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PRELIMINARY REPORT

THE BIOLOGY OF THREE SPECIES OF *BRODIAEA* (AMARYLLIDACEAE) ON THE SANTA ROSA PLATEAU (RIVERSIDE COUNTY)

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Submitted to:

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INTRODUCTION

Brodiaea filifolia Wats. (thread-leaved brodiaea), an herbaceous perennial member of the Amaryllidaceae, is state endangered and a C-1 candidate for federal listing. Its distribution is limited to areas of Riverside, Los Angeles, and San Diego Counties (Berg and Smith 1988). While this species was more widespread in the past, its numbers have been severely reduced due largely to habitat destruction for agriculture and residential development (Armstrong 1978). Of nineteen known occurrences, six are known to have been extirpated by urbanization (Armstrong 1988). Four of the remaining 13 populations, including the largest known population, are protected on the Santa Rosa Plateau Preserve.

Two close congeners of B. filifolia, B. orcuttii (Greene) Hoover (Orcutt's brodiaea) and B. terrestris Kell. subsp. kernensis (Hoov.) Niehaus (earth brodiaea), also occur on the Santa Rosa Plateau. While the latter is fairly common, B. orcuttii is a rare species that is also a C-1 candidate for federal listing. All three species are associated with heavy clay soils in grasslands, often on the edges of vernal pools (Lathrop and Thorne 1985) and in other moist areas.

All species of Brodiaea are reported to be self-incompatible (Niehaus 1971). They depend upon insect vectors to effect cross-pollination for seed production. Asexual reproduction may occur by the production of cormlets as is common among other members of the Amaryllidaceae (Niehaus 1971). No hybrids have been adequately documented for any Brodiaea species and Niehaus (1971) considers the formation of hybrids in the field unlikely; however, Armstrong (pers. comm.) has observed apparent hybrids between B. filifolia and B. jolonensis in San Diego County. But, because B. filifolia and B. terrestris subsp. kernensis occur in sympatry and are similar in morphology and phenology, pollinator infidelity may provide a mechanism for hybridization. Even relatively infertile hybrids may backcross with a fully fertile parent species; thus hybridization may act as a bridge for interspecific gene flow (Stace 1980). Hybridization can thus blur species boundaries, contribute to speciation, and increase genetic variability which might enable species to increase their range of ecological tolerances and thus their geographic ranges (DeLamater and Hodgson 1987). Because of the rarity of B. filifolia, and the importance the populations on the Santa Rosa Plateau to the survival of this species, it is important to assess the likelihood and extent of any hybridization between Brodiaea species.

The purpose of this study was to document the occurrence of B. filifolia and B. orcuttii on the Santa Rosa Plateau Preserve, to make preliminary observations on the pollination ecology of these species, and to investigate the possibility that hybridization may be occurring between Brodiaea congeners on the plateau.

B. General Ecology and Pollination

The three species of Brodiaea occurring on the Santa Rosa Plateau have distinct blooming peaks but overlap to some extent in their blooming periods. B. filifolia is the first species to come into bloom; typically peak bloom for B. filifolia occurs in late April. First bloom usually occurs in late March or early April, and some individuals may still be found blooming as late as early June. The main population on Mesa de Colorado may be roughly divided into east and west sub-populations. The east portion of the population occurs along a vernal stream from the outflow of the largest vernal pool on the mesa to the eastern edge of the mesa. This sub-population typically blooms 1-2 weeks earlier than the main portion of the population.

Brodiaea terrestris subsp. kernensis reaches its peak in May. A great deal of overlap may occur between the blooming dates of this species and B. filifolia, and B. terrestris subsp. kernensis may continue to bloom into June. Because of this overlap there is some potential for pollinator infidelity and the chance for hybridization between these two species.

Brodiaea orcuttii typically reaches peak bloom in mid-June. Unlike either B. filifolia or B. terrestris subsp. kernensis, this species does not have a wide range of blooming dates and is usually only apparent for a week to ten days. Because of its late blooming date there is less potential for hybridization with the other species.

Pollinators of B. filifolia and B. terrestris subsp. kernensis include butterflies (including true butterflies and skippers), syrphid flies (family Syrphidae), several native bees, bumblebees (Bombus spp.) and honeybees (Apis mellifera). Native bees observed pollinating B. filifolia include Bombus californicus, Hoplitus sp., Osmia spp. (Figure 4), and an unidentified Anthophorid (digger-bee).

Preliminary results suggest that honeybees (Figure 5) are the major pollinator of B. filifolia and show some degree of constancy as determined by pollen analysis from bee pollen loads. Osmia is also a frequent visitor to B. filifolia and may have been the original pollinator of this species. The effect of the non-native honeybee to the pollination ecology of Brodiaea and other native plants should not be underestimated. It remains to be determined how constant Osmia and Apis are to B. filifolia and the other Brodiaea species. Further investigation is required to determine if Apis mellifera, a known generalist, may be an unnatural hybridization vector on the plateau.

RESULTS

A. Distribution

B. filifolia occurs in four locations on the Santa Rosa Plateau (Figure 1). All are now protected within the boundaries of the Santa Rosa Plateau Preserve. The largest population, documented by the California Natural Diversity Data Base as occurrences 005 and 006, is actually a single, large population covering at least 60% of the surface area of Mesa de Colorado within the preserve boundaries. Numbers of plants blooming on Mesa de Colorado vary from year to year as each bulb does not necessarily produce every year. During peak blooming some tens of thousands of plants may occur in this population (Figure 3).

A second, small, satellite population occurs on the northern slope of Mesa de Colorado in a seep on dense adobe clays eroding from the mesa basalt. This population numbers about 200 plants in 1990.

A third population occurs along Cole Creek approximately one mile north of the Mesa de Colorado populations. This population is extremely unusual: it blooms two to three weeks later than the mesa populations, it occurs in cracks and crevices in bedrock along the stream side, and the plants in this population are typically 2-3 times as large as the plants in the mesa populations. This population numbers some 200-300 individuals.

A fourth, small population occurs on the Santa Rosa Springs property, a new acquisition east of the main part of the original preserve. This population occurs along a small seasonal stream course in deep clay-silt deposits. This area is still under grazing and may recover somewhat when the cattle lease operation is removed, but numbers fewer than a dozen individuals.

Brodiaea orcuttii is rare and appears to be declining on the Santa Rosa Plateau. Three small populations have been identified (Figure 2). The largest, on Mesa de Colorado, has been monitored since 1985, and has declined each year despite variations in rainfall and the reduction of vegetative competition by two fires. A small population on Mesa de Burro was monitored by Tom Griggs in 1986 but has since disappeared. A third population was discovered in 1988 on the new Santa Rosa Springs property. This population is variable in size from year to year, but a high count of about 40 individuals has been reported.

Brodiaea terrestris subsp. kernensis is a common grassland species throughout the preserve.

Need info on the geographic occurences of the putative hybridizers and hybrid

C. Hybridization

In the late part of the blooming period for B. filifolia and early in B. terrestris subsp. kernensis blooming, there are numerous individual plants on Mesa de Colorado that are apparently intermediate in form between the two species. These purported hybrids were first noted by Tom Griggs when he was manager at the Santa Rosa Plateau between 1984 and 1987. There is a great deal of variability in these "intermediate" forms. Figure 6 illustrates flower form in the three pure Brodiaea species and in these hybrids.

Flower "appearance" itself is insufficient to prove the existence of hybrids, but careful measurement of flower morphology lends strong support to this theory. We measured length of staminodia and perianth tube in ten individuals each of B. filifolia, B. terrestris subsp. kernensis, and the putative hybrids. This data is presented graphically in Figure 7. The lack of overlap in the two pure species and the intermediate clustering of the putative hybrids provides strong evidence for hybridization. The continuous range of values for each group and the generally continuous range of appearance in the flowers suggests a "hybrid swarm".

RECOMMENDATIONS

1. There is strong evidence for hybridization between B. filifolia and B. terrestris subsp. kernensis on the Santa Rosa Plateau. Hybridization between these species may be a neutral phenomenon if hybrids are sterile, but may have either a positive or negative effect on the endangered B. filifolia if there is any degree of fertility in the hybrid offspring. Hybridization needs to be verified by genetic testing, probably using electrophoresis, and if verified the viability and fertility of hybrid plants needs to be examined.

NO* negative impacts possible

viable pollen production in putative hybrids

2. More information is needed on the mechanics of pollination of these three species, including the identity and constancy of pollinators. In particular the identity of native bee pollinators should be established, their degree of plant specificity determined, and the potential impacts of the introduced honeybee, Apis mellifera, evaluated.

* reference
H. Lewis 1961
Am Nat. 95:155-68

ACKNOWLEDGEMENTS

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LITERATURE CITED

Armstrong, W.P. 1988. A recommendation to the California Fish & Game Commission regarding the status of Brodiaea filifolia. Unpublished report, California Native Plant Society.

_____. 1978. Four wildflowers vanishing from northern San Diego County. Environment Southwest No 480:3-6.

Berg, K. and J.P. Smith, Jr. [eds.] 1988. Inventory of rare and endangered vascular plants in California. California Native Plant Society Special Publ. No. 1, 4th edition, Sacramento.

DeLamater, R. and W. Hodgson. 1987. Agave arizonica: an endangered species, a hybrid, or does it matter?. Pp 305-309 in: T.S. Elias [ed.], Conservation and management of rare and endangered plants. California Native Plant Society, Special Publ. No. 2, Sacramento.

Lathrop, E.W. and R.F. Thorne. 1985. A flora of the Santa Rosa Plateau, Southern California. Southern California Botanists, Special Publ. No. 1, Fullerton.

Niehaus, T.F. 1971. A biosystematic study of the genus Brodiaea (Amaryllidaceae). Univ. California Publ. Bot. 60:1-67.

Proctor, M. and P. Yeo. 1972. The pollination of flowers. Taplinger Publishing Co., New York.

Stace, C.A. 1980. Plant taxonomy and biosystematics. Univ. Park Press, Baltimore.

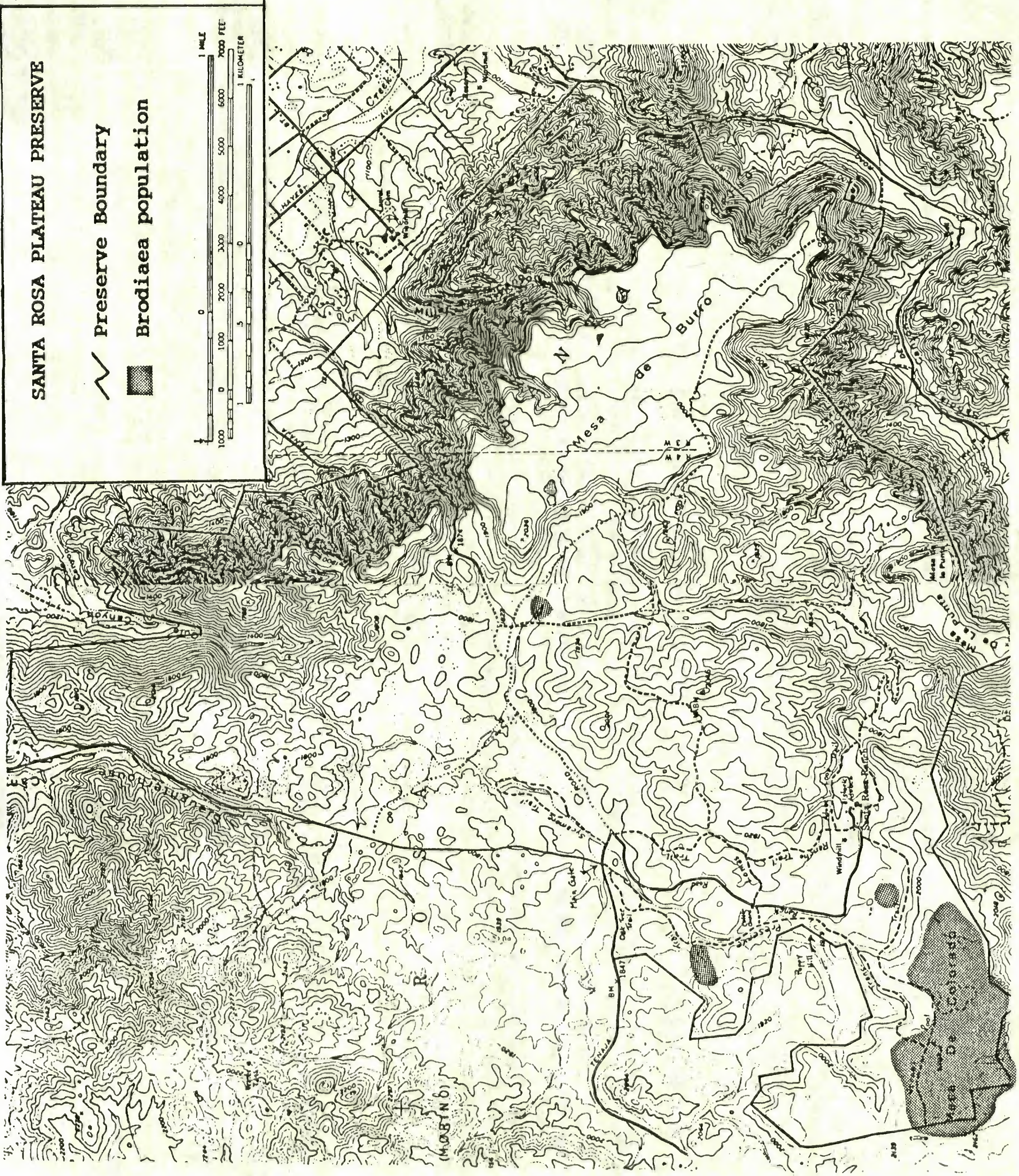

Figure 1. Distribution of <u>Brodiaea</u> <u>filifolia</u> on the Santa Rosa Plateau.

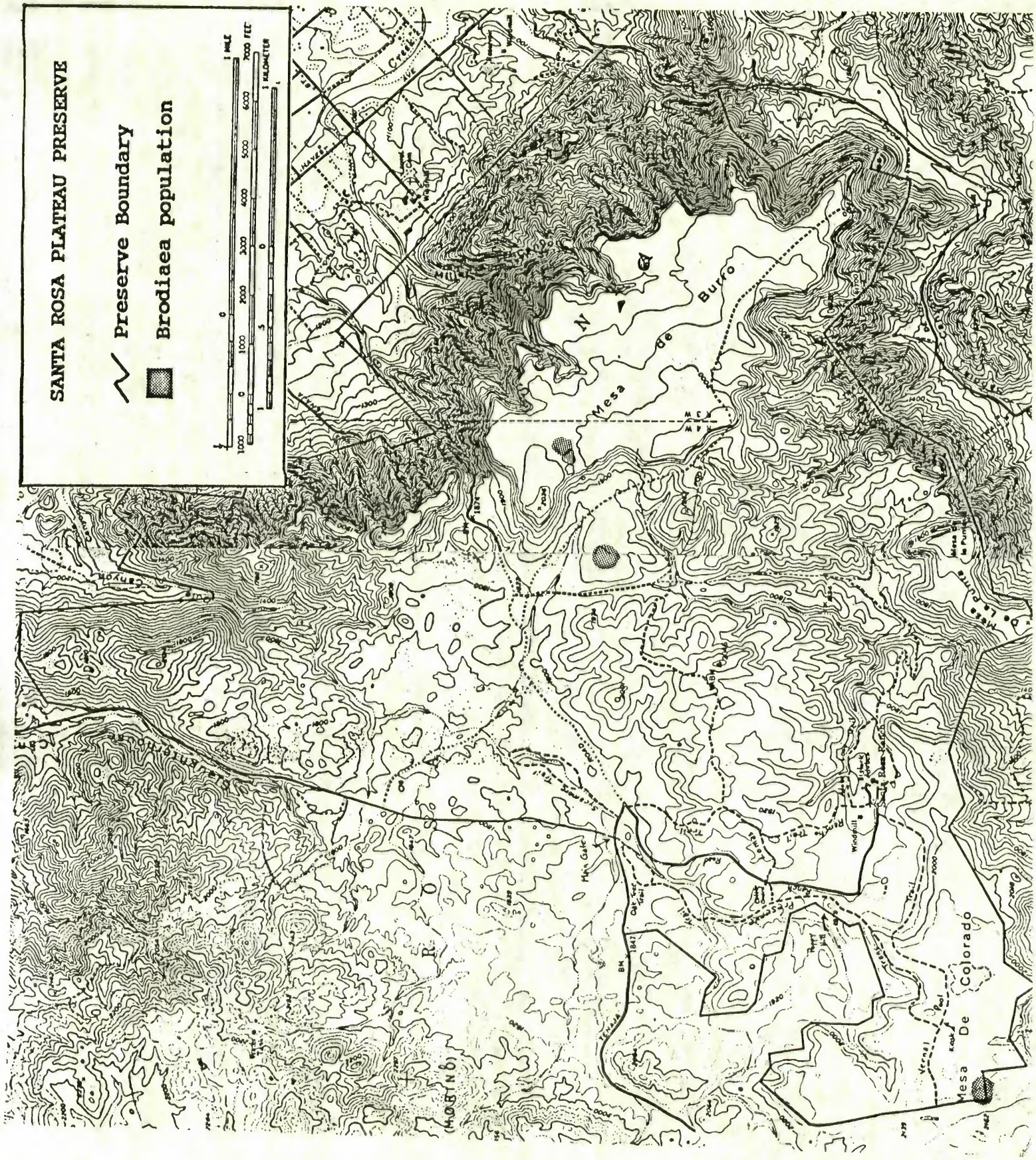

Figure 2. Distribution of Brodiaea orcuttii on the Santa Rosa Plateau.

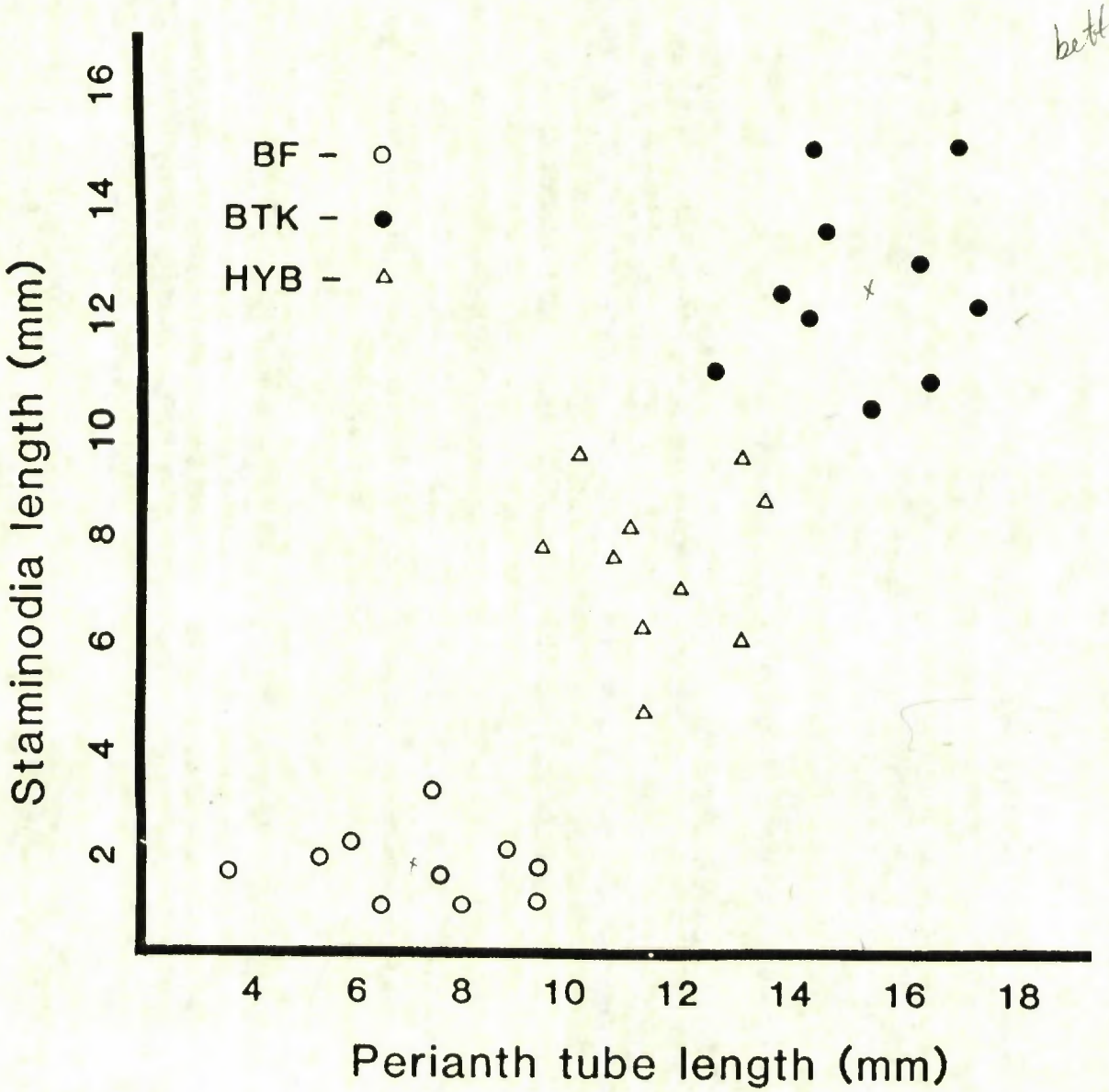

Figure 7. Scatter diagram for B. filifolia (BF), B. terrestris subsp. kernensis (BTK), and putative hybrids (HYB) based on staminodia and perianth tube length (in millimeters)

Figure 3. A dense patch of B. filifolia in flower.

Figure 4. Osmia sp. visiting a B. filifolia blossom.

Figure 5. *Apis mellifera* visiting a *B. filifolia* blossom.

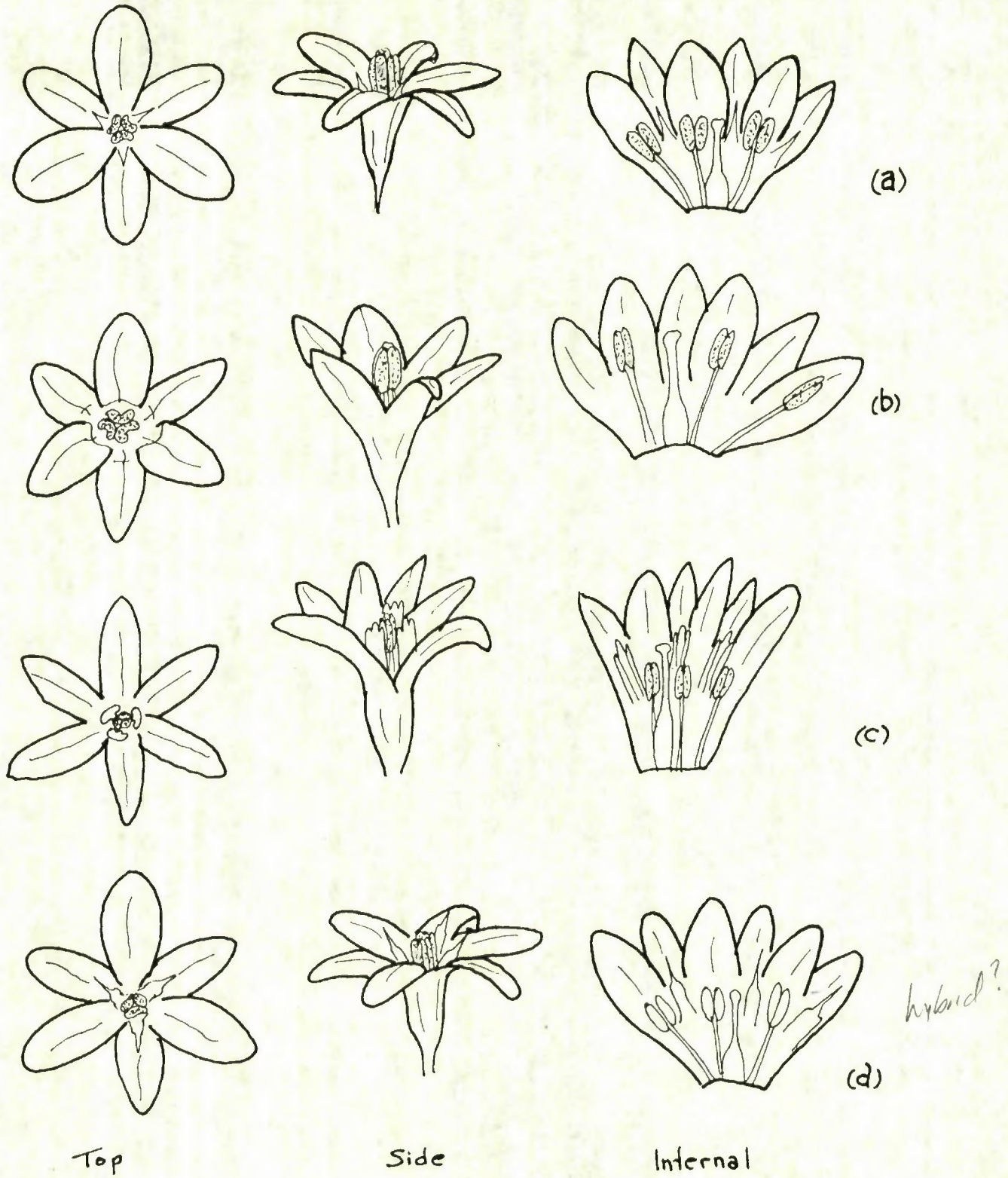

Figure 6. Floral structure in Brodiaea species from the Santa Rosa Plateau. (a) B. filifolia, (b) B. orcuttii , (c) B. terrestris subsp. kernensis, (d) putative hybrid between B. filifolia and B. terrestris subsp. kernensis.