

A Survey for Alkaloids in Hawaiian Plants. I

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ALTHOUGH PLANT ALKALOIDS have been isolated and studied for over 150 years, only a small percentage of the recorded plant species have been investigated and even fewer of the isolated compounds have been carried to full elucidation of their structures. Willaman and Schubert (1955) in their valuable survey of alkaloid-containing plants state that by the end of 1952 about 950 alkaloids were isolated and named and that 1,202 plant species were known to contain alkaloids. Up to that time only about 2 per cent of all recorded plant species had been as much as tested for alkaloids.

The widely varying pharmacological properties of alkaloids always have been a major point of interest and have helped to attract organic chemists to this field of research. This viewpoint, however, was losing ground steadily in the face of mounting successes scored by synthetic drugs. The demonstration by Müller, Schlittler, and Bein (1952) that the alkaloid reserpine was responsible for the hypotensive action of the Indian snakeroot, *Rauwolfia serpentina* Benth., instilled new vigor into natural products research. As a consequence of this work many members of the genus *Rauwolfia* and related genera in the plant family Apocynaceae from all parts of the tropics have been investigated. This recent research has also prompted the chemical study of three of the reported seven Hawaiian *Rauwolfia* species (Gorman *et al.*, 1957).

In order to utilize plant sources for the isolation of alkaloids effectively it is necessary to survey a given flora, and base subsequent

detailed work on the results of such a survey. A number of native floras have been investigated in recent years from this point of view. The most notable of these have been carried out in Australia (Webb, 1949, 1952), and more recently in Papua-New Guinea (Webb, 1955).

Hawaii's flora is unique in two respects: It offers widely diverse vegetational types located within small geographical areas, and its native flora is over 90 per cent endemic, one of the highest endemisms in the world. Yet, except for the recent *Rauwolfia* research (Gorman *et al.*, 1957) and a few isolated instances in the past (e.g., Folkers and Koniuszy, 1939), Hawaii's flora has not been the subject of chemical study, nor has it even been surveyed for alkaloids. The pioneering research of Bushnell and co-workers (1950) drew attention to the antibacterial properties of some plants found in Hawaii and to the important link between Hawaiian flora and native Hawaiian *materia medica*.

The present work is concerned with a survey of some Hawaiian plants for their alkaloid content. While the 96 species tested represent only a small fraction of the recorded species, it is hoped that this work will constitute only the beginning of more extensive surveys in the future.

METHODS

This study was patterned after the survey carried out by Webb (1949, 1952) in Australia. The floristic books by Hillebrand (1888) and by Rock (1913) were used in the study of the indigenous plants of Hawaii. An attempt was made to test indigenous plants predominantly, although some introduced species have been included. A majority of the tests were carried out on freshly collected specimens. To ascertain that herbarium speci-

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mens gave valid results, several cross checks were made. All identifications of plants were made by H. St. John.

EXTRACTION OF PLANT MATERIAL. Two methods of extraction were used. In the first method about 5 grams of chopped or ground dried plant material was extracted with 1 per cent hydrochloric acid at 80° C. for 4-6 hours. The resulting solution was filtered through fine paper and the filtrate was tested with the alkaloid reagents.

In the second method about 5 grams of chopped or ground dried plant material was extracted with Prollius fluid (*vide infra*) for 56 hours at room temperature with occasional stirring. The organic layer was separated and evaporated to dryness at room temperature. The residue was dissolved in 1 per cent hydrochloric acid by heating to 80° C. for 1 hour. The resulting solution was filtered through fine paper and the filtrate tested with the alkaloid reagents.

The second method was used to supplement the first when sufficient plant material was available. It proved useful in clarifying tests which had doubtful results on the basis of the first method alone.

REAGENTS. The following formulations

of the alkaloid test reagents were based on Henry's directions (1929) with certain modifications.

Prollius Fluid. Ether, chloroform, alcohol, and ammonia were mixed in the ratio of 25:8:2.8:1 (by volume).

Mayer's Reagent. Dry mercuric chloride (6.8 g.) and potassium iodide (25 g.) were dissolved separately in water and diluted to make one liter of solution.

Hager's Reagent. A saturated aqueous solution of picric acid.

Wagner's Reagent. Iodine (13 g.) was dissolved in 1 N aqueous potassium iodide to make one liter of solution.

Dragendorff's Reagent. Neutral bismuth nitrate (20 g.) was dissolved in 30 g. cold conc. nitric acid (30 per cent). The solution was filtered and 68 g. potassium iodide in 60 ml. water was added. The resulting solution was allowed to stand for 24 hours, was filtered and diluted to 250 ml. with water.

Silicotungstic Acid Reagent. An aqueous solution of the acid, 0.1 N.

Sonnenschein's Reagent. A warm 4 N solution of disodium hydrogen phosphate was acidified with conc. nitric acid (pH 3). A slight excess of a saturated solution of ammonium

KEY TO ABBREVIATIONS IN TABLE I

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

BINOMIAL	The accepted botanical name. The authority is omitted to conserve space. An asterisk (*) indicates introduced species.
LOCAL NAME	The Hawaiian or vernacular name, if known.
LOCALITY	The nearest town or other prominent map feature.
DATE COLLECTED	Date of actual collection in the field.
DATE TESTED	Date of actual application of spot tests.
PLANT PART(S)	B—bark, Br—branchlet, F—fruit, Fl—flower, H—herb or whole plant, L—leaf, R—root or underground part, S—seed, St—stem, W—wood, I—immature, M—mature.
ALKALOID REAGENTS	M—Mayer's, P—Picric Acid (Hager's), I—Iodine (Wagner's), D—Dragendorff's, S—Sonnenschein's, T—Silicotungstic Acid.
PRECIPITATES	With hydrochloric acid (HCl) or Prollius extracts (organic solvents and ammonia), classified on a tr (trace), + (light), ++ (heavy) basis. A — indicates no precipitation and a ? indicates that the test was meaningless.

TABLE I
RESULTS OF SPOT TESTS FOR ALKALOIDS
(Plants are listed alphabetically within each taxon.)

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES	
						HCl	Prollius
AMARANTHACEAE							
<i>Charpentiera obovata</i> . . .	Papala	Kawaiiki trail, Oahu	23 Jul 57	14 Aug 57	Br, L, St	S+, D+, I+, M+, T+, P+	
<i>C. ovata</i>	Papala	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	L, St	S+++ , D+++ , I+++ , M+++ , T+++ , P+++	S-, D-, I-, M-, T-, P-
ANACARDIACEAE							
<i>Schinus terebinthifolius</i> *	Wilelaiki, Christmas Berry	Tantalus, Oahu	21 Dec 56	1 Oct 57	B, Br, F	Str, D-, I-, M-, T+, P-	
APOCYNACEAE							
<i>Allamanda cathartica</i> var. <i>Hendersonii</i> *	Lani-ali'i, Allamanda	UH campus, Oahu	24 Feb 57	19 Mar 57	F, L, R, St	S-, D+++ , I+++ , M-, T-, P-	S+++ , D+++ , I+++ , M+++ , T+++ , P+++
<i>Alyxia olivaeformis</i>	Maile	Koolau, Oahu	28 Oct 56	4 May 57	Br, F, L, St	S+, D+++ , I+, M+++ , T+, P+++	S+++ , D+++ , I+++ , M+++ , T+++ , P+++
<i>Occhrosia sandwicensis</i>	Holei	Laie trail, Oahu	— Oct 56	20 Mar 57	B, R	S+++ , D+++ , I+++ , M+++ , T+++ , P+++	S+++ , D+++ , I+++ , M+++ , T+++ , P+++
<i>O. sandwicensis</i>	Holei	Pupukea-Kahuku, Oahu	2 Oct 57	4 Oct 57	IF, MF	S+++ , D+++ , I+++ , M+, T+++ , P+	
<i>Rauwolfia Degeneri</i>	Hao	Mokuleia, Oahu	?	1 May 57	B	S+++ , D+++ , I+++ , M+++ , T+++ , P+++	S+++ , D+++ , I+++ , M+++ , T+++ , P+++
<i>R. mauiensis</i>	Hao	Hana district, Maui	?	1 May 57	B	S+, D+, I+, M+, T+, P-	S+, D+, I+, M+, T+, P+
<i>R. sandwicensis</i>	Hao	Aiea trail, Oahu	?	1 May 57	B	S+++ , D+++ , I+++ , M+++ , T+++ , P+++	S+++ , D+++ , I+++ , M+++ , T+++ , P+++
AQUIFOLIACEAE							
<i>Ilex anomala</i>	Kawa'u	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D+, I+, M+, Ttr, P-	Str, D+, I+ M?, T+, P-
ARALIACEAE							
<i>Tetraplasandra</i> sp.	Ohe	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D+, I+, M+, T+++ , P?	
BORAGINACEAE							
<i>Heliotropium anomalum</i>	Hinahina	Mokapu Point, Oahu	20 Jul 57	13 Aug 57	Br, L, Fl, R	Str, D-, Itr, M-, Ttr, Ptr	
CAPRIFOLIACEAE							
<i>Lonicera japonica</i>	Honekakala, Honeysuckle	Aiea trail, Koolau, Oahu	6 Jan 57	1 Oct 57	F, L, St	S+, D+, Itr, M-, T+, P-	

TABLE I—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES	
						HCl	Prollius
CHENOPODIACEAE							
<i>Chenopodium oahuense</i> . . .	'Aweoweo, 'Aheahea	Pohakea Pass, Oahu	26 Nov 56	4 May 57	Fl, L, St	S++, D++, I+, M+, T++, P+	
COMPOSITAE							
<i>Artemisia australis</i>	'Ahinahina	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	Br, L	S+, D-, I-, M-, T+, P-	
<i>Dubautia plantaginea</i> . . .	Na'ena'e	Pupukea, Oahu	28 Oct 56	4 May 57	F, L, St	S++, D++, I+, M+, T++, P+	
<i>Lipochaeta integrifolia</i> . .	Nehe	Mokapu Point, Oahu	20 Jul 57	11 Aug 57	Br, F, L	Str, Dtr, I-, M-, Ttr, P-	
CONVOLVULACEAE							
<i>Ipomoea alba</i>		Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	F, L, St	S++, D++, I++, M++, T++, P+	
<i>I. pes-caprae</i>	Pohuehue	Mokapu Point, Oahu	20 Jul 57	13 Aug 57	Fl, L, St	Str, Dtr, Itr, M-, T+, P-	
<i>Jacquemontia sandwicensis</i>	Pa'u-o-Hi'i-aka, Kakua-o-Hi'i-aka	Barbers Point, Oahu	16 Dec 56	4 May 57	Br, Fl, L, St	S+, D+, I+, M+, T+, P+	S++, D++, I++, M+, T++, P++
CYPERACEAE							
<i>Cladium Meyenii</i>	'Aha-niu	Aiea trail, Koolau, Oahu	6 Jan 57	30 Sep 57	F, Fl, L, R, St	S-, D-, I-, M-, T-, P-	
<i>Gabnia gabniaeformis</i> . .	Uki ?	Aiea trail, Oahu	6 Jan 57	4 May 57	L, R, St	S+, D-, I-, M-, T+, P-	S+, D-, I-, Mtr, Ttr, P-
DIOSCOREACEAE							
<i>Dioscorea bulbifera</i>	Hoi	Waiahole trail, Oahu	2 Mar 57	20 Mar 57	Aerial bulblet	S++, D++, I++, M+, T++, P+	S+, D+, I+, M-, Ttr, P-
<i>D. bulbifera</i>	Hoi	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	L, R, St	S++, D++, Itr, M-, T++, P-	S-, D-, I-, M-, T-, P-
<i>D. pentaphylla</i>	Pi'a	Kawaiiki ditch trail, Oahu	23 Jul 57	14 Aug 57	L, St	S+, D+, I+, M-, T+, P-	
EBENACEAE							
<i>Diospyros ferrea var. sandwicensis</i>	Lama	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	L, St	S-, D-, I-, M-, T-, P-	
<i>D. ferrea</i> var. <i>sandwicensis</i>	Lama	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D-, I-, M-, T++, P-	

<i>D. Hillebrandii</i>	Lama	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	Br, IF, L, St	Str, D-, I-, M-, T+, P-	S-, D-, I-, M-, T+, P-
EPACRIDACEAE							
<i>Styphelia Tameiameiae</i>	Pukiawe	Kawaiiki ditch trail, Oahu	7 Oct 56	4 May 57	F, L, St	S-, D-, I-, M-, T-, P-	
EUPHORBIACEAE							
<i>Aleurites moluccana</i>	Kukui, Candle-nut tree	UH campus, Oahu	24 Feb 57	19 Mar 57	F	S+, D+, I?, M+, T++, Ptr	S-, D-, I-, M-, T-, P-
<i>A. moluccana</i>	Kukui, Candle-nut tree	UH campus, Oahu	24 Feb 57	19 Mar 57	B, Br, L, St	S-, D-, I+, M-, T-, P-	S+, D+, I+, M-, T+, P?
<i>Antidesma platyphyllum</i>	Ha'a, Hame	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	Str, Dtr, Itr, M-, T+, P-	S-, D-, I-, M-, T-, P-
<i>A. pulvinatum</i>	Mehame, Hame	Kawaiiki ditch trail, Oahu	23 Jul 57	14 Aug 57	L, St	S+, Dtr, I-, M-, T+, P-	
<i>Euphorbia celastroides</i>	'Akoko, Koko	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	Br, Fl, L, St	S+, D+, Itr, Mtr, T+, P?	Str, Dtr, I+, M+, Ttr, Ptr
<i>E. clusiaefolia</i>	'Akoko, Koko	Aiea trail, Oahu	6 Jan 57	1 May 57	F, L, St	S-, D-, I-, M-, T-, P-	
<i>E. Degeneri</i> var. <i>Degeneri</i>	'Akoko, Koko	Mokapu Point, Oahu	20 Jul 57	14 Aug 57	Fl, L, St	S-, D-, I-, M-, T-, P-	
<i>E. Hillebrandii</i> var. <i>waimanoana</i>	'Akoko, Koko	Kawaiiki ditch trail, Oahu	7 Oct 56	10 Oct 57	Br, F	Str, D-, I-, M-, T+, P-	
GLEICHENIACEAE							
<i>Dicranopteris linearis</i>	Uluhe, Unuhe	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	FronDs, R, Spores	S-, D-, I-, M-, T-, P-	
GOODENIACEAE							
<i>Scaevola Gaudichaudiana</i>	Naupaka-kuahiwi	Aiea trail, Oahu	6 Jan 57	1 May 57	Fl, L, St	S+, D+, I+, M+, T+, P+	S+, D++, I++, M++, T+, P+
LABIATAE							
<i>Phyllostegia grandiflora</i> var. <i>grandiflora</i>	Kapana	Pohakea Pass, Oahu	26 Nov 56	4 May 57	F, L, St	S+, D+, I+, M-, T+, P-	Str, D+, I+, Mtr, T-, P-
LAURACEAE							
<i>Cassytha filiformis</i>	Kauna'oapehu	Pohakea Pass, Waianaes, Oahu	26 Nov 56	1 Oct 57	L, St	S-, D-, I-, M-, T-, P-	
LEGUMINOSAE							
<i>Acacia Koa</i>	Koa	Tantalus, Oahu	21 Dec 56	4 May 57	Br, F, L, St	S+, D+, I+, M+, T++, P+	S-, D+, I+, M-, T+, P-
<i>A. Koa</i>	Koa	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	B, R	S+, D+, I+, Mtr, T+, P-	
<i>Leucaena glauca</i> *	Koa-haole	UH campus, Oahu	4 Mar 57	20 Mar 57	Br, F, Fl, L, St	S++, D+, I-, M+, T++, P-	S+, D-, I-, M-, T-, P-

TABLE I—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART(S)	ALKALOID PRECIPITATES	
						HCl	Prollius
LILIACEAE							
<i>Dianella sandwicensis</i> ...	'Uki'uki	Kawaiiki ditch trail, Oahu	23 Jul 57	11 Aug 57	F, L, R, St	Str, D—, Itr, Mtr, Ttr, Ptr	
<i>Smilax sandwicensis</i> ...	Hoi-kuahiwi	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	Str, Dtr, Itr, Mtr, Ttr, Ptr	Str, D+, Itr, Mtr, Ttr, Ptr
LOBELIACEAE							
<i>Clermontia Kakeana</i>	'Oha-wai, 'Oha	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	F, L, St	S++, D++, I++, M+, T++, P++	S+, Dtr, Itr, M—, Ttr, Ptr
<i>Cyanea angustifolia</i>	'Oha-wai, 'Oha	Pupukea, Oahu	28 Oct 56	3 May 57	Br, F, Fl, L, St	S++, D++, I++, M++, T++, P++	S++, D++, I+, M++, T++, P+
LOGANIACEAE							
<i>Labordia tinifolia</i> var. <i>tinifolia</i>		Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	MF, L, St	Str, Dtr, Itr, M ?, Ttr, P ?	
LYCOPODIACEAE							
<i>Lycopodium cernuum</i> ...	Huluhulu-a-'iole	Aiea trail, Oahu	6 Jan 57	4 May 57	Br, L, St	Str, Dtr, Itr, M—, T+, P—	Str, Dtr, Itr, Mtr, T+, P—
<i>L. phyllanthum</i>	Wawae-'iole	Aiea trail, Oahu	6 Jan 57	1 Oct 57	L, Spores, St	S++, D++, I+, M+, T++, Ptr	
<i>Pilotum nudum</i>	Moa	Mokapu Point, Oahu	20 Jul 57	13 Aug 57	L, Spores, St	S+, D+, Itr, M—, T+, P—	
LYTHRACEAE							
<i>Cuphea carthagenensis</i> *..	Tarweed	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	Fl, L, St	S+, D+, I+, Mtr, T+, P ?	
MALVACEAE							
<i>Hibiscus Arnottianus</i>	Koki'o-ke'oke'o	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	L, St	S+, D—, I—, M—, T+, P—	
<i>Sida cordifolia</i> (<i>Side fallax</i>)	'Ilima	Mokapu Point, Oahu	20 Jul 57	14 Aug 57	Fl, L, St	Str, D—, I—, M—, Ttr, P—	
MYOPORACEAE							
<i>Myoporum sandwicense</i> var. <i>stellatum</i>	Naio, Bastard Sandalwood	Barbers Point, Oahu	16 Dec 56	1 May 57	Br, F, Fl, L, St	S++, D++, I+, M+, T++, P++	S++, D++, I++, M++, T++, P++

MYRSINACEAE									
<i>Myrsine Lessertiana</i>	Kolea	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	L, St	S++, D++, I++, M++, T++, P++			
MYRTACEAE									
<i>Eugenia Cumini</i> *	Java Plum	Waiahole trail, Oahu	2 Mar 57	22 Mar 57	B, L, St	S+, D-, I+, M-, T-, P-	S+, Dtr, I+, Mtr, T-, P-		
<i>E. sandwicensis</i>	'Ohi'a-ha	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D-, I-, M-, Ttr, P-			
<i>Metrosideros collina</i> ssp. <i>polymorpha</i> , var. <i>glabrifolia</i>	'Ohi'a-lehua	Aiea trail, Oahu	6 Jan 57	4 May 57	Fl, L, St	Str, D+, Itr, M-, T+, Ptr			
<i>M. macropus</i>	'Ohi'a-lehua	Aiea trail, Oahu	6 Jan 57	4 May 57	Fl, L, St	S++, D+, I+, M-, T++, Ptr			
<i>Psidium Cattleianum</i> *	Strawberry Guava, Waiawi-'ula'ula	Kawaiiki ditch trail, Oahu	23 Jul 57	11 Aug 57	Br, F, L, St	Str, D-, Itr, M-, Ttr, P-			
<i>P. Guajava</i> *	Guava, Kuawa	Waiahole trail, Oahu	2 Mar 57	19 Mar 57	IF, L, St	S-, D-, I-, M-, T-, P-	S-, D-, I-, M-, T-, P-		
NYCTAGINACEAE									
<i>Boerhavia diffusa</i>	Alena	Mokapu Point, Oahu	20 Jul 57	13 Aug 57	Fl, L, St	S-, Dtr, Itr, M-, Ttr, P-			
<i>Ceodes umbellifera</i>		Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	Br, L, St	S++, D++, I++, M++, T++, P++			
OLEACEAE									
<i>Osmanthus sandwicensis</i>	Olopua	Aiea trail, Oahu	6 Jan 57	1 May 57	Br, F, L, St	S+, D+, I+, M+, T+, P+	S++, D++, I++, M+, T++, P+		
ORCHIDACEAE									
<i>Spathoglottis plicata</i> *	Philippine Ground Orchid	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	Fl, L, R, S	S+, D+, I+, M-, T+, Ptr			
PALMACEAE									
<i>Pritchardia</i> sp.	Loulu	Summit, Castle trail, Oahu	- Jun 57	11 Aug 57	MS	S+, D+, I+, Mtr, T+, P?			
PANDANACEAE									
<i>Freycinetia arborea</i>	'Ie'ie	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	L, St	S+, D+, I+, M-, T+, P-			
<i>Pandanus odoratissimus</i>	Hala	Waiahole trail, Oahu	2 Mar 57	22 Mar 57	MF, L, R, St, Prop Roots	S-, D-, I-, M-, T-, P-	S+, D?, I-, M-, T-, P-		
PASSIFLORACEAE									
<i>Passiflora edulis</i> *	Liliko'i, Passion Fruit	UH campus, Oahu	2 Mar 57	1 May 57	Br, L, St	S++, D++, I+, M+, T++, P+	S++, D++, I++, M++, T++, P++		
<i>P. edulis</i> cv. <i>flavicarpa</i> *	Yellow-fruited Liliko'i	Cultivated plant	- Jul 57	11 Aug 57	MF	S++, D++, I++, M++, T++, P++			
<i>P. suberosa</i> *	Huehue-haole	Tantalus, Oahu	21 Dec 56	1 Oct 57	F, L, St	S+, Dtr, I-, M-, T+, P-			

TABLE I—Continued

BINOMIAL	LOCAL NAME	LOCALITY	DATE COLLECTED	DATE TESTED	PLANT PART (S)	ALKALOID PRECIPITATES	
						HCl	Prollius
PIPERACEAE							
<i>Piper methysticum</i> *	'Awa	Waiahole trail, Oahu	2 Mar 57	22 Mar 57	L, R, St	S+, D+, I?, M+, T+, Ptr	S++, D+, I+, M+, T+, P+
PITTOSPORACEAE							
<i>Pittosporum glabrum</i> var. <i>glabrum</i>	Ho'awa	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	IF, MF, L, St	S+, D+, Itr, M-, T+, P-	
<i>P. sulcatum</i> var. <i>sulcatum</i>	Ho'awa	Aiea trail, Oahu	6 Jan 57	10 Oct 57	F, L, St	Str, Dtr, Itr, M-, T+, P-	
PLUMBAGINACEAE							
<i>Plumbago zeylanica</i>	'Ilie'e	Pohakea Pass, Waianae, Oahu	26 Nov 56	30 Sep 57	F, Fl, L, St	S-, D-, I-, M-, T-, P-	
POLYPODIACEAE							
<i>Microlepia setosa</i>	Palapalai, Palai	Pohakea Pass, Oahu	26 Nov 56	4 May 57	R, St, Fronds	S++, D+, I-, M-, T+, P-	S-, D-, I++, M-, T-, P-
<i>Sadleria cyatbeoides</i>	'Ama'u	Aiea trail, Oahu	6 Jan 57	4 May 57	R, St, Fronds	S-, D-, I-, M-, T-, P-	S-, D-, I-, M-, T-, P-
<i>Sphenomeris chinensis</i>	Pala'a	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	Fronds, R, Spores	Str, D-, I-, M-, Ttr, P-	
RUBIACEAE							
<i>Bobea elatior</i>	'Ahakea	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D+, Itr, M-, T++, P-	S+, D++, I+, M+, T+, Ptr
<i>Cantium odoratum</i>	Walahe'e, alahe'e	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D+, I-, M+, T+, P+	S+, D+, I+, M+, T+, P+
<i>Coprosma foliosa</i>	Pilo	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	L, St	S+, D+, I+, M-, T+, P?	
<i>Gouldia terminalis</i>	Manono	Manoa Cliff trail, Oahu	6 Aug 57	21 Aug 57	MF, Fl, L, St	Str, Dtr, I-, M-, T+, P-	
<i>Morinda citrifolia</i> *	Noni	Waiahole trail, Oahu	22 Feb 57	20 Mar 57	L, St	S+, D++, I+, M++, T++, P+	S+, D-, I-, M-, T+, P-
<i>Psychotria hexandra</i> var. <i>Rockii</i>			?	4 May 57	L, St	S+, Dtr, I-, M-, T+, P-	
<i>Straussia kaduana</i>	Kopiko-kea	Pupukea-Kahuku, Oahu	2 Oct 57	4 Oct 57	F, L, R, St	S++, D++, I++, M++, T++, P++	
<i>S. Mariniana</i>	Kopiko	Kawaiiki ditch trail, Oahu	23 Jul 57	14 Aug 57	Br, Fl, L, St	S-, D-, I-, M-, T-, P-	S-, D-, I-, M-, T-, P-

<i>S. Mariniana</i>	Kopiko	Kawaiiki ditch trail, Oahu	23 Jul 57	14 Aug 57	ML	S-, D-, I-, M-, Ttr, P-	
<i>S. Mariniana</i>	Kopiko	Kawaiiki ditch trail, Oahu	23 Jul 57	14 Aug 57	IF, MF	S+, D+, I+, M-, T+, Ptr	
RUTACEAE							
<i>Pelea clusiaefolia</i>	Alani	Aiea trail, Oahu	6 Jan 57	4 May 57	B, F, L, St	S+, D+, I+, M-, T++, P-	
<i>P. Wawraeana</i>	Alani	Aiea trail, Oahu	6 Jan 57	22 Mar 57	L, St	S+, D+, I++, Mtr, Ttr, P-	S+, D+, I+, M-, Ttr, P-
<i>P. Wawraeana</i> var. <i>tenuifolia</i>	Alani	Aiea trail, Oahu	6 Jan 57	22 Mar 57	L, St	S++, D++, I++, M+, T++, P-	S++, D++, I++, M+, T+, P+
SANTALACEAE							
<i>Santalum</i> <i>Freycinetianum</i>	'Ili-ahi	Aiea trail, Oahu	6 Jan 57	4 May 57	F, L, St	S+, D+, I-, M-, T+, P-	Str, Dtr, Itr, M-, T+, P-
SAPOTACEAE							
<i>Planchonella (Sideroxylon)</i> <i>sandwicensis</i>	'Ala'a	Manoa Cliff trail, Oahu	19 Oct 57	25 Oct 57	Fl, L, R, St	S++, D+, I+, M+, T++, P+	
TACCACEAE							
<i>Tacca Chantrieri</i> *		Foster Gardens, Oahu (cultivated)	16 Dec 56	30 Sep 57	F, L, St	S+, D+, I+, Mtr, T++, P-	
<i>T. Leontopetaloides</i> *	Pia	Puna, Hawaii	16 Dec 56	19 Mar 57	R	S++, D++, I++, M+, T+, P-	S++, D++, I++, M+, T+, P+
THYMELAEACEAE							
<i>Wikstroemia oahuensis</i>	'Aki'a	Aiea trail, Oahu	6 Jan 57	4 May 57	Fl, L, St	Str, D+, Itr, Mtr, T+, P-	S+, D+, I+, M?, Ttr, Ptr
TILIACEAE							
<i>Elaeocarpus bifidus</i>	Kalia	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	L, St	S-, D-, I-, M-, Ttr, P-	
URTICACEAE							
<i>Boehmeria grandis</i>		Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	Fl, L, St	S+, D-, I-, M-, T+, P-	S+, D+, Itr, M+, T+, P-
<i>Pipturus albidus</i>	Mamaki	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	L, St	S-, D-, I-, M-, T-, P-	
<i>Touchardia latifolia</i>	Olona	Manoa Cliff trail, Oahu	6 Aug 57	19 Aug 57	Br, F, L, St	S++, D++, I+, M+, T++, P+	S-, D-, I-, M-, T-, P-
VERBENACEAE							
<i>Verbena litoralis</i> *	Ha'uoi, owi	Kawaiiki ditch trail, Oahu	23 Jul 57	13 Aug 57	Fl, L, St	S+, D+, I+, Mtr, T+, Ptr	
ZYGOPHYLLACEAE							
<i>Tribulus cistoides</i>	Nohu	Mokapu Point, Oahu	20 Jul 57	11 Aug 57	Fl, L, St	S+, D+, I+, M-, T+, P-	

TABLE 2
SPECIES SHOWING POSITIVE TESTS WITH THE SIX REAGENTS

BINOMIAL	FAMILY	PLANT PART(S) TESTED
<i>Acacia Koa</i>	Leguminosae	Branchlet, Fruit
<i>Allamanda cathartica</i> var. <i>Hendersonii</i> *	Apocynaceae	Fruit, Leaves, Root, Stem
<i>Alyxia olivaeformis</i>	Apocynaceae	Branchlet, Fruit
<i>Canthium odoratum</i>	Rubiaceae	Fruit, Leaves, Stem
<i>Ceodes umbellifera</i>	Nyctaginaceae	Branchlet
<i>Charpentiera obovata</i>	Amaranthaceae	Branchlet
<i>C. ovata</i>	Amaranthaceae	Leaves, Stem
<i>Chenopodium oahuense</i>	Chenopodiaceae	Flowers, Leaves, Stem
<i>Clermontia Kakeana</i>	Lobeliaceae	Fruit, Leaves, Stem
<i>Cyanea angustifolia</i>	Lobeliaceae	Branchlet, Fruit, Flowers
<i>Dioscorea bulbifera</i>	Dioscoreaceae	Aerial bulblets
<i>Dubautia plantaginea</i>	Compositae	Fruit, Leaves, Stem
<i>Ipomoea alba</i>	Convolvulaceae	Fruit, Leaves, Stem
<i>Jacquemontia sandwicensis</i>	Convolvulaceae	Branchlet, Flowers
<i>Morinda citrifolia</i> *	Rubiaceae	Leaves, Stem
<i>Myoporum sandwicense</i> var. <i>stellatum</i>	Myoporaceae	Branchlet, Fruit, Flowers
<i>Myrsine Lessertiana</i>	Myrsinaceae	Leaves, Stem
<i>Ocrosia sandwicensis</i>	Apocynaceae	Bark, Root, Fruit
<i>Osmantbus sandwicensis</i>	Oleaceae	Branchlet, Fruit
<i>Passiflora edulis</i> *	Passifloraceae	Branchlet, Mature fruit
<i>Pelea Wawraeana</i> var. <i>tenuifolia</i>	Rutaceae	Leaves, Stem
<i>Piper methysticum</i> *	Piperaceae	Leaves, Root, Stem
<i>Planconella (Sideroxylon) sandwicensis</i>	Sapotaceae	Flowers, Leaves, Stem, Root
<i>Rauwolfia Degeneri</i>	Apocynaceae	Bark
<i>R. mauensis</i>	Apocynaceae	Bark
<i>R. sandwicensis</i>	Apocynaceae	Bark
<i>Scaevola Gaudichaudiana</i>	Goodeniaceae	Flowers, Leaves, Stem
<i>Straussia kaduana</i>	Rubiaceae	Fruit, Leaves, Root, Stem
<i>Tacca Leontopetaloides</i> *	Taccaceae	Tuber
<i>Touchardia latifolia</i>	Urticaceae	Branchlet, Fruit

An asterisk (*) after the name denotes an introduced species.

molybdate was added. The resulting yellow precipitate was filtered, washed with water, acidified with conc. nitric acid, and dissolved in a hot 2 N solution of sodium carbonate. The solution was evaporated to dryness and ignited at dull red heat until all the ammonium salts had volatilized. The residue was moistened with conc. nitric acid and again ignited. The product, sodium phosphomolybdate, was dissolved in ten times its weight of a mixture of one volume of conc. nitric acid and nine volumes of water.

TESTING PROCEDURE. Approximately 0.2 ml. of the plant extract was treated with ca. 0.1 ml. of the reagent on a watch glass. The precipitates (if any) usually formed immediately and the results were evaluated after ten

minutes' standing. The precipitates were graded visually and estimated as trace, light, or heavy.

RESULTS AND DISCUSSION

Table 1 lists the results of the alkaloid tests which were carried out on 96 plant species, representing 77 genera and 49 families.

None of the test reagents was specific for alkaloids when used alone. However, when a species gave positive reactions with all six reagents, the presence of alkaloids was strongly suggested. Conversely, those plants giving consistently negative tests almost certainly did not contain alkaloids.

Included in the above table are species of nine genera which have never been tested for

alkaloids before. They are: *Charpentiera*, *Clermontia*, *Cyanea*, *Dubautia*, *Jacquemontia*, *Pelea*, *Straussia*, *Tacca*, and *Touchardia*. Those endemic to the Hawaiian Islands are: *Clermontia*, *Cyanea*, *Dubautia*, *Straussia*, and *Touchardia*. Pioneering work in these genera should afford fruitful rewards for workers interested in alkaloids.

SUMMARY

Preliminary investigations concerning the presence of alkaloids in 96 species of Hawaiian plants, representing 77 genera and 49 families, indicated that 30 species contained alkaloids. Thirty-two species gave negative tests while the remainder were listed as doubtful.

The testing procedure consisted of extracting various plant parts with hydrochloric acid and testing the extract separately with six test reagents. The acid extraction was supplemented in some cases by an ammonia-mixed organic solvent solution. The precipitates were graded visually on a trace, light, or heavy basis. Only those species which gave a light and/or heavy precipitate with all six test reagents were classified as containing alkaloids.

Among the 30 species which gave positive tests for alkaloids, 9 genera were represented for which no previous alkaloid information exists. These 9 genera, 5 of which are endemic to the Hawaiian Islands, should afford fruitful sources for future studies for alkaloids.

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