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Faunal Changes in Bromeliad Tank Communities as a Result of Throughfall pH Changes

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Abstract

Throughfall in forests is known to increase pH as a result of many neutralizing components on the tree. The purpose of this study was to examine how the change in pH due to Throughfall, affected the faunal composition in bromeliad tank communities. A total of 46 bromeliad tanks were sampled, which contained 2300 protists in 18 morphospecies. No significant correlation was found between pH and height on the tree or pH and volume of the tank sample. A decrease in diversity was noticed with the increase in volume of water in the tanks corresponding to heavy rainfall caused by hurricane Michelle. Abundance and richness did not have a significant correlation with pH. The average pH was 6.29 (±0.706), while the average pH for precipitation in the Monteverde area is 4.88. The difference in pH values is a result of a large increase in rain to the region during the study and because of throughfall effects.

Resumen

Es conocido que el agua que cae a través del bosque aumenta en pH como resultado de varios elementos neutralizantes en el árbol. El propósito de esta investigación era examinar como el cambio en el pH causa de dicha caída del agua afectaba la composición de la fauna de las comunidades en tanques de bromelias. En total se colectó agua en 46 tanques de bromelias, en los cuales se encontró 2300 protistas en 18 morfo especies. No se encontraba ninguna correlación significativa entre el pH y la altura del árbol o pH y el volumen de la muestra de agua en el tanque. Se noto una disminución en la diversidad con un aumento en el agua en los tanques. No se encontró una correlación significativa en la abundancia y riqueza con el pH. El promedio del pH era 6.29 (±0.706), mientras el promedio del pH de la precipitación en el área de Monteverde es 4.88. La diferencia en los valores de pH es el resultado de un aumento de lluvia en la región durante la investigación y los efectos de la caída del agua.

Introduction

The Bromeliaceae family contains around 2000 species, which are located from the tropics to warm-temperate regions of the New World. The epiphytic species within the family are well adapted to xerophytic conditions. These adaptations include water-storage tissue in leaves, well-developed spines and crassulacean acid metabolism. Also, water storage tanks are formed by a tightly overlapping rosette of leaves on the short stem of the bromeliad. In addition to holding water, the tank collects and stores detritus material from the canopy above, from which the plant is able to obtain a large amount of its nutrients (Utley and Burt-Utley 1983). Richardson (1999) considers bromeliads to be essential to the survival of many animal species and provides a breeding ground for those with aquatic stages in their life cycles. During dry periods, of even a few days, the ground and leaf litter can become extremely dry, while bromeliad tanks still provide water, shelter, resources, and nutrients.

The pH of the water in bromeliad tanks affects the composition of the faunal life within the tank (Calla 1999). Changes in pH are affected by throughfall, which is the (Levi & Levi, 1968; Brusca & Brusca, 1990; Coddington et al., 1990; Rodriguez & Guerrero, 1998; Thibault, 1999). They eat insects, detritus and have been known to participate in brood cannibalism (Brusca & Brusca, 1990; Mora, 1990; Rodriguez & Guerrero, 1998).

Furthermore *Goniosoma longipes*, a Neotropical harvestmen was observed to form aggregations with an average of 34.2 per group but with a female bias (Machado et al., 1999). The aggregation size has also been experimentally determined in the field to be inversely related to time needed to reach roost stability (Coddington et al., 1990).

There are several hypothesizes about groups and their composition but little is known about the order Opiliones. Some Neotropical harvestmen form inverted masses and when disturbed will vibrate rapidly which is suspected to be a predatory defense much like the spider family Pholcidae, (Foelix, 1996). Opilionids have other forms of defense including catalepsy (playing dead), leg autonomy and the release of noxious oil or spray to deter small predators such as ants (Kaestner, 1967; Levi & Levi, 1968; Foelix, 1996; Machado et al., 1999).

Opilionids form groups as an anti-predator defense mechanism. The use of noxious oil will be more effective in mass quantities to repel predators. Smaller aggregations will reform groups quicker to create a more effective defense against larger predators. Furthermore, the longer a population is left alone, the larger the group will be. By living in groups, competitively superior individuals, demonstrated by the length of the tibia, will experience decreased predation and represent a higher proportion of the population.

METHODS

A sample population of 65 opilionids of the most common species in disturbed habitats in Estación Biológica Monteverde, Monteverde, Puntarenas, Costa Rica (Thibault, 1999) was collected. Each individual was marked with blue nail polish applied to the dorsal side of the abdomen. A small number was placed on the wet nail polish to help recognize individuals.

Four individual controlled habitats were constructed to observe the opilionids. Three of the habitats were inside glass aquariums with approximate dimensions of 20 cm by 30 cm by 20 cm (width by length by height respectively) and one habitat that was 30 cm by 50 cm by 30 cm. Each aquarium was suspended so communities could be viewed from underneath without disturbance. Rotting detritus was collected from the field to offer a realistic observation surface and its size was proportional to the size of population it would support. Additionally it was a source of food for the opilionids. Wood or bark was preferred by myself since it offered a sturdy and often uniform surface to aid data collection while simulating preferred natural conditions.

The original 65 individuals were subdivided into groups of five, 10, 20, and 30. Population sizes were chosen after doing a field census with a range of one to 35 individuals and a mean of five for all types of habitats. Additionally, Machado et al. (1999) reported a naturally occurring average of 34 individuals in the *G. longipes.* The first three groups were put into three equally small habitats and the group of 30 was added to the largest habitat then given one day to adjust to their new habitats. The populations were observed daily at the Estación Biológica Monteverde from October 21 to November 16, 2001 and were removed from their roost site hourly for six hours during daytime hours. Prior to each disturbance the location of the opilionids on the roost was recorded.

Following data collection, the opilionids were measured and sexed. The tibia of the second pair of legs from the dorsal side was measured using a dissecting microscope (± 0.1 mm). The sex of the opilionid was determined using a method described by Rodriguez & Guerrero (1976). The opilionid is viewed ventrally under a microscope while a thumb holds down its abdomen. Then a dissecting probe is placed perpendicular to the sternum directly below the genital operculum. Slowly and uniformly, pressure is applied with the thumb and dissecting probe until the reproductive organ (ovipositor in females and aedeagus in males) appears from beneath the genital operculum.

RESULTS

There were 58% females (N =38) and 42% (N = 28) males in a randomly collected opilionid population. Moreover the general population had a mean tibia length of 3.52 mm (SD ± 0.27 mm). The tibia length of the male ranged from 3.3 mm to 4.1 mm with a mean *of 3.72* mm (SD ± 0.22 mm). The female's tibia length was between 3.0 mm and 3.7 mm with an average of 3.38 mm (SD ± 0.20 mm) (Fig. 1) and the tibia length was significantly different between males and females (T-test P-value < 0.0001, F-value = 341.526).

The general population trends between tibia length and if the individual was found at the roost in groups or alone showed a significant difference. Individuals that were in groups had a mean tibia length of 3.546 mm (SD ± 0.281 mm) while isolated opilionids were 3.480 mm (SD ± 0.241) (Fig. 1) (ANOVA P-value = 0.0041, F-value = 8.320, DF = 1,544). Although location of the male and tibia length had a significant difference, there was a negative correlation between tibia length and if the individual was alone yet it was not statistically significant (Fig. 2 (a)) (Regression P-value = 0.1053, F-value = 2.796, R^2 = 0.088). The same applied with tibia length and being in a group, there was a positive but not a statistically significant regression (Fig. 2 (b)) (Regression P-value = 0.1743, F-value = 1.940, R^2 = 0.063).

The impact of disturbance in relevance to the population size was measured throughout the experiment. The amount of disturbances had a significant negative regression for the populations of five, 20 and 30 individuals (Fig. 3 (a, c, d)) (P-value = 0.0038, F-value = 9.314, R^2 = 0.171; P-value < 0.0001, F-value = 25.305, R^2 = 0.360; P-value = 0.0073, F-value = 7.903, R^2 = 0.149 respectively). The regression for population of ten was not statistically significant (Fig. 3b) (P-value = 0.2076, F-value = 1.634, R^2 = 0.035). When measuring the percent return of individuals to the roost, there did not appear to be a relation to initial population size and the speed individuals returned to the roost after disturbance (Fig. 4) (ANOVA P-value = 0.2749, F-value = 1.304, DF = 3, 162).

DISCUSSION

As a defense against predators, opilionids can feign death, experience leg autonomy and release a displeasing secretion that contains quinones and phenols (Brusca & Brusca, 1990; Machado et al., 1999). Some species can even spray predators in which group dynamics may aid in defense (Kaestner, 1967). Many animals enhance their survival chances by living with others of their own species. Group defense is sometimes an effective way to deal with predators that no one individual could repel (Alcock, 1984). Therefore it is beneficial for individuals to live in a group and there may be competition for an optimal place within the group.

Leg length showed a significant difference among males in groups and alone. Within a group, the average tibia length of males was longer. This difference may be a result of reduced predation. Not only can groups of social insects carry out effective repelling attacks, but also can be so intimidating that some predators will flee before even making contact with the colony (Alcock 1984). Furthermore the group is not always used as a warning system, but rather individuals trying to keep others between themselves and potential danger (Alcock 1984). Central locations should be considered the safest and occupied by competitively superior individuals. This behavior has been observed in ground-nesting gulls, where the youngest are forced to the edge of the group, where they will be the first to encounter a predator (Alcock 1984).

Machado et al. (1999) published a paper on how there was a significant difference in tibia length comparing if the individual was in the group or alone. In my study there was no observed significance of tibia length between females in and out of groups. But my data did support Levi & Levi's claim that there was a significant size difference between the sexes. Females may not experience the same social pressures as males and therefore varying tibia lengths represent the population. Furthermore the equality in tibia lengths may be due to females leaving the group to scout a better site to oviposit their eggs. Once at the edge the female and smaller males have two options: look for a more favorable solitary habitat or to stay on the outskirts and protect the central individuals (Alcock 1984). There seems to be no preference to either option.

As expected, the number of disturbances did have a negative effect on population size. Repeated pertubances would make the habitat less favorable and eventually the individuals would search for a less perturbed habitat. Despite the protection offered by grouping, if the roost is repeatedly disturbed they will seek out a new roost. If the colony is repeatedly perturbed, then the whole colony may look for a new location, like some bees (Alcock 1984). The rate of return to the previously disturbed habitat is similar across all population sizes but there is a decrease in population size observed as the number of disturbances increases in all populations.

Several new conclusions were discovered but many more lay hidden in the leaf litter of the forests. Further investigations should be conducted on the location of individuals in groups, for instance the locality of females and size of the tibia to determine if the selfish herd hypothesis exists with opilionids. Another possible investigation may be how much secreted oil is needed to repel common opilionid predators or if it has an effect on the predator in comparison to group size.

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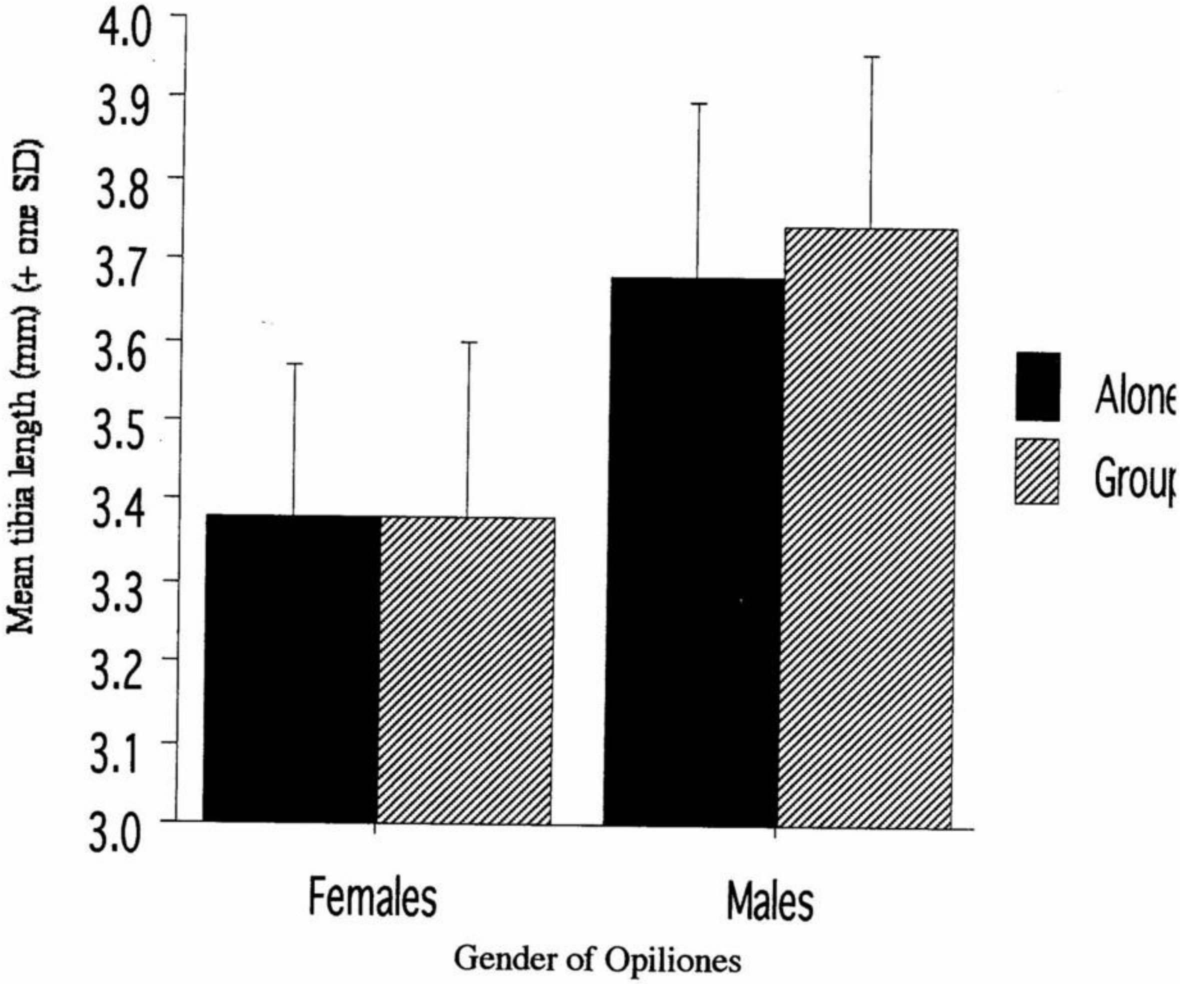

Figure 1. Comparison of mean tibia length, gender and social arrangement (mean tibia length with gender (ANOVA $P < 0.0001$, $F = 309.861$, $DF = 3, 162$); mean tibia length with social arrangement (ANOVA $P = 0.0041$, $F = 8.320$, $DF = 1, 544$); mean tibia length with gender and social arrangement (ANOVA $P = 0.0821$, $F = 3.034$, $DF = 1, 1, 1, 542$).

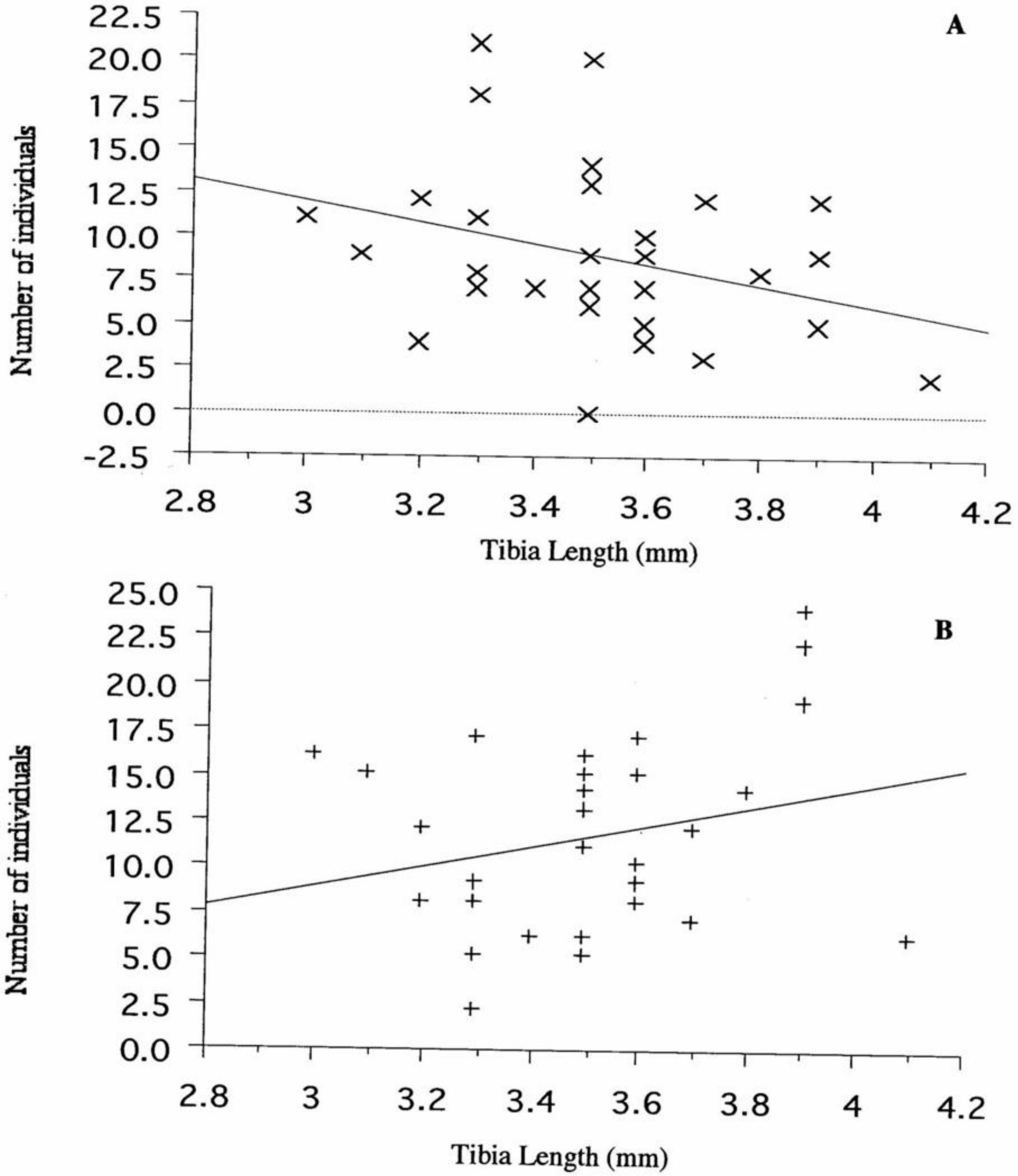

Figure 2. Relation of (a) solitary individuals and tibia length (mm) (ANOVA $P = 0.1053$, $F = 2.796$, $DF = 1, 29$) and (b) individuals in groups and tibia length (mm) (ANOVA $P = 0.1743$, $F = 1.940$, $DF = 1, 29$).

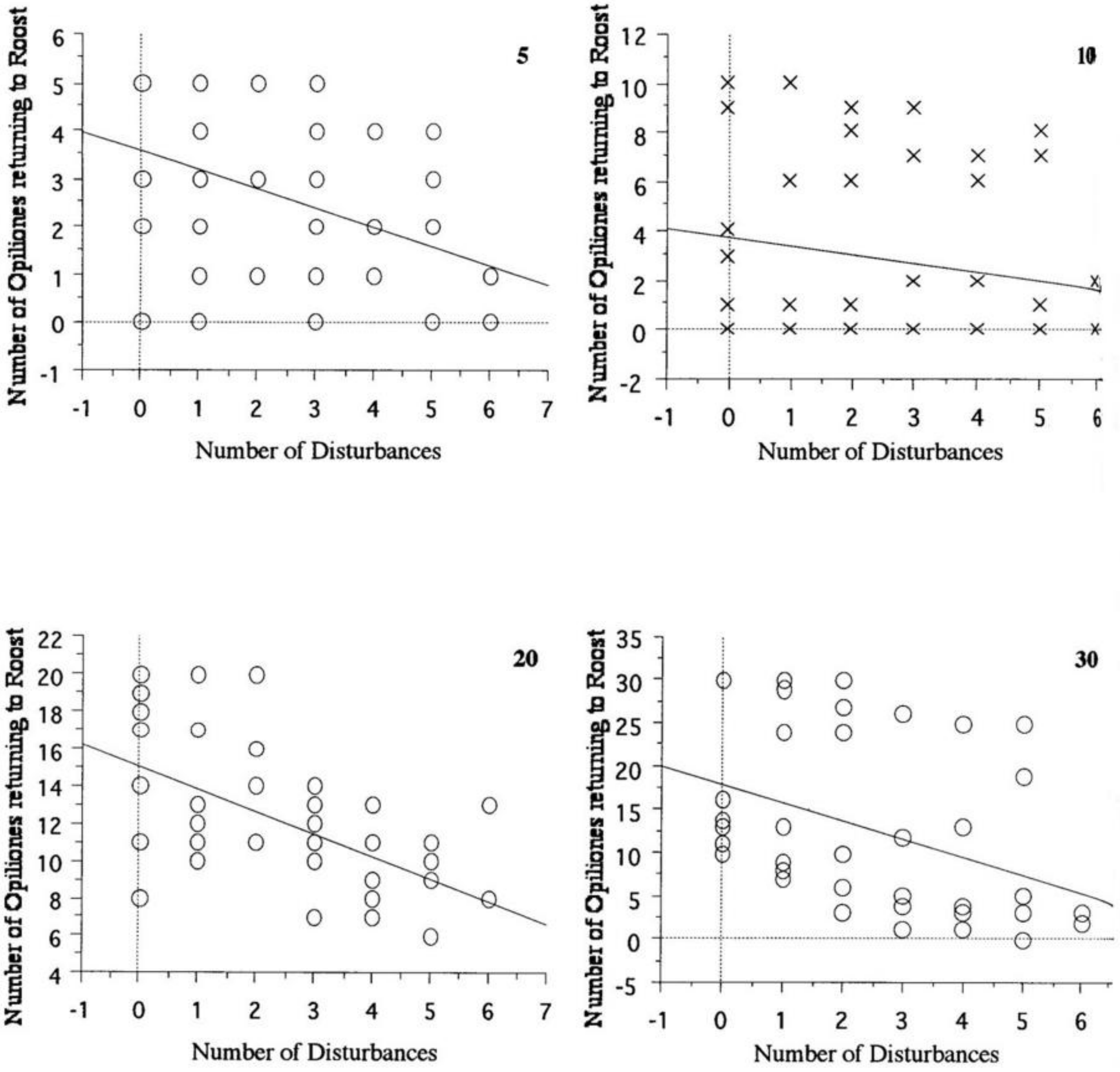

Figure 3. Correlation across different population sizes and number of disturbances ((a) inital population = 5, P = 0.0038, R^2 = 0.171; (b) initial population = 10, P = 0.2076, R^2 = 0.035); (c) initial population = 20, P < 0.0001, R^2 = 0.360; (d) initial population = 30, P = 0.0073, R^2 = 0.149).

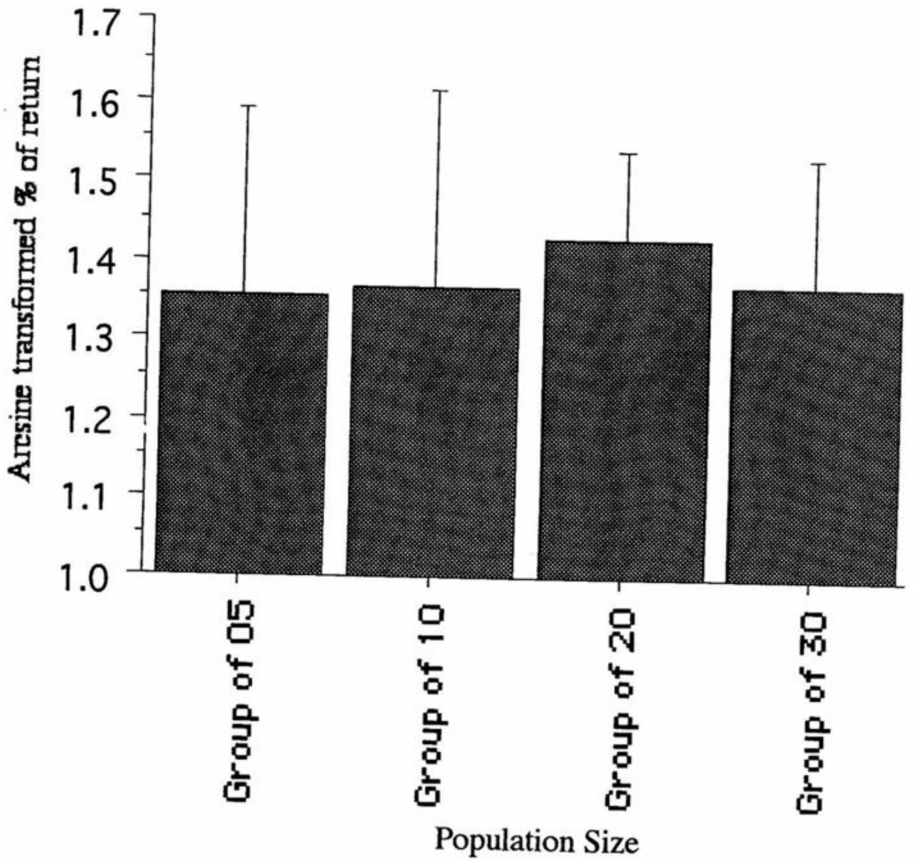

Figure 4. Arcsine transformation on the percent return among opilionids in different group sizes (ANOVA P=0.2749, F=1.304, DF= 1, 1, 1, 542).