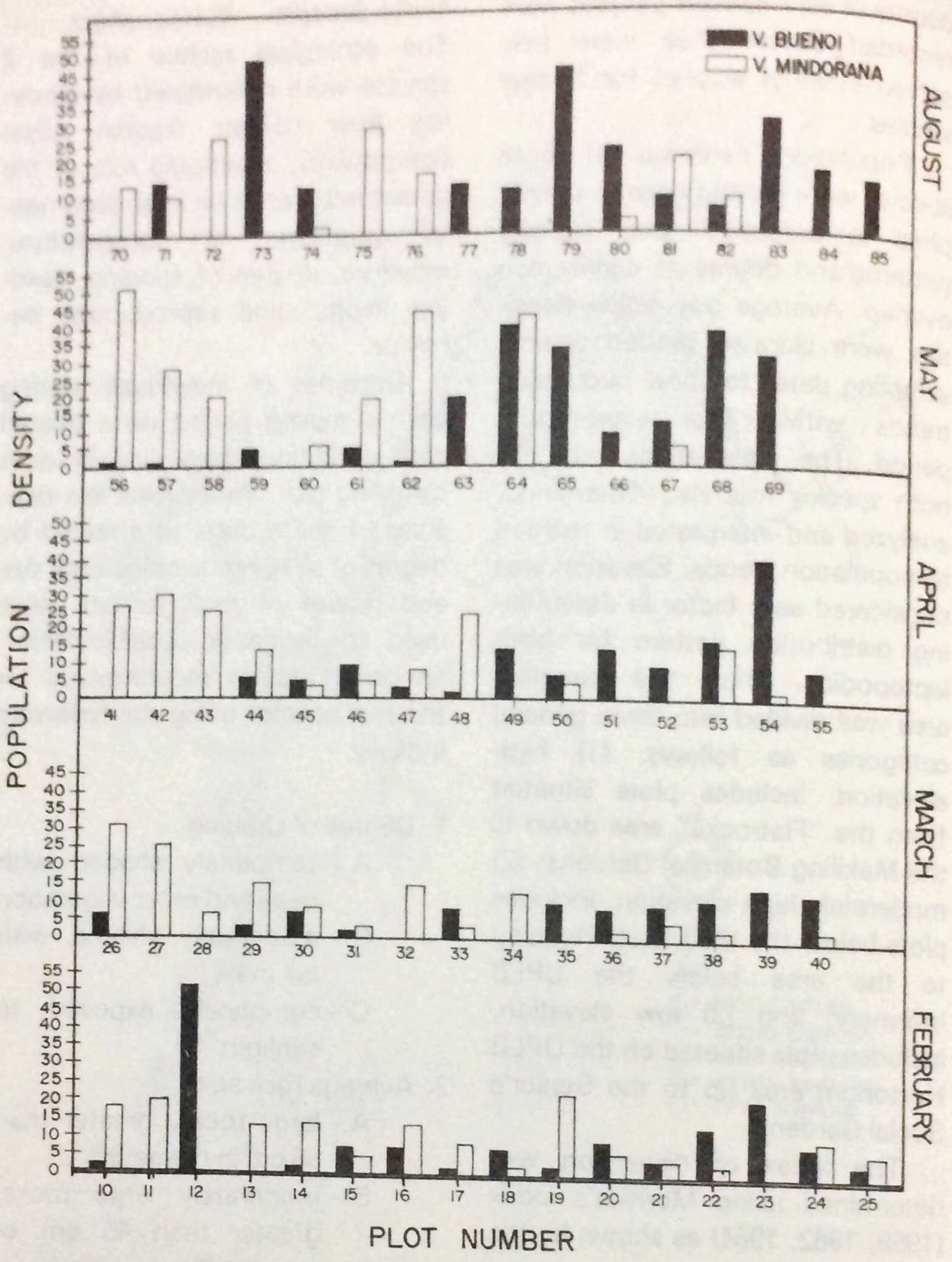

Fig. 2. Density of *Valleriola buenoi* and *V. mindorana* per 4 sq m in the various sampling periods.

were collected from the field and reared in a 60 x 120 cm aquarium, where the habitats of *V. buenoi* and *V. mindorana* were simulated. Possible food prey, such as Collembola, small adult flies (Diptera), and other minute insects were provided at regular intervals. Feeding behavior, mating behavior, oviposition and other pertinent information were recorded.

RESULTS AND DISCUSSION

Density and Distribution Patterns.

Fig. 2 shows the density of both species per 4 sq m as plotted against each plot number. Plot No. 12, which was located right after the Makiling Botanical Garden (MBG) bridge, gave the highest density for *V. buenoi* with 51 individuals. Plot no. 56, situated below the UPCF tennis court, gave the highest density for *V. mindorana* with 51 individuals. The lowest density for both species was recorded from plots harboring pure populations of either *V. buenoi* or *V. mindorana*.

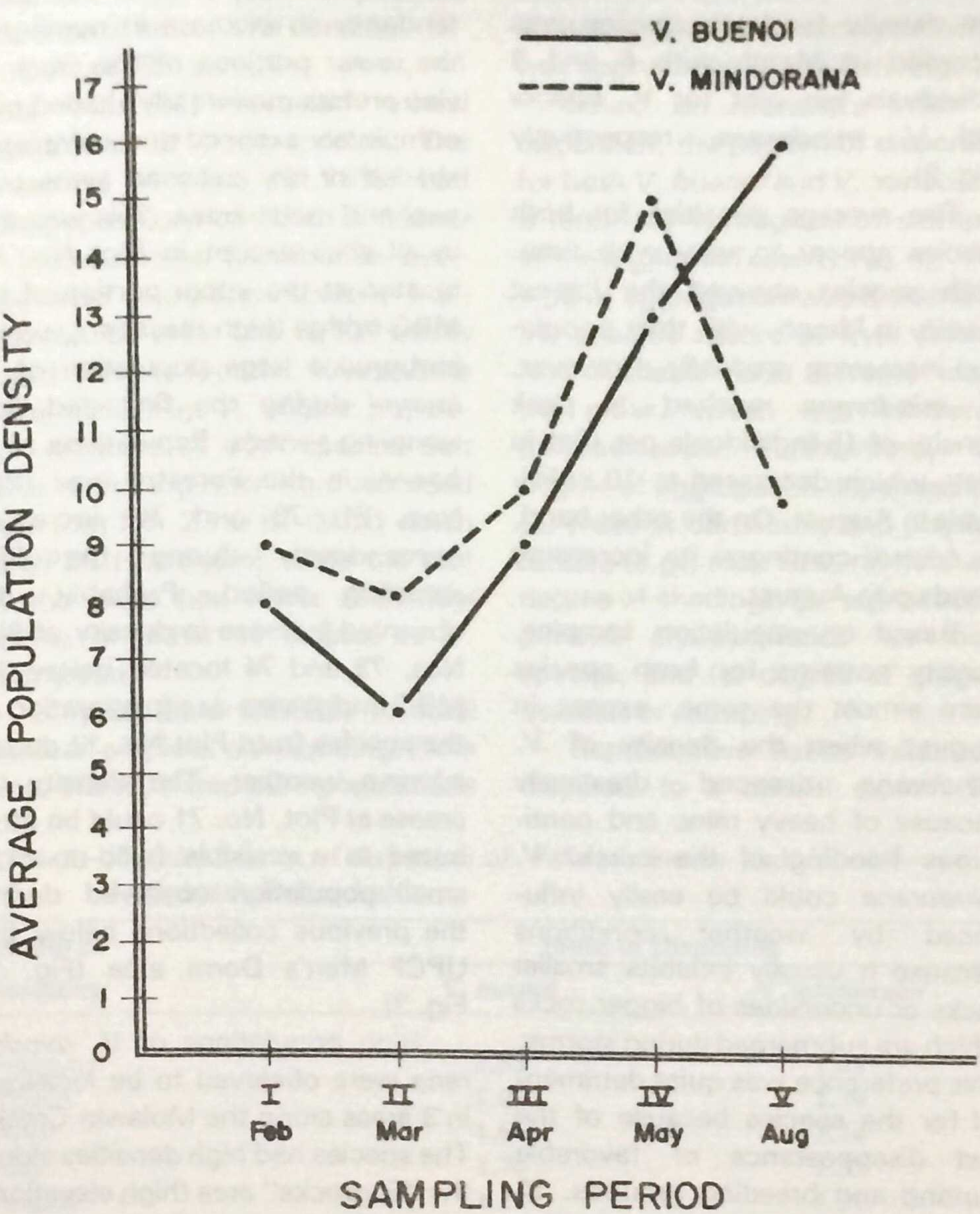

Fig. 3. Average density of *Valleriola buenoi* and *V. mindorana* from February to August, 1977.

Considering 14-16 plots per sampling period (including only Plot Nos. 10-25 for the first sampling), the month of August had the highest average density for *V. buenoi,* with an average of 16 individuals per plot. The highest average density for *V. mindorana,* of 15 individuals per plot, was obtained in May. The lowest average density for both species was recorded in March with 6 and 8 individuals per plot for *V. buenoi* and *V. mindorana,* respectively (Fig. 3).

The average densities for both species appear to vary with time. Both species showed the lowest density in March, with their population increasing gradually. However, *V. mindorana* reached its peak density of 15 individuals per plot in May, which decreased to 10 individuals in August. On the other hand, *V. buenoi* continued its increasing trend up to August.

Based on population samples, density patterns for both species were almost the same, except in August when the density of *V. mindorana* dropped drastically because of heavy rains and continuous flooding of the creek. *V. mindorana* could be easily influenced by weather conditions because it usually inhabits smaller rocks or undersides of bigger rocks which are submerged during storms. This preference was quite detrimental for the species because of the fast disappearance of favorable hunting and breeding grounds. *V. buenoi* can tolerate harsh weather conditions because it prefers to alight on exposed portions of rocks which are not completely submerged during floods. *V. buenoi* is also an aggressive flier and can easily avoid the effects of floods, thus enabling it to propagate its population despite adverse weather conditions.

Elevation seems to affect the population of *V. buenoi* due to its tendency to increase in number in the lower portions of the creek. It also prefers moderately shaded over completely exposed and completely shaded or dry exposed areas over cool and moist areas. This was true in all sites except in Plot No. 12. located at the upper portion of the MBG bridge (high elevation), which harbored a large population of *V. buenoi* during the first and fifth sampling periods. Populations of *V. buenoi* in the Forestry area (Plot Nos. 71, 73 and 74) increased tremendously during the fifth sampling period. Probably, the observed increase in density of Plot Nos. 73 and 74 located below the MBG bridge was due to migration of the species from Plot No. 12 during adverse weather. The density increase at Plot. No. 71 could be attributed to a possible build-up of a small population observed during the previous collections below the UPCF Men's Dorm area (Fig. 1; Fig. 2).

High populations of *V. mindorana* were observed to be localized in 3 areas along the Molawin Creek. The species had high densities along the "Flatrocks" area (high elevation) which was densely shaded with tall trees, below the UPCF tennis court and Men's Dorm (high elevation) which were relatively shaded with tall trees, and below the IRRI Staff Housing up to the area opposite the College Infirmary (moderately high elevation) which were relatively shaded areas. In general, high population densities of *V. mindorana* were found in areas with high elevation. This implies a possible influence of altitude on density.

Out of 85 sampling plots, 41 plots (48.24%) revealed mixed populations of both species. The remaining 44 plots (51.76%) had pure populations of either *V. buenoi* or *V. mindorana*. Distribution overlaps were located particularly from Plot No. 56 (near the UPCF tennis court) down to Plot No. 40 (opposite Baker Hall) (Fig. 1). Higher population densities of both species that were found together were recorded from Plot No. 29 to 81 (MBG down to UPLB Hortorium) while the rest of the plots had lower individual counts of either *V. buenoi* or *V. mindorana*.

Only 33 plots (38.82% of total number of plots disregarding Plots Nos. 1-9) harbored pure populations of either species — 18 for *V. buenoi* and 15 for *V. mindorana*. The plots from "Flatrocks" down to the UPCF tennis court (8 plots) had pure populations of *V. mindorana*, while those at the Baker Hall area (3 plots) sheltered individuals of *V. buenoi* only. The zone of overlap between the two species was approximately 3,000 m or two-thirds of the total stretch of the creek surveyed which was approximately 4,000 m (Fig. 1).

Based on Morisita's index of dispersion, the pattern of dispersion for both *V. buenoi* and *V. mindorana* is randomly contagious or clumped all throughout (Table 1; Fig. 1). This type of aggregation was dictated by the specific nature of their habitat (the available rock surfaces along the creek) which was inherently discontinuous. Furthermore, the degree of aggregation depended on: (a) weather conditions and physical factors (e.g., rock size, rainfall, and degree of shading); (b) reproductive pattern characteristics for both species; and (c) degree of gregariousness or clumping.

Reproductive habits influenced dispersal to a certain extent. For

Table 1. Morisita's index of dispersion of *Valleriola buenoi* and *V. mindorana* in the five sampling periods.

Month of Sampling	Index of Dispersion [1]	
	V. buenoi	V. mindorana
February	2.53	1.31
March	1.07	1.70
April	1.64	1.24
May	1.78	1.33
August	1.38	1.31

[1] See formula in Materials and Methods.

instance, the males were generally polygamous in nature, while most females were in the company of just a few males. This was observed to be true for both species. To a certain degree, both species were observed to have gregarious tendencies, in which the individuals of both species were often seen hunting together for prey on the same rock surface without showing signs of aggression.

The observed male-female ratios for both species showed that *V. buenoi* males always outnumbered the females during the first three samplings. During the fourth sampling, both sexes were more or less equal in number, and in the fifth sampling, the females outnumbered the males. The trend in population density of *V. buenoi* (Fig. 3), followed an increasing tendency despite the presence of fewer females in the beginning. As for *V. mindorana,* there was a relatively even distribution of both sexes among the individuals throughout the sampling period. This trend is probably not very significant with regards to its expected effects on population density. What happened was that when there were more males, the density of individuals during the next sampling decreased. These assumptions were made based on the belief that the sex ratio of previous collections would draw up the population density trends of the succeeding collections. It was also assumed that the previous collections represented the general conditions prevailing in the study area — although no two sampling plots overlap. Furthermore, current information does not permit any conclusive interpretation on the possible effect of sex ratio on population densities, because of the need to look at other possible parameters, e.g., generation time, net reproductive rate, rate of increase, age-specific natality rate, mortality rate, longevity, rates of emigration and immigration and effective distances of dispersal.

Niche Breadth Relationships

Physical Factors and Population Density. — *V. mindorana* preferred areas which were completely or moderately shaded with vegetation (types A and B, respectively) (Table 2; Fig. 4 and 5). Whenever they were collected in exposed areas (type C, Fig. 6), they were found on the edge of the creek where there were some vegetation and litter. It seems that *V. mindorana* is adapted to habitats at any elevation, as long as the required vegetation cover or cool condition exists. *V. buenoi,* on the other hand, seemed to prefer moderately shaded to completely exposed areas (types B and C, respectively) with more individuals collected in completely exposed areas. Although patchy populations of *V. buenoi* were encountered in areas with moderately high elevation (UPCF Men's Dorm and MBG areas), they were observed to adapt better in areas with lower elevation, probably because these areas lacked the vegetation cover characteristic of higher elevations.

Since both species preferred to

Table 2a. Leptopodid density (in % ratio) in relation to degree of shading, average rock size and nature of rock surface (12 February, 1977).

Plot Number	% Ratio of *V. buenoi* to *V. mindorana*	Degree of Shading*	Average Rock Size**	Nature of Rock Surface
1	0:100	A	—	—
2	0:100	A	—	—
3	0:100	B	—	—
4	0:100	A	—	—
5	0:100	A	—	—
6	0:100	A	—	—
7	0:100	B	—	—
8	0:100	B	—	—
9	0:100	B	—	—
10	5.26:94.74	B	—	—
11	0:100	A	B	rough, mossy
12	100:00	C	B	smooth
13	0:100	A	B	smooth, some moss & lichens
14	6.66:93.34	B	C	smooth
15	61.54:38.46	B	B	smooth with lichens
16	36.36:64.64	B	B	smooth, some with lichens
17	10:90	A	C	smooth
18	80:20	B	B	smooth, some with lichens
19	8.33:91.67	B	B	smooth
20	62.50:37.50	C	C	smooth
21	50:50	B	B	smooth
22	81.25:18.75	B	C	smooth
23	100:0	B	C	smooth
24	47.06:52.94	B	B	smooth
25	37.50:62.50	B	B	smooth

Table 2b. Leptopodid density (in % ratio) in relation to degree of shading, average rock size and nature of rock surface (12 March, 1977).

Plot Number	% Ratio of *V. buenoi* to *V. mindorana*	Degree of Shading*	Average Rock Size**	Nature of Rock Surface
26	16.22:83.38	B	A	smooth, some moss & lichens
27	0:100	A	C	rough, with moss & lichens
28	0:100	A	B	mossy rocks
29	16.67:83.33	B	C	smooth, some moss & lichens
30	46.67:53.33	B	B	smooth, ferns all around
31	33.33:66.67	B	B	smooth
32	0:100	B	B	smooth, with lichens
33	66.67:33.33	C	C	rough, with lichens & algae
34	0:100	A	C	smooth, with lichens
35	100:0	C	C	smooth
36	81.82:18.18	C	D	smooth
37	66.67:33.33	B	C	smooth
38	84.62:15.38	B	C	smooth
39	100:0	B	B	smooth
40	86.67:13.33	B	C	smooth, with lichens

stay in relatively shaded areas (B areas) at certain portions of the creek, it may be inferred that type B habitats denote zones of overlaps, being noticeably intermediates of types A and C (Table 2). Type A habitats were usually occupied by *V. mindorana* while type C habitats by *V. buenoi*.

Rock size strongly influenced the degree of population aggregation for both species. Large to medium-

Table 2c. Leptopodid density (in % ratio) in relation to degree of shading, average rock size and nature of rock surface (9 April, 1977).

Plot Number	% Ratio of *V. buenoi* to *V. mindorana*	Degree of Shading*	Average Rock Size**	Nature of Rock Surface
41	0:100	B	C	smooth, some moss & lichens
42	0:100	B	C	rough, with moss & lichens
43	0:100	A	C	with lichens and moss
44	30:70	B	B	smooth, with lichens
45	55.56:44.44	C	C	smooth, with lichens
46	66.67:33.33	C	C	smooth
47	33.33:66.67	B	C	smooth, with lichens
48	7.41:92.59	B	B	smooth, with lichens
49	100:0	C	C	smooth
50	63.64:36.36	C	C	smooth, with lichens
51	100:0	C	C	smooth
52	100:0	C	C	smooth
53	53.33:46.67	B	B	smooth
54	95.35:04.65	B	C	smooth
55	100:0	B	C	smooth

sized rocks were preferred by both species, although groups of two or four individuals were occasionally found on smaller rocks.

Feeding Habits. — When flies (drosophilids and chironomids) were introduced in the aquarium, both species became quite active. *V.*

Table 2d. Leptopodid density (in % ratio) in relation to degree of shading, average rock size and nature of rock surface (23 May, 1977).

Plot Number	% Ratio of *V. buenoi* to *V. mindorana*	Degree of Shading*	Average Rock Size**	Nature of Rock Surface
56	1.92:98.08	B	B	rough, with moss & lichens
57	3.45:96.55	A	C	with lichens and moss
58	0:100	A	C	with lichens and moss
59	100:0	B	C	smooth, with lichens
60	0:100	B	B	smooth, with lichens
61	24:76	B	C	smooth, with lichens
62	2.17:97.83	B	C	smooth with lichens
63	100:0	A	B	smooth, with lichens
64	47.62:52.38	B	C	smooth, with lichens
65	100:0	C	C	smooth
67	70.59:29.41	B	C	smooth
68	100:0	B	C	smooth
69	100:0	B	C	smooth

mindorana occupied the mossy rocks away from the water while *V. buenoi* stayed on the smooth rock partially submerged in water. They positioned themselves on top of the rocks, cautiously viewing their surroundings for possible prey. They moved their heads upward, downward, and sideward during hunting.

Upon seeing a fly on top of the

Table 2e. Leptopodid density (in % ratio) in relation to degree of shading, average rock size and nature of rock surface (25 August, 1977).

Plot Number	% Ratio of *V. buenoi* to *V. mindorana*	Degree of Shading*	Average Rock Size**	Nature of Rock Surface
70	0:100	B	C	rough, with lichens & moss
71	58.33:41.67	B	C	with lichens and moss
72	0:100	A	B	smooth with moss
73	100:0	C	C	smooth
74	87.71:12.29	B	C	smooth with lichens
75	0:100	A	C	with lichens and moss
76	0:100	A	C	smooth, with lichens & moss
77	100:0	B	C	smooth, with lichens
78	100:0	B	C	smooth, with lichens
79	62.5:37.5	B	C	smooth, with lichens
80	88.46:11.54	B	C	smooth, with lichens
81	30:70	B	C	smooth, with lichens & moss
82	43.75:56.25	B	C	smooth
83	100:0	C	C	smooth
84	100:0	B	B	smooth, with lichens
85	100:0	B	B	smooth

* DEGREE OF SHADING
- A — completely shaded with trees and other vegetation
- B — moderately shaded with tall trees
- C — completely exposed to sunlight

** AVERAGE ROCK SIZE
- A — large rocks, greater than 90 cm in diameter
- B — moderately large rocks, greater than 45 cm or equal to 90 cm in diameter
- C — small rocks, less than or equal to 45 cm in diameter

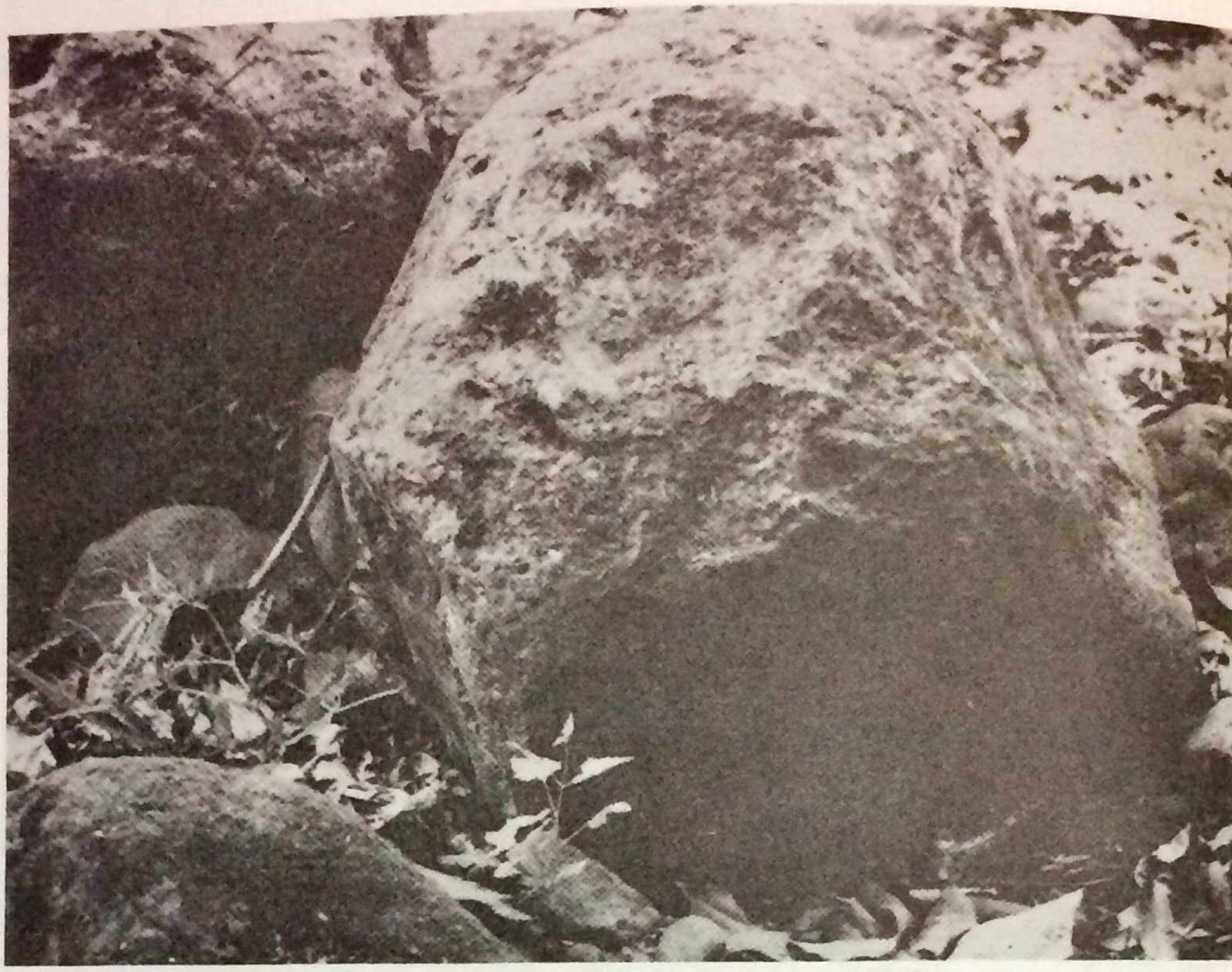

Fig. 4. Habitat of *Valleriola mindorana* showing lichenous rock with bryophte growth. Molawin Creek, Mt. Makiling.

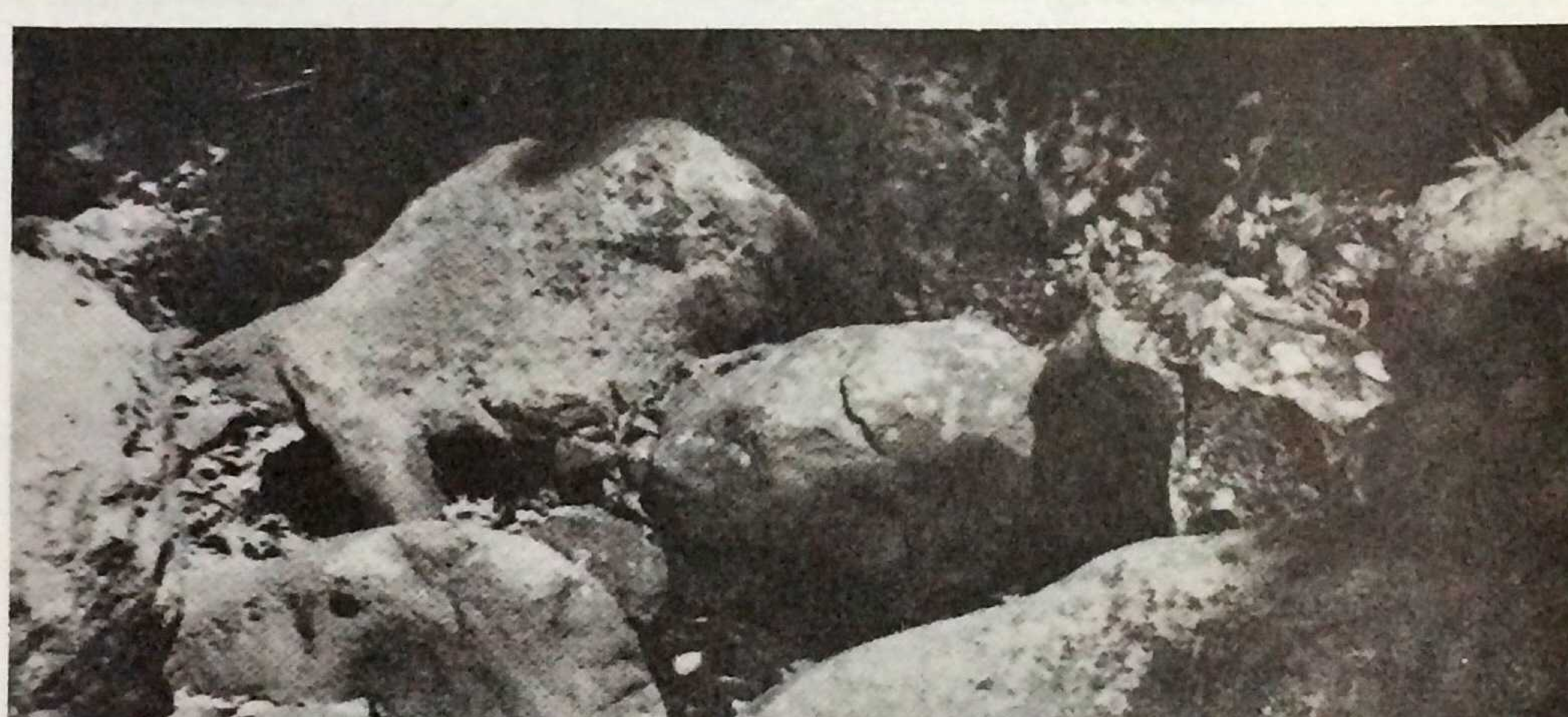

Fig. 5. Rock surface typical of intermediate areas where both *Valleriola buenoi* and *V. mindorana* occur, Molawin Creek, Mt. Makiling.

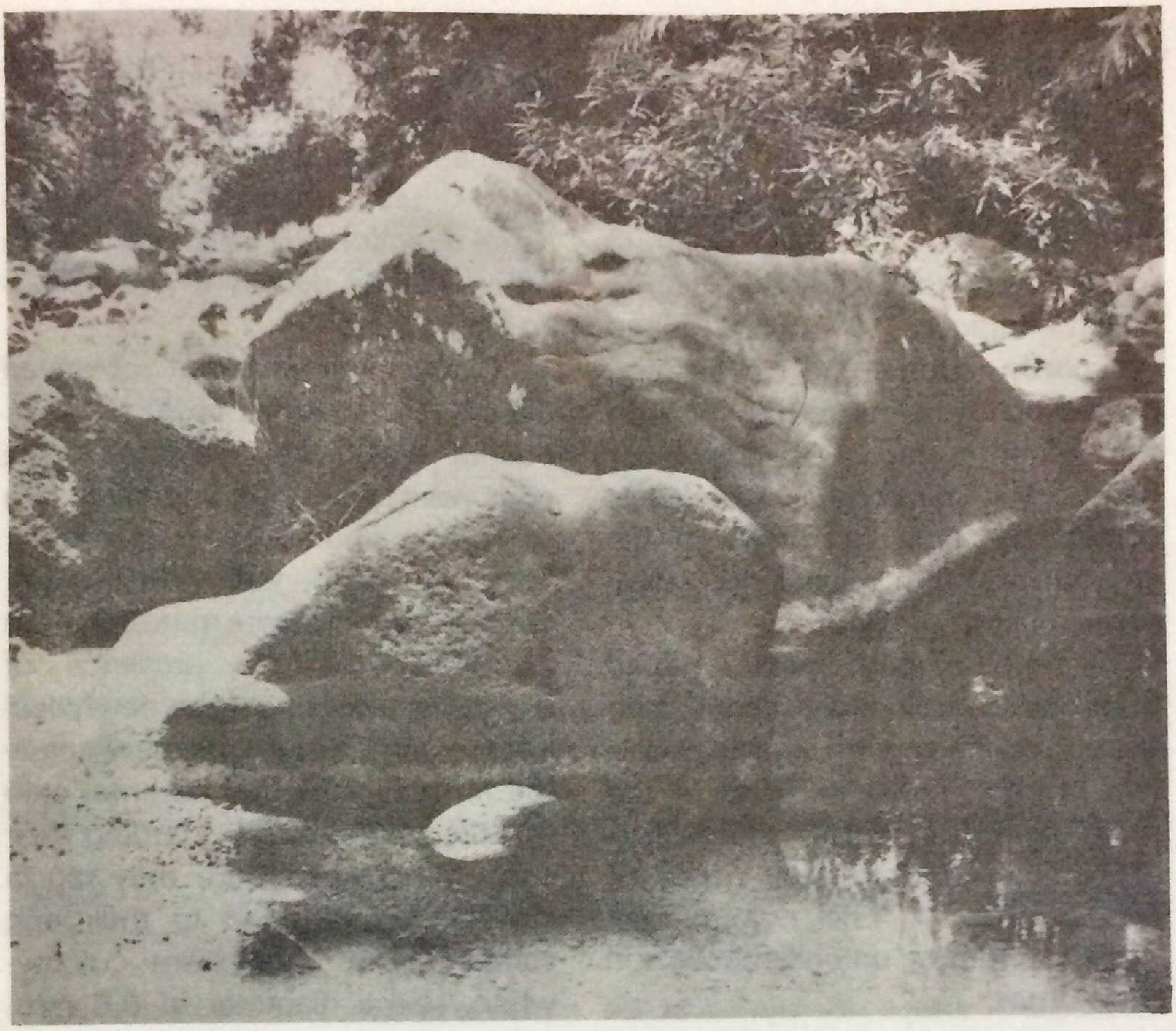

Fig. 6. Habitat of *Valleriola buenoi* showing smooth rock partly submerged in water, Molawin Creek, Mt. Makiling.

rock, *V. mindorana* approached it with rapid, jerky movements and stopped 1.5 cm away. Then, with a sudden movement it punched upon the prey and caught it with its spiny forelegs. It took a while before it was able to stick its labium into the fly's abdomen. Using its beak which has a suction mechanism for holding the prey, it ran into a crevice nearby which was quite safe from other leptopodids and ants on the rock. It stayed there for about 25 min sucking its food, until a smaller fly alighted nearby. Seeing the other fly, it dropped its food and "jumped" on the new prey using its forelegs first. It took about 5 min to consume the smaller fly. After dropping it, the bug picked up the first prey with its beak and consumed it within 10 min, after which it continued to hunt for other food. *V. buenoi* also followed the same feeding pattern. They were voracious predators and selective with regards to food. The leptopodids showed a strong preference for flies over other insects like small beetles and lepidopterans.

Competition was observed to occur among the spiders, gerrids, and the leptopodids under laboratory conditions. Moreover, the gerrids and the spiders preyed on the bugs. When the gerrids and spiders were removed from the aquarium and only the leptopodids were left, interspecific competition between the two species seemed to be very light since they occupied separate rocks inside the aquarium. Under field conditions, *V. buenoi* stayed on partly submerged rocks and picked up dead insects floating on the water surface. On the other hand, *V. mindorana* individuals sometimes took short trips to the smooth rock but stayed on mossy rocks most of the time.

Nymphs of both species stayed under or in rock indentations with the adults. They were usually prevalent in cool, moist portions of the rocks near litter areas, a condition probably related to their mode of food-getting — one nymph was observed to prey on collembolans in moist litter.

Reproductive Behavior. — Mating was not observed in aquarium culture so it was studied strictly in the field. Courtship and mating behavior was observed to be essentially the same for both species. Courtship occurred during daytime, especially during sunny mornings after a rain or shower. This usually took place on rock surfaces where there were aggregations of several individuals.

Courtship behavior was accompanied by chasing and abrupt thrusts of the male on the female. It usually took 3 to 5 attempts before a successful mount could be effected, after which they rested side by side, with the male normally preferring the left side. A variation occurred in *V. mindorana* in which the male stayed on top of the female while in copula. When disturbed, the male dismounted and they ran on the same direction still attached to each other. Mating usually lasted from 3 to 5 min.

Oviposition was not observed directly but a cluster of 30 to 50 *V. buenoi* eggs was collected. The eggs were laid on the underside of a smooth, medium-sized rock about 1 m away from the water edge. Oviposition sites were quite constant as proven by the presence of eggshell clusters near the newly-laid egg cluster. The parents, particularly the female, exhibited parental care for they were always guarding their eggs. When disturbed, they ran in circles then returned to their egg clusters. The eggs were creamy-white, had a diameter of 0.5 mm, oblong in shape, and a little bit pointed basally.

Dispersal. — During heavy rains and storms, individuals of both species were rendered sluggish and were incapable of long flights as contrasted with their ability to fly during sunny weather. The farthest they could go was 45 cm compared to approximately 90 cm or more during favorable weather. Of the two species, *V. buenoi* was more agile and aggressive in its flight.

When the creek was flooded, *V. buenoi* individuals were quite abundant on large rocks, where they nestled on rock crevices and holes so they could be safe. *V. mindorana* stayed on the underside of big rocks during heavy rains. During floods, some individuals sought refuge on large rocks away from the creek. Whether some individuals were drowned during floods because of their submerged habitats was uncertain and may not be sufficient to explain the observed decrease in *V. mindorana* population in August. Heavy rains and storms during this season caused them to seek refuge on large rocks away from the creek.

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