COAST SALISH CAMAS CONSERVATION

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Final Programmatic Report

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Summary

We surveyed 27 populations of camas (*Camassia leichtlinii* and *Camassia quamash*) in the San Juan Islands (and nearby Samish Island) and transferred plants from each of these populations to a protected conservation and research garden at Spring Street International School. We investigated possible morphological variation between these populations and compared the distribution of camas in the San Juan archipelago with what is known about the geographic distribution of different native Coast Salish peoples. We also investigated genetic variation using the currently available nuclear genetic markers for *Camassia spp*, and identified some new microsatellite loci for further investigation of genetic diversity. Work was carried out with the help of local students, land managers, property owners and interested community members to promote conservation of local camas populations and use of local stocks for restoration.

Project objectives

The San Juan archipelago supports extensive albeit patchy populations of both *Camassia quamash* (blue camas) and *Camassia leichtlinii* (great camas), and there is considerable historical, ethnographic and physical evidence of widespread Coast Salish cultivation of camas in the islands, including 19th century observations of women tilling marked fields (Suttles 2005). Camas is one of the iconic wildflowers of Western Washington, locally abundant on public lands throughout the region and regarded as an indicator of Native American cultural landscapes. Little was known about its historical ecology, however, or the competing effects of isolation on scores of islands and Native American cultivation on its genetic and phenotypic diversity. Our field studies confirm local beliefs that camas abundance has declined considerably over the last 25-50 years and continues to decline. This may be largely cultural: Coast Salish gardens were located near beaches and streams where residential development in the San Juan Archipelago is most intense (San Juan is one of Washington State's fastest growing counties). On public lands, meanwhile, camas populations appear to be declining due to competition from non-native grasses and shrubs in the absence of traditional cultivation practices (hoeing, weeding and burning).

We accordingly identified a short-term need to identify and protect representative local populations of camas across the San Juan Islands, and to establish secure nursery stocks encompassing the species' natural and anthropogenic diversity in the archipelago. In the long term, understanding the role of Native American cultivation and cultural diversity in camas diversity lays a foundation for the restoration and sustainable stewardship of relic cultural (that is, Coast Salish horticultural or agricultural) landscapes on public lands in the San Juan archipelago, and potentially elsewhere in Western Washington where camas was historically grown by other Coast Salish peoples.

Our original objectives were:

1. Survey and sample extant populations of camas across the San Juan Archipelago.

2. Assess underlying morphological variation in extant camas populations by growing specimens in a common garden.

3. Explore genetic variation within extant local camas populations using published sequences of noncoding regions of closely related Liliaceae.

4. Establish and maintain genetically diverse camas morphotypes from the San Juan Archipelago as a source of documented bulbs for restoration projects.

5. Provide recommendations for the stabilization of extant camas populations and the restoration or recreation of camas garden ecosystems on public lands.

6. Compare camas phylogeography with the pre-Contact distribution of different Coast Salish groups as a basis for estimating the role of culture and human selection on diversity.

7. Involve Native American and other local students in learning how Coast Salish gardening transformed landscapes and cultivars, as a case study of human ecology.

Methods

We collected 5-6 bulbs from each of 27 camas populations in the San Juan archipelago. At each collection site, we measured stalk height, number of flowers or seed capsules and flower color of at least 20 plants, as well as bulb weight for the bulbs that were collected. We also recorded data on the associated plant community, soil depth and structure, slope and aspect, hydrology, charcoal evidence of pre-Contact burning, and the disturbance history of the site (archeological exposures, historic structures, roads, trails). Plants were collected between May 3 and June 5, 2007. Grade 6 and Grade 7 science classes at Spring Street School helped plant the collected bulbs in our conservation and research garden at their school. Information on the project, its methods and objectives was provided to the students during science class sessions.

Local students helped us extract DNA from leaf tissue collected from the garden plants. We sequenced non-coding regions (the trnL(UAA)-intron and intergenic spacer between the trnL-(UAA)-3'-intron and trnF-(GAA)gene) from a subset of the samples. In order to develop finer-scale genetic tools we located novel microsatellite loci through a process of enrichment and screening following methods developed by Hamilton *et al* (1999), Glenn and Schable (2005), and Wang *et al* (2007). We identified six novel microsatellite loci with sufficient flanking sequences to develop primers.

Data on morphological characteristics (stalk height, flower number, seed capsule number, flower color) and date of flowering were collected in 2008 for plants that flowered in the conservation garden. Morphological characteristics from the initial surveys and from the garden plants were compared across the collection, and we attempted to identify unique morphotypes as well as the likeliest drivers of morphological differences. Pre-Contact

distribution of Coast Salish groups (from ethnographic and linguistic literature, Suttles 1951b, 1990) was compared to the distribution of camas diversity.

As a result of this project and related work with native plants we received the donation of the use of approximately 5 acres of land for growing native plant species (approximately ¼ acre of this will be planted in camas from this project) and have started a native plant conservation program: the Islands Plant Diversity Bank. This program uses volunteers to collect seeds of local plant species for *ex situ* conservation, research, and propagation for restoration and native plant sales.

Results

We were able to survey more populations of camas in 2007 than we initially anticipated (27 as opposed to 20) and, as a result of our outreach activities, we were invited to visit a number of additional populations in 2008 that were not included in the initial survey. When Brook Brouwer joined the project as an intern in 2008, he gathered detailed data (including soil chemistry and soil arthropod communities) on three more populations of *C. quamash*, and began a long-term study of a *C. quamash* patch on Waldron Island.

We will begin propagating locally collected camas at Hudson Farm for use in restoration projects in November 2008, assisted by local volunteers and student intern Tasha Wilson. The San Juan National Historical Park is using camas seed collected by their own staff and volunteers to try to restore a prairie at American Camp, San Juan Island, but there are no other projects restoring camas on public lands. Nonetheless we have been approached by a number of private landowners interested in restoring native meadows on their land. At this time, we have substantial seed collections from Lopez and Waldron Islands, and our establishment of an Islands' Plant Diversity Bank to supply and encourage the use of local native plant stocks in restoration generally has been gaining attention. Since August 2008, volunteers have been collecting seeds from local woody plants for propagation and sale at the San Juan Conservation District and Master Gardeners' Foundation's Annual Native Plant Sales. Seed collections of camas and other geophytes and herbaceous plants began in July and these plants will be available at local native plant sales in 2009.

The published primer pairs for camas and related Liliaceae turned out to be too coarse to differentiate between the islands camas stocks we collected in our conservation garden. To develop a finer-scale genetic tool we probed the camas genome for microsatellite loci, succeeding in identifying six novel microsatellite loci and developing primers for testing four of them. Further research with these loci should provide us with a map of genetic relationships between our 27 collected camas populations. Identification of novel camas microsatellite loci is itself a considerable advance that will be useful to other researchers.

Although we were unable to genetically identify any unique camas genotypes that could have resulted from selection by Coast Salish gardeners, our survey did discover a unique camas morphotype that may be associated with cultivation: a stable, late-flowering, nine-tepaled *Camassia leichtlinii* (camas generally have six tepals). The frequency of this morphotype was low (1 in 20 plants surveyed) but possibly represents a relic cultivar. We will conduct further field surveys with volunteers from Orcas Island in May 2009 to seek other individuals with the same morphological characteristics.

We found only a few sites with soil conditions and contexts that suggested relic camas gardens *i.e.* non-stratified charcoal rich soils with documented nearby archeological sites. This may be due to several factors. Coast Salish began replacing camas in their gardens with potatoes (*Solanum tuberosum*) in the 1790s (Suttles 1951a). European settlers in the 1850s-1870s avoided the toil of clearing woodlands by settling in Coast Salish gardens, where they mainly planted Eurasian grasses for sheep pastures. Recent residential build-out has undoubtedly destroyed many old camas gardens. Most of the camas patches that we sampled are on isolated rocky outcrops where neither farming nor homebuilding are practical.

Fortunately, this project has contributed to protecting two of the three sites we identified as probable relic Coast Salish gardens: Wilding Farm on Shaw Island (private) and Indian Island (BLM). We have reported our findings to Washington State Parks, the manager of the third site (Blind Island), and will continue making protection recommendations.

Many local students participated in this project: Grade 6 and Grade 7 science students at Spring Street International School; four high school student volunteers from Lopez High School and Spring Street International School; two undergraduates from Lopez Island; two undergraduates from the University of Nice (France); and one graduate student from Lopez Island. Three local students assisted in the genetics analysis and learned the basics of plant genetic techniques: DNA extraction; restriction enzyme analysis; amplification by polymerase chain reaction (PCR); gel electrophoresis; dye terminator sequencing and microsatellite genotyping.

(We note that the one Native American high school student in our program this past year elected to study analytical chemistry rather than genetics. After his internship with us, he moved on to an internship at the NASA Jet Propulsion Laboratory—a success of another kind, even if it did not have to do with camas!)

During the course of the project botanist-geneticist Madrona Murphy and Kwiáht director Russel Barsh have made 15 presentations on Coast Salish camas cultivation, including a major public lecture at the Lopez Community Center, and classroom presentations to the regional Marine Naturalists Program (Friday Harbor Whale Museum), Leadership San Juan County (Skagit Valley Community College), Bulloch Farm's annual permaculture summer course, and eight Elderhostel tours (Skagit Valley Community College), as well as the Musqueam First Nation (arranged by the University of British Columbia).

A significant unanticipated outcome was the donation of the use of approximately 5 acres of private land on Lopez Island to continue camas and other native plant propagation and research. This encouraged us to establish formally the Islands' Plant Diversity Bank and begin the collection of seeds for local plant sales (17 species thus far). The only college-level facility in the islands, Skagit Valley Community College, has promised additional help for the Islands' Plant Diversity Bank through an annual "service course" beginning September 2009, that will grant credit for learning and doing seed and bulb collection and propagation of camas and other native plants.

There is a strong local-foods movement and large number of local producers (vegetables, beef and lamb, orchards, vineyards) in San Juan County. Our surveys and presentations sparked considerable local interest in growing camas as food. Fifteen private landowners and gardeners from four different islands have requested information on growing camas

or enhancing and protecting camas on their property. One of the grocers on Lopez has also inquired about the possibility of selling camas produced locally for use as food.

We have also made progress in getting more local students trained in genetics: two of the local students who worked with use on genetics this year are planning on returning next summer to assist on further projects and in focusing more on genetics and biochemistry in their university studies. And while we did not find any Coast Salish students last year we received a letter of "interest" from the Lummi Indian Nation, which has historical ties to the islands, and have begun corresponding with young researchers at Musqueam, another Coast Salish people, with the expectation that one of them will intern with us in 2009.

Follow-up activities

We will continue re-visiting several camas populations annually to better understand the impacts of herbivory (mainly Columbia deer) on camas growth and survival; studying the camas collection growing in our research garden; presenting our research to the public; pursuing our initial success in identifying microsatellite loci for camas genotyping; and providing technical advice, bulbs and seeds to public landowners. Camas will form a key component of our evolving Islands' Plant Diversity Bank at Hudson Farm, Lopez, and we hope to continue to recruit more local volunteers for seed collection and propagation—as well as more local gardeners and farmers for experimental camas food production.

A major interest of ours will continue to be the identification, study and restoration of old Coast Salish camas gardens in particular on public lands. We have made a start with relic gardens on BLM and State Park property, and have begun a discussion with the National Park, which believes it has a relic garden at its American Camp property. Kwiáht enjoys an excellent working relationship with the San Juan County Land Bank, which now owns nearly three square miles of shoreline and upland property, and we will be vigilant, in the course of plant surveys on Land Bank tracts, for camas occurrences.

Our initial camas survey was not designed to evaluate the impacts of herbivory on camas, a factor highlighted by a dissertation on the Gulf Islands just completed by Tara Martin at the University of British Columbia. The presence of Columbia deer had a visible effect on camas size and density at the camas patches we visited, and monitoring deer presence and effects would provide useful information for camas conservation—as would deer exclusion experiments, which were beyond the scope of this NFWF project.

Discussion

We have demonstrated that camas can be transplanted while in bloom with good success (100% survival in our study); camas was collected while in bloom and stored for up to 4 days with their bulbs and roots in water. This suggests that camas can be salvaged at any time of year without appreciably decreasing its survival.

We did not find any evidence of asexual propagation (bulb splitting) in the field, although it was clearly evident in the commercial bulbs that we purchased for comparison. We are continuing to investigate this apparent inconsistency. In the mean time we achieved good germination and survival with camas seed collected in the field, and either planted in late fall, or stratified (kept chilled in a refrigerator) for over 60 days. Seed grown plants may

be more useful for assessing morphological differences, as they will not exhibit residual effects of environmental conditions. Seedlings apparently take up to five years to reach blooming size, however, and thus cannot be used for short-term projects such as this one.

We did not find evidence of fire in most of our collection sites, suggesting that while fire may have been a tool used in Coast Salish gardening it may not be necessary for ensuring the survival of camas. Soil depth, organic matter, and the absence of herbivory pressure were the best predictors of size for the 542 plants for which we collected data in 2007. Indeed, intensive herbivory by Columbia deer may represent the greatest threat to camas survival on public lands, where we saw the most striking evidence of deer pressure. The population of Columbia deer appears to be significantly higher than it was in pre-Contact times, based on historical documents from the 1850s, and hunting or excluding deer was almost certainly a part of Coast Salish camas management.

Continuing research on weeding, burning and hoeing by our student Brook Brouwer may provide an answer to unresolved questions about asexual reproduction, and the possible importance of fire and disturbance in promoting camas meadows.

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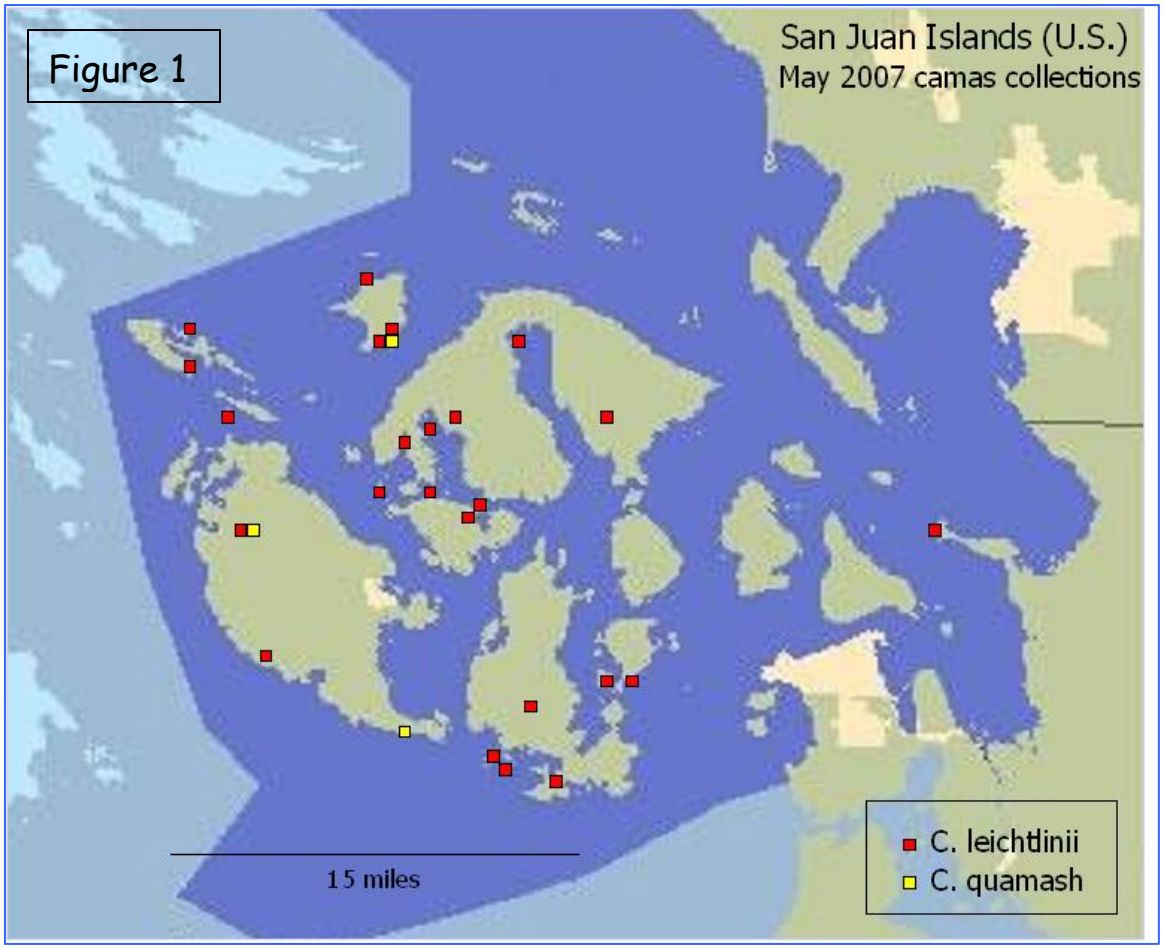
Figure 1
San Juan Islands (U.S.)
May 2007 camas collections
15 miles
C. leichtlinii
C. quamash


Figure 2: Camas bulb with tuberous roots

Figure 3: Camas growing in a woodland opening, Waldron Island.

Figure 4: Camas color variation in the field; dark blue, light blue, and white in adjacent individuals.

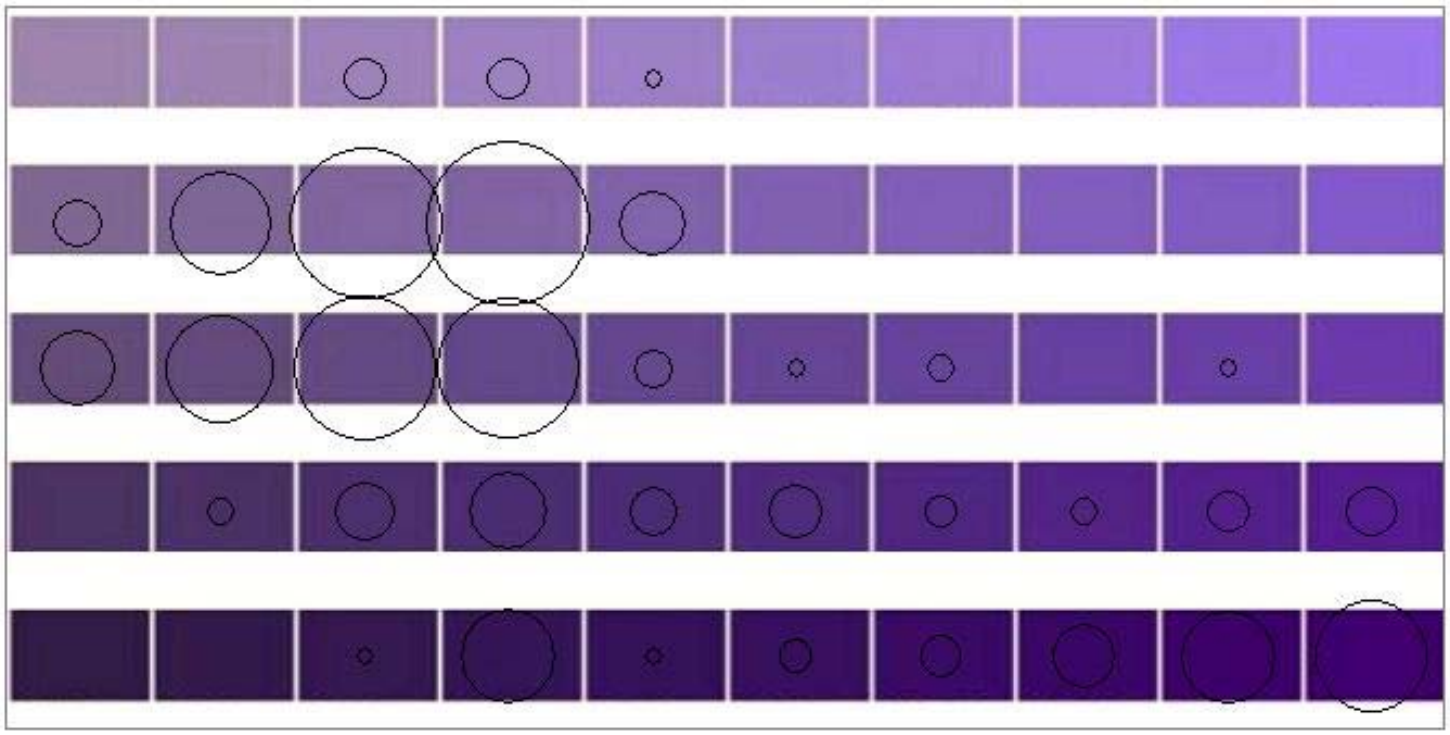

Figure 5: Color of camas bulbs when collected in the field (above) and when examined in our common garden the following spring (below).

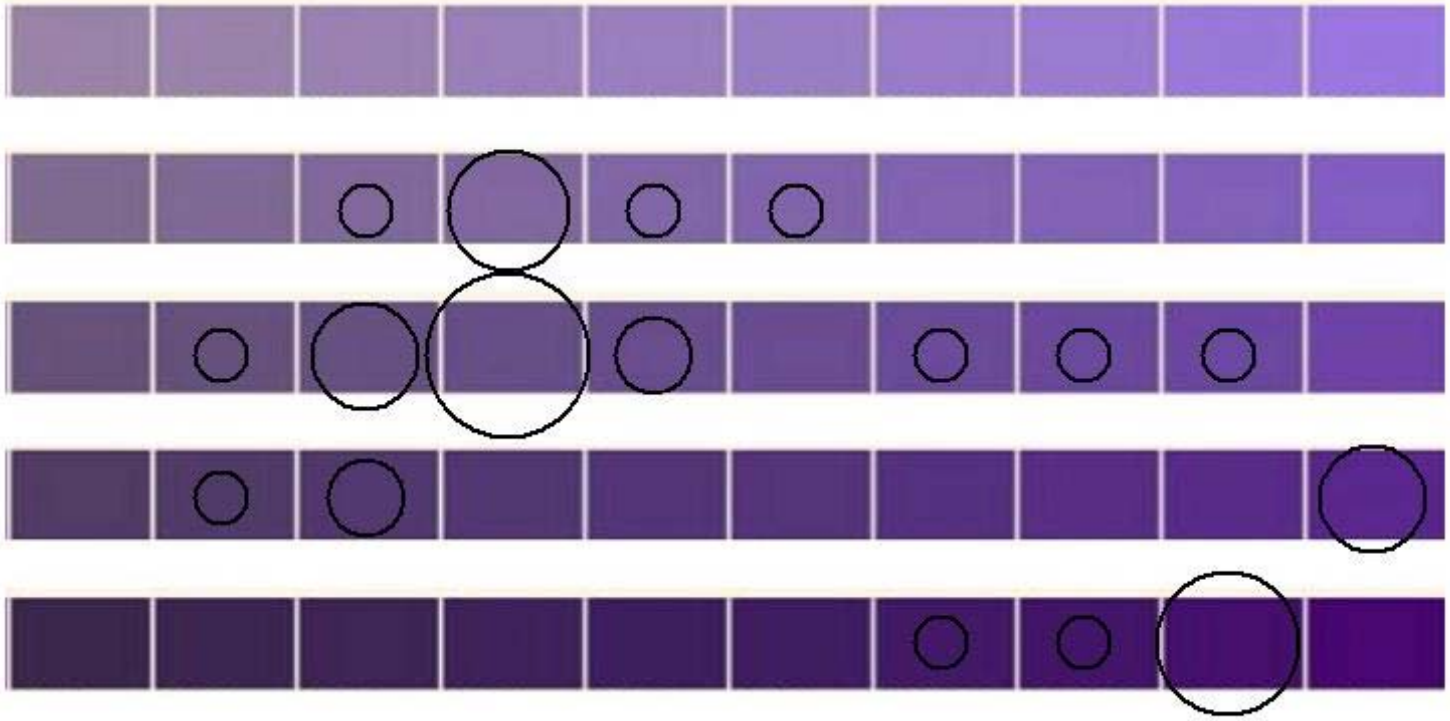

Figure 6: Stalk height of camas when collected in the field (red is *C. quamash*, gray is *C. leichtlinii*).

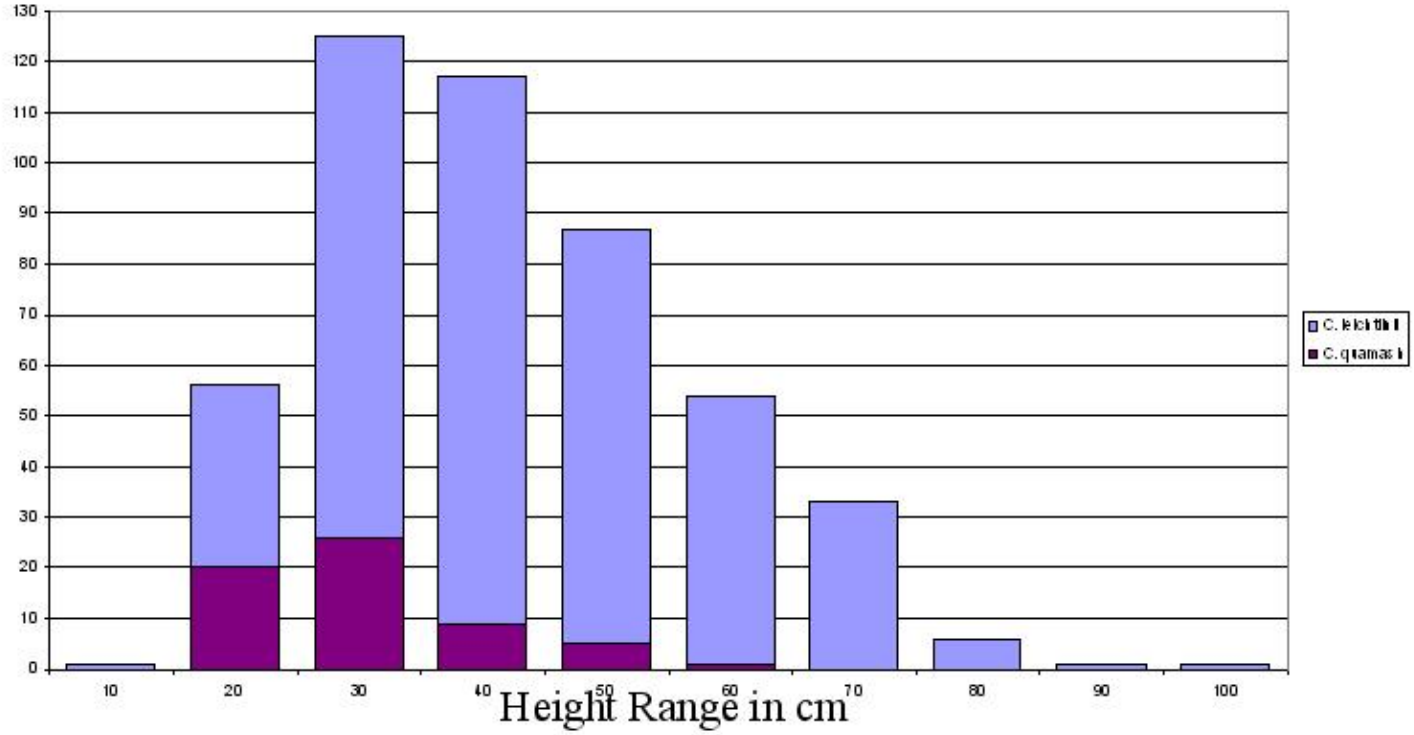

Figure 7: Flower number in relation to stalk height, at time of field collection.