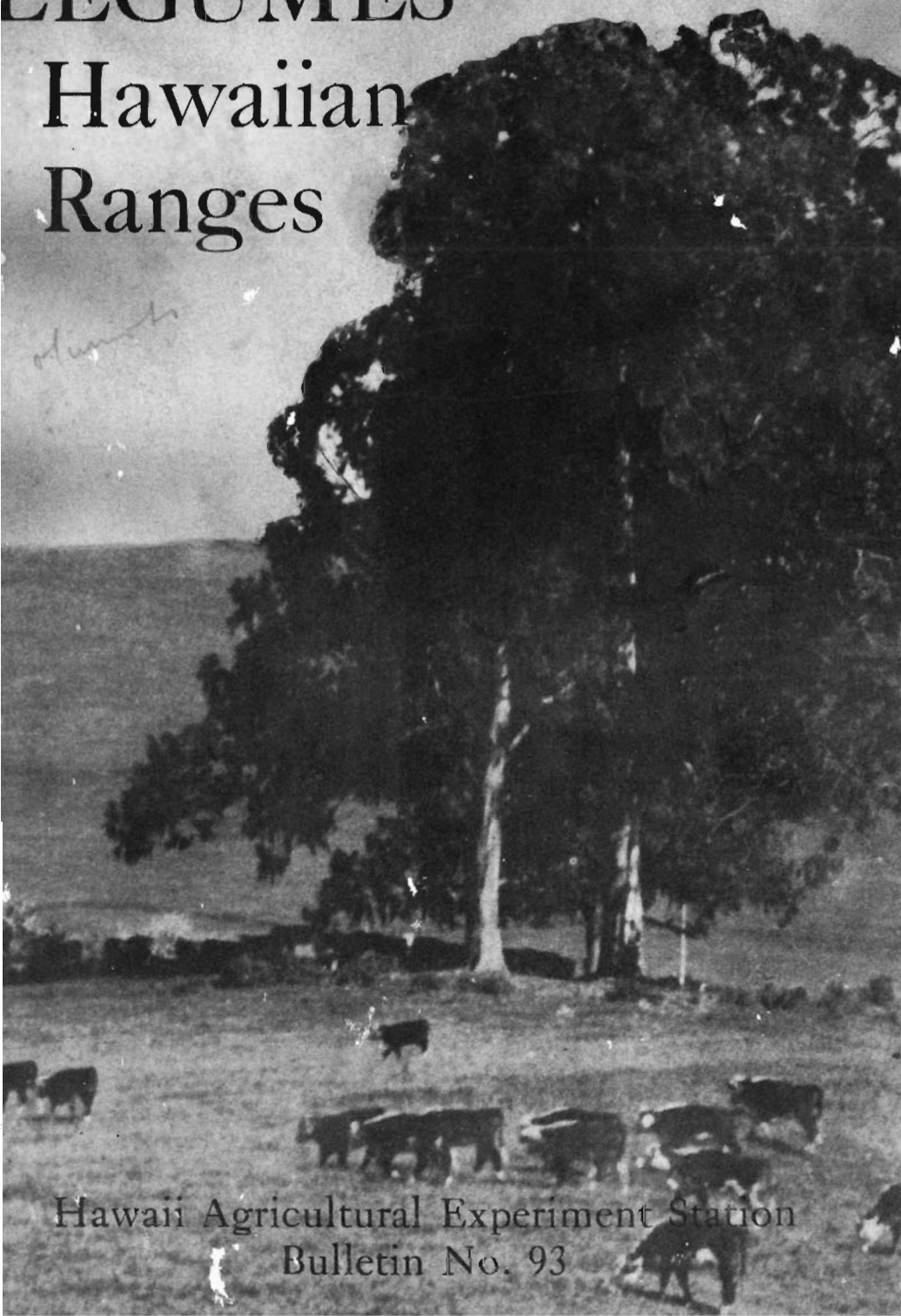


# LEGUMES OF THE Hawaiian Ranges

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# LEGUMES OF THE HAWAIIAN RANGES

by

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MARCH, NINETEEN HUNDRED AND FORTY-FOUR.



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## INTRODUCTION

The number of leguminous forage species found in pastures throughout the Hawaiian Islands is large, owing to the wide range in climatic conditions. At low elevations tropical species predominate, but at higher elevations many of the most desirable temperate zone pasture legumes are found. Despite the number of adapted species, legumes do not form an important part of most pasture swards. Nearly all of the forage legumes have been introduced, and limited distribution is due in part to sporadic planting and relatively slow natural spreading. Many attempts by ranchers to establish legumes have failed, and the conclusion has often been reached that it is impractical to maintain them in tropical pastures.

It must be admitted that there is a dearth of information regarding pasture legumes in the tropics (9). There are no proven practices such as are available for temperate zone conditions. In the cool uplands where the best of the temperate zone legumes are adapted, there are still the agronomic problems of proper soil preparation, methods of inoculation, the need of lime and phosphate, and of grazing management to maintain the different species. In the lowlands is added the problem of suitable species (4). While the total number of leguminous species in the tropics is very large (8), few publications treat of legumes specifically for forage, and there is even less information regarding pasture legumes and their maintenance under grazing conditions. However, the present distribution of a considerable number of desirable pasture legumes and the occasional pasture where they have been maintained as an important part of the sward give rise to the belief that, with more adequate knowledge of the proper species and the best practices for their establishment and maintenance, legumes can become an important part of the grazing mixture in many parts of the Territory.

The Territory has special need for legumes in its pastures. Protein concentrates are imported in large quantities, especially for dairy animals, and constitute the most costly part of the dairy ration. Imported concentrates are also being used to a limited degree for fattening beef cattle, both in pens and in pastures. Such car-

like or leaflike structures, called stipules, which are usually long-persistent or fall off only with age. The stipules vary considerably in shape and size among species and are useful in some instances in identifying the plants in the vegetative stage.

Flowers of legumes are grouped in a head or in a raceme. In either case the individual flowers are attached to a central axis, each by its own short stalk or pedicel. If the flowers are borne at the end of the stem, they are said to be in a terminal inflorescence; if the flowers are arranged in the axils of the branches, they are said to be in an axillary inflorescence. A papilionaceous (butterfly-shaped) legume flower is characteristic and can be easily identified by the structure. The corolla is made up of 5 petals. The uppermost petal (called the standard petal) curves upwards and is somewhat broader than the rest. On either side are the wing petals, which are separate from each other. Between the wing petals is a pair of structures, often united, called the keel petals, a name derived from their boat-like shape. The essential sexual organs, the stamens and the pistil, are within these keel petals. Another type of legume flower has the regular form with the petals and sepals alike. Most legumes have 10 stamens. When all 10 stamens are united into a sheath, the arrangement is called monadelphous, but when 9 stamens are united into a sheath and the tenth stamen is free, the arrangement is called diadelphous.

The fruit of a legume is a pod, usually long-cylindrical or flattened, with raised ridges or sutures on both edges. In some pods, the suture on only one side splits open to free the seeds within. In others, the two sutures split open with violence, owing to unequal drying of the pod, forcing the seeds to fly many feet away. In some species the pod never splits open, and the seeds are exposed only when the pod decays.

# ZONAL DISTRIBUTION AND ADAPTABILITY OF LEGUMES

## DISTRIBUTION

A series of vegetation zones of Hawaii has been proposed by Ripperton and Hosaka (6). These zones are based largely on a survey of the distribution of established species in pastured lands. The zoning makes possible the grouping of similar environments on all the islands and provides a basis for evaluating the optimum requirements of rainfall, temperature, and altitude for each species. Although localized climates and physiographic and soil factors materially alter the growing conditions described for a zone as a whole, the zones are useful in considering the present habitat and probable ultimate distribution of legumes.

Following are the general characteristics of each zone and the legumes which are found in each:

*Zone A.*—Low elevations on the leeward sides of the islands. Rainfall is less than 20 inches annually. This is the hottest and driest zone. Rainfall is principally of kona (southwest) origin, most of which comes in the winter. Kona rainfall is subject to greater variation from year to year than trade-wind rainfall. It is often torrential so that the proportion of the rainfall utilized by the plant is small. The natural vegetation is sparse; it consists largely of drought-resistant shrubs except on the coastal flats, where the roots of certain trees and shrubs penetrate to ground water and support good growth. Certain annual grasses are able to develop and seed during the short intervals of sufficient rainfall. The annual legumes are conspicuously absent.

*Zone B.*—Principally on the lee sides of the islands from sea level to 3,000 feet. The annual rainfall, which measures about 20 to 40 inches, comes principally in the winter from the southwest. Much of what has been said of zone A applies to zone B. The natural vegetation is drought-resistant shrubs, quite dense in places, with a considerable growth of annuals during the rainy season. The heavier rainfall of this zone permits the development of numerous deep-rooted leguminous shrubs, especially in small gullies and depressions which concentrate the moisture. A number of good herbaceous legumes develop during the winter months.

*Zone C<sub>1</sub>.*—Found on both leeward and windward sides of the islands from sea level to about 2,500 feet. The annual rainfall is

about 40 to 60 inches. Since much of the rainfall is of trade-wind origin, it is less variable than in zones A and B and is sufficient in amount to support a dense and varied plant population. Most of the zone was probably once forested. Cleared lands support a vigorous growth of perennial grasses, as well as numerous perennial and annual herbs. Many of the herbaceous legumes which are annuals in zone B are short-lived perennials in this phase. The summer months are normally dry enough to permit normal ripening of the seeds, which germinate the following winter or spring. Both temperate and tropical species are adapted. Most of the temperate species make seasonal growth in the winter and spring, while the tropical species tend to be perennial in growth.

*Zone C<sub>2</sub>*.—Occurs only on the islands of Hawaii, Maui, and Kauai from 2,500 to 4,000 feet altitude. Rainfall is similar in amount and distribution to the low phase of this zone. In this high phase, though many of the more temperature-sensitive tropical legumes are not adapted, a number of the most common temperate species are found. These species develop in the early spring and summer. In moist areas bordering zone D, the moisture-loving types such as white clover are found, while in the dry sections the distinctly annual types such as black medic, bur clover, and Indian yellow clover grow.

*Zone D<sub>1</sub>*.—Lies principally on the windward side of the islands from sea level to 1,500 feet or less. With 60 inches or more of annual rainfall, this phase is not conducive to growth of desirable legumes because the soils are generally quite acid, leached, and poorly aerated. This phase has probably the greatest need for good forage legumes to balance the grass forage, which is commonly low in protein, minerals, and total dry matter.

*Zone D<sub>2</sub>*.—Lies above the low phase and receives 100 inches or more of rainfall annually. Limited sunshine and very acid, often boggy, soils preclude the growth of most legumes. Normally this phase is used as a forest reserve.

*Zone D<sub>3</sub>*.—Found on the islands of Hawaii, Maui, and Kauai where it lies between 4,000 and 7,000 feet altitude with an annual rainfall varying from 50 inches in the upper to 100 inches in the lower elevation. Its climate is thus moist and cool, and there is considerable fog. The porous ash soil, common to much of this phase, is well-adapted to legumes. The annual types like black medic, bur

clover, and Indian yellow clover normally do not persist, probably because of lack of sunshine and absence of a dry season, which are necessary for the seed to cure. Wherever the ash soil is of sufficient depth and proper grazing methods are used, a mixture of white clover and low hop clover with Kentucky bluegrass, orchard grass, and ryegrass is possible.

*Zone E<sub>1</sub>.*—Occurs between 4,000 and 7,000 feet on the islands of Maui and Hawaii. It has an annual rainfall of 50 inches or less, with dry periods during the summer months. Those parts on the windward side adjoining zone D<sub>3</sub> contain the moisture-loving legumes such as white clover, but growth is often seasonal. Many of the annual legumes like black medic, bur clover, and Indian yellow clover, which are common to zone C<sub>2</sub>, are also found in the leeward areas above it. In this high, cool climate, growth begins late in the spring. Where the loose, ashy soil is of sufficient depth, excellent, although seasonal, legume growth can be developed. Over much of the phase, the soil is too coarse-textured and thin for pasture development.

*Zones E<sub>2</sub> and E<sub>3</sub>.*—Extend from 7,000 feet to the summits of the high mountains. Continuous low temperatures preclude growth of most species; practically none of the land in these phases is used for pasture.

## ADAPTABILITY

The native and long-established species of legumes in Hawaiian pastures are generally widely distributed, and their present distribution represents the limits of their adaptability except, of course, where burning or clearing has destroyed them. Many species, however, are of recent introduction and limited distribution. Their zonal adaptability is judged on the basis of successful stands now occurring in pastures and nursery trials in the various zones.

It should be kept in mind that within each zone there is a considerable range in moisture as well as temperature. The transition from dry to wet and from a high to a low temperature is gradual (i.e., the wet part of zone B may be the same as the dry part of zone C). Moreover, localized factors such as very steep slopes and eroded areas are not taken into account except as they are a result of the climate.

The species found in the various vegetation zones are listed in table 1.

Table 1.—Zonal adaptability of legumes found in Hawaiian pastures.<sup>1</sup>

SPECIES		ZONES									
SCIENTIFIC NAME	COMMON NAME	A	B	C <sub>1</sub>	C <sub>2</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	E <sub>1</sub>	E <sub>2</sub>	E <sub>3</sub>
<i>Acacia farnesiana</i>	Klu	× <sup>2</sup>	×× <sup>3</sup>								
<i>Acacia koa</i>	Koa			×	×	×	×	×	×	×	
<i>Alysicarpus vaginalis</i>	One-leaved clover		×								
<i>Cajanus cajan</i>	Pigeonpea		×	×	×	×					
<i>Cassia leschenaultiana</i>	Japanese tea		×	×		×					
<i>Cassia occidentalis</i>	Miki palaoa; coffee senna		×	×	×	×					
<i>Crotalaria incana</i>	Fuzzy rattle pod		×	×		×					
<i>Crotalaria longirostrata</i>	Long-beaked rattle pod			×	×						
<i>Crotalaria mucronata</i>	Rattle pod		×	×							
<i>Desmanthus virgatus</i>	Desmanthus; dwarf koa		×	×							
<i>Desmodium canum</i>	Kaimi Spanish clover		×	×	×	×	×				
<i>Desmodium discolor</i>	Giant beggarweed		×	×	×						
<i>Desmodium tortuosum</i>	Florida beggarweed		×	×	×	×					
<i>Desmodium triflorum</i>	Three-flowered beggarweed		×	×	×	×					
<i>Desmodium uncinatum</i>	Spanish clover		×	×	×	×					
<i>Indigofera endecaphylla</i>	Creeping indigo		×	×	×	×					
<i>Indigofera suffruticosa</i>	Indigo		×	×	×	×					
<i>Lespedeza cuneata</i>	Perennial lespedeza			×	×	×					
<i>Lespedeza striata</i>	Common lespedeza			×	×	×					
<i>Leucaena glauca</i>	Koa haole; ekoa	×	×	×	×						
<i>Lotus angustissimus</i>	Slender birdsfoot trefoil			×	×	×	×	×			
<i>Lotus corniculatus</i>	Birdsfoot trefoil					×	×	×			
<i>Lotus hispidus</i>	Hairy birdsfoot trefoil				×				×		
<i>Lotus uliginosus</i>	Big birdsfoot trefoil					×	×	×			
<i>Medicago hispida</i>	Bur clover		×	×	×				×	×	
<i>Medicago lupulina</i>	Black medic		×	×	×				×	×	
<i>Medicago minima</i>	Little bur clover				×						
<i>Medicago sativa</i>	Alfalfa			×	×			×			

Table 1.—Zonal adaptability of legumes found in Hawaiian pastures.<sup>1</sup>—Continued

SPECIES		ZONES									
SCIENTIFIC NAME	COMMON NAME	A	B	C <sub>1</sub>	C <sub>2</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	E <sub>1</sub>	E <sub>2</sub>	E <sub>3</sub>
<i>Melilotus alba</i>	White sweet clover		×	×	×						
<i>Melilotus indica</i>	Indian yellow clover		×	×	×				×		
<i>Mimosa pudica</i>	Sensitive plant; hilahila			×		×					
<i>Phaseolus lathyroides</i>	Wild pea bean		×	×		×					
<i>Pithecellobium dulce</i>	Opiuma; madras thorn		×	×							
<i>Prosopis chilensis</i>	Algaroba; kiawe	×	×	×							
<i>Pueraria thunbergiana</i>	Kudzu			×	×	×					
<i>Samanea saman</i>	Monkeypod; rain tree		×	×		×					
<i>Sophora chrysophylla</i>	Mamani				×				×	×	
<i>Stylosanthes guianensis</i>	Trifolio		×	×	×						
<i>Stylosanthes guianensis</i> var. <i>subviscosus</i>	Creeping trifolio; meladinho										
<i>Tephrosia purpurea</i>	Ahuhu; fish poison	×	×	×							
<i>Trifolium arvense</i>	Rabbit-foot clover								×	×	
<i>Trifolium hybridum</i>	Alsike clover				×			×			
<i>Trifolium pratense</i>	Red clover				×			×			
<i>Trifolium procumbens</i>	Low hop clover				×		×	×	×		
<i>Trifolium repens</i>	White clover				×		×	×	×		
<i>Trifolium subterraneum</i>	Subterranean clover				×			×	×		
<i>Ulex europaeus</i>	Gorse; furze				×			×	×		
<i>Vicia sativa</i>	Common vetch				×			×	×		
<i>Vicia villosa</i>	Hairy vetch				×			×	×		
Total number		4	26	33	32	20	7	14	13	3	0

<sup>1</sup> Adaptability as used here means the ability of the plant to establish and maintain itself in a pasture under natural environmental conditions when subjected to normal grazing.

<sup>2</sup> Adapted to a limited degree.

<sup>3</sup> Well-adapted.

## EXPLANATION OF DESCRIPTIONS

Forty-nine legumes found in Hawaiian pastures are described in this bulletin. Included are all types of plants, from large perennial trees and shrubs to the smallest annual herbs. Many of these have no forage value; some are pasture pests because of their thorns or because of their aggressive growth and the resulting suppression of desirable species; a few are probably poisonous to animals if eaten in appreciable quantities. The Descriptions of Species provide a fairly complete inventory of the leguminous species found in the pastures of the Territory.

These Descriptions are presented in alphabetical order, according to their scientific names. The common names given may be English, Hawaiian, or both, dependent on their general familiarity. Although botanical descriptions have been made as nontechnical as possible, it has been found necessary to include some technical terms. These are defined in the glossary (see page 75). Consideration has been given to the country of origin and distribution of each crop, climatic conditions suited to the crop, agronomic practices in establishing the crop, and its persistence, palatability, and nutritive value.

Preceding the Descriptions is a simple key to aid in identifying the plants. In all cases the most conspicuous or obvious structure of a plant is described. In using the key to identify a plant, the reader makes successive choices from pairs of contrasting descriptions. Eventually he comes to the identification.

For those not familiar with the use of botanical keys, an example is presented. To find the exact identity of the common algaroba or kiawe, follow these steps: (1) Read lines *a* and *aa*.

*a* Plants with leaflike branches ending in thorns.

*aa* Plants without leaflike branches.

(2) Now look at your plant and decide which of the two statements in the key applies to it. You will notice that the algaroba does not have leaflike branches ending in thorns. Hence, the second statement, *aa*, applies to it. (3) Therefore, read lines *b* and *bb* next.

*b* Plants with simple true or false leaves.

*bb* Plants with trifoliate, pinnate, or bipinnate leaves.



(4) Examine your plant again, and you will find that the algaroba does not have simple leaves, so you go on to *bb*. (5) Now read the statements which follow *bb*.

*c* Leaves bipinnate.

*cc* Leaves pinnate or trifoliate.

(6) You see that the leaves of your plant are bipinnate, so read the statements under *c* next.

*d* Flowers in a raceme.—*Prosopis chilensis*.

*dd* Flowers in a head.

(7) Observe the flowers of your plant, and you will notice that they are in a raceme. Thus you have proved that your plant is *Prosopis chilensis*, or algaroba.



## KEY TO SPECIES

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<i>a</i> Plants with leaflike branches ending in thorns.....	<i>Ulex europaeus</i> 70
<i>aa</i> Plants without leaflike branches.	
<i>b</i> Plants with simple true or false leaves.	
<i>c</i> Leaves oval to orbicular, $\frac{1}{2}$ to $1\frac{1}{4}$ inches long.....	<i>Allyscarpus vaginalis</i> 23
<i>cc</i> Leaves linear and slightly curved, 4 to 6 inches long.....	<i>Acacia koa</i> 23
<i>bb</i> Plants with trifoliate, pinnate or bipinnate leaves.	
<i>c</i> Leaves bipinnate.	
<i>d</i> Flowers in a raceme.....	<i>Prosopis chilensis</i> 55
<i>dd</i> Flowers in a head.	
<i>e</i> Flowers pink.	
<i>f</i> Pods $\frac{1}{2}$ to $\frac{3}{4}$ inch long, a suberect small bush.....	<i>Mimosa pudica</i> 53
<i>ff</i> Pods 4 to 7 inches long, a spreading tree.....	<i>Samanea saman</i> 58
<i>ee</i> Flowers yellow or white.	
<i>f</i> Flowers yellow.	
<i>g</i> Shrub 5 to 7 feet tall, pods cylindrical, about $2\frac{1}{2}$ inches long.....	<i>Acacia farnesiana</i> 22
<i>gg</i> Tree 50 to 100 feet tall, pods flat, 3 to 5 inches long.....	<i>Acacia koa</i> 23
<i>ff</i> Flowers white.	
<i>g</i> Seed pods spirally twisted, about 4 inches long.....	<i>Pithecellobium dulce</i> 55
<i>gg</i> Seed pods straight.	
<i>h</i> Seed pods about $\frac{1}{8}$ inch wide, $2\frac{1}{2}$ to 4 inches long.....	<i>Desmanthus virgatus</i> 30
<i>hh</i> Seed pods about $\frac{1}{2}$ inch wide, 4 to 6 inches long....	<i>Leucaena glauca</i> 41
<i>cc</i> Leaves pinnate or trifoliate.	
<i>d</i> Leaves pinnate.	
<i>e</i> Leaves ending in tendrils.	
<i>f</i> Flowers 2 together in the axil of the leaf, leaflets notched at apex.....	<i>Vicia sativa</i> 70
<i>ff</i> Flowers 20 to 30 in a cluster, leaflets tapering to a short point at apex.....	<i>Vicia villosa</i> 72
<i>ee</i> Leaves not ending in tendrils.	
<i>f</i> Flowers yellow.	
<i>g</i> Plants 25 to 50 feet tall, seed pods four-winged, 4 to 6 inches long.....	<i>Sophora chrysophylla</i> 59
<i>gg</i> Plants 1 to $2\frac{1}{2}$ feet tall, seed pods not winged.	
<i>h</i> Flowers about $\frac{1}{2}$ inch in diameter, seed pods $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long, $\frac{1}{8}$ to $\frac{1}{4}$ inch wide.....	<i>Cassia leschenaultiana</i> 26
<i>hh</i> Flowers $1\frac{1}{4}$ to $1\frac{3}{4}$ inches across, seed pods 4 to 6 inches long, about $\frac{1}{4}$ inch wide.....	<i>Cassia occidentalis</i> 27
<i>ff</i> Flowers white, purplish-pink, or reddish.	
<i>g</i> Seed pods flat, $1\frac{3}{4}$ to $2\frac{1}{4}$ inches long.....	<i>Tephrosia purpurea</i> 62
<i>gg</i> Seed pods slender, 1 inch or less long.	
<i>h</i> Seed pods strongly curved, about $\frac{5}{8}$ inch long, stipules threadlike, about $\frac{1}{8}$ inch long.....	<i>Indigofera suffruticosa</i> 38

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hh Seed pods straight, $\frac{3}{4}$ to 1 inch long, stipules lance-shaped, about $\frac{1}{4}$ inch long.....	37
..... <i>Indigofera endecaphylla</i>	
dd Leaves trifoliate.	
e Flowers yellow.	
f Seed pods each a spiny bur.	
g Flowers 1 to 3 in a cluster, at the end of a stalk $\frac{1}{8}$ to $\frac{1}{4}$ inch long, stem hairy.....	49
..... <i>Medicago minima</i>	
gg Flowers 2 to 7 in a cluster, at the end of a stalk $\frac{1}{2}$ to $\frac{3}{4}$ inch long, stem glabrous.....	46
..... <i>Medicago hispida</i>	
ff Seed pods not spiny burs.	
g Seed pods less than $\frac{1}{4}$ inch long.	
h Flowers closely clustered together in a headlike structure.	
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jj Seed pods light brown at maturity.....	65
..... <i>Trifolium procumbens</i>	
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..... <i>Melilotus indica</i>	
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h Stipules leaflike.	
i Common flowering stalk 2 to 4 inches long.	
j Leaves hairy, flowers 3 to 7 in a cluster.....	44
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jj Leaves smooth, flowers 8 to 12 in a cluster.....	46
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..... <i>Crotalaria longirostrata</i>	
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..... <i>Crotalaria incana</i>	
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..... <i>Desmodium canum</i>	

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h Plants 5 to 10 feet tall.....	<i>Desmodium discolor</i> 32
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ii Flowers $\frac{1}{4}$ to $\frac{3}{8}$ inch long, borne on flower stalk about $\frac{1}{8}$ inch long.....	<i>Desmodium uncinatum</i> 36
ff Seed pods not indented and chainlike.	
g Flowers formed in a head or clustered together in the axils of the leaves.	
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i Plants upright, $1\frac{1}{2}$ to 3 feet tall, stipules linear, about $\frac{1}{8}$ inch long.....	<i>Lespedeza cuneata</i> 39
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kk Plants upright, stems not rooting at the nodes, stipules $\frac{1}{2}$ to $\frac{3}{4}$ inch long.....	<i>Trifolium hybridum</i> 63
jj Stems hairy, leaves hairy.	
k Flowers in a globose or somewhat ovoid head, stipules ovate, $\frac{3}{4}$ to 1 inch long....	<i>Trifolium pratense</i> 64
kk Flowers in a cylindrical head, stipules about $\frac{1}{4}$ inch long.....	<i>Trifolium arvense</i> 63
gg Flowers arranged in a raceme.	
h Plants, vines.....	<i>Pueraria thumbergiana</i> 57
hh Plants, not vines.	
i Seed pods cylindrical, 4 to 5 inches long.....	<i>Phaseolus lathyroides</i> 54
ii Seed pods ovoid or spirally twisted.	
j Seed pods ovoid or egg-shaped, flowers white.....	<i>Melilotus alba</i> 51
jj Seed pods spirally twisted 2 or 3 times, flowers violet or blue.....	<i>Medicago sativa</i> 50

## DESCRIPTIONS OF SPECIES

### *Acacia farnesiana* (L.) Willd. (Fig. 1)

#### Klu

**Habit:** A shrub, 5 to 7 feet tall.

**Stem:** Freely branching, with sharp spines.

**Leaf:** Bipinnate, the leaflets linear-oblong, about  $\frac{1}{8}$  inch long.

**Stipule:** A straight thorn,  $\frac{1}{2}$  to 1 inch long.

**Flower:** Bright yellow, sweet-scented, in a globular head, about  $\frac{3}{8}$  inch in diameter.

**Seed pod:** Cylindrical, somewhat curved, about  $2\frac{1}{2}$  inches long and about  $\frac{1}{2}$  inch wide, dark reddish-brown when ripe, filled with a pithy substance.

**Seed:** Oval, about  $\frac{1}{4}$  inch long, flattened, smooth, brown.

**Distribution and habitat:** Klu, a native of tropical America, is now widely distributed in all tropical countries. In the islands it is commonly found in zones A and B, below about 700-foot altitude.

**Importance and use:** Klu is rarely eaten by cattle and is regarded as a serious pest in the pasture because of its thorns.

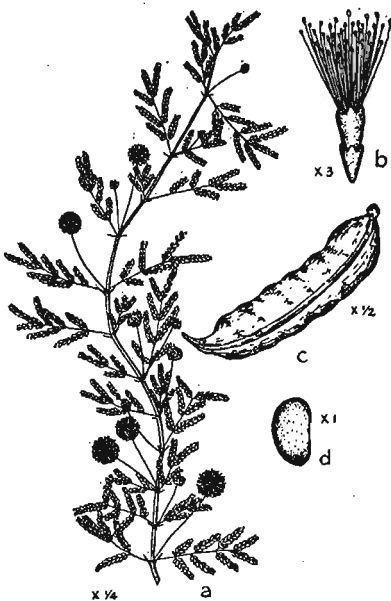


Fig. 1. *Acacia farnesiana*: a, habit; b, flower; c, pod; d, seed.

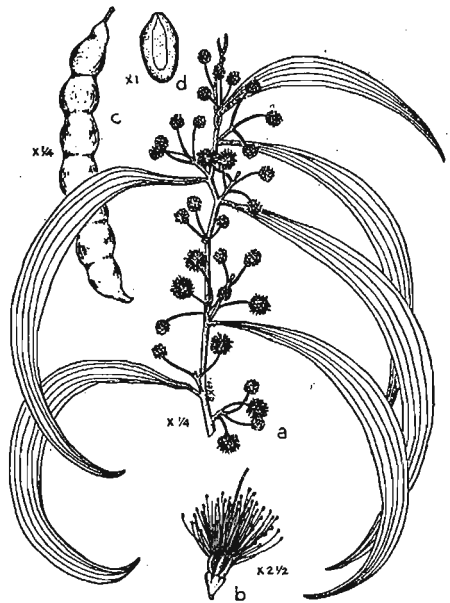


Fig. 2. *Acacia koa*: a, habit; b, flower; c, pod; d, seed.

**Acacia koa Gray (Fig. 2)**

**Koa**

**Habit:** An erect to somewhat spreading tree, 50 to 100 feet tall.

**Stem:** Branching, rather smooth.

**Leaf:** Bipinnate, with 12 to 15 pairs of leaflets, the leaflets about  $\frac{1}{4}$  inch long and  $\frac{1}{8}$  inch wide; the false leaf simple, linear, slightly curved, 4 to 6 inches long,  $\frac{3}{8}$  to  $\frac{3}{4}$  inch wide, leathery.

**Stipule:** Sublanceolate, about  $\frac{1}{2}$  inch long, pointed.

**Flower:** Yellow, many clustered in a globular head, about  $\frac{3}{8}$  inch in diameter, at the end of a stalk  $\frac{1}{2}$  inch long.

**Seed pod:** Flat, straight or slightly curved, 3 to 5 inches long, about  $\frac{1}{2}$  inch wide, smooth, brown when ripe.

**Seed:** Oblong, flat, about  $\frac{3}{8}$  inch long, dark, shiny.

**Distribution and habitat:** Koa is native to the Hawaiian Islands and has a wide range of adaptability. It is found throughout all phases of zones C and D, as well as E<sub>1</sub> and E<sub>2</sub>, and is a common tree in the forests.

**Importance and use:** Koa is relished by livestock, which feed on the young leaves of the lower branches. An open koa stand is regarded as ideal for pasture because the grasses and legumes grow well under and between the trees. The trees also provide shade and protection against wind for the animals. Because of the relatively shallow root system of koa, the trampling of cattle has caused large areas of previously fine stands to be completely or partially destroyed.

**Alysicarpus vaginalis (L.) DC. (Fig. 3)**

**One-leaved clover**

**Habit:** A low, somewhat prostrate and spreading plant, about  $1\frac{1}{2}$  feet high.

**Stem:** Freely branching, jointed, hairy.

**Leaf:** Simple, oval to globular,  $\frac{1}{2}$  to  $1\frac{1}{4}$  inches long,  $\frac{3}{8}$  to  $\frac{3}{4}$  inch wide, hairy on both surfaces.

**Stipule:** Lanceolate, pointed, about  $\frac{1}{4}$  inch long.

**Flower:** Reddish-yellow to purplish, about  $\frac{1}{4}$  inch long, with 6 to 15 in a raceme  $\frac{1}{2}$  to  $1\frac{1}{4}$  inches long.

**Seed pod:** Cylindrical, about  $\frac{3}{4}$  inch long, with 3 to 6 segments.

**Seed:** Oval to oblong, about  $\frac{1}{8}$  inch long, reddish-brown.

**Distribution and habitat:** One-leaved clover, a native of the Old World, is found in many tropical countries. In the Territory, it is found only in zone B pastures around Koko Head, Oahu.

**Importance and use:** Cattle and horses feed on the plant, but it is regarded as only fair forage. It produces many seeds but spreads slowly and shows no sign of becoming an important forage plant.

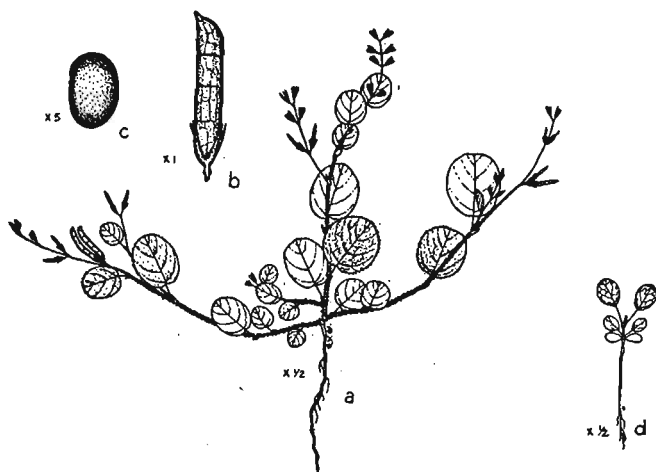


Fig. 3. *Alysicarpus vaginalis*: a, habit; b, pod; c, seed; d, seedling.

### **Cajanus cajan** (L.) Millsp. (Fig. 4)

(*Cajanus indicus* Spreng.)

#### Pigeonpea

**Habit:** An erect, shrubby plant, 4 to 8 feet tall.

**Stem:** Somewhat woody at base, freely branching, conspicuously ridged, densely covered with soft, minute hairs.

**Leaf:** Trifoliate, the leaflets lanceolate to oblanceolate, pointed at tip, the margin entire, green on the upper surface, grayish-white on the lower surface, downy on both surfaces, the central leaflet larger and on a longer stalk than the two lateral ones.

**Stipule:** Lanceolate, about  $\frac{1}{8}$  inch long, downy.

**Flower:** Yellow, about  $\frac{5}{8}$  inch long, smooth, 4 to 8 on a hairy flower stalk; calyx hairy, tubular, the margin toothed.

**Seed pod:** Linear, 2 to 3 inches long, compressed, long pointed at tip, 3- to 5-seeded, with depressions between the seeds, covered with downy hairs.

**Seed:** Oval, about  $\frac{1}{4}$  inch across, light brown or mottled with darker brown.

**Distribution and habitat:** Pigeonpea is native to tropical Asia and is cultivated chiefly for the seed crop in most tropical countries. Pigeonpea is primarily a plant of the semidry lowlands, but it has a rather wide range of adaptation as to altitude, soil, and rainfall. In Hawaii it is found in zones B, C<sub>1</sub>, C<sub>2</sub>, and the drier parts of D<sub>1</sub>. Pigeonpea seeds most heavily at low levels, but in the semidry districts the common variety has seeded at elevations as high as 3,500 feet. In general, however, pigeonpea should not be planted above about 2,500 feet altitude.



**Importance and use:** One of the great advantages of pigeonpea in dry districts is the increased growth and palatability of grasses interplanted with it. The tall, deep-rooted bushes shade the ground and probably benefit the soil through accumulation of nitrogen. Such grasses as Rhodes, Bermuda, and molasses are well-adapted to interplanting with pigeonpea. If a pigeonpea pasture is rested at intervals, it will generally continue to provide good pasturage for a number of years, with an excellent carrying capacity and a fine finish for fattening cattle.

The forage of pigeonpea is not relished by animals in the immature stage, and grazing should probably not be permitted until the early green-pod stage.

A number of strains of pigeonpea occur in the islands. The flower color of the common strain is yellow, but in other strains it is reddish. The seed color varies from nearly white to dark brown. The strains also differ greatly in their growth habits and seed production. Development of a strain better adapted to grazing would be most advantageous.

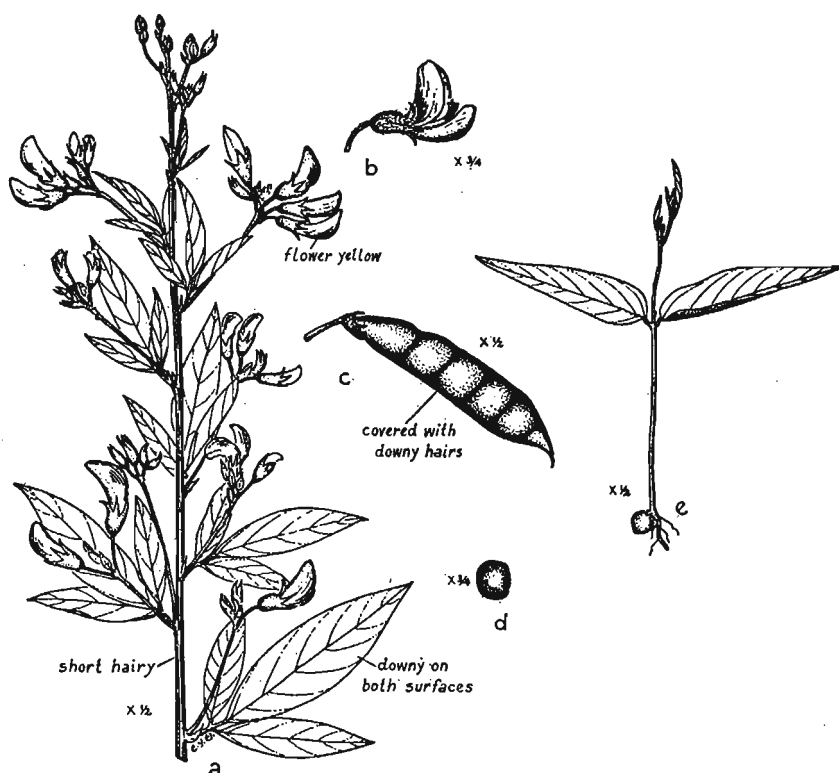


Fig. 4. *Cajanus cajan*: a, habit; b, flower; c, pod; d, seed; e, seedling.

*Cassia leschenaultiana* DC. (Fig. 5)

## Japanese tea

**Habit:** An upright or nearly erect plant, 1 to 2½ feet tall.

**Stem:** Somewhat woody at base, purple, covered with short, soft hairs.

**Leaf:** Pinnate, 2 to 3 inches long, with approximately 18 paired leaflets, and a small, round, projecting gland near the base of the common leafstalk, the leaflets ¼ to ¾ inch long, hairy, often light purple.

**Stipule:** Linear, about ⅜ inch long, hairy.

**Flower:** Yellow, about ½ inch in diameter, the flowering stalk ⅛ to ¼ inch long; calyx about ¼ inch long, the lobes lanceolate, yellowish.

**Seed pod:** Linear, slightly curved, 1¼ to 1½ inches long, ⅛ to ⅙ inch wide, hairy.

**Seed:** Quadrangular, flat, about ⅛ inch long, brownish.

**Distribution and habitat:** Japanese tea is native to India and the East Indies.

In the Territory, it is a common plant in waste places and pastures below about 3,000 feet in zones B, C<sub>1</sub>, and D<sub>1</sub>.

**Importance and use:** Japanese tea is sometimes eaten by livestock, but it is generally regarded by the ranchers as an undesirable plant. Because of its free seeding habit, it develops dense stands in some areas, especially when a pasture has been recently plowed.



Fig. 5. *Cassia leschenaultiana*: a, habit; b, flower; c, pod; d, seed; e, seedling; f, reduced habit.

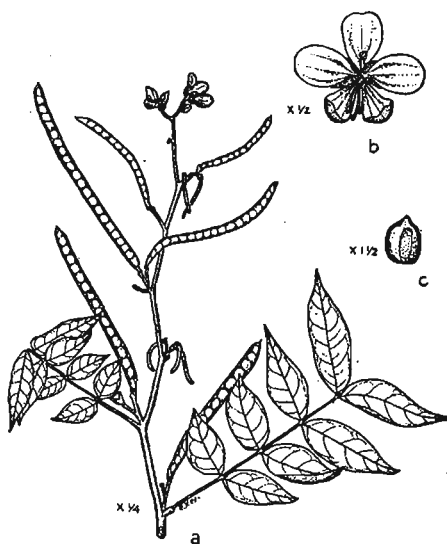


Fig. 6. *Cassia occidentalis*: a, habit; b, flower; c, seed.

**Cassia occidentalis L. (Fig. 6)**

Miki palaoa; coffee senna

- Habit:** An upright plant, 1 to 2½ feet tall.
- Stem:** Somewhat woody at base, branching, glabrous or sparsely hairy.
- Leaf:** Pinnate, the leaflets 3- to 5-paired, broadly lanceolate, 2 to 3 inches long, ¾ to 1¼ inches wide, on short leafstalk, smooth on both sides.
- Stipule:** Linear, about ⅜ inch long.
- Flower:** Yellow, 1¼ to 1¾ inches in diameter; calyx 4-lobed, the lobes lanceolate, smooth.
- Seed pod:** Rather flat, 4 to 6 inches long, about ¼ inch wide, glabrous or sparsely hairy.
- Seed:** Oval, slightly compressed, about ⅜ inch long, light brown, shiny.
- Distribution and habitat:** Miki palaoa, a native to tropical America, is a common weed in all warm regions. In the islands it is found in pastures and cultivated fields of the lower elevations in zones B, C<sub>1</sub>, and D<sub>1</sub>.
- Importance and use:** This plant is rarely grazed by cattle and horses. It is said to be poisonous to livestock although locally there is no evidence of stock poisoning.

**Crotalaria incana L. (Fig. 7)**

Fuzzy rattle pod

- Habit:** An upright plant, 2 to 3 feet tall.
- Stem:** Somewhat woody at base, branching freely, covered with short, white hairs.
- Leaf:** Trifoliate, the leaflets elliptical to lanceolate, 1¼ to 1½ inches long, ½ to 1 inch wide, densely hairy.
- Stipule:** Linear, about ⅜ inch long, hairy, falls off easily.
- Flower:** Yellow, about ½ inch long, the upper petal ⅜ to ½ inch wide; calyx 5-lobed, ¼ to ½ inch long, the lobes lanceolate, hairy.
- Seed pod:** Cylindrical, 1¼ to 1½ inches long, distinctly grooved on the upper side, hairy.
- Seed:** Triangular, about ⅜ inch long, dark brownish-green, shiny.
- Distribution and habitat:** Fuzzy rattle pod, a native of tropical America, is now widely distributed in other tropical countries. In the islands it is commonly found in waste places and pastures of lower elevations in zones B, C<sub>1</sub>, and D<sub>1</sub>.
- Importance and use:** Fuzzy rattle pod is very seldom eaten by animals. Often it volunteers in considerable quantity in newly plowed pastures but gradually diminishes as the grasses become established.

***Crotalaria longirostrata* H. and A. (Fig. 8)**

## Long-beaked rattle pod

**Habit:** An upright plant, 2 to 3 feet tall.

**Stem:** Somewhat woody at base, many-branched, covered with short hairs.

**Leaf:** Trifoliate, the leaflets elliptical or oblanceolate, the central leaflet  $\frac{1}{2}$  to 1 inch long,  $\frac{1}{8}$  to  $\frac{3}{8}$  inch wide, the lateral ones slightly smaller.

**Stipule:** Linear, pointed, about  $\frac{1}{8}$  inch long, hairy.

**Flower:** Yellow, about  $\frac{1}{2}$  inch long, many in a raceme; calyx 5-lobed, pointed, hairy.

**Seed pod:** Oblong, about  $\frac{3}{4}$  inch long, hairy.

**Seed:** Oval, about  $\frac{1}{8}$  inch long, brownish, shiny.

**Distribution and habitat:** Long-beaked rattle pod is a native of Mexico. In the islands it is found in a few localized places in fairly moist sections of zones C<sub>1</sub> and C<sub>2</sub>.

**Importance and use:** It is rarely eaten by livestock. Its seeds profusely and in certain pastures where it forms dense stands it is regarded as a pest.

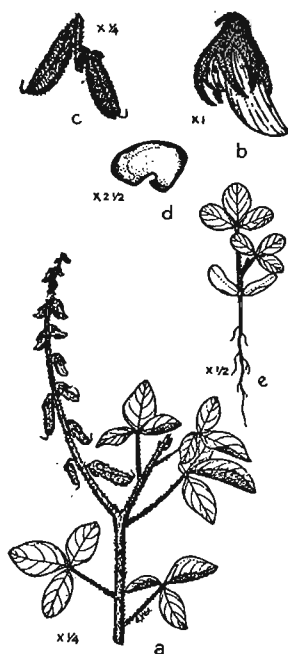


Fig. 7. *Crotalaria incana*: a, habit; b, flower; c, pods; d, seed; e, seedling.



Fig. 8. *Crotalaria longirostrata*: a, habit; b, flower; c, pod; d, seed.

***Crotalaria mucronata* Desv. (Fig. 9)**  
 (*Crotalaria saltiana* Andr.)

Rattle pod

**Habit:** An erect plant, 2 to 4 feet high.

**Stem:** Partly woody at base, somewhat branching, the branches covered with soft, short hairs.

**Leaf:** Trifoliate, the common leafstalk 1 to 2 inches long, the leaflets elliptic, oblong or oblanceolate,  $\frac{3}{4}$  to 2 inches long, smooth on the upper surface, hairy beneath, the central leaflet longer than the two lateral leaflets.

**Stipule:** Linear, about  $\frac{1}{8}$  inch long, pointed, falls off easily.

**Flower:** Yellow, about  $\frac{1}{2}$  inch long, with an upturned oval petal between two linear petals; calyx 5-lobed from the middle, the lobes lanceolate and tapering to a point, hairy.

**Seed pod:** Cylindrical,  $1\frac{1}{2}$  to  $1\frac{3}{4}$  inches long,  $\frac{1}{4}$  to  $\frac{3}{8}$  inch wide, glabrous, with a distinct groove on the upper side, yellow when mature.

**Seed:** Kidney-shaped, about  $\frac{1}{8}$  inch long, light brown, shiny.

**Distribution and habitat:** Rattle pod, a native of India, is a naturalized plant in most tropical regions. In Hawaii it is common in the lowlands in zones B and C<sub>1</sub>.

**Importance and use:** Rattle pod is sometimes eaten by cattle and horses, but it is generally considered a poor forage. It often volunteers in considerable quantity in plowed pastures of B and C<sub>1</sub> zones but seldom persists to any extent when the grasses become established.

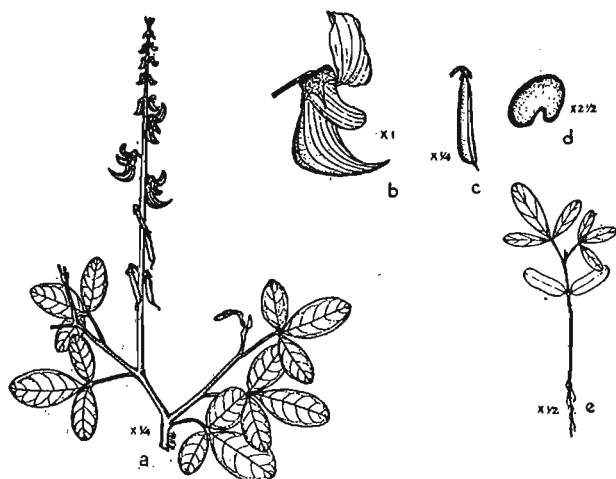


Fig. 9. *Crotalaria mucronata*: a, habit; b, flower; c, pod; d, seed; e, seedling.

*Desmanthus virgatus* (L.) Willd. (Fig. 10)

## Desmanthus; dwarf koa

**Habit:** An upright bush, 5 to 10 feet tall.

**Stem:** Somewhat woody at base, slender and pithy above, tender, glabrous, with distinct ridges.

**Leaf:** Bipinnate, with 10 to 20 pairs of leaflets, oblong-linear, small, smooth; petiole bearing an ovate-oblong gland between the lowest pair of leaflets.

**Stipule:** Hairlike, about  $\frac{1}{8}$  inch long.

**Flower:** White, with several in a head,  $\frac{1}{4}$  to  $\frac{3}{8}$  inch across, with many conspicuous hairlike stamens.

**Seed pod:** Slender, straight or slightly curved,  $2\frac{1}{2}$  to 4 inches long, about  $\frac{1}{8}$  inch wide, glabrous, shiny, splitting on two sides, 20- to 30-seeded.

**Seed:** Oval to ovate, slightly compressed, about  $\frac{3}{8}$  inch long, brown, shiny.

**Distribution and habitat:** *Desmanthus* is a native of tropical and subtropical America. It is a common plant in all warm countries. In the Territory this species is restricted to a few localities or small sections. It grows well below about 500 feet in zones B and C.

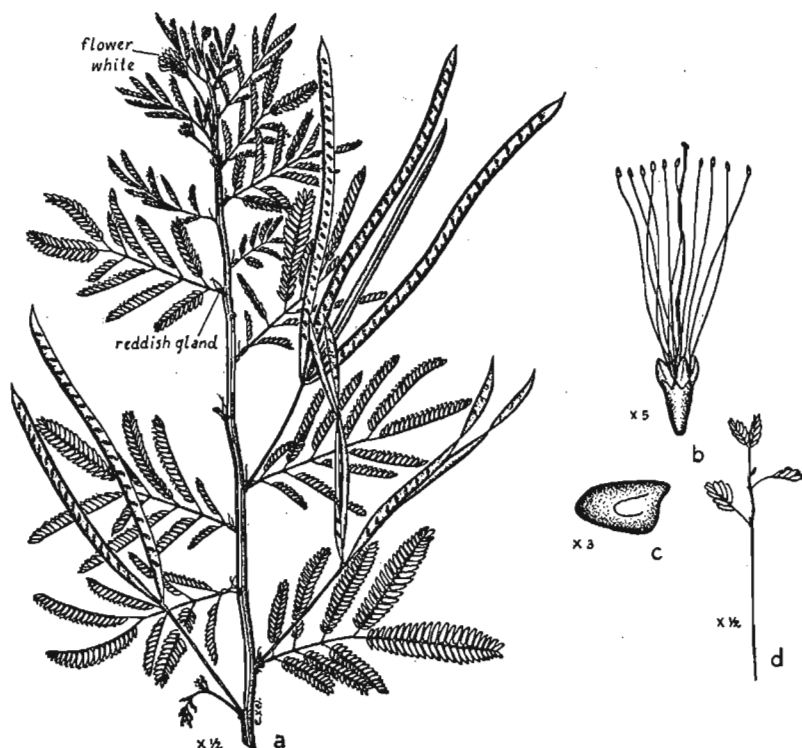


Fig. 10. *Desmanthus virgatus*: a, habit; b, flower; c, seed; d, seedling.

**Importance and use:** Desmanthus makes excellent growth and produces abundant seed under natural conditions. During dry seasons most of the leaves fall off, but as soon as the rains come new shoots develop rapidly. Once established, desmanthus forms a solid stand by natural seeding. It is well eaten by animals, although not as palatable as koa haole. It recovers very well when cut periodically and persists under grazing if not stocked too heavily.

**Desmodium canum** (Gmel.) Schinz and Thellung. (Fig. 11)

Kaimi Spanish clover

**Habit:** A creeping or loosely spreading plant, 6 to 20 inches high.

**Stem:** Branching, partly woody at base, covered on upper parts with fine, grayish hairs.

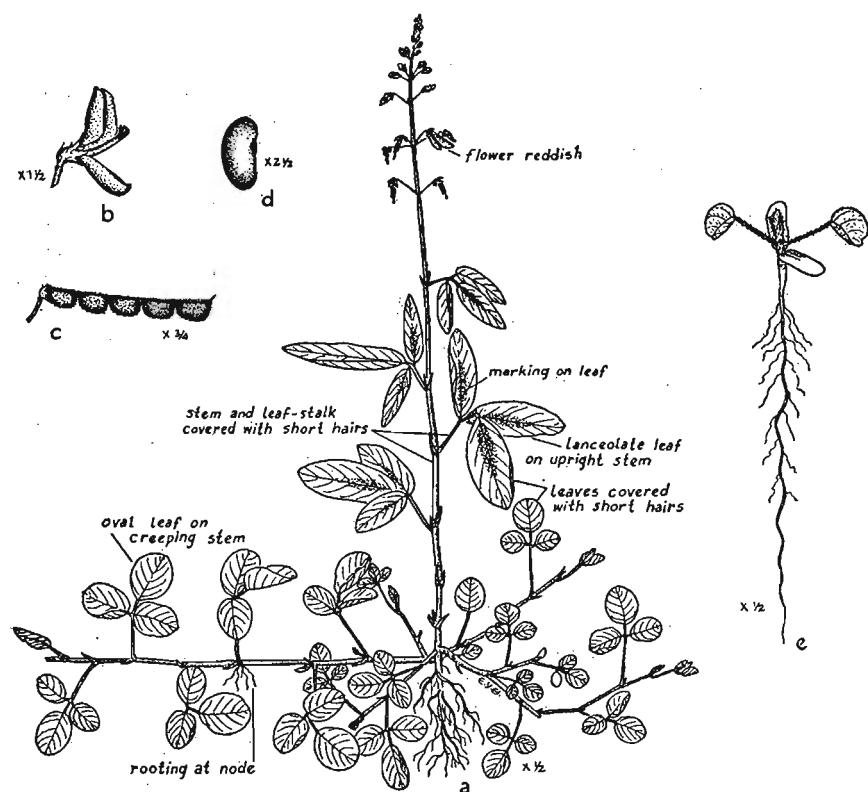


Fig. 11. *Desmodium canum*: a, habit; b, flower; c, pod; d, seed; e, seedling.

**Leaf:** Trifoliate, the leaflets glabrous or sparsely hairy on upper surface, covered with short grayish hairs on lower, the central leaflet larger and on a longer stalk than the lateral ones, the leaflets on the prostrate stem oval to round, the leaflets on the erect stem lanceolate, usually with whitish marking in the center.

**Stipule:** Lanceolate, pointed,  $\frac{1}{8}$  to  $\frac{1}{4}$  inch long, brown, hairy.

**Flower:** Reddish or lavender, becoming blue or purple with age, 20 or more in a terminal raceme, 5 to 10 inches long; calyx small, with pointed lobes.

**Seed pod:** Flat, indented and chainlike but straight on upper suture, with 4 to 7 joints, 1 to  $1\frac{1}{2}$  inches long,  $\frac{1}{8}$  inch wide, covered with short brown hairs.

**Seed:** Kidney-shaped, about  $\frac{1}{8}$  inch long and  $\frac{1}{16}$  inch wide, light brown.

**Distribution and habitat:** Kaimi Spanish clover is a common tropical American plant. In the Territory it was first seen about 13 years ago on Kauai. A recent distribution survey shows that it is also found in restricted moist localities of Oahu, Maui, and Hawaii. It is adapted to the lower elevations in zones C<sub>1</sub>, C<sub>2</sub>, D<sub>1</sub>, and D<sub>2</sub>. It is relatively tolerant of acid soil conditions.

**Importance and use:** Under natural conditions Kaimi Spanish clover produces many erect flowering stems with lance-shaped leaves, but when frequently grazed or clipped, creeping, nonflowering stems with oval to round leaves are produced. These creeping stems branch rather freely and develop many roots at the nodes. In a pasture, this clover first establishes itself in open spaces between the clumps and runners of grasses and persists in association with such aggressive grasses as kikuyu, paspalum, and Bermuda. It is a prolific seeder, especially during the warmer months, and can be easily established in the pasture by broadcasting or disking in the seed in the grass plot. Its creeping habit of growth makes it especially well-adapted to relatively heavy and continuous grazing throughout the year. This legume is a welcome addition to the pastures of zone D<sub>1</sub> which are almost devoid of good forage legumes.

### **Desmodium discolor** Vog. (Fig. 12)

#### Giant beggarweed

**Habit:** An erect, slender plant, 5 to 10 feet tall.

**Stem:** Somewhat woody at base, densely hairy, producing few branches.

**Leaf:** Trifoliate, the leaflets oval to ovate,  $1\frac{1}{4}$  to  $2\frac{1}{2}$  inches long,  $\frac{3}{4}$  to  $1\frac{1}{2}$  inches wide, entire along margin, densely covered with soft, fine, short hairs, the central leaflet larger than the lateral ones, and on stalk three times as long.

**Stipule:** Lanceolate, pointed, about  $\frac{1}{8}$  inch long, hairy.

**Flower:** Pinkish, about  $\frac{1}{4}$  inch long, many crowded together on long flower stalks toward the top of the plant; calyx small, the lobes about as long as the tube, hairy.

**Seed pod:** Slender, indented on both sutures and chainlike,  $\frac{3}{4}$  to 1 inch long, sparsely hairy, greenish to reddish in color, with 4 to 6 joints, the end joint largest.



**Seed:** Oval, about  $\frac{1}{8}$  inch long, light colored, shiny.

**Distribution and habitat:** Giant beggarweed is a native of Brazil. This species has been recently introduced into the islands by the Hawaii Agricultural Experiment Station and planted in trial gardens in a number of zones. It appears to be adapted to zones B, C<sub>1</sub>, and C<sub>2</sub>, where it produces abundant flowers.

**Importance and use:** This species is perennial in zones of moderate moisture and has persisted for 4 years at the Haleakala Branch Station on Maui in a paddock which has been periodically grazed. It is very palatable and may have some possibilities in semimoist scrub pastures at low to middle elevations.

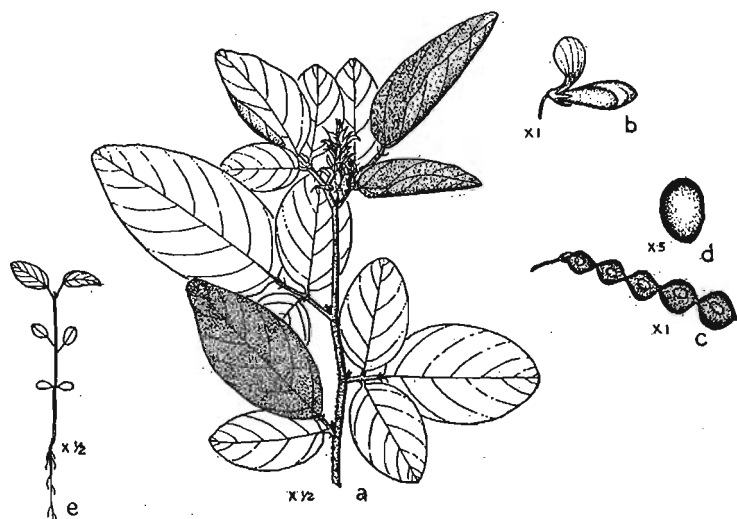


Fig. 12. *Desmodium discolor*: a, habit; b, flower; c, pod; d, seed; e, seedling.

### *Desmodium tortuosum* (Sw.) DC. (Fig. 13)

#### Florida beggarweed

**Habit:** An erect herb, 2 to 4 feet tall.

**Stem:** Somewhat woody at base, cylindrical, glabrous in the lower part, clothed with short, fine hairs toward the upper part.

**Leaf:** Trifoliate, the leaflets lanceolate, elliptic, or ovate, sparsely covered with short hairs, the central leaflet larger and on a stalk 4 times longer than those of the lateral leaflets.

**Stipule:** Broadly lanceolate, pointed, glabrous, the margin often fringed with hair.

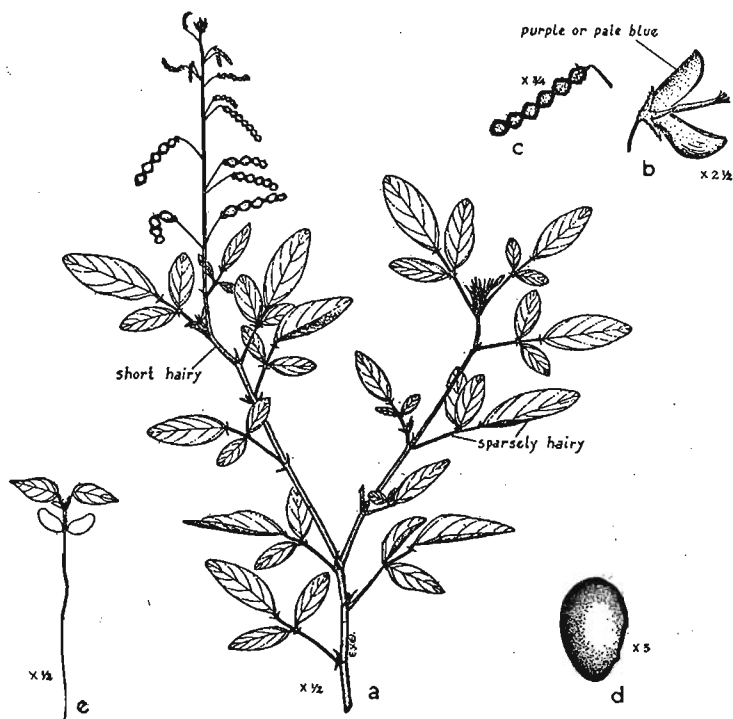


Fig. 13. *Desmodium tortuosum*: a, habit; b, flower; c, pod; d, seed; e, seedling.

**Flower:** Purple or pale blue, about  $\frac{1}{8}$  inch long, borne on a slender flower stalk about  $\frac{1}{2}$  inch long; calyx small, hairy.

**Seed pod:** Indented about equally on both sutures and chainlike, with 3 to 7 joints, covered with short hairs.

**Seed:** Oval, about  $\frac{1}{8}$  inch long, light yellowish-brown, shiny.

**Distribution and habitat:** Florida beggarweed is a native of the West Indies and is now widely distributed throughout the tropics. In the Territory it is occasionally found in localized areas in zones B, C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>, below about 3,000 feet altitude.

**Importance and use:** Florida beggarweed is a freely branching and rapidly growing plant. When the stem is cut or grazed, many shoots develop in a relatively short period. It is not long-lived, but under favorable conditions it may persist for several years. At the Haleakala Branch Station on Maui, it has persisted under periodic grazing for 4 years. Florida beggarweed is a prolific seeder; after the first planting, many young seedlings are usually produced. Animals relish this legume; it should be more widely planted in the pastures.

*Desmodium triflorum* (L.) DC. (Fig. 14)

## Three-flowered beggarweed

**Habit:** A creeping plant, forming a dense mat.

**Stem:** Hairy, freely branching, slender, rooting at the nodes.

**Leaf:** Trifoliate at the end of a common sparsely hairy leafstalk, the leaflets oval to broadly obovate, smooth or sparsely hairy, margin entire, the central leaflet slightly larger and on a longer stalk than the two lateral leaflets.

**Stipule:** Lanceolate, pointed, about  $\frac{1}{8}$  inch long, glabrous or sparsely hairy.

**Flower:** Blue or reddish-blue, about  $\frac{3}{8}$  inch long, 2 to 4 together in the axil; calyx 5-toothed, slender and long, silky.

**Seed pod:** Indented and chainlike, with about 4 joints, the upper suture straight,  $\frac{3}{8}$  to  $\frac{5}{8}$  inch long, about  $\frac{1}{8}$  inch wide.

**Seed:** Kidney-shaped, about  $\frac{3}{8}$  inch long, light brown, shiny.

**Distribution and habitat:** Three-flowered beggarweed is a native plant in the tropics of the eastern hemisphere. In Hawaii it is occasionally found in all the lowland pastures of zones B, C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>. It makes its best growth in fairly moist localities, but during the rainy winter season it develops well even in the dry regions.

**Importance and use:** Three-flowered beggarweed forms a beautiful turf in association with a short grass such as Bermuda, and once established in a pasture, it is persistent. The animals like it, but the plant is too small to provide an appreciable amount of forage. It does add some variety to the forage and, at the same time, enriches the soil. As plants are often found with leaves two to three times the size of the normal leaves, there is a possibility of developing a more robust strain. Because this plant is so persistent in the lowland pastures, further study and selection seem worthwhile.

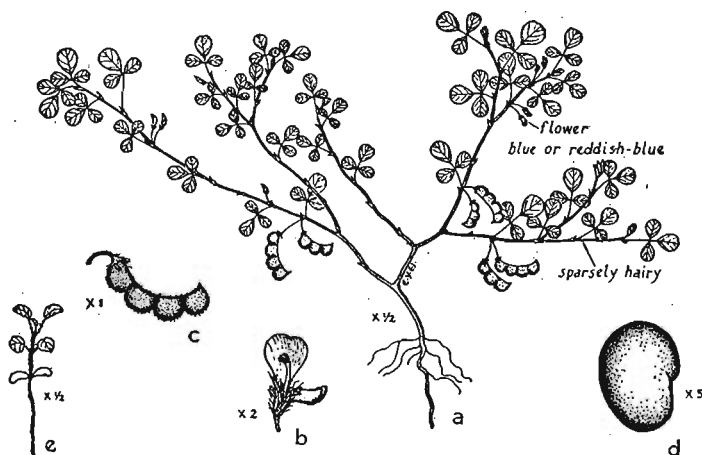


Fig. 14. *Desmodium triflorum*: a, habit; b, flower; c, pod; d, seed; e, seedling.

**Desmodium uncinatum** (Jacq.) DC. (Fig. 15)

## Spanish clover

**Habit:** An erect or semierect plant, 1 to 2 feet tall.

**Stem:** Woody at base, glabrous or often sparsely clothed with short hairs.

**Leaf:** Trifoliate, the leaflets lanceolate, 1 to 1½ inches long, ½ to ¾ inch wide, with whitish patch in the middle, smooth above, slightly hairy on the under side, the margin entire, the terminal leaflet larger than the two lateral ones.

**Stipule:** Lanceolate, with tapering point, ⅛ to ⅙ inch long, found only on young stem.

**Flower:** White, greenish-white, or slightly pinkish, ¼ to ⅜ inch long, with individual stalk about ⅛ inch long, arranged on a long raceme; calyx 4-lobed.

**Seed pod:** Indented on both sutures and chainlike, 1 to 1½ inches long, ⅛ inch wide, hairy.

**Seed:** Bean-shaped about ⅛ inch long, ⅙ inch wide, light brown.

**Distribution and habitat:** Spanish clover is native to tropical America but now has pantropical distribution. In the Territory, it is widely distributed

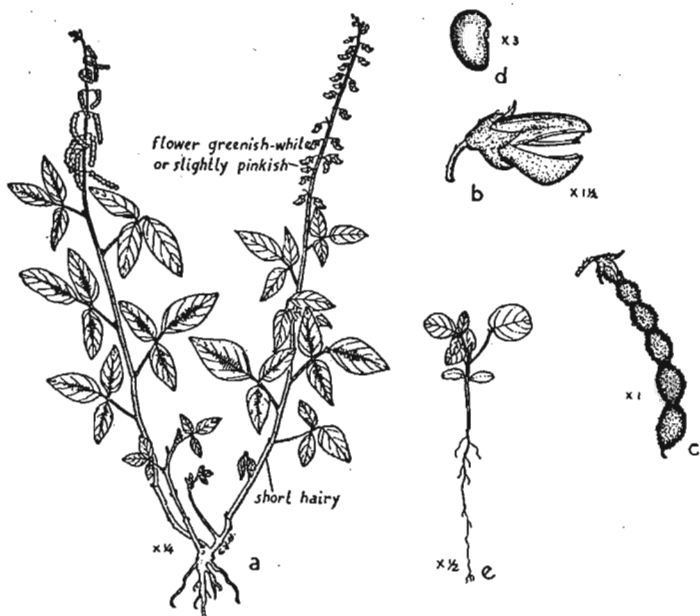


Fig. 15. *Desmodium uncinatum*: a, habit; b, flower; c, pod; d, seed; e, seedling.

from sea level to about 4,000 feet elevation in zones B, C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>. The most extensive stands are found at middle altitudes at Ulupalakua, Maui, and Kapapala and Waikii, Hawaii.

**Importance and use:** Under favorable conditions, Spanish clover makes excellent growth and produces abundant forage. It forms an excellent association with Bermuda grass. It also grows well with Rhodes grass, Natal redtop, and kukaipuaa. Spanish clover has a deep tap root and can withstand drought well. It can also survive heavy grazing and recovers rapidly.

This legume is a variable plant; some individuals have a distinctly trailing habit, others, a more upright growth. The flower color also varies from almost white to deep pink. The deep-pink-flowered strain is a larger plant than the white-flowered strain and is usually found at higher elevations. Occasionally the two distinct types of plants are seen growing together in a pasture. In dry locations the forage is well eaten, but in wet zones it is said to be little grazed. Because of its wide distribution and persistence under grazing, it is one of the most important pasture legumes in Hawaii.

### *Indigofera endecaphylla* Jacq. (Fig. 16)

#### Creeping indigo

**Habit:** A low, creeping plant, 3 to 5 feet long.

**Stem:** Partly woody at base, slightly compressed, reddish, sparsely clothed with short, appressed, white hairs.

**Leaf:** Pinnate, the leaflets alternately arranged, narrowly elliptic,  $\frac{1}{2}$  to 1 inch long,  $\frac{1}{4}$  to  $\frac{3}{8}$  inch wide, dark green, the margin entire, the upper surface glabrous, the lower surface covered with white appressed hairs.

**Stipule:** Lanceolate, long pointed, about  $\frac{1}{4}$  inch long, the midrib distinct.

**Flower:** Purplish-pink,  $\frac{1}{8}$  to  $\frac{1}{4}$  inch long, arranged on a long central stalk.

**Seed pod:** Slender, cylindrical,  $\frac{3}{4}$  to 1 inch long, sparsely covered with short appressed hairs, 6- to 9-seeded.

**Seed:** Rectangular, about  $\frac{1}{8}$  inch long, light brown to brown, dull.

**Distribution and habitat:** Creeping indigo is native to tropical Africa. In recent years it has been introduced into many of the tropical regions as a cover crop. Nursery trials indicate that it grows well from sea level to about 3,000 feet in zones B, C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>.

**Importance and use:** Creeping indigo has a strong root system. A single plant produces many branches that spread out in all directions, riding over surrounding herbs and grasses. This plant roots at the nodes if the soil surface is moist. It is a prolific seeder; under Hawaiian conditions hundreds of pods are produced on a single plant. When cut or grazed, it produces many young shoots and persists for a number of years. Seedlings develop rather slowly but when once well-established, they grow rapidly and produce large amounts of forage.

While creeping indigo is a popular green manuring crop in the tropics, some doubt exists as to its forage value. The Florida Agricultural Ex-

periment Station reports that it is toxic to rabbits but no tests were conducted with larger animals. In Africa it is reported as a valuable forage plant. At the Haleakala Branch Station on Maui, creeping indigo was planted in one of a series of pasture mixtures and has been grazed during the past three years. Beef animals have eaten it readily and without ill effects. However, creeping indigo made up only a small part of the entire pasture sward. Especially outstanding was the stimulating effect of the legume on the associated grass growth. If subsequent trials verify the results of present experiments, creeping indigo may become a valuable pasture legume in Hawaii.

### *Indigofera suffruticosa* Mill. (Fig. 17)

#### Indigo

**Habit:** An erect plant, 3 to 5 feet tall.

**Stem:** Rather woody, branching, sparsely covered with short, appressed hairs.

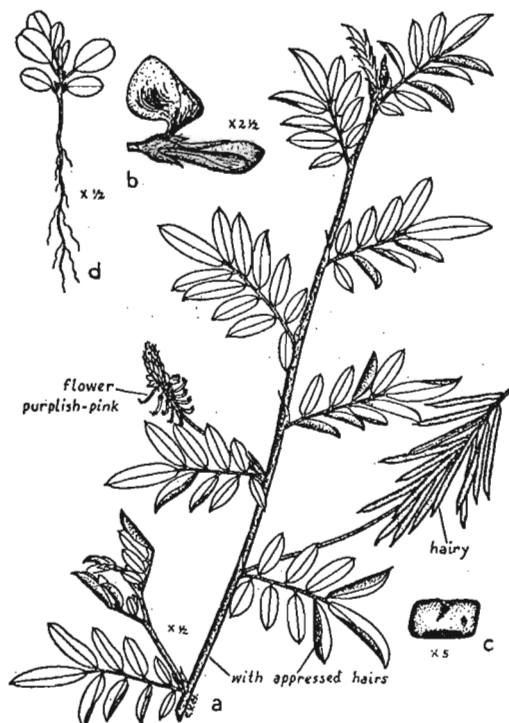


Fig. 16. *Indigofera endecaphylla*: a, habit; b, flower; c, seed; d, seedling.

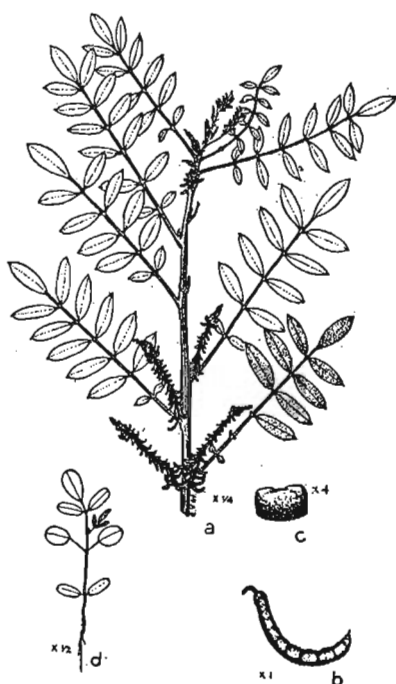


Fig. 17. *Indigofera suffruticosa*: a, habit; b, pod; c, seed; d, seedling.

**Leaf:** Pinnate, with 4 to 6 pairs of leaflets, the leaflets oblong to oblong-elliptical,  $\frac{3}{8}$  to 1 inch long,  $\frac{1}{8}$  to  $\frac{1}{2}$  inch wide.

**Stipule:** Threadlike, about  $\frac{1}{8}$  inch long.

**Flower:** Reddish, about  $\frac{1}{8}$  inch long, arranged in a cluster; calyx about  $\frac{1}{2}$  inch long.

**Seed pod:** Strongly curved, cylindrical, about  $\frac{5}{8}$  inch long, many crowded together, sparsely covered with very short hairs, brown when ripe.

**Seed:** Rectangular, about  $\frac{1}{8}$  inch long, reddish-black, shiny.

**Distribution and habitat:** Indigo, a native of tropical America, is a widely distributed weed in all warm countries. In Hawaii it is found in waste places and pastures below about 3,500 feet altitude, in zones B, C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>.

**Importance and use:** When present in small amounts, indigo is often well eaten by cattle and horses and adds variety to the forage. But when it occurs in rather dense stands, it approaches the proportions of a pest, shading and crowding out the more desirable forage plants. Indigo sheds many of its leaves during the dry season but makes new growth with the coming of the first rains.

### *Lespedeza cuneata* (Dum de Cours) G. Don (Fig. 18)

#### Perennial lespedeza

**Habit:** An upright, somewhat bushy plant,  $1\frac{1}{2}$  to 3 feet tall.

**Stem:** Somewhat woody, covered with short, brown hairs, branching, very leafy.

**Leaf:** Trifoliate, the common leafstalk  $\frac{1}{8}$  to  $\frac{1}{4}$  inch long, the leaflets wedge-shaped to oblanceolate,  $\frac{1}{4}$  to  $\frac{1}{2}$  inch long,  $\frac{3}{8}$  to  $\frac{1}{8}$  inch wide, the midrib projecting beyond the tip, the margin entire, the lower surface covered with short, white, appressed hairs, the upper surface glabrous or slightly clothed with inconspicuous hairs, the central leaflet longer than the two lateral leaflets.

**Stipule:** Linear, pointed, about  $\frac{1}{8}$  inch long.

**Flower:** Greenish, often with a faint touch of yellow, about  $\frac{1}{8}$  inch long, 1 to 3 in the axil of the leaf; calyx 5-lobed, deeply cut, clothed with white, appressed hairs.

**Seed pod:** Ovate to oval, about  $\frac{1}{8}$  inch long, brown, clothed with white, appressed hairs.

**Seed:** Kidney-shaped, about  $\frac{1}{8}$  inch long, yellowish-green to straw-colored, hard, shiny.

**Distribution and habitat:** Perennial lespedeza is a native of Asia. Nursery trials in Hawaii show that the species grows fairly well and produces abundant seeds at elevations below about 3,000 feet in zones C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>. Once established, it develops year after year from the crown, as does alfalfa.

**Importance and use:** This species has not proved to be very important in the United States for pasturage although claims were made earlier for such utilization. Thus far it has assumed little importance in Hawaiian pastures.

Elsewhere this species has not been as popular as the annual species for grazing. It is stated, however, that for land of low fertility few, if any, plants will furnish as good a cover and, at the same time, provide as much summer grazing as perennial lespedeza. Studies indicate that grazing is most successful when the plant is about 4 to 6 inches high. At this stage of growth, the plant is soft and palatable.

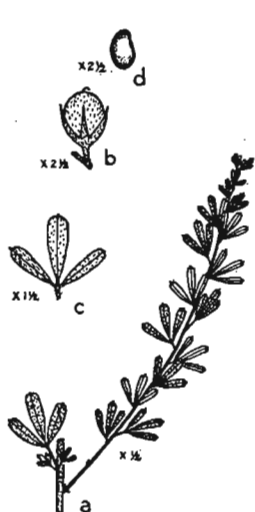


Fig. 18. *Lespedeza cuneata*: a, habit; b, pod; c, leaf; d, seed.

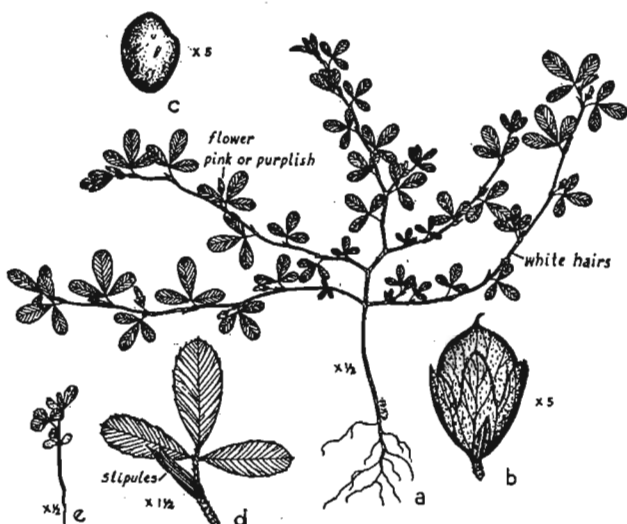


Fig. 19. *Lespedeza striata*: a, habit; b, pod; c, seed; d, leaf; e, seedling.

### *Lespedeza striata* (Thunb.) H. and A. (Fig. 19)

#### Common lespedeza

**Habit:** A commonly prostrate plant, often becoming suberect, 4 to 8 inches high, 6 to 12 inches long, with long tap root.

**Stem:** Cylindric, somewhat woody, freely branching, covered with white, downward-pointing, appressed hairs.

**Leaf:** Trifoliate at the end of a short common leafstalk, leaflets oblong to oblanceolate,  $\frac{1}{4}$  to  $\frac{1}{2}$  inch long,  $\frac{1}{8}$  to  $\frac{1}{4}$  inch wide, smooth except for the hairy-fringed margin.

**Stipule:** Broadly lanceolate, pointed, about  $\frac{1}{8}$  inch long, light brown, thin.

**Flower:** Pink or purple, about  $\frac{1}{8}$  inch long, 1 to 3 in the axis of the leaves; calyx lobes ovate, about equal.

**Seed pod:** Oval, about  $\frac{1}{8}$  inch long, sharp-pointed, with conspicuous netted veins, sparsely covered with very short hairs.

**Seed:** Oval, about  $\frac{1}{8}$  inch long, dark, with light markings, dull.



**Distribution and habitat:** Common lespedeza, a native of Asia, has become an important pasture legume in the United States, especially in the southern states. In the Territory it is found on Hawaii and Maui, in limited localities. It appears to be best adapted to zones C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>.

**Importance and use:** Common lespedeza grows well in association with low bunch-type grasses such as Natal redtop. When planted with such sod-forming species as carpet grass and Bermuda, it appears to be easily crowded out. In spite of repeated attempts to establish it, this legume has never become of any appreciable importance in the Hawaiian pastures. Because of its proven ability elsewhere to grow on soils too poor for most other legumes, it warrants further trial here.

Other annual varieties of lespedeza that are of interest from the forage standpoint are Kobe, Tennessee 76, and Korean. The Kobe is a larger and coarser plant of somewhat more erect habit than the common lespedeza. The Tennessee 76 is a late maturing variety that makes a larger growth than the common lespedeza. The Korean lespedeza is a distinct species with broad leaflets and a broad stipule. The growth is large and coarse and, except in thick stands, the habit is prostrate.

### *Leucaena glauca* (L.) Benth. (Fig. 20)

Koa haole; ekoa

**Habit:** A woody shrub or small tree, 10 to 30 feet tall.

**Stem:** Smooth, conspicuously covered with lenticels.

**Leaf:** Bipinnate, the leaflets linear-oblong, pointed, slanting at base, small.

**Stipule:** Triangular, about  $\frac{1}{8}$  inch long, glabrous.

**Flower:** White, many clustered in a globular head, 1 to  $1\frac{1}{4}$  inches in diameter, at the end of a slender stalk about  $1\frac{1}{2}$  inches long.

**Seed pod:** Flat, 4 to 6 inches long, about  $\frac{1}{2}$  inch wide, clustered in a finger-like manner at the end of a stalk, covered with very fine hairs when young.

**Seed:** Oblong, about  $\frac{1}{4}$  inch long, slightly compressed, brown, shiny with hard seed coat.

**Distribution and habitat:** Koa haole is a tropical American plant, now found throughout the tropics. In the Territory it is widespread at elevations below about 1,500 feet, in zones A, B, and C<sub>1</sub>.

**Importance and use:** The long tap root enables the plant to persist under dry conditions. While it makes little growth during dry spells, it recovers rapidly and sends out many shoots when the rains come. It is usually considered a small shrub, but in some localities it attains treelike proportions and grows in dense thickets. It is a perennial, and when cut or grazed, it will continue to produce new shoots from the woody stem.

This plant plays an important part in local ranching, particularly in the low, dry, leeward sections. The seeds are easily and cheaply gathered, and large quantities have been scattered in pastures by the ranchers. Only 8 to 10 percent of the seeds germinate without preliminary treatment. But if the hard seed is scarified by a machine, by hot water, or acid treatment, 80 to 100 percent germination is obtained. Koa haole forage has as high

a protein content as alfalfa and is relished by all kinds of livestock. Careful management of pastures containing this legume is required. Overgrazing will destroy the stand; on the other hand, undergrazing permits the plants to reach too great a height for effective grazing. If the plant becomes too tall, it must be cut back, a laborious and costly task. For most effective grazing, the old stems should not exceed 3 to 4 feet in height. It will persist, however, if cut close to ground level. Best results are secured when the koa haole is kept sufficiently low and open so that a good under cover of grasses develops. A desirable combination is koa haole and Guinea grass.

Horses, pigs, and rabbits feeding on this plant lose some of their hair; however, it has not been reported that cattle show ill effects from quantities normally fed. In Mauritius, in the Mediterranean, the dry seed is collected, boiled, and used as a cattle feed. In the West Indies the natives are said to use the seeds and pods for food.

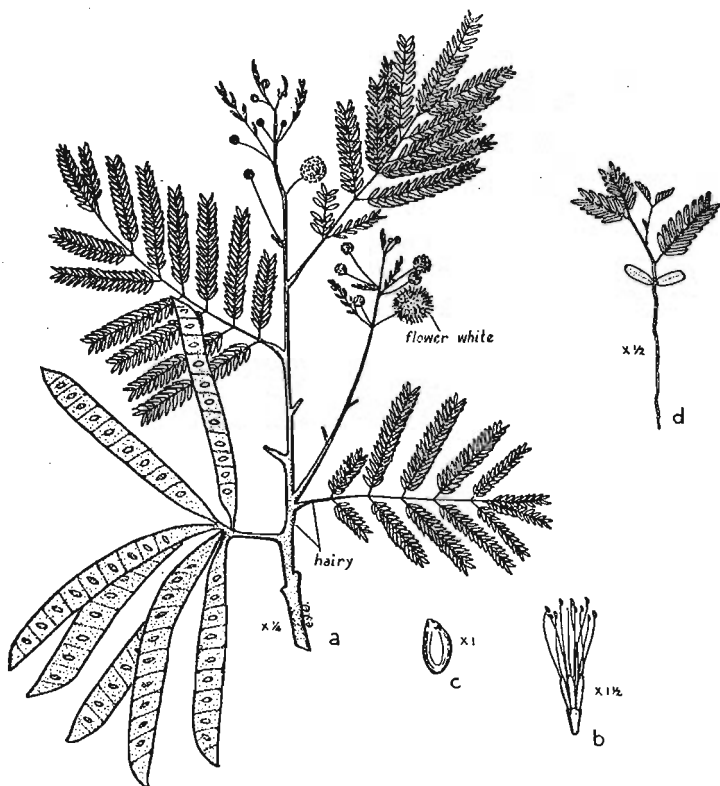


Fig. 20. *Leucaena glauca*: a, habit; b, flower; c, seed; d, seedling.

**Lotus angustissimus L. (Fig. 21)**

## Slender birdsfoot trefoil

**Habit:** A freely branching, procumbent plant with a 2- to 6-foot spread.

**Stem:** Slender, covered with soft, whitish hairs.

**Leaf:** Trifoliate, the leaflets obovate and pointed at tip, entire along margin, covered with white hairs, few veins, the stalk of the central leaflet longer than those of the two lateral ones.

**Stipule:** Ovate-lanceolate, leaflike,  $\frac{1}{8}$  to  $\frac{1}{4}$  inch long, the midrib off-center.

**Flower:** Yellow, about  $\frac{1}{8}$  inch long, 2 to 4 in a cluster, at the end of a common stalk  $\frac{3}{4}$  to  $1\frac{1}{4}$  inches long; calyx lobes twice as long as the tube, hairy.

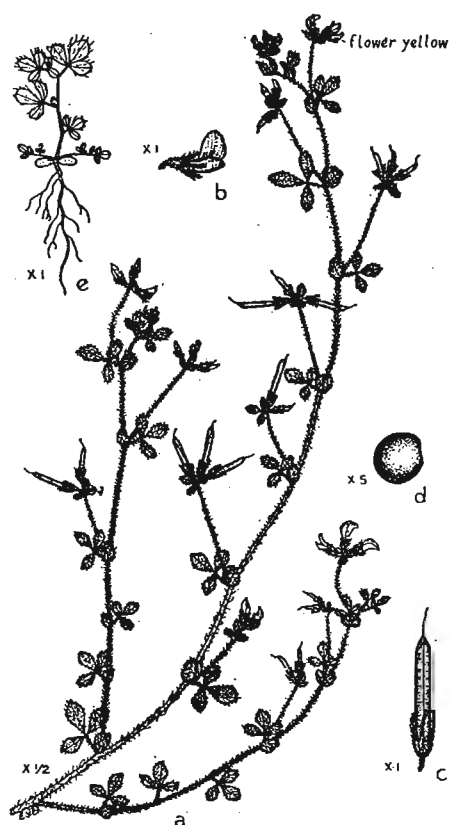


Fig. 21. *Lotus angustissimus*: a, habit; b, flower; c, pod; d, seed; e, seedling.

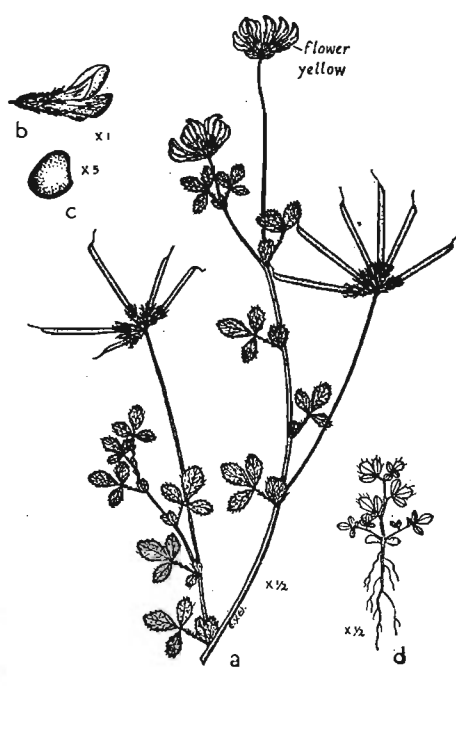


Fig. 22. *Lotus corniculatus*: a, habit; b, flower; c, seed; d, seedling.

**Seed pod:** Linear, straight, terete,  $\frac{1}{2}$  to  $\frac{3}{4}$  inch long.

**Seed:** Oval, about  $\frac{1}{2}$  inch across, light brown.

**Distribution and habitat:** Slender birdsfoot trefoil is native to Eurasia. In the islands it is established only in localized areas at Kaupakulua and Olinda, Maui. It is a moist land species that grows well at middle elevations in zones C<sub>1</sub>, C<sub>2</sub>, D<sub>1</sub>, D<sub>2</sub>, and D<sub>3</sub>.

**Importance and use:** The numerous branches produced by this legume climb over low grasses and herbs. They also spread out among taller plants, adding variety to the forage composition. Although the species of *Lotus* grow well in nursery plots and protected areas, they tend to be killed out in grazed pastures if not carefully managed. They have not as yet assumed any importance in Hawaii. If subsequent tests show that this genus can persist under grazing conditions, it should be a valuable addition in the cool wet zones. Of the several species of *Lotus*, slender birdsfoot trefoil seems to be the most promising as a pasture legume.

### **Lotus corniculatus L. (Fig. 22)**

#### **Birdsfoot trefoil**

**Habit:** A freely branching, decumbent or procumbent plant, 1 to 3 feet long.

**Stem:** Weak, slightly angular, sparsely clothed with soft hairs.

**Leaf:** Trifoliate, the leaflets obovate or oblanceolate,  $\frac{5}{8}$  to  $\frac{3}{4}$  inch long,  $\frac{1}{8}$  to  $\frac{3}{8}$  inch wide, hairy, entire along margin, the middle leaflet stalk the longest.

**Stipule:** Similar to and often as large as the leaflets, the midrib off-center.

**Flower:** Yellow, often reddish on upper lip, 3 to 7 in a cluster, on a stalk about  $\frac{1}{8}$  inch long; calyx 5-lobed, pointed, smooth or sparsely hairy, as long as the tube.

**Seed pod:** Linear, cylindrical, straight,  $\frac{3}{4}$  to  $1\frac{1}{4}$  inches long, splitting into halves with a slight twist at maturity, many-seeded, the seeds partially separated by transverse partitions.

**Seed:** Oval, about  $\frac{1}{2}$  inch long, dark brown, shiny.

**Distribution and habitat:** Birdsfoot trefoil is native to Eurasia. In the Territory it is found only in a few patches. Birdsfoot trefoil is best adapted to rainy or swampy locations at moderate altitude of zones D<sub>1</sub>, D<sub>2</sub>, and D<sub>3</sub>. It grows well in poor soil and in rough terrain.

**Importance and use:** When established, birdsfoot trefoil grows well because of its stout perennial root system, but it cannot stand hard grazing. It is relished by stock and is considered good forage. Birdsfoot trefoil is somewhat acid-tolerant and can grow on poor lands where other clovers do not develop well. Analyses of the plant show it to be approximately equivalent to other common pasture legumes in feeding value.

**Lotus hispidus** Desf. (Fig. 23)

## Hairy birdsfoot trefoil

**Habit:** A trailing to weakly climbing plant, freely branching, 1 to 2½ feet across.

**Stem:** Hollow, sparsely covered with brown hairs.

**Leaf:** Trifoliate, leaflets obovate-lanceolate, ¼ to ½ inch long, ⅛ to ¼ inch wide, pointed at tip, covered with brown hairs on both surfaces.

**Stipule:** Leaflike, somewhat cordate at base, about ¼ inch long and ⅛ inch wide, hairy.

**Flower:** Yellow, about ⅜ inch long, 3 to 4 in a cluster, at the end of a common stalk ¾ to 1¼ inches long; calyx with 5 narrow lobes, hairy.

**Seed pod:** Terete, ½ to ¾ inch long, rugose, black when ripe.

**Seed:** Angular-oblong, about ⅜ inch long, brown.

**Distribution and habitat:** Hairy birdsfoot trefoil is native to the Mediterranean region. It is adapted to semimoiest localities of zones C<sub>2</sub>, D<sub>2</sub>, and E<sub>1</sub>. This plant is established in localized pastures at Ulupalakua, Maui, and Kilauea, Hawaii.

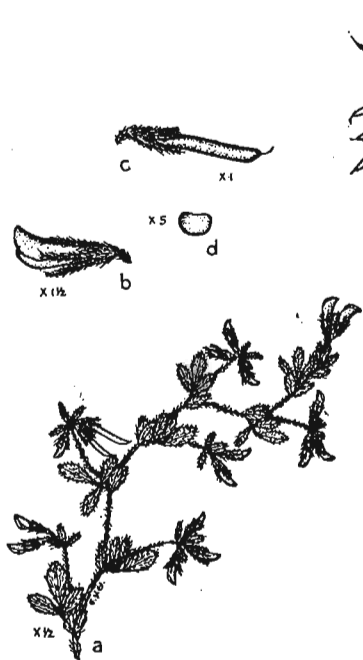


Fig. 23. *Lotus hispidus*: a, habit; b, flower; c, pod; d, seed.



Fig. 24. *Lotus uliginosus*: a, habit; b, flower; c, pod; d, seed.

**Importance and use:** Hairy birdsfoot trefoil is said to withstand drier conditions than the other species of *Lotus* planted for forage. It is a non-aggressive plant that grows among the pasture grasses as a companion species. Hairy birdsfoot trefoil is relished by grazing animals and is a desirable plant in a pasture mixture. However, it is difficult to maintain in good stands under grazing conditions.

***Lotus uliginosus* Schk. (Fig. 24)**

(*Lotus major* Sm.)

**Big birdsfoot trefoil**

**Habit:** A freely branching, procumbent plant, 3 to 6 feet long.

**Stem:** Weak, freely branching, trailing, hollow, often rooting at the nodes, smooth, or often sparsely hairy when young.

**Leaf:** Trifoliate, the leaflets obovate, smooth at margin, with few veins, more prominent on under surface, the middle leaflet on a longer stalk than the lateral ones.

**Stipule:** Oval, leaflike,  $\frac{3}{8}$  to  $\frac{1}{4}$  inch long, the midrib off-center.

**Flower:** Rich yellow, 8 to 12 in a cluster, on a common stalk 2 to 4 inches long; calyx teeth spreading backwards and outwards in bud.

**Seed pod:** Cylindrical, 1 to  $1\frac{1}{2}$  inches long, about  $\frac{3}{8}$  inch wide.

**Seed:** Rounded oval, about  $\frac{1}{8}$  inch long, usually greenish, often light yellow.

**Distribution and habitat:** Big birdsfoot trefoil is indigenous to northern Europe, where it is widely used in marshy pastures. In the Territory, big birdsfoot trefoil is localized in wet middle-altitude pastures in zones D<sub>1</sub>, D<sub>2</sub>, and D<sub>3</sub>. Big birdsfoot trefoil is somewhat acid-tolerant and will grow luxuriantly even in swamps.

**Importance and use:** Big birdsfoot trefoil persists under a wide range of soil conditions and roots freely at the nodes to form a good stand. It grows better if there are plants on which the trailing stems can find support. In New Zealand it has been planted to great advantage in swampy lands where other forage legumes do not grow. In such localities, seeds are broadcast, and the resultant plants grow between the herbs and gradually bring about an improvement in the plant composition of the pasture.

***Medicago hispida* Gaertn. (Fig. 25)**

**Bur clover**

**Habit:** A creeping to slightly ascending plant, 1 to 3 feet across.

**Stem:** Glabrous, usually 4-angled, branching.

**Leaf:** Trifoliate, the leaflets broadly obovate or wedge-shaped, toothed on the upper margin, usually hairless or with few hairs on the lower surface, the midrib extending beyond the tip, the veins straight, branching little, the central leaflet usually larger and on a longer stalk than the lateral ones.

**Stipule:** Irregular, conspicuous, about  $\frac{1}{4}$  inch long, finely toothed, smooth.

**Flower:** Yellow, about  $\frac{1}{8}$  inch long, 2 to 7 in a cluster, on stalk  $\frac{1}{2}$  to  $\frac{3}{4}$  inch long; calyx sparsely hairy, the teeth equal, pointed.

**Seed pod:** A bur, 2 to 3 times spirally twisted, about  $\frac{1}{8}$  inch long and about  $\frac{1}{4}$  inch wide, covered with hooked or curved spines, conspicuously veined, several-seeded.

**Seed:** Kidney-shaped, about  $\frac{1}{8}$  inch long, light brownish-yellow.

**Distribution and habitat:** Bur clover is a native of Eurasia. It is generally distributed in all the warm temperate and tropical regions. In the Territory it is one of the most widely distributed pasture legumes. It is found from sea level to 5,000 feet elevation, in zones B, C<sub>1</sub>, C<sub>2</sub>, and E<sub>1</sub>. The spiny burs facilitate the dissemination of the plant by animals. Pheasants and quail feed on the burs and help spread the seeds.

**Importance and use:** Bur clover is one of the most important pasture legumes in Hawaii. When once established in a pasture, it maintains itself indefinitely with little need for reseeding. Seeds of bur clover contain a considerable proportion of hard seeds which retain their vitality in the soil for a number of years. This condition seems to be particularly true where the seeds remain in the bur.

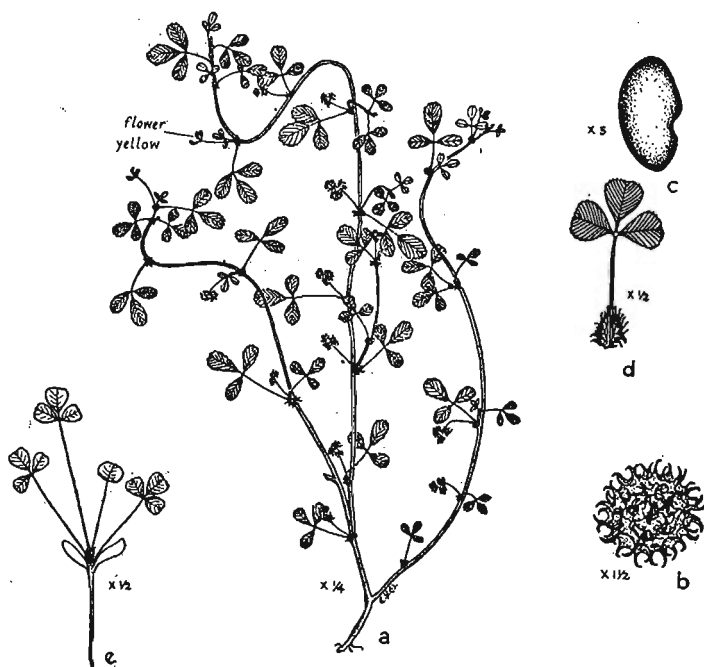


Fig. 25. *Medicago hispida*: a, habit; b, bur; c, seed; d, leaf; e, seedling.

Ranchers state that bur clover retains a relatively high nutritive value throughout its entire growth period; however, the young plants are said to be less palatable to animals than those that have attained early mature growth. The species grows rapidly during the spring and summer months in the upper zones and is a definite winter annual in the lower zones. The ability to crawl over and between the surrounding plants enables it to grow in combination with sod grasses such as Bermuda and paspalum, as well as with bunch grasses such as Natal redtop, perennial rye, and brome. Where this legume is established, it adds materially to the quality of the feed.

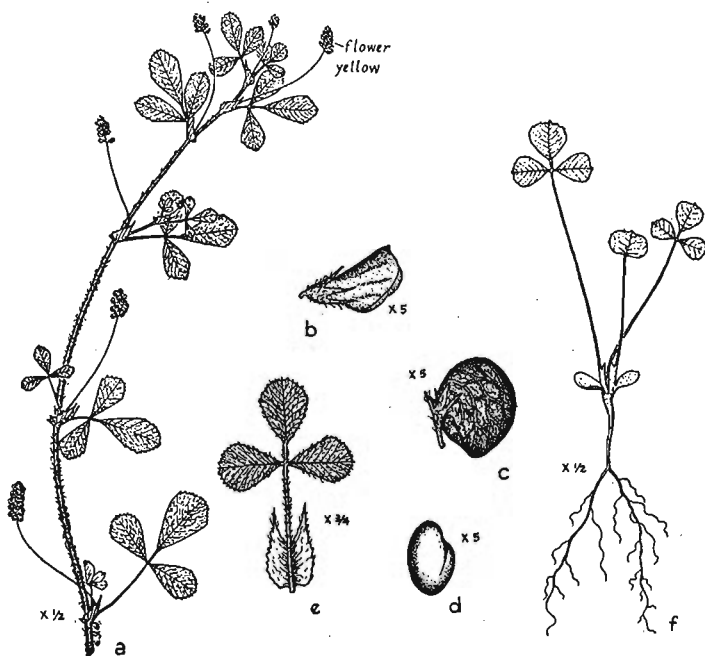


Fig. 26. *Medicago lupulina*: a, habit; b, flower; c, pod; d, seed; e, leaf; f, seedling.

### *Medicago lupulina* L. (Fig. 26)

#### Black medic

**Habit:** A loosely branching, semierect to prostrate plant.

**Stem:** Hairy, 4-angled, 1 to 3 feet long, the growing ends ascending.

**Leaf:** Trifoliate, the leaflets obovate or oval, usually hairy on both surfaces, toothed on the upper margin, mucronate, with rather straight veins, the middle leaflet on a longer stalk than the lateral ones.



**Stipule:** Broad, irregular,  $\frac{1}{4}$  to  $\frac{3}{8}$  inch long, with sharp points on the margin, sparsely hairy.

**Flower:** Yellow, about  $\frac{3}{8}$  inch long, in a cluster at the end of a slender stalk longer than the leaf; calyx half the length of the corolla, with 5 tapering teeth, persistent.

**Seed pod:** Kidney-shaped, about  $\frac{3}{8}$  inch long, black at maturity, hairy, half-twisted, 1-seeded.

**Seed:** Kidney-shaped, about  $\frac{1}{8}$  inch long, with a distinct projection, yellowish or greenish-yellow.

**Distribution and habitat:** Black medic is indigenous to Europe and Asia and is now widely distributed in all temperate and subtropical countries. In Hawaii it is well-established over considerable areas. Black medic grows on a wide variety of soils but will not tolerate high acidity. It is adapted to zones B, C<sub>1</sub>, C<sub>2</sub>, and E<sub>1</sub>. In the lower zones it is found during the winter months.

**Importance and use:** Among the short-lived clovers, black medic is regarded locally as one of the best of the forage legumes. When it is established in a pasture, it perpetuates itself indefinitely by producing a large quantity of viable seeds year after year. As is true of other annual clovers, it requires a dry season to ripen its seeds. It is a companion species in a pasture and develops with bunch grasses such as Natal redtop, brome, rye, and cocksfoot. It is also capable of growing with sod grasses such as paspalum, Bermuda, and Kentucky bluegrass. It has a strong tap root and can withstand drought fairly well. Black medic is often mistaken for hop clover because the flowers look much alike. But it can easily be distinguished from hop clover by its creeping habit, somewhat square, hairy stems, and large, rather compact group of seed pods which become black when ripe.

### ***Medicago minima* L. (Fig. 27)**

#### **Little bur clover**

**Habit:** A prostrate plant, often climbing over low grass.

**Stem:** Freely branching, 1 to 2 feet long, terete, covered with short, white, soft hairs.

**Leaf:** Trifoliate, the leaflets obovate to wedge-shaped, margin toothed near the tip, silky hair on both surfaces, the central leaflet on a longer leaf-stalk than the two lateral leaflets.

**Stipule:** Broadly lanceolate, about  $\frac{1}{4}$  inch long, pointed, hairy, often with a few teeth near base.

**Flower:** Yellow, about  $\frac{3}{8}$  inch long, 1 to 3 in a cluster at the end of a stalk  $\frac{1}{8}$  to  $\frac{1}{4}$  inch long.

**Seed pod:** A globular bur, about  $\frac{1}{4}$  inch in diameter, 4- to 8-seeded, several times coiled, hairy, the spines slender, spreading, slightly hooked.

**Seed:** Kidney-shaped, about  $\frac{1}{8}$  inch long, brownish, shiny.

**Distribution and habitat:** Little bur clover is a native of the Mediterranean region. In the Territory it is found in only one locality at Ulupalakua, Maui, where it is making excellent growth. Judging from the behavior of the plant, it is adapted to semim moist parts of zone C<sub>2</sub>, at middle altitude.

**Importance and use.** Little bur clover is regarded as a nourishing forage in the pastures of Australia. It is relished by all grazing animals. The plants growing in the Maui pasture have produced abundant seeds, so that eventually this species may become an important pasture legume in the islands.

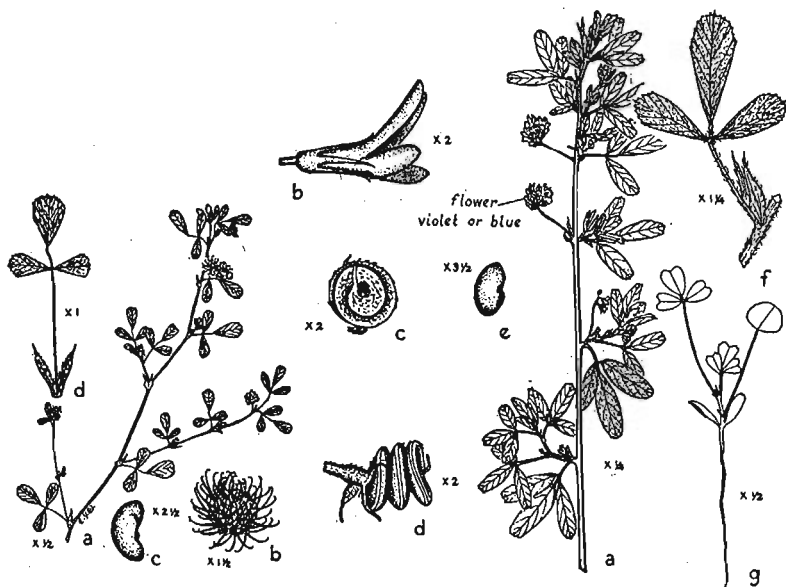


Fig. 27. *Medicago minima*: a, habit; b, bur; c, seed; d, leaf.

Fig. 28. *Medicago sativa*: a, habit; b, flower; c, pod, top view; d, pod, side view; e, seed; f, leaf; g, seedling.

### *Medicago sativa* L. (Fig. 28)

#### Alfalfa

**Habit:** A long-lived, erect plant, 2 to 4 feet tall, with long tap root.

**Stem:** Glabrous or often sparsely hairy toward the upper part, often 4-angled towards the top, somewhat woody at base, producing many stems from the root crown.

**Leaf:** Trifoliate, the leaflets oblong to wedge-shaped, toothed on margin toward the apex, glabrous or with few scattered hairs, the midrib projecting as a sharp point, the terminal leaflet slightly larger and on a longer leafstalk than the lateral leaflets.

**Stipule:** About  $\frac{3}{8}$  inch long, usually coarsely toothed, smooth, the tip divided into 2 long, narrow points.

**Flower:** Violet or blue, the petals about  $\frac{1}{4}$  inch long, arranged in oblong inflorescence on long stalk; calyx 5-toothed.

**Seed pod:** Spirally twisted 2 to 3 times, about  $\frac{1}{8}$  inch in diameter, several-seeded, hairy.

**Seed:** Kidney-shaped to oval, about  $\frac{1}{8}$  inch long, yellowish-brown or greenish-yellow.

**Distribution and habitat:** Although alfalfa is generally believed to be native to southwestern Asia, it is now widely distributed in all countries having relatively dry, hot summers. Its greatest use is under irrigation or in semiarid countries, where the deep tap root utilizes moisture in the subsoil. It is also grown in cool, humid climates, but coincidence of high temperature and high humidity is detrimental. Alfalfa is occasionally found throughout the islands in fairly moist pastures of zones C<sub>1</sub>, C<sub>2</sub>, and D<sub>3</sub>. It also develops well in deep and well-drained irrigated lands of zones A and B, where the climate is hot and dry.

**Importance and use:** In Hawaii, because alfalfa is not able to persist in pastures against the many perennial creeping grasses and herbs, it is not planted for pasturage. Although alfalfa produces a heavy tonnage of cut forage for a year or two after planting, it is rarely grown as a soilage crop, principally because of the difficulty of controlling noxious weeds and creeping grasses. The detrimental effect of high humidity and temperature often experienced in the lower zones causes rapid reduction of both the stand and yield of the ratoon crops.

### **Melilotus alba Desr. (Fig. 29)**

#### **White sweet clover**

**Habit:** An erect, branching plant, 2 to 4 feet tall.

**Stem:** Somewhat woody at base, cylindrical, smooth, pithy.

**Leaf:** Trifoliate, the leaflets elongate, oblanceolate or oblong, about  $\frac{3}{4}$  inch long, sparsely covered with short hairs on lower surface, glabrous on upper, the margin toothed, the central leaflet larger and on a longer stalk than the lateral ones.

**Stipule:** Slender, pointed, about  $\frac{1}{4}$  inch long.

**Flower:** White, fragrant, about  $\frac{1}{8}$  inch long, 20 or more in a long, rather loose inflorescence; calyx lobes short.

**Seed pod:** Ovate, about  $\frac{1}{8}$  inch long, wrinkled, smooth, black, usually 1-seeded.

**Seed:** Kidney-shaped to suboval, about  $\frac{3}{8}$  inch long, with conspicuous groove on one side, light brown.

**Distribution and habitat:** White sweet clover appears to have originated in southeast Europe and southwest Asia. It is used in both the Corn Belt and Great Plains regions of the United States. In the islands it is seen only occasionally on the ranges of zones B, C<sub>1</sub>, and C<sub>2</sub> during the winter and spring months. It is known to make satisfactory growth in soils too poor for the establishment of better legumes.

**Importance and use:** While not generally regarded as first-class forage, white sweet clover is used rather extensively elsewhere as a hay crop and as temporary pasture. White sweet clover has been planted in pastures at several localities in Hawaii but has not increased.

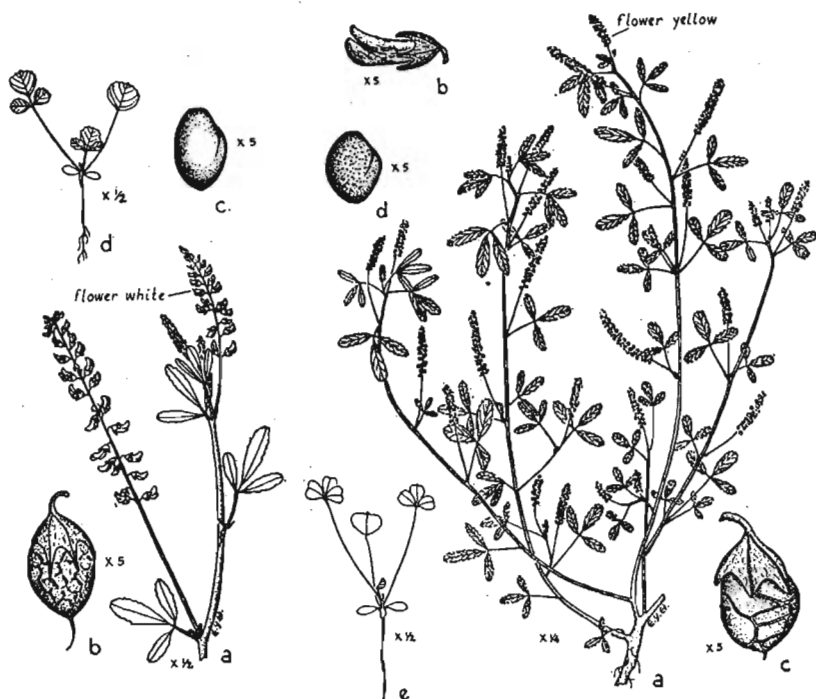


Fig. 29. *Melilotus alba*:  
a, habit; b, pod; c,  
seed; d, seedling.

Fig. 30. *Melilotus indica*: a, habit; b, flower;  
c, pod; d, seed; e, seedling.

### ***Melilotus indica* All. (Fig. 30)**

#### Indian yellow clover

**Habit:** An erect, short-lived plant, 1 to 2 feet tall.

**Stem:** Somewhat woody at base, glabrous or often sparsely hairy at tip.

**Leaf:** Trifoliate, the leaflets obovate, oblanceolate or wedge-shaped, somewhat fleshy, toothed at margin, glabrous or with few scattered hairs, the veins straight and practically unbranched, the central leaflet slightly larger and on a longer stalk than the two lateral leaflets.

**Stipule:** Lanceolate, pointed, about  $\frac{1}{4}$  inch long, the lower part often slightly toothed.

**Flower:** Yellow, about  $\frac{1}{8}$  inch long, 20 or more arranged on a long flowering stem; calyx reddish, sparsely covered with white hairs, with 5 equal teeth.

**Seed pod:** Subglobular, about  $\frac{3}{8}$  inch long, brownish, 1-seeded, wrinkled, with netted veins.

**Seed:** Suboval, about  $\frac{1}{2}$  inch long, reddish-brown, with slightly rough surface.

**Distribution and habitat:** Indian yellow clover, which is a native of Eurasia, is now widely distributed in all the temperate and subtropical countries. In Hawaii it is not widely dispersed, but there are a number of localities where the plant has become important. It is found in zones B, C<sub>1</sub>, C<sub>2</sub>, and E<sub>1</sub>. Indian yellow clover grows rapidly in the drier section of the central Waimea plain on the island of Hawaii, from 2,500 to 4,000 feet altitude. It has also been found in a few places at much lower elevations during the winter months. As stated elsewhere, Indian yellow clover is not adapted to acid soils but grows well in thin soil areas. Applications of lime are often made to secure satisfactory stands and growth.

**Importance and use:** In the Hawaiian pastures where it is adapted and well-established, Indian yellow clover produces many seeds and reappears year after year after the winter and spring rains. The objectionable features of Indian yellow clover are a short growing season and a tendency in the early growth stages to cause bloating of cattle. Elsewhere it is not rated very highly, but in Hawaii it is considered to have value in a pasture because of its fattening qualities and its ability to grow on relatively poor soils. In Louisiana this clover is used as a soil-improving crop in the sugarcane fields.

### ***Mimosa pudica* L. (Fig. 31)**

Sensitive plant; hilahila

**Habit:** A prostrate to slightly ascending plant, 1 to 2½ feet long, often forming a small, compact bush about 2 feet tall.

**Stem:** Somewhat woody at base, usually reddish, armed with scattered prickles.

**Leaf:** Bipinnate, the leafstalk hairy, the leaflets lanceolate or unevenly oblong, pointed, reddish-brown on lower surface, ciliate with appressed hairs, the leaf and leaflets folding back when touched.

**Stipule:** Lanceolate, pointed, about  $\frac{1}{8}$  inch long, with hairs on the margin.

**Flower:** Pink, in a globular head, at the end of a hairy flower stalk about 1 inch long.

**Seed pod:** Somewhat flat, slightly curved,  $\frac{1}{2}$  to  $\frac{3}{4}$  inch long,  $\frac{1}{8}$  inch wide, with 2 to 5 swollen, disk-shaped seed chambers, smooth except for the margin which is provided with bristles, borne in a cluster.

**Seed:** Ovate, flattened, about  $\frac{1}{8}$  inch long, brownish, shiny.

**Distribution and habitat:** Sensitive plant, a native of tropical America, is now widely distributed throughout the warm countries. In Hawaii it is found principally in the moist windward C<sub>1</sub> and D<sub>1</sub> zone pastures of all the islands.

**Importance and use:** Under natural conditions or light grazing, sensitive plant develops into a small clump with thorny stems. It is eaten little by cattle, and sometimes reaches the proportions of a pest by crowding out the surrounding grasses. When mowed occasionally or grazed heavily, the young, tender growth is well eaten. While not a first-class forage, it is generally regarded as a desirable species in the moist zones where few other forage legumes will grow. In pastures where this plant is common, the Kaimi Spanish clover is also adapted and is much to be preferred for planting.



Fig. 31. *Mimosa pudica*: a, habit; b, flower; c, pod; d, seed; e, seedling.



Fig. 32. *Phaseolus lathyroides*: a, habit; b, flower; c, pods; d, seed.

### *Phaseolus lathyroides* L. (Fig. 32)

#### Wild pea bean

**Habit:** An erect or nearly erect plant, 2 to 3 feet tall.

**Stem:** Branching, somewhat woody at base, hollow above, covered with short hairs.

**Leaf:** Trifoliate, the leaflets oblong to ovate, glabrous on upper surface, hairy on lower.

**Stipule:** Lanceolate, tapering to a point, about  $\frac{1}{4}$  inch long.

**Flower:** Dark purple, about 1 inch long, borne on flower stalk 10 to 20 inches long; calyx 5-toothed, smooth.

**Seed pod:** Linear, cylindrical, slightly curved, 4 to 5 inches long, covered with small short hairs, 20- to 30-seeded.

**Seed:** Oblong,  $\frac{1}{8}$  to  $\frac{3}{8}$  inch long, brown to gray.

**Distribution and habitat:** Wild pea bean, native to tropical America, is now widely distributed over the tropics. In Hawaii it is found occasionally in the lowland pastures of zones B, C<sub>1</sub>, and D<sub>1</sub>.

**Importance and use:** Wild pea bean commonly volunteers in newly plowed pastures but gradually disappears as the sod grasses become established, especially under heavy, continuous grazing. In one experiment at the Haleakala Branch Station, under rotational grazing, it has persisted well for 4 years, with new trailing shoots developing from the crown of the plant after each grazing. It is eaten to a certain extent by cattle and adds variety to the pasture mixture, but it is probably not to be recommended for planting.

### *Pithecellobium dulce* (Roxb.) Benth. (Fig. 33)

Opiuma; madras thorn

**Habit:** A rapidly growing tree, 25 to 50 feet tall.

**Stem:** Freely branching, the branches drooping, with smooth, light gray bark.

**Leaf:** Bipinnate, the leaflets oval to ovate-lanceolate, about  $1\frac{3}{4}$  inches long, glabrous, pale green.

**Stipule:** A straight thorn, about  $\frac{1}{8}$  inch long.

**Flower:** White, about  $\frac{3}{8}$  inch long, clustered, about 20 in a head, on long, drooping, paniced racemes.

**Seed pod:** Spirally twisted, about 4 inches long and about  $\frac{1}{2}$  inch wide, with light red coloration when mature.

**Seed:** Roundish, flat, about  $\frac{1}{4}$  inch in diameter, black, shiny.

**Distribution and habitat:** Opiuma, a native of Central America, is now fairly well distributed in the tropics. In the islands it is found occasionally in the pastures of lower elevations in zones B and C<sub>1</sub>.

**Importance and use:** Opiuma is said to be eaten by cattle, but it is not generally regarded as a forage plant. In certain sections of Kona, Hawaii, it is becoming a serious pasture pest. The mynah birds feed on the fruit and help to spread the seeds.

### *Prosopis chilensis* (Mol.) Stuntz<sup>1</sup> (Fig. 34)

Algaroba; kiawe

**Habit:** A tall, spreading tree, 25 to 50 feet tall, the root system shallow, spreading.

**Stem:** Freely branching, the wood hard, reddish.

<sup>1</sup> Since the Hawaiian algaroba has not been definitely determined the specific name *chilensis* is given because it has been called this for a long time. Dr. Lyman Benson, who has recently made a study of the American species of *Prosopis* (Amer. Jour. Bot. 28: 748-754. 1941.), is studying the Hawaiian plant.

**Leaf:** Bipinnate,  $1\frac{1}{2}$  to 3 inches long, with small round glands, the leaflets linear-oblong, glabrous or often sparsely hairy.

**Stipules:** Ovate, about  $\frac{1}{8}$  inch long.

**Flower:** Greenish-yellow, about  $\frac{1}{8}$  inch long, borne in a raceme 2 to 4 inches long.

**Seed pod:** Slender, slightly curved or straight, flat at maturity, 4 to 8 inches long, glabrous, yellow when ripe, borne in drooping clusters.

**Seed:** Angular-oblong, about  $\frac{1}{4}$  inch long and about  $\frac{1}{8}$  inch wide, light brown, enclosed in a horny structure.

**Distribution and habitat:** Algaroba, a native of Central America, is generally accepted as being the same as the "mesquite" of Texas, Oklahoma, Arizona, and other southwestern states of the United States. It is believed to have been introduced into the islands by Father Bachelot of



Fig. 33. *Pithecellobium dulce*: a, habit; b, flower; c, pod; d, seed; e, seedling.



the Catholic Mission in 1828. From the single tree he planted, seeds were gathered and planted in other places, and today algaroba is the dominant plant in the dry coastal lowlands of all the islands. It makes its best growth where the roots of the tree reach the fresh ground-water table.

**Importance and use:** Algaroba is commonly recognized as the most valuable introduced tree in the Territory. From the standpoint of the rancher it is especially valuable because it provides necessary shade for the animals in the dry and hot zones, and the bean crop that drops during the period from about June to November is an excellent feed. The beans are often gathered and ground into a meal that serves as a substitute for grain in various concentrate rations. No reliable data are available as to the yield of pods, although it has been reported that a mature tree may bear as much as 200 pounds or more annually. The leaves of the tree are grazed to some extent, but, from a forage standpoint, they are regarded as of considerably less importance than the beans. The algaroba meets a special need in the grazing program of many ranches located principally in the dry zones because it provides forage during the dry summer months.

At present, algaroba is probably established in every locality to which it is adapted. Naturally developed seedlings grow rapidly and tend to form dense thickets. Since algaroba shows considerable variation as to stature of the tree, degree of spininess, number of leaflets, and size and yield of pods, selections of superior strains could no doubt be made.

### ***Pueraria thunbergiana* (Sieb. and Zucc.) Benth. (Fig. 35)**

#### **Kudzu**

**Habit:** A spreading, perennial vine.

**Stem:** Woody, strong, hairy, with many shoots developing from the crown.

**Leaf:** Trifoliate, the leaflets ovate and angularly lobed, 4 to 8 inches long, leathery, smooth or nearly so on upper surface, densely covered with soft grayish hairs on lower, the leafstalk hairy.

**Stipule:** Peltate, broadly ovate, about  $\frac{1}{4}$  inch long, hairy.

**Flower:** Dull purple red with rather large yellow spot near the base, about  $\frac{3}{4}$  inch long, in pendent raceme.

**Seed pod:** Thin, 2 to 3 inches long, about  $\frac{1}{4}$  inch wide, covered with fairly stiff, spreading brown hairs.

**Seed:** Oval or oblong, about  $\frac{1}{8}$  inch long, dark, shiny.

**Distribution and habitat:** Kudzu, a native of the Orient, is now found in many of the warm countries. It is best adapted to a warm, moist climate, but because of the stored plant food in the roots, it can stand protracted drought when once established. In the Territory kudzu will grow from sea level to about 3,000 feet elevation, in zones C<sub>1</sub>, C<sub>2</sub>, and D<sub>1</sub>.

**Importance and use:** Kudzu is a fast-growing plant and produces long, prostrate branches which root at many of the joints if the soil is moist and the contact good. New plants are established in this manner. In the

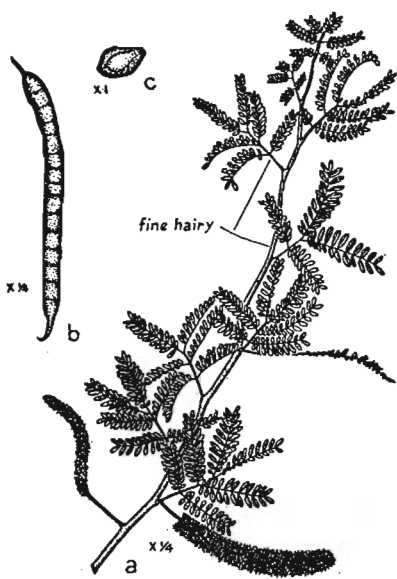


Fig. 34. *Prosopis chilensis*: a, habit; b, pod; c, seed; d, seedling.

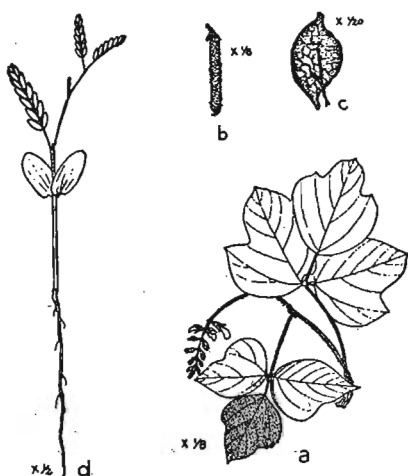


Fig. 35. *Pueraria thunbergiana*: a, habit; b, pod; c, enlarged root.

southern parts of the United States it is recommended for both pasturage and cut feed, especially on poor, eroded lands. At least a year is required to establish the crop, and it must be carefully managed to maintain the stand. Excellent yields in forage are reported from lands too poor for good growth of better legumes. Kudzu, unlike some other crops, is known to retain its palatability during the entire growing season.

Kudzu has not assumed any importance as a grazing or soilage crop in Hawaii, although one small planting near Kamuela, Hawaii, in zone C<sub>2</sub>, has persisted for 15 years under periodic grazing. Growth is seasonal, principally in the spring and summer months, but forage is abundant during this period.

### **Samanea saman (Jacq.) Merr. (Fig. 36)**

Monkeypod; rain tree

**Habit:** A spreading tree, 50 to 75 feet tall.

**Stem:** Freely branching, the wood hard, the bark rough.

**Leaf:** Bipinnate, the leaflets subelliptical,  $\frac{3}{4}$  to  $1\frac{1}{4}$  inches long,  $\frac{3}{8}$  to 1 inch wide, 3- to 8-paired.

**Stipule:** Lanceolate, pointed, about  $\frac{1}{4}$  inch long, hairy.

**Flower:** Pinkish, clustered in a head, about  $1\frac{1}{4}$  to  $2\frac{1}{2}$  inches in diameter.

**Seed pod:** Rather straight, 4 to 7 inches long, about  $\frac{3}{4}$  inch wide, somewhat fleshy, with sweet and sticky pulp, blackish when ripe.

**Seed:** Oval to oblong, about  $\frac{1}{8}$  inch long, slightly flattened, brownish, shiny.

**Distribution and habitat:** Monkeypod, a native of the northern part of South America, is now widely distributed in all warm countries. In the islands it is commonly found in all the fairly moist lowland pastures of zones B, C<sub>1</sub>, and D<sub>1</sub>.

**Importance and use:** The pod of this plant is regarded as fair feed by many stockmen. The leaves are rarely eaten. It affords shade for the animals but is generally of little importance from a forage standpoint.

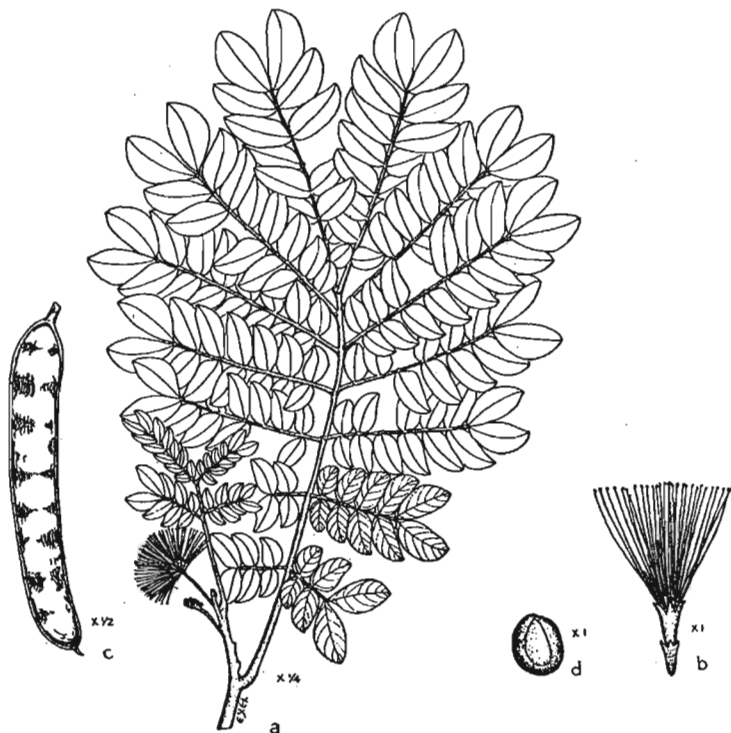


Fig. 36. *Samanea saman*: a, habit; b, flower; c, pod; d, seed.

***Sophora chrysophylla* (Salisb.) Seem. (Fig. 37)**

**Mamani**

**Habit:** An erect to spreading tree, 25 to 50 feet tall.

**Stem:** Branching, the young stems covered with fine, short hairs, the wood hard.

**Leaf:** Pinnate, about 6 inches long, with 6 to 10 pairs of leaflets, the leaflets elliptic to oblong, about 1 inch long and about  $\frac{3}{8}$  inch wide, hairy.

**Stipule:** Absent.

**Flower:** Yellow, about 1 inch long, in a raceme; calyx about  $\frac{3}{8}$  inch long.

**Seed pod:** Four-winged, 4 to 6 inches long, about  $\frac{3}{8}$  inch wide, somewhat constricted between the seeds, hairy.

**Seed:** Oval, about  $\frac{1}{4}$  inch long, rather compressed, yellow, shiny.

**Distribution and habitat:** Mamani is a native of the Hawaiian Islands and is found principally in the upland pastures at 4,500 to 10,000 feet elevation. It is a characteristic plant in zones C<sub>2</sub>, E<sub>1</sub>, and E<sub>2</sub>, often being the dominant tree species.

**Importance and use:** Mamani is only occasionally eaten by cattle, but sheep and goats seem to relish it and feed on the leaves as high as they can reach. It is regarded as poor forage by ranchers, but it is an excellent tree to have in the upland pastures because it provides shelter as well as fence posts. A fence post of mamani is said to last for 25 or more years under normal conditions.

### *Stylosanthes guianensis* (Aubl.) Sw.

#### Trifolio

**Habit:** A bushy plant, 2 to 4 feet high, with a dense, spreading mass of leaves.

**Stem:** Freely branching, somewhat woody, covered with short, soft hairs.

**Leaf:** Trifoliate, the leaflets lanceolate, pointed at tip, 1 to  $1\frac{1}{2}$  inches long, entire along margin, densely covered with soft hairs on both surfaces, on hairy stalks about  $\frac{1}{2}$  inch long.

**Stipule:** Partly clasping the stem, densely covered with hairs, with two narrow-pointed bracts about  $\frac{1}{8}$  inch long.

**Flower:** Yellow, about  $\frac{1}{4}$  inch long, 10 to 15 in a cluster in the upper nodes of the stem, surrounded with reddish, hairy sheaths or bracts.

**Seed pod:** Obovate, about  $\frac{1}{8}$  inch long, 1-seeded, enclosed in calyx lobes, the outer pods becoming ripe before the inner ones.

**Seed:** Kidney-shaped, about  $\frac{3}{8}$  inch long, straw-colored.

**Distribution and habitat:** Trifolio is a native of tropical South America. It was introduced into Hawaii in 1938, and nursery trials show that the plant is adapted to zones B, C<sub>1</sub>, and C<sub>2</sub>.

**Importance and use:** In recent years trifolio has received some attention from ranchers in tropical countries. The feeding value is considered to be high, and in palatability trials this legume has been readily consumed. It is said to be tolerant of acid soils but not of swampy conditions. It is also said to be drought-resistant and to develop a deep root system. Reports from Brazil indicate that, once established in a pasture, trifolio is capable of spreading even under severe competition. In a grazing trial conducted in Australia it was found that, in the early stages of growth, trifolio was somewhat unpalatable to cattle. In Hawaii it has produced excellent yields in zones B and C<sub>1</sub> when cut periodically.

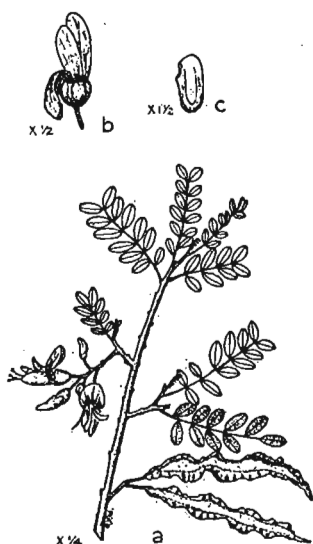


Fig. 37. *Sophora chrysophylla*: a, habit; b, flower; c, seed.

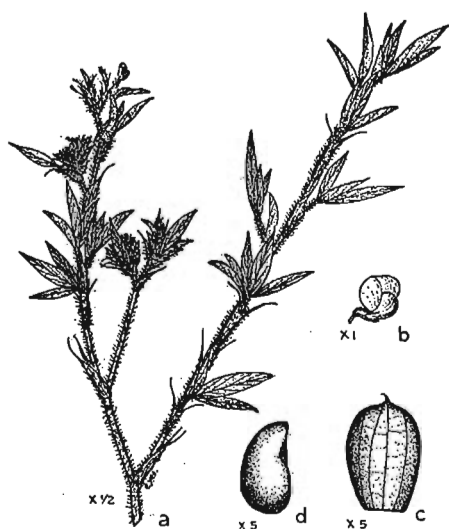


Fig. 38. *Stylosanthes guianensis* var. *subviscosus*: a, habit; b, flower; c, pod; d, seed.

### *Stylosanthes guianensis* (Aubl.) Sw. var. *subviscosus* Sw. (Fig. 38)

#### Creeping trifolio; meladinho

**Habit:** A prostrate to suberect plant.

**Stem:** Finer than trifolio.

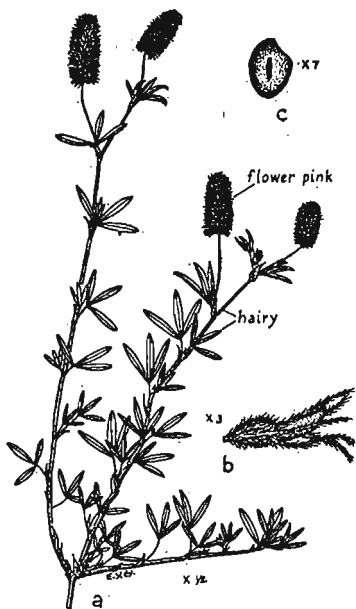
**Leaf:** Narrow, 1 to 1½ inches long, densely covered with soft, glandular hairs.

**Distribution and habitat:** Creeping trifolio is native to Brazil. It has a similar adaptability to that of trifolio.

**Importance and use:** Creeping trifolio has received some attention in Brazil and in Australia as a promising pasture legume. In a grazing test at the Haleakala Branch Station, creeping trifolio has persisted in a mixed sward for a period of 4 years under rotational grazing. The animals have eaten it well, but thus far the legume has not spread to any extent nor has it produced an appreciable amount of pasturage. Elsewhere it is regarded as slow in spreading during the initial stage of development. Further experimentation is needed with this plant.

***Tephrosia purpurea* (L.) Pers. (Fig. 39)**

Ahuhu ; fish poison

**Habit:** An upright plant, 2 to 3 feet tall.**Stem:** Somewhat woody at base, hairy when young.**Leaf:** Pinnate, the leaflets linear or oblong, 4- to 6-paired, each about  $\frac{1}{2}$  inch long and about  $\frac{1}{8}$  inch wide, smooth on upper surface, hairy on lower surface.**Stipule:** Linear, pointed, about  $\frac{1}{8}$  inch long.**Flower:** White, often faintly purplish, about  $\frac{1}{2}$  inch long; calyx about  $\frac{1}{8}$  inch long.**Seed pod:** Flat, straight or slightly curved,  $1\frac{1}{4}$  to  $2\frac{1}{4}$  inches long, about  $\frac{1}{8}$  inch wide, fine, hairy, splitting into 2 valves at maturity.**Seed:** Oblong to kidney-shaped, flat, about  $\frac{1}{8}$  inch long, light brown with darker mottling.**Distribution and habitat:** Ahuhu is a native of tropical Asia, Australia, and Polynesia. In Hawaii it is occasionally found on all the islands below about 200 feet in the dry locations of zones A, B, and C.**Importance and use:** Ahuhu is regarded as fair forage by ranchers who have pastures in the dry lowlands, but it is not propagated.Fig. 39. *Tephrosia purpurea*: a, habit; b, flower; c, seed; d, seedling.Fig. 40. *Trifolium arvense*: a, habit; b, flower; c, seed.

**Trifolium arvense L. (Fig. 40)**

## Rabbit-foot clover

**Habit:** An erect, fairly long-lived plant, 6 to 15 inches tall.

**Stem:** Slender, freely branching, hairy.

**Leaf:** Trifoliate, the leaflets linear or oblanceolate, white, hairy, faintly toothed at upper margin, the veins rather straight, the stalks about equal.

**Stipule:** Lanceolate, about  $\frac{1}{4}$  inch long, reddish, hairy.

**Flower:** Pink, in a cylindrical head about  $\frac{3}{4}$  inch long; calyx toothed, very silky.

**Seed pod:** Oval, about  $\frac{1}{8}$  inch long, 1-seeded.

**Seed:** Suboval, about  $\frac{1}{2}$  inch long, yellowish-green.

**Distribution and habitat:** Rabbit-foot clover is native to Eurasia. In the Territory it is found only in the Humuula region on the island of Hawaii, at 6,000 to 8,000 feet altitude in zones E<sub>1</sub> and E<sub>2</sub>, where the climate is dry and the soil rocky and shallow.

**Importance and use:** Rabbit-foot clover is well eaten by sheep and other grazing animals. A noteworthy characteristic of this plant is its long flowering season, often lasting throughout the year at Humuula. It grows well with Kentucky bluegrass, hairy oatgrass, and filaree (*Erodium cicutarium*).

**Trifolium hybridum L. (Fig. 41)**

## Alsike clover

**Habit:** An upright plant, about 2 feet high, with many basal leaves.

**Stem:** Freely branching, smooth.

**Leaf:** Trifoliate at the end of a long, smooth leafstalk, the leaflets oval to obovate,  $\frac{3}{4}$  to  $1\frac{1}{4}$  inches long, glabrous, round or often toothed at tip, slightly serrated on lower margin, the central leaflet slightly larger than lateral ones.

**Stipule:** Two-branched,  $\frac{1}{2}$  to  $\frac{3}{4}$  inch long, gradually tapering to points, the basal portion partly clasping the stem.

**Flower:** Pale pink to pinkish-white, about  $\frac{1}{8}$  inch long, in globular head, axillary, borne on stalks which are longer than the leafstalks, the flowers turning downward after fertilization; calyx with 5 narrow, equal teeth, tube very short.

**Seed pod:** Oblong, about  $\frac{1}{8}$  inch long, glabrous, 1- to 3-seeded.

**Seed:** Oval to obcordate, about  $\frac{1}{8}$  inch long, dark green, glabrous, shiny.

**Distribution and habitat:** Alsike clover appears to have originated in the southeastern Mediterranean region. It has been introduced into all temperate countries, where it is used in poorly drained lands not adapted to red clover. This legume, planted in both lowland and upland pastures of

Hawaii, has never persisted, although it appears adapted to the moist localities of zones C<sub>2</sub> and D<sub>3</sub>.

**Importance and use:** This plant is not a hybrid between red and white clover, as is commonly believed. The growth habit is somewhat similar to that of red clover, but under pasturage it becomes prostrate. It is not a long-lived plant; normally it persists for perhaps 4 years. Although probably not as palatable as certain other species of *Trifolium*, it is nutritious forage.

### ***Trifolium pratense* L. (Fig. 42)**

#### Red clover

**Habit:** A decumbent plant.

**Stem:** Freely branching, 3 to 5 feet long, cylindrical, somewhat shallowly grooved, hollow or pithy, sparsely covered with soft hairs.

**Leaf:** Trifoliate at the end of a fairly long and sparsely hairy leafstalk, the leaflets oval, oblong, or oblanceolate, entire or with few short teeth on margin, glabrous or nearly so on the upper surface, conspicuously hairy on the lower surface, with many distinct veins.

**Stipule:** Ovate,  $\frac{3}{4}$  to 1 inch long, membranaceous, with two narrow, long-pointed wings, glabrous except at the tips, which are surmounted by few long hairs.

**Flower:** Magenta to reddish, many in a globose or somewhat ovoid head, the head  $\frac{3}{4}$  to 1 inch in diameter; calyx sparsely hairy.

**Seed pod:** Oblong, a 1-seeded capsule, about  $\frac{1}{8}$  inch long, the apex splitting at maturity.

**Seed:** Kidney-shaped, about  $\frac{1}{16}$  inch long, with a projection on one side, yellow to violet in color.

**Distribution and habitat:** Red clover appears to have originated in the same region as alsike clover, and is now extensively grown throughout the cool, humid regions of the world. In Hawaii it is found sparingly in a few localities in zones C<sub>2</sub> and D<sub>3</sub>. It is not adapted to acid soils and requires good drainage.

**Importance and use:** Red clover is one of the most extensively planted legumes in the cool, humid sections of the United States. It is sometimes sown alone, but more frequently as a mixture with grasses. Timothy and red clover are a common mixture. It is often cut for hay for the first year or so and then pastured. In Hawaii it has never been possible to maintain a good stand, although it makes vigorous initial growth. Occasional plants continue to grow well for several years. Red clover may conceivably have a place here in pasture mixtures for cool, humid areas, because of its good initial growth, although it probably cannot be expected to persist more than a few years. The failure to establish a permanent stand of red clover in the islands may be attributed to the poor seeding of the plant.

Red clover is almost completely sub-sterile and has to be cross-pollinated by bees to develop seeds. Bumblebees are regarded to be most efficient in cross-pollinating the flowers, but in some regions hive bees



have been effective. When red clover was first introduced into New Zealand, it failed to set seed; when bumblebees were introduced, a large seed crop was harvested.

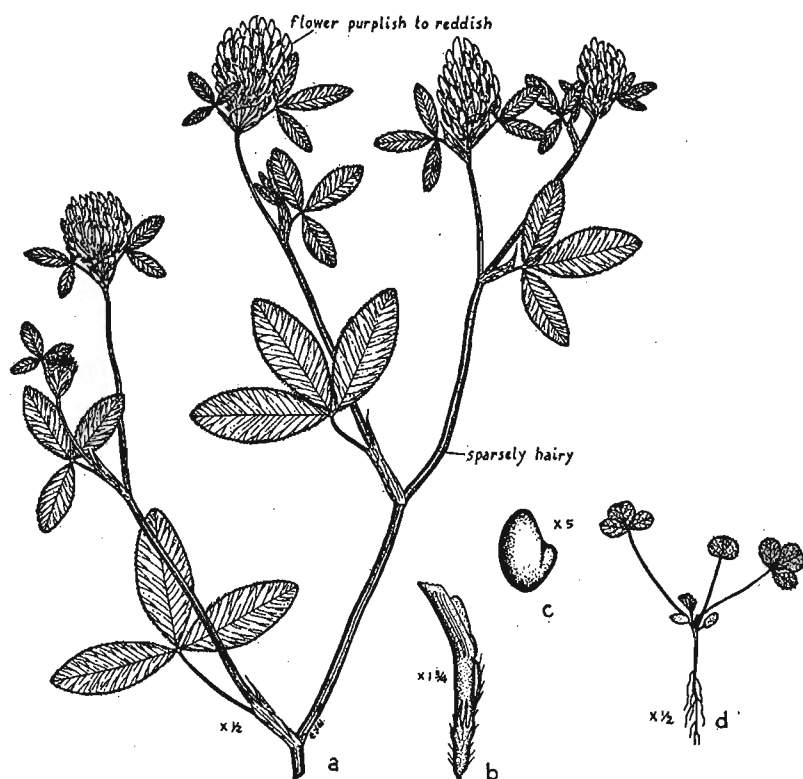


Fig. 42. *Trifolium pratense*: a, habit; b, flower; c, seed; d, seedling.

### *Trifolium procumbens* L. (Fig. 43)

Low hop clover

**Habit:** A low-spreading, decumbent plant.

**Stem:** Branching, hairy toward the ends.

**Leaf:** Trifoliate, the leaflets wedge-shaped to obovate, smooth or with few hairs on the nerves, toothed on the upper half of margin, the veins straight, the stalk of the central leaflet longer than those of the lateral leaflets.

**Stipule:** Broadly triangular, about  $\frac{1}{8}$  inch long, partly adnate to leafstalk, the margin sparsely hairy.

**Flower:** Yellow, about  $\frac{1}{8}$  inch long, turning downward when fertilized, clustered in a head at the end of a stalk longer than the leaf, the stalk covered with white, appressed hairs; calyx 5-parted, the teeth long, unequal.

**Seed pod:** Globular, about  $\frac{3}{8}$  inch long, enclosed in the petals, 1-seeded, light brown at maturity, smooth.

**Seed:** Oval, about  $\frac{3}{8}$  inch long, light brown, shiny.

**Distribution and habitat:** Low hop clover is common in Europe but probably has the same origin as alsike and red clovers. It is planted extensively in the southern parts of the United States. In the Territory it is found principally in the cool, moist uplands of zones C<sub>2</sub>, D<sub>2</sub>, D<sub>3</sub>, and E<sub>1</sub> in association with Yorkshire fog, ryegrass, and paspalum. This legume is tolerant of acid and thin soils; it is often seen growing in exposed areas between tufts of grass. Apparently it cannot endure so dry conditions as bur clover and black medic.

**Importance and use:** Low hop clover is rather widely distributed in Hawaii and is regarded as a very good grazing species, although not generally the equal of bur clover or black medic. It is a relatively small plant with small leaflets and seldom produces a large amount of forage. However, it has a long growing season and, because of its profuse seeding, is quite persistent in a pasture.

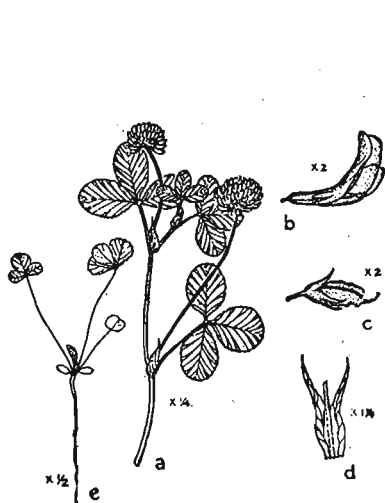


Fig. 41. *Trifolium hybridum*: a, habit; b, flower; c, pod; d, stipule; e, seedling.

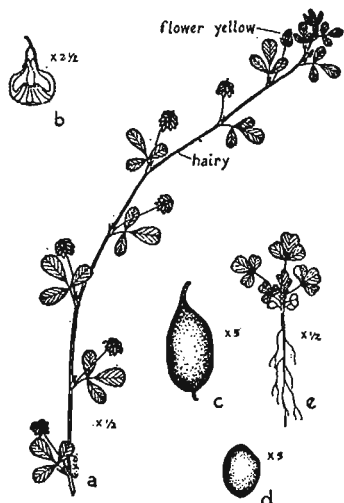


Fig. 43. *Trifolium procumbens*: a, habit; b, flower; c, pod; d, seed; e, seedling.

**Trifolium repens L. (Fig. 44)**

White clover

**Habit:** A long-lived, creeping plant, 2 to 5 feet long, rooting at the nodes.

**Stem:** Smooth, branching in all directions.

**Leaf:** Trifoliate on a long slender stalk that ascends at right angles to the stem, with variable markings, the leaflets obovate to obcordate, all about equal in size, glabrous, the margin short-toothed, the veins straight, the leafstalks equal.

**Stipule:** Broadly lanceolate, pointed,  $\frac{3}{8}$  to  $\frac{1}{2}$  inch long, membranaceous, glabrous.

**Flower:** Mostly white, but variously tinted with pink or purple, about  $\frac{3}{8}$  inch long, on a short stalk, drying up and turning downward when fertilized, 30 to 40 in a terminal cluster, the head extending above the leaves; calyx with 5 equal teeth, smooth.

**Seed pod:** Oblong, about  $\frac{1}{8}$  inch long, 3- to 4-seeded, slightly constricted between the seeds, splitting open along one side at maturity.

**Seed:** Kidney-shaped, about  $\frac{1}{16}$  inch long, light brown to pinkish.

**Distribution and habitat:** White clover is indigenous to southeast Europe and southwest Asia and is now common to all the humid temperate and subtropical regions. In Hawaii it is widely distributed in moist uplands of zones C<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub>, and E<sub>1</sub>, between 2,500 and 7,000 feet altitude. All indications show that white clover is spreading into the pastures of lower levels. It is not adapted to poor, thin soils but can tolerate fairly acid soil conditions. Very good stands can sometimes be found where the soils approach swampiness. Like other *Trifolium* species, it responds to applications of phosphate.

**Importance and use:** White clover is the most important pasture legume in the moist, temperate regions of the world. It is an important legume in the upper zones of Hawaiian pastures and is regarded as the best of all clovers for grazing. In rich soils the plant spreads rapidly and produces abundant forage throughout most of the year in the wetter zones. Once established, it is very persistent and competes successfully with sod grasses as well as with open bunch grasses. The bulk of the roots are shallowly placed, but the tap roots penetrate to greater depths than those of most grasses. This quality enables white clover to withstand relatively dry periods. Ranchers state that cattle avoid the flowers, thus encouraging spontaneous reseeding of the pasture year after year. The stems creep on the surface of the ground and develop roots so readily that the growing point is seldom injured by grazing animals. In fact, close grazing is important in establishing and maintaining white clover in the early spring when most grasses make more rapid growth than the clover and tend to shade and crowd it out. In certain pastures of rattail grass (*Sporobolus capensis*), the white clover is doing very well as a mixture. The runners grow between the stems of the grass, close to the ground, and send down roots even in the center of the clump. This good growth of white clover is maintained as long as the rattail grass is cropped short; when the pasture is undergrazed, the clover is smothered out. (Many

ranchers believe that breeding cows do very well in rattail-white clover association pastures.) Even in the Bermuda-white clover association, the grass should be grazed short to encourage the development of the clover. It grows well even with such an aggressive plant as kikuyu, if the grass is cropped short. However, continuous severe grazing will repress growth of white clover. Periodic mowing is an effective aid in removing excess grass growth in ungrazed tufts.

There are several strains of white clover in the Territory, differing somewhat in plant size and flower color, but little is known as to their relative forage value or adaptation. A large variety known as Ladino clover is utilized on the mainland for both hay and pasturage.

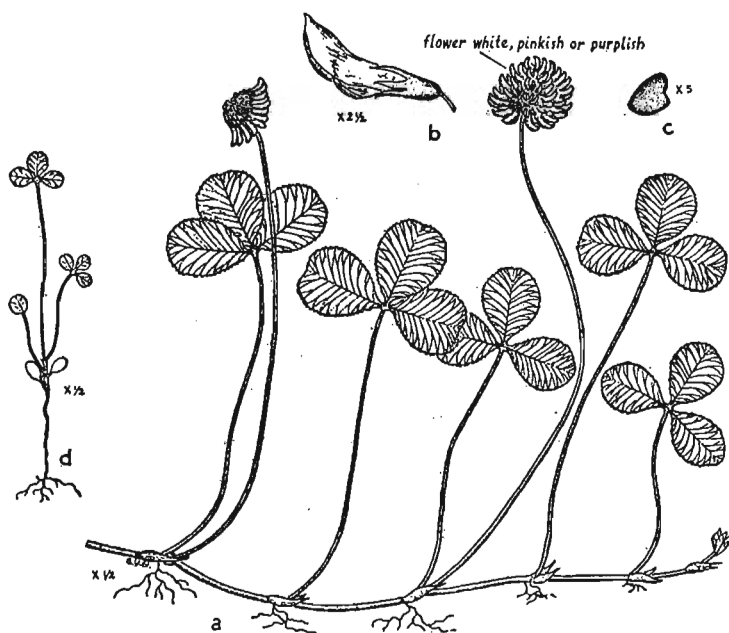


Fig. 44. *Trifolium repens*: a, habit; b, flower; c, seed; d, seedling.

### *Trifolium subterraneum* L. (Fig. 45)

#### Subterranean clover

**Habit:** A prostrate plant, 2 to 4 feet long, with a strong root system.

**Stem:** Thick, cylindrical, hairy, not rooting at the nodes.

**Leaf:** Trifoliate, the leaflets oval or obovate, with conspicuous variable markings, the margin entire or often toothed slightly towards the upper end, sparsely hairy on the upper surface, densely hairy on the lower surface.

**Stipule:** Broad,  $\frac{1}{4}$  to  $\frac{1}{2}$  inch long, 2-branched, finely pointed, membranaceous.

**Flower:** Creamy-white or pinkish, about  $\frac{3}{8}$  inch long, 3 to 4 at the end of an erect stalk  $1\frac{1}{2}$  to 3 inches long; calyx purplish toward the tip, teeth slender and hairy. At maturity the stalk bends down and buries the flowers near the surface of the soil. When the flowers touch the ground, they reverse their position with the calyx teeth pointing upward, and the whole head is pushed into the soil. Then the flower part becomes fibrous and protects and holds the developing seeds in place.

**Seed pod:** A spiny bur, oval, about  $\frac{1}{8}$  inch long, 1-seeded, single, or 2 to 4 in a cluster.

**Seed:** Oval, about  $\frac{1}{16}$  inch long, shiny, dark purplish.

**Distribution and habitat:** Subterranean clover is native of the Mediterranean regions. Nursery trials indicate the possible establishment of the clover in Hawaiian pastures in zones C<sub>2</sub>, D<sub>2</sub>, and E<sub>1</sub>. A combination of winter rainfall and summer drought is most favorable to the development of this clover. In regions of summer rainfall, the species has been subject to rust attack and has failed to develop viable seeds during the rainy season. It is best adapted to well-drained, sandy soils and will tolerate a lower fertility level than most of the other clovers.

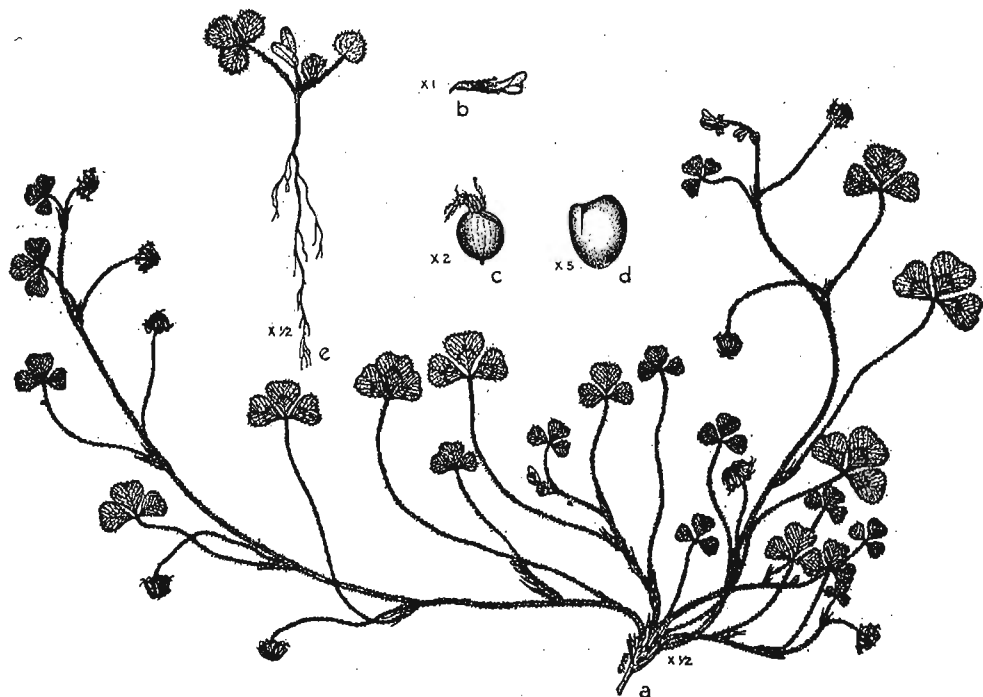


Fig. 45. *Trifolium subterraneum*: a, habit; b, flower; c, pod; d, seed; e, seedling.

**Importance and use:** Subterranean clover is a short-lived plant that perpetuates itself by seed burs that form underneath the surface of the soil. In Australia it is regarded as a pioneer legume and is usually planted in relatively poor lands to build up the fertility of the soil. It has been proved that subterranean clover will withstand heavy grazing, will grow in association with both short-lived and long-lived grasses in permanent pastures, and will maintain itself from year to year as a self-sown crop. In Hawaii, subterranean clover has not become established in pastures, although nursery trials in a number of places indicate that its establishment is a possibility.

### ***Ulex europaeus* L. (Fig. 46)**

#### **Gorse; furze**

**Habit:** An upright, spiny shrub, 2 to 5 feet tall.

**Stem:** Freely branching, somewhat hairy, each leafy branch ending in a sharp thorn.

**Leaf:** Trifoliate,  $\frac{1}{4}$  to  $\frac{1}{2}$  inch long, found only on seedlings.

**Stipule:** Absent.

**Flower:** Bright yellow, about  $\frac{1}{2}$  inch long; calyx yellowish, slightly shorter than the petals, with 2 minute bracts.

**Seed pods:** Compressed, about  $\frac{1}{2}$  inch long, densely hairy.

**Seed:** Ovate or triangular, about  $\frac{1}{8}$  inch long, shallowly notched on the broader end, brownish, shiny.

**Distribution and habitat:** Gorse is a native of Europe and is now found in many countries. In the islands, this plant is recorded only from Olinda, Maui, where it is found occasionally in the pasture.

**Importance and use:** Gorse has no forage value and is regarded as a serious potential pest because of its thorns and the rapidity with which it spreads. It produces abundant seeds and invades a new area in a short time.

### ***Vicia sativa* L. (Fig. 47)**

#### **Common vetch**

**Habit:** A trailing plant, 2 to 5 feet long.

**Stem:** Freely branching, square in section, hollow, often slightly winged at the corners, downy.

**Leaf:** Pinnate, the tip ending in 2 or 3 tendrils, the leaflets 6- to 7-paired, oblong to lanceolate, notched at apex, with a distinctly projecting midrib, hairy on both surfaces.

**Stipule:**  $\frac{1}{4}$  to  $\frac{3}{8}$  inch long, clasping the stem, hairy, broadly divided, the teeth tapering to a sharp point.

**Flower:** Reddish-purple,  $\frac{1}{2}$  to  $\frac{3}{4}$  inch long, 2 together in the axil of the leaf, rarely 1 or 3, on a very short stalk; calyx tubular on the lower half, the upper half narrowly divided.

**Seed pod:** Linear-oblong, 1 to 2 inches long, about  $\frac{1}{8}$  inch wide, glabrous at maturity, hairy when young, 5- to 10-seeded, dark brown to black when ripe.

**Seed:** Round,  $\frac{1}{8}$  to  $\frac{3}{8}$  inch across, dark brown.

**Distribution and habitat:** Common vetch is native to Europe, where it is extensively grown for forage. In the islands it is found only in fairly cool, moist pastures between 2,500 to 4,000 feet elevation in zones C<sub>2</sub>, D<sub>2</sub>, and E<sub>1</sub>. Common vetch tolerates acid but grows best in neutral soils.

**Importance and use:** Common vetch is a seasonal plant, making its growth from about February to July. It is best to plant common vetch among tall grasses. It withstands moderate grazing and adds materially to the value of the paddock. It seeds profusely and will maintain itself indefinitely through natural seeding if some plants are allowed to mature. In Hawaii its distribution is limited, but it is an important legume in a number of fine pastures. It makes smaller growth than hairy vetch but is more persistent.



Fig. 46. *Ulex europaeus*: a, habit; b, flower; c, pod; d, seed.

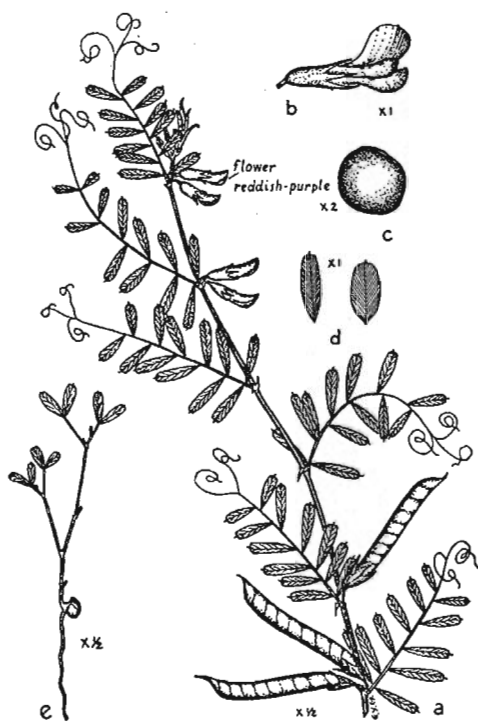


Fig. 47. *Vicia sativa*: a, habit; b, flower; c, seed; d, variable leaves; e, seedling.

*Vicia villosa* Roth. (Fig. 48)

## Hairy vetch

**Habit:** A slender, twining, short-lived plant, 4 to 8 feet long, almost glabrous to densely hairy.

**Stem:** Weak, branching, angular, with slightly raised ridges, sparsely to densely covered with white, woolly hairs.

**Leaf:** Pinnate, the tip ending in 3- to 5-branched tendrils, the leaflets lanceolate, about  $\frac{1}{2}$  inch long, both surfaces clothed with white, woolly hairs, the margin smooth.

**Stipule:** Two-branched, the upper lobe larger than the lower, about  $\frac{1}{4}$  inch long, hairy.

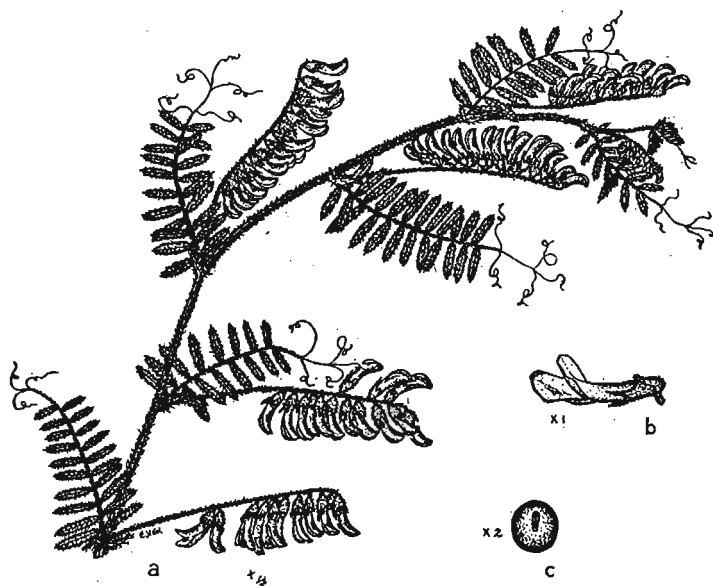


Fig. 48. *Vicia villosa*: a, habit; b, flower; c, seed.

**Flower:** Blue violet, about  $\frac{1}{2}$  to  $\frac{3}{4}$  inch long, 20 to 30 borne in a long, one-sided cluster; calyx with three long slender and two very short lobes, sparsely hairy.

**Seed pod:** Oblong-rhomboid, about  $1\frac{1}{2}$  inches long, pale-colored, smooth, containing 2 to 8 seeds.

**Seed:** Globular, about  $\frac{1}{8}$  inch in diameter, blackish.

**Distribution and habitat:** Hairy vetch is native to Europe and from there it has been introduced into other temperate countries. In the Territory this



plant is found only in limited areas on Hawaii, where it is growing with Yorkshire fog, cocksfoot, and ryegrass. It is best adapted to high, cool, semimoist localities in zones C<sub>2</sub>, D<sub>3</sub>, and E<sub>1</sub>, where the drainage is good. It is tolerant of moderate soil acidity and elsewhere is regarded as fairly drought-resistant.

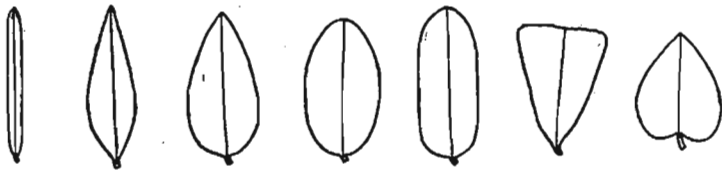
**Importance and use:** Under normal conditions hairy vetch is an annual, but often, when growing in favorable localities, it lives for about 2 years. Hairy vetch grows well in tuft-grass pastures where the weak stems can find support. In pure stands it is considered as only moderately satisfactory for pasturage because it is rather unpalatable to animals, but when planted with grass it is freely eaten. In the Territory it makes a more robust growth than common vetch but is more seasonal in growth and harder to maintain in the pasture.

*Vicia villosa* is a variable species. Several strains have been developed and these are regarded as distinct varieties by some workers; others do not distinguish among them.

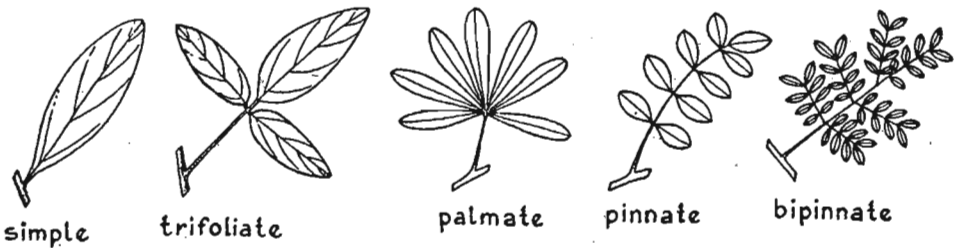
# ILLUSTRATED GLOSSARY



various kinds of stipules



linear lanceolate ovate oval oblong cuneate cordate



simple trifoliate palmate pinnate bipinnate

## LEAVES



head

## FLOWERS



raceme

## GLOSSARY OF BOTANICAL TERMS

- ADNATE. Growing together (said of unlike structures).
- AGGRESSIVE. Growing rapidly and tending to crowd out other species in the sward.
- ANNUAL. Living for one year.
- APPRESSED. Lying flat for its whole length.
- ASCENDING. Growing slantingly upward.
- AXIL. The angle between a leaf or branchlet and the stem.
- BRACT. A reduced or modified leaf, often scalelike.
- BI-. A Latin prefix meaning two, twice, or double.
- BRISTLE. A stiff hair.
- CALYX. The outer circle of parts or cup, often green, at base of flower.
- CILIATE. Marginally fringed with short, usually stiff hair.
- CORDATE. Heart-shaped with the point upward.
- COROLLA. The usually brightly colored part or parts next to the outer circle in the flower.
- CUNEATE. Wedge-shaped.
- DECUMBENT. Mostly reclining, but with the tips growing upward.
- DEHISCENCE. The mode of opening of a fruit, such as a pod.
- DENTATE. Toothed like the teeth of a saw.
- ELLIPTIC. Oblong with the ends regularly rounded.
- EMARGINATE. Shallowly notched at the tip.
- ENTIRE. Even; not toothed or divided.
- FOLIATE. With leaflets.
- FORB. An herbaceous plant; not a grass.
- GERMINATION. The first act of growth in a seed.
- GLABROUS. Smooth; without hairs.
- GLAND. A secreting surface or organ.
- GLANDULAR. Sticky, bearing glands.
- GLOBOSE. Nearly spherical.
- GLOBULAR. Nearly globose.
- HABIT. The general aspect of a plant, or its mode of growth.
- HABITAT. The locality or type of place in which a plant grows.
- HAIRS. Threadlike outgrowths on the surface of an organ.
- HEAD. A dense, round cluster of flowers or fruits.
- HILUM. The scar on a seed, indicating the point of attachment.
- INFLORESCENCE. The flower-bearing part of a plant.
- KIDNEY-SHAPED. Resembling the outline of a kidney.
- LANCEOLATE. Several times longer than wide, broadest below the middle and tapering to the tip; shaped like the head of a lance.
- LATERAL. On the side.
- LEAFLET. A single part of a compound leaf.
- LENTICEL. A porous scar, usually raised, on a stem surface.

- LINEAR. Long and narrow with parallel sides.
- MARGIN. The edge or boundary line of a body.
- MEMBRANACEOUS. Thin and soft, usually translucent.
- MUCRONATE. Having the midrib of the leaf projecting as a small, sharp point.
- NERVE. A simple or unbranched vein.
- NODE. The joint of a stem at which leaves are normally inserted.
- OB-. Inverted.
- OBLONG. Longer than broad, with nearly parallel sides.
- OVAL. Broadly elliptical.
- OVATE. Shaped like the outline of a hen's egg, broad end down.
- PANICLE. A loose, many times branching flower cluster.
- PEDICEL. An individual flower stalk.
- PEDUNCLE. The common flower stalk.
- PELTATE. Attached to its stalk on the lower surface, rather than at base or margin.
- PERENNIAL. Living for several years.
- PETIOLE. The leafstalk.
- PINNATE. With leaflets on either side of a single leafstalk.
- POD. A dry, hollow fruit like that of the garden pea or bean.
- PROCUMBENT. Trailing.
- PROSTRATE. Lying flat on a surface.
- PUBESCENT. Covered with hairs.
- RACEME. An inflorescence of stalked flowers on an elongated common axis.
- RETROSE. Pointing downward.
- RHOMBOID. Quadrangular with the lateral angles obtuse.
- RUGOSE. Wrinkled.
- SESSILE. Without stalk of any kind.
- SPREADING. Diverging; nearly prostrate.
- STIPULE. Small, leafy, or scalelike outgrowth at the base of the leafstalk.
- SUB-. Almost or partly so.
- SUTURE. A line of dehiscence or junction in dry fruits.
- SWARD. A turf, or the surface of soil thickly covered with grass and clover.
- TAP ROOT. A main, descending root, with a stout, tapering body.
- TENDRIL. A slender leafless organ produced by the modification of a stem or leaf, and which enables the plant to climb and coil itself around a support.
- TERETE. Somewhat cylindrical, circular in cross section.
- TOOTHED. Dentate, or with teeth along the margin.
- TRIFOLIATE. With three leaflets.
- TRUNCATE. Cut off squarely.
- VILLOUS. Shaggy with soft hairs.

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