SOFT-LEAVED PAINTBRUSH (*CASTILLEJA MOLLIS*) DEMOGRAPHY ON SANTA ROSA ISLAND, CHANNEL ISLANDS, CALIFORNIA

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RESEARCH NOTE

Castilleja mollis (Pennell) (soft leaved paintbrush) is a green semi-parasitic subshrub in the Scrophulariaceae, listed as endangered by the federal government in 1997 (U.S. Fish and Wildlife Service 1997). It was thought to be distributed along the mainland coast in San Luis Obispo County and on Santa Rosa and San Miguel islands (Hoover 1970; Munz 1973). However, it is now recognized as a taxon restricted to Santa Rosa Island (Ingram 1990; Heckard et al. 1991), where it is found in two isolated populations occupying coastal dune scrub along the northern shores of the island. It grows in close proximity to a near relative, *C. affinis* ssp. *affinis*, at both locations, and hybrids form between the two taxa (Ingram 1990). Historic records indicated a broader range for *C. mollis* on the island, but herbarium specimens show that these were actually *C. affinis* ssp. *affinis* locations (Ingram 1990). *C. mollis* was collected from San Miguel Island in the 1930s, but no specimens were found in subsequent surveys (Junak, pers. comm. 1994) or as part of this research, and it is believed extirpated from that island (U.S. Fish and Wildlife Service 1997). Both Santa Rosa Island populations were open to access by cattle, deer and elk until June 1998, when the cattle were removed from the island. Stem breakage from ungulate trampling has been cited as a threat to *C. mollis* by botanists for many years (Ingram 1990), and it was a major factor in the federal listing decision (U.S. Fish and Wildlife Service 1997).

This research provides basic information on *Castilleja mollis* ecology, distribution, and abundance and establishes a long-term monitoring program for both populations on Santa Rosa Island. Systematic, island-wide *C. mollis* surveys were made in 1994, along with pilot sampling in non-permanent randomly located plots to determine density, damage, hybridization potential, and host plant and community associations. Permanent demography plots were sampled annually in the summers of 1995 to 1998.

In April and May 1994, historic locations and potential *C. mollis* habitats were surveyed on foot. Plants were mapped as they were found, voucher specimens were collected and stored at the Santa Barbara Botanic Garden, population boundaries were mapped, and numbers of plants within boundaries were estimated. A very large *C. mollis* population occurs intermittently along about 4 km of the northwestern shore of Santa Rosa Island between Jaw Gulch and Sandy Point. More than 1,000 individuals occur there in sandy openings or on thin sandy soils over limestone terrace deposits in scattered groups of ten to several hundred individuals. Estimates indicated that several hundred plants existed on the sandy north- and northwest-facing bluffs of Carrington Point, in narrow bands where vegetation has less than about 60% cover and trailing disturbance from cattle, deer, and elk is minimal. This population apparently hybridizes with *C. affinis* ssp. *affinis*, which is most common on the uppermost slopes of the bluff.

In June 1994, six 25 x 4-m plots were randomly sampled at each population to better quantify *C. mollis* abundance and condition. Numbers of plants and broken stems were counted for estimates of plant density and damage levels, floral and leaf characters were measured to estimate the spatial distribution of possible hybridization with *C. affinis* ssp. *affinis*, distances to nearest neighbors were measured to determine potential host plants, and community composition was recorded. A total of 1,002 plants was counted in the twelve plots. The mean number of plants/m^2 on Carrington Point was 0.51 ± 0.38 (standard deviation), and 1.16 ± 0.75 at Jaw Gulch. Broken stems averaged 55% of all stems in plots at Carrington Point, and 44% at Jaw Gulch. Floral and leaf measurements indicated that hybridization may be occurring where *C. mollis* grows in close contact with *C. affinis* ssp. *affinis*. The two taxa are in closest proximity along the upper elevation of the northwest-facing bluff slopes at Carrington Point, and on the slopes above the terrace between Jaw Gulch and Sandy Point. By far the most frequent nearest perennial plant neighbor to *C. mollis* ,and its most likely host, was *Isocoma menziesii*. The plant community at both sites is a degraded, fragmented dune scrub dominated by prostrate *I. menziesii*, with scattered *Astragalus miguelensis*, *Atriplex californica*, and *Erigeron glaucus*. Patches of *Distichilis spicata* and *Bromus diandrus* occur with annual grasses and herbs in openings among the shrubs. At Jaw Gulch, the community also includes substantial cover of *Eriogonum grande* var. *rubescens* and *Mesembryanthemum crystallinum*. Both mapping surveys and plot censuses indicated that ungulate trailing was common in the population boundaries. Deer scat was seen most frequently at

Carrington Point, while elk scat was more frequent at Jaw Gulch. Cattle used both areas and were present during all of the 1994 field work.

Nine permanent, randomly located, 5 x 5-m demography plots were installed June to August 1995. Three pairs of plots were located at Carrington Point, each pair consisting of an upslope and a downslope plot. Three plots were established on the nearly level marine terraces west of Jaw Gulch. For plot location, the occupied habitat was subdivided into thirds along the east-west length of the population, and plot locations were randomly chosen within each third. The upslope/downslope plot pairs at Carrington Point were designed to track performance of plants that may be influenced by *C. affinis* ssp. *affinis*, versus those that should be less affected. Because the main terrace *C. mollis* occurrence at Jaw Gulch did not appear influenced by *C. affinis* ssp. *affinis*, paired plots were not established there. All plants, or ramets, within plots were mapped and tagged. Numbers of live stems were counted on each tagged plant, and the numbers of broken and browsed stems were counted. Stems were tallied as browsed only when it was clearly apparent that browsing had occurred. Numbers of inflorescences were recorded for each stem. For five randomly chosen inflorescences per plot, numbers of flowers and phenological stages were recorded. Insect damage to stems and inflorescences was recorded, as were any other unusual plant characteristics. The plots were resampled in the summers of 1996, 1997, and 1998. Each plot was searched for seedlings and new vegetative plants annually, all plants previously mapped were relocated and measured or recorded as dead, and general habitat conditions and species present were noted. Data were summarized by plot and averaged independently for each population.

C. mollis generally grows by the production of branches from a woody caudex that forms at or just below the soil surface. More rarely, groups of stems appear to emerge from deep roots that are commingled with those of *I. menziesii*. Generally, this caudex or stem grouping is within or at the edge of an *I. menziesii* plant mat, and the *C. mollis* branches grow within the *I. menziesii* canopy. Branches of *C. mollis* can range from one centimeter to nearly a meter in length, are brittle and woody, and can persist for several years if undisturbed. Plants are mapped and tagged at the caudex or where a tight group of stems emerges from the ground unassociated with a caudex. Plants are tagged as new in the plot only when they have this central, branching tendency. The longest branches sometimes run along the ground surface and appear to re-emerge from duff at the soil surface up to several decimeters from the caudex. When this happens, these branches are traced to their origin to determine to which tagged plant they belong. A total of 437 plants, or ramets, have been tagged in the demography study from its inception in 1995 through 1998: 277 at Carrington Point (n=6 plots) and 160 at Jaw Gulch (n=3 plots). Both measurements of plant size (number of stems and length of longest stem), as well as the annual plant mapping, indicate that plants vary greatly in size and shape from year to year. Populations tend to be dominated by small established plants at both sites, by both measures of plant size. Mean density of plants in plots is generally lower at Carrington Point (1.04 plants/m^2 over the four years) than at Jaw Gulch (1.24 plants/m^2). Less than half of the plants form inflorescences each year.

There has been very high turnover of plants in plots at both sites during the study. In 1998, only about half of the plants previously mapped in plots were still there. Plant loss has ranged from none to more than half of the plants present in the plot the previous year. However, this loss is nearly replaced by the formation of new vegetative plants, or ramets, each year. Establishment of plants from seed virtually did not occur 1995 to 1997. In 1998, there was a flush of seedling recruitment in the westernmost pair of plots at Carrington Point, and several other plots had one or two seedlings. At Carrington Point, the net result of this pattern of turnover has been fluctuation about a mean of 22 plants per plot 1995 through 1997, with an increase to nearly 36 plants per plot in response to the recruitment episode. At Carrington Point, the numbers of plants in plots ranged from 20.3 ± 13.8 to 23.3 ± 16.5 from 1995 through 1997 (n=6 plots), while mean plant density rose to 36.3 ± 28.2 in 1998. At Jaw Gulch, the average plant density was highest in 1995, at 37.3 ± 8.7 plants per plot (n=3 plots); it declined to 21.3 ± 11.1 in 1996, and rose to 32.6 ± 11.8 in 1998.

Scraping of the ground surface by deer and elk during the fall and winter rutting season was a significant source of mortality in some plots in some years at both sites, killing from zero to more than 40% of plants in the affected plots. The caudex is uprooted and killed, *I. menziesii* plants are also lost, and patches of bare ground ranging up to a meter or more in diameter are created by this activity. Deer were active at Carrington Point, while elk prints and scat were associated with the damage at Jaw Gulch. Damage appears to be higher at Jaw Gulch than at Carrington Point. Other causes of plant mortality are not obvious. From 1995 to 1998, the mean percent of plants at each site with broken and ungulate-browsed stems has ranged from slightly less than one-third to about two-thirds of all plants present. Generally, stem breakage results in the loss of entire inflorescences. Additionally, a majority of plants exhibit some insect feeding damage to leaves or inflorescenses. When it occurs on inflorescences, insect damage generally results in the loss of several individual flowers rather than entire inflorescences.

Recruitment from seed generally occurs annually in other Pacific coastal *Castilleja* species (Weatherwax, pers. comm. 1997). This research shows that for 1995 to 1998, plants or ramets lost from the *C. mollis* sample populations have been replaced mainly by vegetative reproduction. Without the small flush of seedlings that occurred in 1998, the Carrington Point population would be seen as fluctuating for the short-term about a low mean plant density, while the Jaw Gulch population appeared to declining slightly. A continued lack of *C. mollis* recruitment from seed could result in population declines when vegetative plant mortality is high and sustained. Stem breakage by trampling, browsing and

insect damage can all reduce seed set with cumulative negative effects on population growth potential over many years. Mortality of established plants from the deer and elk scraping activity can further reduce reproductive output from an established population.

C. mollis has apparently maintained a presence in the face of generally high plant loss through vegetative resprouting and the formation of new caudices that persist for one to several years. Sexual reproduction has contributed very little to population turnover during the course of this study. Given the apparent importance of vegetative reproduction for short-term population maintenance, conservation measures should focus for the short-term on preservation and restoration of community structure to ensure vegetative growth and improve the longevity of existing plants. To ensure persistence over the long term, conservation management should seek to reduce and eliminate ungulate damage to plants that reduces the annual seed rain, prevents the development of a seed bank, and creates conditions unfavorable for seedling regeneration. The conservation goal should be to restore the balance of both vegetative and sexual *C. mollis* reproduction within dune scrub communities that can support long-lived individuals of both *C. mollis* and its host plants.

Keywords: California Channel Islands, Santa Rosa Island, *Castilleja mollis*, soft-leaved paintbrush, endangered, demography, disturbance, ungulates.

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