

## A Survey for Alkaloids in Hawaiian Plants, III

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IN CONTINUATION of our systematic survey for alkaloids in Hawaiian plants<sup>2</sup> we have collected and tested additional plant species on Oahu, Hawaii, Maui, and Kauai. Of the 71 samples in the present report, 15 represent species which had been tested by us previously. These results are included here since 13 of these samples were collected at different locations and 2 gave test results at variance with previous findings. All specimens were collected from living plants. In parts I and II of this survey testing for alkaloids was carried out as described by Webb (1949, 1952) in his classical phytochemical study of the Australian flora. In following up some positive tests as indicated in the survey with actual isolation of alkaloids on a preparative scale, it has been noted by us and by others (*e.g.*, Raffauf, 1958) that extraction and testing as done for the survey led occasionally to erroneous conclusions. For the present work an extraction procedure was used which more nearly parallels those commonly employed in preparative work. This was followed by a crude separation of the quaternary bases from all others. Both portions were then tested with Mayer's reagent, which is considered to be the most selective of the customary alkaloid reagents. It may be noted that Yeh *et al.* (1959), in their recent phytochemical study of the Taiwan flora, also have used this modified procedure.

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### METHODS

The following procedure is the one which is recommended by Raffauf (1958).

A 20 g. sample of dried plant parts was ground in a Waring blender with the addition of some 95 per cent ethanol. The material was then extracted with 150 ml. of boiling ethanol for 2 hr. The insoluble plant parts were removed by suction filtration and the alcoholic filtrate was evaporated to dryness on a steam bath under reduced pressure. The residue was dissolved by stirring with a mixture of 50 ml. ether and 50 ml. of 5 per cent hydrochloric acid. Part of the aqueous acidic extract containing the non-quaternary alkaloids was tested with Mayer's reagent. The validity of a positive alkaloid test was confirmed by adding powdered sodium chloride to another portion of the acidic extract. If the addition of sodium chloride caused turbidity, the solution was clarified before being tested with Mayer's reagent.

The ammoniacal layer of the initial separation which contained the quaternary bases was acidified with a few drops of concentrated hydrochloric acid and then tested with Mayer's reagent. A positive test was confirmed by the addition of sodium chloride.

The precipitates were evaluated on a + to ++++ basis by visual comparison with the following standards. A solution of brucine in 2 per cent hydrochloric acid at a concentration of 0.4 mg/ml corresponds to +; 1.3 mg/ml is equivalent to ++; 4 mg/ml is equivalent to +++; and any precipitate larger than that is assigned ++++.

The standard for quaternary alkaloids was a 2 per cent hydrochloric acid solution of isoreserpiline methochloride. A concentration of 0.05 mg/ml was assigned +; 0.17 mg/ml, ++; 0.5 mg/ml, +++; and more than 0.5 mg/ml was assigned ++++.

Preparation of Mayer's reagent was described by Swanholm *et al.* (1959).

## RESULTS AND DISCUSSION

Table 1 lists the results of the alkaloid tests which were carried out on 71 plant species representing 56 genera and 39 families. Six of the 7 new species in Rutaceae which have been tested show a large enough alkaloid content to merit further investigation as does *Sophora chrysophylla*, a newly tested member of Leguminosae.

## KEY TO ABBREVIATIONS IN TABLE 1

The results of the spot tests are given in the following order in abbreviated form:

BINOMIAL, accepted botanical name; authority is omitted to conserve space.

LOCAL NAME, Hawaiian or vernacular name, if known.

LOCALITY, nearest town or other prominent map feature.

DATE COLLECTED, date of actual collection in the field.

DATE TESTED, date of actual application of spot test.

PLANT PART(S), B—bark, Br—branchlet, F—fruit, Fl—flower, L—leaf, R—root or underground part, RB—root bark, St—stem.

TABLE 1  
RESULTS OF SPOT TESTS FOR ALKALOIDS  
(Plants listed alphabetically within each taxon)

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES		COMMENTS
						HCl	NH <sub>4</sub> OH	
AMARANTHACEAE								
<i>Charpentiera elliptica</i>	papala	Waianae, Oahu	12/59	13/1/61	L,Br	-	+	endemic genus
<i>C. obovata</i>	papala	Auahi, Maui	28/8/58	13/4/59	L,B	++	tr	endemic genus
<i>Charpentiera</i> sp.	papala	Waianae, Oahu	4/11/58	15/4/59	L,B	tr	-	endemic genus
ANACARDIACEAE								
<i>Rhus chinensis</i> var. <i>sandwicensis</i>	Hawaiian sumach, neneleau	Waianae, Oahu	12/59	31/1/61	L	-	++	endemic variety
APOCYNACEAE								
<i>Prevalyxia macrocarpa</i>	kaulu	Waianae, Oahu	4/11/58	21/2/59 15/11/58 3/2/59 13/1/59 27/1/59	L B St,B RB B	- - + - -	+ - tr - tr	a sample from the Koolau range was tested in Part II endemic genus
AQUIFOLIACEAE								
<i>Ilex anomala</i>	kawa'u	Pupukea Trail, Oahu	11/59	20/1/61	L	-	-	a sample from Aiea was tested in Part I endemic species

TABLE 1—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES		COMMENTS
						HCl	NH <sub>4</sub> OH	
<b>ARALIACEAE</b>								
<i>Cheirodendron gaudichaudii</i>	olapa	Auahi, Maui	28/8/58	22/4/59	L		—	endemic species
<i>C. ugadense</i>	olapa	Manuka, Hawaii	11/58	17/4/59	L,St,F	++	—	endemic species
<i>Reynoldsia maniensis</i>	ohe, ohe makai	Ulupalakua, Maui	28/8/58	10/2/59 2/2/59	L B	—	—	endemic species
<i>R. sandwicensis</i>		Ewa, Oahu	10/58	10/11/58	L,St,B	—	—	
<i>Tetraplasandra hawaiiensis</i>	ohe	Manuka, Hawaii	11/58	30/4/59	L	—	tr	endemic species
<i>T. meiantra</i>	ohe	Manuka, Hawaii	11/58	17/4/59	B,F	tr	—	endemic species
<b>BOMBACACEAE</b>								
<i>Pachira insignis</i>		Manuka, Hawaii	11/58	15/4/59	B,L	+	—	introduced species
<b>CHENOPODIACEAE</b>								
<i>Chenopodium oahuense</i>	'aweoweo, 'aheahea	Waianae, Oahu	12/59	13/1/61	L,Br,F	++	+	a sample from another location tested in Part I endemic species
<b>COMPOSITAE</b>								
<i>Argyroxiphium sandwicense</i>	silversword, pohinahina ahinahina	Haleakala, Maui	20/8/58	16/4/59 18/3/59	L B	—	—	endemic genus
<b>CONVOLVULACEAE</b>								
<i>Jacquemontia sandwicensis</i>	pa'u-o-Hi'i-aka, kakua-o-Hi'i-aka	Blowhole, Oahu	10/59	20/1/61	Br	—	+	a sample from another location was tested in Part I endemic species
<b>EPACRIDACEAE</b>								
<i>Styphelia tameiameia</i>	pukeawe, mai'ele, kawaii	Waianae, Oahu	11/58	6/5/59 6/5/59	St L	—	—	indigenous, but widespread
<b>ERICACEAE</b>								
<i>Vaccinium</i> sp.	'ohelo	Haleakala, Maui	26/8/58	27/2/59	L,F,St	—	—	
<b>EUPHORBIACEAE</b>								
<i>Anidesma pulvinatum</i>	ha'a, hame, mehame	Manuka, Hawaii	11/58	16/5/59	L,B	—		a sample from Oahu was tested in Part I endemic species
<i>Euphorbia heterophylla</i>	'akoko, koko	Waianae, Oahu	12/59	17/1/61	L,Br	—	tr	introduced weed
<i>Euphorbia</i> sp.	akoko, koko	Auahi, Maui	28/8/58	15/4/59	B	—	—	

TABLE 1—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES		COMMENTS
						HCl	NH <sub>4</sub> OH	
GERANIACEAE <i>Geranium cuneatum</i> var. <i>tridens</i>	hinahina	Haleakala, Maui	26/8/58	5/1/59	R,L,St,B	-	-	endemic species
GOODENIACEAE <i>Scaevola</i> <i>chamissoniana</i> <i>S. frutescens</i>	naupaka- kuahiwi naupaka- kahakai	Pupukea, Oahu Punaluu, Oahu	11/58 8/59	14/2/59 7/10/59 14/3/60	L,B B,F L	- - -	++ - +	endemic species indigenous, but wide- spread endemic species
<i>S. glabra</i>	ohenaupaka	Kokee, Kauai	12/4/60	4/60	L,St	+		endemic species
GRAMINEAE <i>Oplismenus</i> <i>birtellus</i>	honohono maoli, basket grass	Oahu	4/11/58	14/5/59	L		-	introduced species
LABIATAE <i>Phyllostegia</i> <i>grandiflora</i>	kapana	Pupukea Trail, Oahu	11/59	24/1/61	L,St	-	++	a sample from the Waianae range tested in Part I endemic species
LEGUMINOSAE <i>Papilionatae</i> <i>Canavalia</i> <i>galeata</i>	puakauhi, 'awikiwiki	Firebreak Trail, Waianae Mts., Oahu	11/58	12/1/59	B	+		endemic species
<i>Erythrina</i> <i>sandwicensis</i>	wiliwili	Ulupalakua, Maui	27/8/58	14/3/59 14/3/59	Fl,L B	- tr	- tr	
<i>Sophora</i> <i>chrysophylla</i>	mamane	Haleakala, Maui	26/8/58	10/2/59 7/1/59	L B	+++ ++	++	endemic species
LILIACEAE <i>Dracaena aurea</i>	halapepe	Auahi, Maui	28/8/58	23/2/59 23/2/59 10/3/59	B L F,Fl	- - tr	tr - tr	endemic species
LOBELIACEAE <i>Clermontia</i> <i>arborescens</i>	oha wai	Pupukea, Oahu	10/58	8/1/59	L	-	-	endemic genus
MALVACEAE <i>Hibiscadelphus</i> <i>bualalaiensis</i> <i>Kokia rockii</i>	hau kuahiwi koki'o	Manuka, Hawaii Manuka, Hawaii	11/58 11/58	17/4/59 20/4/59	L L	- tr	- -	endemic genus endemic genus
<i>Sida fallax</i>	'ilima	Blowhole, Oahu	10/59	31/1/61	L,B,Br	-	+	a sample from another location tested in Part I indigenous, but wide-spread

TABLE 1—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES		COMMENTS
						HCl	NH <sub>4</sub> OH	
MORACEAE <i>Pseudomorus sandwicensis</i>	a'ia'i	Firebreak Trail, Waianae Mts., Oahu	4/11/58	17/2/59	B	-	-	endemic species
MYRSINACEAE <i>Myrsine lessertiana</i>	kolea	Firebreak Trail, Waianae Mts., Oahu	11/58	12/3/59	B,L	-	-	endemic species
		Makawao, Maui	26/8/58	6/5/59	B,F,L	-	-	
MYRTACEAE <i>Metrosideros collina</i> ssp. <i>polymorpha</i>	'ohi'a-lehua	Puna, Hawaii	11/58	10/3/59	L,St	-	-	a sample from Oahu was tested in Part I
NYCTAGINACEAE <i>Ceodes umbellifera</i>	papala, kepau	Pupukea, Oahu	11/59	31/1/61	L	tr	+	endemic subspecies
OLEACEAE <i>Osmanthus sandwicensis</i>	pua, olopua	Waianae, Oahu	12/59	20/1/61	L,F	+	++++	a sample from the Koolau range was tested in Part I
		Waianae, Oahu	12/59	20/1/61	B,Br	+	+++	endemic species
		Manuka, Hawaii	11/58	15/4/61	L,St,Fl	-	+	endemic species
PALMAE <i>Pritchardia beccariana</i>	loulu	Manuka, Hawaii	11/58	27/4/59	L		+	endemic species
PASSIFLORACEAE <i>Passiflora triloba</i>		Kaaawa, Oahu	11/58	20/4/59	L	-	tr	introduced species
PITTOSPORACEAE <i>Pittosporum eugenoides</i>	ho'awa	Manuka, Hawaii	11/58	16/4/59	L,B	-	-	
<i>P. bosmeri</i>	ho'awa	Puna, Hawaii	11/58	17/4/59	L	-	-	endemic species
<i>P. kauaiense</i>	ho'awa	Kokee, Kauai	12/59	28/1/61	L,B	+	+	endemic species
<i>P. spatbulatum</i>	ho'awa	Pupukea, Oahu	11/59	28/1/61	L,B	+	+	endemic species
POLYPODIACEAE <i>Elaphoglossum reticulatum</i>	ekaha	Pupukea Trail, Oahu	11/59	18/1/61	L	-	-	endemic species
<i>Microlepia setosa</i>	palai, palapalai	Waianae, Oahu	12/59	18/1/61 24/1/61	R L,Br,St	- tr	+++ tr	retest of a new sample

TABLE 1—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES		COMMENTS
						HCl	NH <sub>4</sub> OH	
RHAMNACEAE								
<i>Alphitonia ponderosa</i>	kauila, kauwila, o'e	Auahi, Maui	28/8/58	23/4/59	L,B,F	-	-	endemic species
<i>Colubrina oppositifolia</i>	kauila	Manuka, Hawaii	11/58	17/4/59	L	-	-	endemic species
RUBIACEAE								
<i>Bohea elatior</i>	'ahakea	Pupukea Trail, Oahu	11/59	11/1/61	L	+	++	a sample from Aiea was tested in Part I endemic genus
<i>Gardenia remyi</i>	nanu	Manuka, Hawaii	11/58	20/4/59	L	-	-	endemic species
<i>Gouldia terminalis</i>	manono	Kokee, Kauai	12/59	17/1/61	L,Br	tr	+	a sample from Manoa was tested in Part I endemic genus
<i>Straussia</i> sp.	kopiko	Kokee, Kauai	12/59	31/1/61	L	+	+	endemic genus
		Makawao, Maui	26/8/58	14/3/59	L	+	tr	endemic genus
				23/2/59	B	-	-	
RUTACEAE								
<i>Fagara dipetala</i>	heae	Kokee, Kauai	12/4/60	4/60	F,L,St	+++		endemic species
		Kokee, Kauai	12/4/60	4/60	L	+++		
		Kokee, Kauai	12/4/60	4/60	B	++++		
<i>F. kavaiensis</i>	a'e, hea'e	Kokee, Kauai	12/4/60	4/60	L,St	++		
<i>Pelea anisata</i>	mokihana, mokehana	Kokee, Kauai	12/4/60	4/60	L,B	+		endemic species
<i>P. barbiger</i>	uahea Pele	Kokee, Kauai	12/4/60	4/60	L,B	+++		endemic species
<i>P. haleakalae</i>		Waikamoi, Maui	26/8/58	16/4/59	B	+	tr	endemic species
				10/3/59	L	++	++	
				9/3/59	St	tr	tr	
<i>P. nealae</i>		Kokee, Kauai	12/4/60	4/60	L,St	+		endemic species
<i>Platydesma remyi</i>	pilo-kea	Kokee, Kauai	12/4/60	4/60	L	++++		endemic genus
SANTALACEAE								
<i>Santalum ellipticum</i>	'ili-ahi	Waianae, Oahu	12/59	28/1/61	L,Br	tr	++	endemic species
SAPINDACEAE								
<i>Alectryon macrococcus</i>	mahoe	Auahi, Maui	28/8/58	20/4/59	B,F,L	-	-	endemic species
<i>Dodonaea eriocarpa</i>	'a'ali'i, kumakani	Kokee, Kauai	12/59	13/1/61	L,Br	+	+	indigenous, but wide-spread
<i>Sapindus oahuensis</i>	'aulu, kaulu	Waianae, Oahu	12/59	28/1/61	L,B,Br	-	+	retest of a new sample
				27/1/59	B	-	-	endemic species

TABLE 1—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES		COMMENTS
						HCl	NH <sub>4</sub> OH	
SAPOTACEAE								
<i>Nesoluma polynesianum</i>	keahi	Firebreak Trail, Waianae Mts., Oahu	11/58	27/1/59	B	-	-	indigenous
		Waikamoi, Maui	26/8/58	14/3/59	L	-	tr	
<i>Sideroxylon rhyncospermum</i>	ala'a	Auahi, Maui	8/58	20/4/59	B L	- -	- -	endemic species
SAXIFRAGACEAE								
<i>Broussaisia arguta</i>	kanawao	Pupukea Trail, Oahu	11/59	13/1/61	L	-	+	another sample was tested in Part II endemic genus
STERCULIACEAE								
<i>Waltheria americana</i>	hi'aloa, 'uhaloa, kanakaloa	Blowhole, Oahu	10/59	31/1/61 12/1/61 12/1/61	L,Fl B L	+ + tr	+++ - -	indigenous, but widespread
THYMELAEACEAE								
<i>Wikstroemia furcata</i>	'akia	Kokee, Kauai	12/4/60	4/60	L,B	+		endemic species
URTICACEAE								
<i>Pipturus albidus</i>	mamake, mamaki	Waianae, Oahu	12/59	25/1/61	L,St,F	-	-	a sample from the Koolau range tested in Part I endemic species

## REFERENCES

RAFFAUF, R. F. 1958. Private communication.

SWANHOLM, C. E., H. ST. JOHN, and P. J. SCHEUER. 1959. A survey for alkaloids in Hawaiian plants, I. Pacific Sci. 13(3): 295-305.

WEBB, L. J. 1949. An Australian phytochemical survey, I. Alkaloids and cyanogenetic com-

pounds in Queensland plants. Bull. Coun. Sci. Industr. Aust. 241: 1-56.

———. 1952. An Australian phytochemical survey, II. Alkaloids in Queensland flowering plants. Bull. Coun. Sci. Industr. Res. Aust. 268: 1-99.

YEH, P. Y., L. C. LIN, and S. S. YANG. 1959. The alkaloid contents of plants in Taiwan (I). J. Taiwan Pharm. Assoc. 11(1): 4-7.