Some Preliminary Results on the Status of the Oahu Species of *Banza* (Orthoptera: Tettigoniidae: Copiphorinae)

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ABSTRACT

The status of the two species of *Banza* from the Island of Oahu, *B. parvula* and *B. unica* is brought into question due to results of rearing out adults from eggs oviposited by a wild caught *Banza parvula*. Basic techniques for rearing *Banza* are discussed and some preliminary observations on their reproductive biology are also given. Two matings of *Banza parvula* were observed in the lab and their behavior are described in a preliminary fashion. The results put the current classification of *Banza* into question an show the potential of this group for evolutionary studies.

The Hawaiian Islands have only two endemic genera of grasshopper, both in the family Tettigoniidae (subfamily Copiphorinae), *Banza* and the closely related monotypic genus *Conocephaloides*. In 1869, Walker described the species *parvula* from the island of Oahu as belonging to the palearctic genus *Saga*. In 1870, he erected the genus *Banza* in which *parvula* was later included by Kirby (1906). Nine species and one variety have been described since then, including the atypical, very large long-winged *Banza nihoa* Hebard (1926). *Banza* have been found on all of the main islands, plus Nihoa. All are believed to be single island endemics with two species each on Kauai, Maui, and Oahu, one species and one variety on Hawaii and a single species on Molokai, Lanai and Nihoa.

The status of certain *Banza* species have been questioned from time to time (i.e. Brunner v. W. 1895, Hebard 1922 and Zimmerman 1949), most notably by Perkins concerning the Oahu species. In 1899, Perkins revised the genus *Banza* under the name of *Brachymetopa*. He apparently was unaware of Walker's 1869 and 1870 treatments which included the Oahu *parvula* species. Instead of Walker's *parvula*, Perkins included two other species described from Oahu, *blackburni* by Bormans in 1882 and *discolor* by Redtenbacher in 1891. Perkins also described one new Oahu species, the smaller *unica*. Table 1 illustrates how he separated the species. He did use morphological characters to separate *unica* from *blackburni* and *discolor*, but could not distinguish the latter two Oahu species based on morphological features.

TABLE 1. Characters used by Perkins (1899) to separate Oahu species of *Banza*.

	Color	
	Body	Face
discolor	brown	black
blackburni	green	green
unica	green	gren with a black triangle in center with yellow along its margin

[1]Journal Series No. 3064 of the Hawaii Institute of Tropical Agriculture and Human Resources.
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TABLE 2. *Banza* collected by Perkins at one locality on Oahu over a two day period and reported upon in 1910.

	Male	Female
discolor (brown with black face)	24	1
blackburni (green)	1	18 or 19
blackburni (green) with black triangle (without yellow margins)	1	1 or 2

Perkins (1899) knew that some of the other Hawaiian species exhibited green and brown morphs and since he had not seen a male of the green *blackburni,* he questioned the status of *discolor* and *blackburni.* Also, from available information and collections, he might not have seen a brown *discolor* female either. Based on the black face of the brown *discolor,* Perkins decided to leave the species separated. Some years later, he spent two days collecting *Banza* at one location on Oahu in the mountains above Honolulu, and collected 26 male and 21 female *Banza.* Table 2 gives the numbers and forms of *Banza* he collected.

Despite the distinguishing color pattern (of the body and face) used by Perkins to differentiate the three taxa, it should be noted that black speckled markings are present over the wings and most of the body of *discolor* and the green *blackburni* with the black triangle on the face, referred to from here as the "intermediate" form. This feature is absent in *unica.* Based on the results from the collection of *Banza* specimens from a single locality (Table 2), Perkins decided to synonymize *discolor* under *blackburni* and concluded that the color differences used to distinguish the two species were no more than sexually dimorphic features of a single interbreeding species. However, based on the small numbers of brown females and green males that were collected from a single locality, he speculated that the development of sexual dimorphism was not yet complete. Kirby (1906) placed *Brachymetopa blackburni* in the genus *Banza* and in 1922 Hebard synonomized *blackburni* under Walker's *parvula,* and questioned the status of the remaining *Banza* species, as did Zimmerman in 1949.

Although the species *unica* was described from a single female collected with a series of *parvula,* its status as a good species was never questioned. It is a much smaller species and not only has the yellow border along the lateral margins of the triangle, but also some morphological differences (i.e. shape and venation of tegmina and spines on the tibia) are present. However, the results of rearing a range of adult morphotypes from eggs oviposited by a *parvula* female inseminated in the wild, brings the status of *unica* into question.

Little is known of *Banza*'s reproductive biology. On two occasions, *parvula* have been observed to mate in the laboratory. These observations are presented here in a preliminary fashion in hopes it will serve as a starting point for more extensive evolutionary studies of this interesting group.

METHODS AND MATERIALS

As the name *Banza* suggests (ban — Old High German meaning proclamation and -za, Greek meaning intense) they sing. Their call can be heard in the evenings at higher elevations (i.e. over 450 m). This call is very high pitched and relative to the introduced tettigoniids found in Hawaii, is faint. While tracking down a singing

male in the evening of April 15, 1985, on Mount Tantalus (650 m) Marianne Early and I came across a gravid *Banza parvula* female. The specimen was brought back to the lab and placed into a gallon glass jar with a cardboard lid and folded cardboard on the inside to provide hiding places. The adult female proved to be omnivorous and a variety of food material was provided. Eventually a diet of oatmeal, *Drosophila* larval medium (corn meal, soybean meal, corn syrup and agar medium) and adults of *Drosophila silvestris* (frozen to kill) was settled upon. Since they were known to oviposit into plant tissue (Perkins 1906), a variety of vegetables and foliage were provided to induce oviposition. These were not successful in inducing oviposition. Moistened cotton dental rolls have been used to induce oviposition by other tettigoniids (Marrable 1980), but gave very limited success with *Banza*. Moistened absorbent cotton placed in petri dish bottoms proved to be very successful, with the female ovipositing about ten eggs in two days. After every seven to ten days, the petri dish was removed from the gallon jar and replaced with another petri dish with moistened cotton. The petri dishes that were removed from the gallon jar were covered to retain moisture in the cotton containing the eggs. Occasionally, water was added to the cotton when it appeared to be getting dry. When the eggs hatched, the nymphs were placed separately into 5×5×5 cm clear plastic boxes with moistened blotter paper on the bottom. Later instars were placed separately into 5×5×7.5 cm boxes. The nymphs were fed oatmeal, adult *Drosophila silvestris* and *Drosophila* larval medium. The cages were cleaned and sterilized with 95% ethanol every 3–4 days and the moistened blotter paper and food were replaced. The room had natural light and overhead florescent lights which were on an average of ten hours a day, usually during daylight hours. The temperature in the laboratory ranged from 21° to 24°C.

Mating behavior was observed between two separate pairs of virgin female and male *parvula*. One pair was collected on Mt. Kaala (1300 m) and the other on Mt. Tantalus (650 m). The females were collected as immatures and reared to adults. Colonies from each mated pair were started using the method described above.

RESULTS AND DISCUSSION

The gravid female *parvula* collected from Tantalus oviposited 55 eggs into 15 petri dishes over a period of two months. The first eggs hatched after about two months following oviposition. The eggs turned from brown to a green-brown within a week of hatching. From the original 55 eggs, 29 hatched, 15 were cannibalised by the *parvula* mother and the remaining 11 did not hatch. Eight were successfully reared to adults. These lab reared *Banza* were similar in size with wild caught individuals. The majority of the nymphal mortality occurred during the 1st and 2nd instars. It took approximately two months for the nymphs to mature from egg hatch to adult eclosion. Three died in their last nymphal instar within a half hour of each other for no apparent reason. The instar and sex of the nymphs could be determined by the development of the genitalia alone, but monitoring the change in the width of the head was found to greatly facilitate the determination of the instar.

When the eggs hatched, the nymphs were all green. Zimmerman (1949) stated that some species exhibit polychromatism in the nymphal stages, and, of the eleven *Banza* reared to last instar, two males which were green in earlier instars emerged as brown last instar nymphs. This dichromatism is not unusual for the subfamily Copiphorinae, in which *Banza* is placed. These two brown last instar males emerged as the common brown bodied, black-faced individuals. Of the six other specimens that were reared to adults, three males and two females were similar to the interme-

TABLE 3. A comparison of a female *Banza parvula* inseminated in the field and her adult offspring reared in the laboratory. These are compared with typical *Banza parvula* and *Banza unica.*

	1.	2.	3.	4.	5.*	Morph	Sex**
parvula	-	-	-	R	G/B		
unica	X	X	X	A	G		
Mother	-	-	-	R	G	p	
#1	-	-	-	R	B	p	M
#2	-	-	-	R	B	p	M
#3	X	-	-	R	G	I	M
#4	X	-	-	R	G	I	M
#5	X	-	-	R	G	I	M
#6	X	-	-	R	G	I	F
#7	X	-	-	R	G	I	F
#8	X	X	X	A	G	u	F

*1. Black triangle on face
2. Yellow stripe on lateral margin of black triangle on face
3. Red and Yellow on apical edge of tegmina
4. Tegmina apex rounded = R and acute = A
5. Green form = G and Brown form = B

**(p = *parvula*-like, I = Intermediate form, u = *unica*-like, M = male, F = fmeale)

diate form and one was, astonishingly, a female that fit the description of *unica.* Table 3 shows characters that have been used to separate the species and the characters of the individuals reared in the laboratory.

There are at least two possible explanations for the range of color morphs and patterns present in *Banza* population from Oahu. First, it is possible that *parvula* is a highly polymorphic species encompassing the entire range of color morphs and patterns as shown in Table 3 (including that of *unica*). This implies that individuals fitting the description of *unica* are rare segragants of what would otherwise be considered to be *parvula.*

The second possibility is that both *parvula* and *unica* are "good" biological species but that there is a small amount of natural hybridization between the two populations. Thus, the "intermediate" green-bodied forms with black triangles on the face collected in the natural population by Perkins (1910) and also those individuals reared from the single female collected from the wild (Table 3) may represent hybrid individuals. Also, it is interesting to note that two individuals that fit the general description of *unica* except that the black triangle bordered by yellow margins is absent (i.e. green-faced) have been collected from the natural populations. One was collected in 1907 on Pu'u Ohulehule and the second was collected by W. Perreira in May, 1986 on Mt. Tantalus. Also, at the Bishop Museum, a black faced female *Banza* collected in Waianae has a note attached stating it had green tegmina.

The validity of either explanation for the range of color patterns in the Oahu *Banza* populations must be tested by examining the presence or absence of reproduction barriers between the two taxa. Hybridization experiments among the various morphotypes will certainly be essential for elucidating these questions.

Perkins (1899) showed that male genitalia were useful to separate species between islands, but Zimmerman's (1949) attempt to separate Oahu *parvula* and

unica species by using male genitalia was not successful. Much depends on the orientation of the claspers, which are influenced by how the abdomen changes in shape when it was dried for examination. There are some morphological differences between the Oahu species, notably on the wings (i.e. wing shape and venation). At this time, *unica* should not be synonymized under *parvula* until both taxa are studied in detail utilizing more than morphological features.

I observed two matings in the lab of pairs collected from Mt. Tantalus and Mt. Kaala which exhibited much the same behavior. After the male was put in with the female, he started to sing only after their antennae touched. The song consisted of shorter chirps than previously heard from solitary field and lab reared males. After the antennae touched, the male curved his abdomen under his body, with the tip of the abdomen directed anteriorly. The brown *parvula* males have on the venter of the abdomen a longitudinal cream colored stripe bordered on either side with rose colored stripes. These stripes are visible from the front when the abdomen is curved under. I saw no receptivity signal by the female when the male aggressively mounted her. One pair copulated for 1.5 hours, the other pair for 30 minutes. On two occasions when the female moved during copulation, the male made a few short chirps. It appears that the male embeds his claspers into the female at the base of the ovipositor; the wounds and scars that might occur could give an indication whether a wild caught female has mated. After the copulation was terminated, if the female approached the male, he would stand on his middle and hind pair of legs, swing his forelegs up high, open his mandibles, and occasionally try to grab her. This attempted grabbing of the female appeared very feeble: it seemed to be more of a threat display.

CONCLUDING REMARKS

Perkin's (1910) work raised questions about the status of *Banza* populations on Oahu. Later works like those of Hebard (1922) and Zimmerman (1949) attempted to sort out the status of taxa in the genus *Banza* based on morphology. It is obvious now that more than a morphological study is needed to differentiate the species of *Banza.* Since the early 1960s, the endemic species of Hawaiian *Drosophila* have been studied with a multidisciplinary approach. A similar biosystematic treatment is required with *Banza.*

In thoroughly understanding *Banza,* we will also greatly increase our knowledge of Tettigoniidae. Brown (1983) states that the reproductive behavior, including differences in the songs used at various stages of courtship is not as well documented in the Tettigoniidae as the other two major orthopteran families (i.e. the Acrididae and Gryllidae). *Banza* is an excellent study group for acoustical and behavioral analyses. Populations can be located by the song of the males and be studied in the field or be brought back to the laboratory to be studied. Ecological studies can also be performed on the populations in their native habitat.

Although Orthoptera have been utilized in genetic studies since the pioneering work of McClung (1905), most work has been done on the Acrididae (Hewitt 1979). Genetic studies on *Banza* would not only provide information on chromosomal karyotypes and numbers in tettigoniids, they will enhance our understanding of speciation patterns in these Hawaiian grasshoppers.

The ability to rear them in the laboratory not only facilitates the genetic studies discussed above, but will also enable us to conduct hybridization studies. As discussed earlier, hybridization studies will be essential in determining the taxonomic status of species in this group. By applying the multidisciplinary approach used to

study the Hawaiian *Drosophila* to study *Banza,* some of the same theories that have been tested (e.g. speciation via the founder effect, see Carson 1971 and Carson and Templeton 1984) might be addressed. Also, the unique geological features of the Hawaiian Archipelago, including formation of "kipukas" ("islands" of vegetation surrounded by lava), deep valleys, single file formation of the islands and the rise and fall of the ocean levels during the recent Pleistocene resulting in mountains tops being connected and separated, provide biologists an opportunity to investigate the natural history of this group of insects. A thorough study of *Banza* will undoubtably make it an important model for other studies of tettigoniids.

ACKNOWLEDGMENTS

The author would like to thank Dr. K.Y. Kaneshiro, Mr. K. Kanegawa and Dr. T. Shelley of the Hawaiian Evolutionary Biology Program for assistance in many aspects of this work. The author also wishes to thank Dr. J.W. Beardsley, Dr. M.W. Johnson, Mr. W. Perriera and Mr. H. Chiba of the University of Hawaii Entomology Department for additional assistance and Dr. S.L. Mongomery for the original encouragement to work with *Banza.*

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