Olonā (*Touchardia latifolia* Gaudich.): Testing the tensile strength of wild populations

Juliana Mikioi Wichman

Research

Abstract

Olonā (*Touchardia latifolia* Gaudich.) is an endemic Hawaiian plant used by Hawaiians to make some of the strongest cordage in the world. Within the **ahupua'a** (land division) of Hā'ena on Kaua'i, there are wild populations of **olonā** growing however, no one in Hā'ena knows how to manage or prepare the fibers. The mission of Limahuli Garden is to perpetuate traditional cultural knowledge as well as to grow and perpetuate native Hawaiian cultural plants. Therefore a long-term project to cultivate and teach community members about sustainable use of **olonā** was proposed to perpetuate an important cultural practice. I investigated three populations of **olonā** to determine whether growing conditions influence cordage strength. I hypothesized that Limahuli Valley has cultivatable **olonā** and ideal growing conditions as talked about by Handy & Handy (1972), and would produce plants that had stronger fibers. I collected individuals from three different growing conditions. A modified tensile strength test was designed and two-ply cordage of 25 cm long, comprised of 6, 12 and 24 individual fibers did not support my hypothesis, but lead me to hypothesize that stem diameter (age of plant) rather than environmental growing conditions effect the fiber strength. Limahuli Valley has established wild populations of **olonā**, which if managed properly, might yield stronger fibers and lead to the establishment of a successful community population.

Introduction

Olonā (*Touchardia latifolia* Gaudich.) is an endemic Hawaiian plant that can still be found in selected areas of the main Hawaiian Islands (Wagner 1990). It is a member of the Urticaceae family, however, like other native Hawaiian plants, it has lost its stinging nettles and instead has some of the world's strongest fibers that was a world commodity prior to the introduction of synthetic cordage (Kepler 1998). **Olonā** was once an extensively cultivated plant used by Hawaiians for various artifacts including the base of feather cloaks, lashings, fish lines and carrying nets (Abbott 1992, Krauss 1993, Summers 1990). The desired cordage was once a commodity because its natural 'fibers' (actually laticifers (Harvey 1999)) are extremely long, strong and durable (see Figure 1).

Wild patches of **olonā** in Limahuli valley in Hā'ena on the north shore of Kaua'i show up in records of the Pacific Tropical Botanical Gardens (PTBG), later known as the National Tropical Botanical Gardens (NTBG) as early as 1971 (Stern 1971), and searches into the valley have found several more populations in the main drainages of Limahuli Valley suggesting that **olonā** cultivation most likely occurred in Hā'ena. According to Kamakau (1976) populations up to two acres were cultivated and managed. Unfortunately, when Hawaiians were displaced from their land and access restricted, populations of **olonā** grown in the marshy upland forests (Handy & Handy 1972, Kamakau 1976, Loeffler 2003) were abandoned and materials

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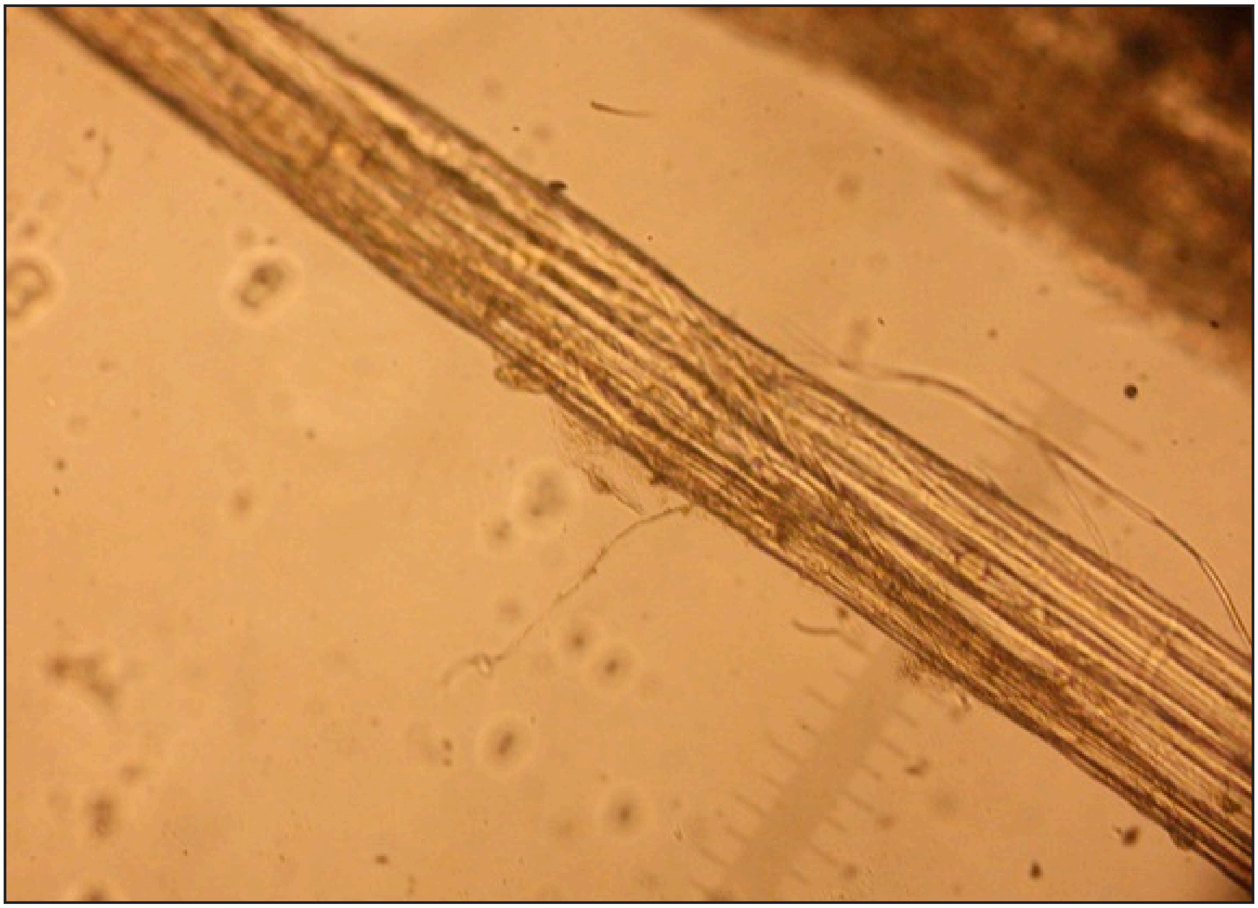

Figure 1. Image from a light microscope show the twisting and surface structure of an individual lactifer of **olonā** (*Touchardia latifolia* Gaudich.) which interlock with other lactifers to form some of the strongest bonds found in natural fibers.

easier to access and in abundance such as **hau** (*Hibiscus tiliaceus* L.) took their place.

Preliminary inquiries of the **kupuna** (elders) and youth in Hāʻena indicate that no one currently knows how to prepare or use **olonā**. Limahuli Gardens in Hāʻena, desires to perpetuate traditional cultural knowledge. Having these **olonā** sites within the garden's management has begun a dialog to initiate cultural awareness and create an easily accessible **olonā** patch for sustainable community use and education.

Methods

This project encompassed a range of methods and materials. Personal interviews, analysis of herbarium specimens and field collections helped me to obtain the initial information and materials. Once materials were gathered, a tensile strength test was conducted through experimental reconstruction of cordage, physical microscopy analysis of fibers and mechanical manipulation of the cordage.

Interviews

Semi-structured interviews (Alexadies 1996) were conducted with members of the community in Hāʻena ranging in age between young adults to respected elders. Interviews questioned the informants about their knowledge and use of **olonā**.

Herbarium Research

Herbarium specimens of **olonā** were examined at PTBG to gather basic information about the plant's reproductive cycle, variation, and location of documented **olonā** patches.

Field Collections

Field sites were determined based on knowledge of a local informant who identified and located three different populations of **olonā** within Limahuli Valley. Populations were designated as 1 A & B, 2 and 3. After locating these populations from three different drainages, plants were collected to test their fiber strength. A slight variation in environmental conditions, upper canopy shade, water accessibility and growing location (in or near the stream bed), suggested that environmental conditions might affect fiber strength.

Once at population sites, initial survey of the visible health of the population was conducted and ideal looking branches referenced in Kamakau (1976) were selected for harvest. These stalks typically lacked browning on the outer bark, averaged 1.3 cm in diameter, and were barely over 2 m tall. Voucher specimens were produced for each population and deposited into PTBG.

Experimental Reconstruction, Physical Microscopy and Mechanical Manipulation

The upper portion of the stems (where the leaf scar/nodes are really tight together) were cut off and either used for specimens or discarded. The remaining part of the stem was stripped of its bark, and inner woody material discarded. The **olonā** bark was then rolled with the inside facing out, to help flatten it out. These rolls were then placed in buckets of water for 42 hours to help ret, or loosen the fibers. The water was changed once, at 24 hours. When soaking was completed, strips were rinsed and allowed to dry so that individual fibers (126 fibers) of at least 30 cm could be extracted.

A light microscope was used to look at individual fiber composition, and ensure that only one fiber was being pulled. Kirby's (1963) basic principle was used to test tensile strength. My experiment was designed so that individual fibers were rolled into a 2-ply cord of either 6, 12, and 24 fibers (see Figure 2) using an S twist. To account for variability in breakage weight, each cord size (6, 12, 24) was created in triplicate.

Cords were trimmed to 25 cm long to remove untwisted ends. One end was placed in a folded piece of cardboard

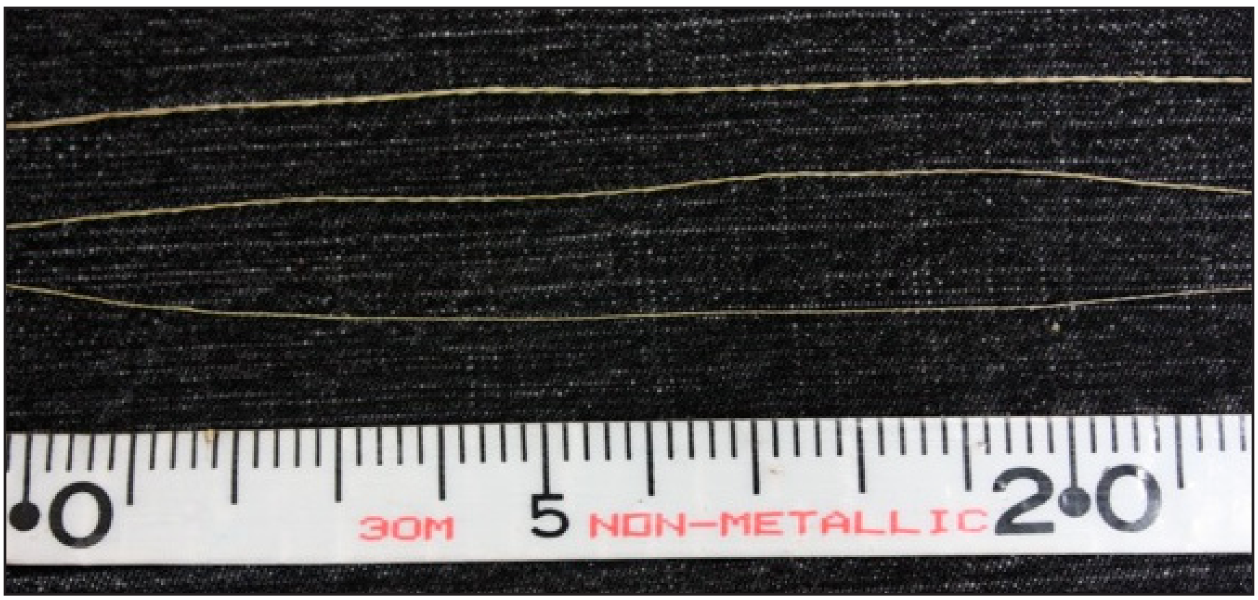

Figure 2. Top to bottom; 24, 12, & 6 two-ply **olonā** (*Touchardia latifolia* Gaudich.) cordage from Limahuli, Kaua'i, tested for strength.

and wrapped around once to prevent slipping. An end was then anchored into a secure spot using a C clamp. The loose end of the cord was folded into another piece of cardboard and wrapped until the distance from the secured end to the edge of the free cardboard was 10 cm. A second C clap tightened the loose end and cordage diameter measurements were made at about 1 cm from either end and in the middle. A 100 pound fish scale was then hooked into the hanging C clamp and manually pulled horizontally until the cord broke (Figure 2).

The procedure was repeated until all samples were tested. After running the test on populations 1A and 2, it was inferred that the diameter (age of plant/maturity) could effect the fiber strength, and another individual from population 1(B) was processed as above to determine their strength and recorded (Table 3).

Results

Interviews

Semi-structured interviews with community members of Hā'ena helped to determine the location of the three **olonā** populations used in this study, however, other populations were mentioned, but not located. The majority of informants had little or no knowledge of **olonā**'s use, however, many expressed an interest in the plant, and in how to make cordage.

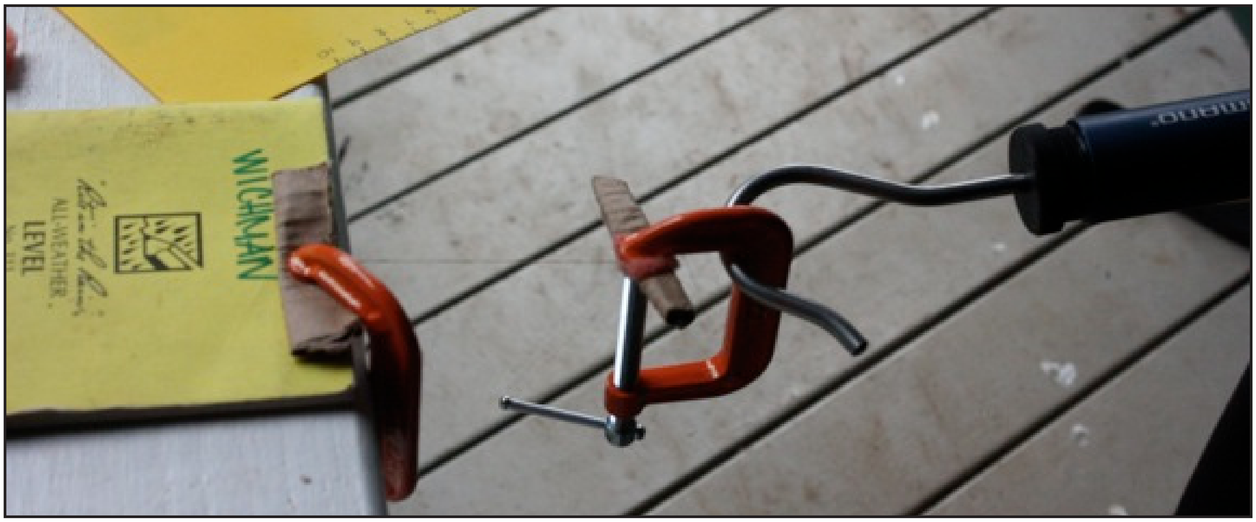

Figure 3. Experimental method for testing strength of **olonā** (*Touchardia latifolia* Gaudich.) cordage in Hāʻena, Kauaʻi. Two C-clamps secure each end of the cord within a fold of cardboard. One end is secured to a fixed object (table) and the other to a scale used to measre the breaking strength.

Herbarium Research

Herbarium research conducted at PTBG helped identify previous location sites of collected **olonā** on the island of Kauaʻi, and specifically within Limahuli. The earliest herbarium **olonā** specimen within Limahuli Valley was by W.L. Stern in 1971. Evidence for reproductive structures such as, inflorescences or seeds, among herbarium specimens for Kauaʻi were charted (Table 1) to indicate a possible flowering cycle.

Table 1. Possible flowering cycle of **olonā** (*Touchardia latifolia* Gaudich.) on Kauaʻi based on absence or presence of reproductive structures on herbarium specimens at PTBG.

Month	Present	Absent
January		X
February		X
March		X
April		X
May	X	
June	X	
July	X	
August	X	
September	X	
October	X	
November	X	
December	X	

Field Collections

Three field sites were chosen for study. Table 2 illustrates field notes taken when assessing the health and size of the three population, diameter at base of individual plants selected for experimental reconstruction, and specimen numbers deposited into PTBG. Herbarium specimens were collected and deposited into PTBG.

Experimental Reconstruction

Experimental reconstruction of **olonā** cordage tested the tensile strength of fibers from individual plants of three different populations. Testing of the constructed two-ply cordage did not show a significant difference between populations (1B, 2 and 3) however, further tests were conducted with an individual from population 1 whose basal diameter was almost 1 cm larger (Table 3) to see if age (indicated by diameter size) would have any effect, and results show that maturity may play a significant role in strength.

Physical Microscopy

Physical microscopy was used for further analysis of individual fibers and breakage points in cordage to see if there were microscopic differences not easily recognized by the naked eye.

Discussion

Comparing two individuals from population 1 which were different in diameter (A: 2.5 cm and B:1.2 cm) suggested that the larger individual (presumably more mature) had stronger fibers (Table 3). This could indicate that there is a preferred time and age to harvest **olonā** for optimal cord-

Table 2. Field notes taken at the time of collection of fiber samples from **olonā** (*Touchardia latifolia* Gaudich.) in Hā'ena, Kaua'i.

Population #	Coll. #	Habitat	Population Size	Diameter at base	Notes
1	JMW 080	In medium stream bed with constant flowing water, partial sunlight	56 individuals	A 2.5 cm; B 1.2 cm	Infestation of white fly and scales are present on the leaves of a few individuals. About a dozen individuals give rise to the entire population. One large individual had a base stem of almost 2". Only white venation was seen. No inflorescences present. Two specimens were collected to see if there was a correlation with diameter size and fiber strength. Smaller diameter stuck to the stalk more than the larger one. No reproductive structures present. (N 22. 20580, W 159.58050)
2	JMW 081	In small stream bed with constant flowing water, shaded	4 individuals	1.3 cm	Only two individuals counted at this site-below the bamboo patch. Only white venation was seen. No inflorescences present. Of all the populations, this was the hardest to remove from the bark in one piece and thus make it hard to get long fibers. No reproductive structures present. (N22.20934 W159.57265)
3	JMW 082; JMW 083	In stream bed of intermittent drainage in sunlight and shade	N/A (largest population)	1.6 cm	Distinct venation of red and white plants. Largest population. Evidence of recent flooding present in valley. No reproductive structures present. Four samples were taken at population 3, one red veined, and one white veined from top, mid and lower sections of the patch. Presences of scales on some individuals. (N22. 21460,W159.57182)

Table 3. Average breakage weight and diameter of twisted cord of **olonā** (*Touchardia latifolia* Gaudich.) in Hā'ena, Kaua'i, for each population. Populations 1B, 2 and 3 had similar basal diameters, whereas population 1A had a diameter almost 1cm larger.

	Population											
	1A			1B			2			3		
	6	12	24	6	12	24	6	12	24	6	12	24
Average Diameter of cord (mm)	0.04	0.11	0.19	0.02	0.04	0.12	0.04	0.06	0.12	0.05	0.11	0.15
Average Breakage weight (lbs)	2.5	5.7	8.8	0	2.8	4.7	0	1.2	3.7	0.03	2.3	4

age strength. It was also noted in field collections (Table 2) that the larger diameter was easier to remove from the stalk. It was impossible to determine the age of the individuals tested within this study simply because they were not from a managed population, but based on size, data support previous documentation by Summers (1990), Kamakau (1976) and Handy & Handy (1972) that there is a proper time to harvest plants (between twelve to eighteen months), and also supports why cultivation was so important.

Summer (1990) also indicated that the best stems for harvest were about 2.5-5 cm in diameter. Population 1A fit this size, although at the smaller end of this range. When tested, the larger diameter plants produced cordage that had a tensile strength almost double that of smaller, immature plants (Table 3). The data does not show a strong correlation between fiber strength and environmental conditions, such as growing in ephemeral or intermittent streams with or without shade, but suggest that all populations have potential to produce harvestable desired fibers if allowed to mature and harvested at the appropriate age.

The substantial variance of fiber strength among the largest cord of 24 individual fibers with an average strength range of 3.7 lbs to 8.8 lbs, and the smallest cord of 6 fibers with an average strength range of 0 lbs to 2.5 lbs, shows variation among individuals, but strongly suggests that age plays an important role. Strength of the cordage can be directly linked to the maturity of the plant as Funk (1982) states that length of individual fibers at maturity can surpass 1.5 m, and a longer fiber length allows the cordage to hold better, thus producing a stronger cord (Grainge 1975).

Table 2 shows that population 1 had the largest basal diameter of 2.5 cm, greatest strength overall and largest noticeable individual fibers, whereas population 2 had the smallest basal diameter of 1.3 cm, the weakest in strength and smallest noted fibers. It was noted that the fibers were harder to extract from the stem and made them significantly shorter, and thinner in population 2.

The limited cultural use and knowledge of **olonā** leaves many questions unanswered. The remote locations of **olonā** populations has restricted access to many people and has restricted the practice of a once important tool of the Hawaiian culture. The goal of a community-accessible population could be achieved by transplanting some of the current populations into lower elevations. However, proper management practices of the current populations, understanding the population structure, and cultivation will ultimately determine the success of establishing a community population.

Conclusions

The knowledge of **olonā** cultivation and use as cordage in the Hawaiian culture has decreased with the introduction of modern technology and tools, almost to a point that it has been forgotten and only known as an artifact in stories. With wild populations and community interest/involvement knowledge and use of this plant could be perpetuated.

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