

ALKALOID-SCREENING OF SWEDISH PLANTS

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Abstract—A method is given for a semi-quantitative determination of the alkaloid concentration in dried plant material. In a screening of two hundred plants in Sweden, wild and cultivated, the following plants not previously known to contain alkaloids gave a positive reaction corresponding to an alkaloid concentration of more than 0.05 per cent of the dried plant: *Linnea borealis* and *Valeriana sambucifolia*; and, additionally, the following gave a positive reaction corresponding to at least 0.01 per cent: *Armeria maritima*, *Bartonia aurea*, *Cobaea scandens*, *Euphrasia frigida*, *Galium aparine*, *Hemerocallis conspicua*, *Lonicera periclymenum*, *Melampyrum pratense*, *Odontites litoralis*, *Pedicularis palustris*, *Pedicularis silvatica*, *Phragmites communis*, *Picea abies*, *Pinguicula vulgaris*, *Platanthera bifolia*, *Plantago media*, *Polygala vulgaris*, *Polygonum viviparum*, *Rhamnus cathartica*, *Rhamnus frangula*, *Silene rupestris*, *Sorbus intermedia*, *Spergula arvensis*, *Spergula marginata*, and *Veronica officinalis*. The following plants, previously reported to contain alkaloids, gave a positive reaction corresponding to more than 0.05 per cent: *Ligustrum vulgare*, *Succisa pratensis*, and *Valeriana officinalis*. In the plant family Scrophulariaceae ten out of nineteen species investigated gave a positive reaction corresponding to at least 0.01 per cent of alkaloids. Earlier reports indicating the presence of alkaloids in the following plants were not confirmed: *Alnus glutinosa*, *Anthemis tinctoria*, *Butomus umbellatus*, *Calla palustris*, *Chamaenerion angustifolium*, *Corylus avellana*, *Euphorbia peplus*, *Geranium molle*, *Glaux maritima*, *Herniaria glabra*, *Odontites verna*, *Pyrola rotundifolia*, and *Scirpus Tabernaemontani*. The present results are compared with earlier reports available from the literature.

INTRODUCTION

EUROPEAN plants have been investigated extensively, and information on alkaloid-bearing plants is available in several monographs.¹⁻¹⁰ The result of investigations of some plants which gave no reaction with alkaloid reagents may not have been published, so that it is not generally known if they contain alkaloids; and obviously many plants have not as yet been investigated for alkaloid content.

The purpose of the present study was to obtain more thorough information on Swedish plants as potential sources of new alkaloids. The various species included in the present screening were not collected randomly. We chose some because it was not known whether or not alkaloids occur in the family or genus; we chose others because alkaloids are known to occur in some but not in all species of the family or genus. However, plants belonging to families

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¹ A. HUSEMANN, A. HILGER and T. HUSEMANN, *Die Pflanzenstoffe in chemischer, physiologischer, pharmakologischer und toxicologischer Hinsicht*, Springer, Berlin (1882-1884).

² G. DRAGENDORFF, *Die Heilpflanzen der verschiedenen Völker und Zeiten*, Enke, Stuttgart (1898).

³ F. CZAPEK, *Biochemie der Pflanzen*, Fischer, Jena (1921).

⁴ C. WEHMER, *Die Pflanzenstoffe*, Fischer, Jena (1929-1935).

⁵ G. KLEIN, *Handbuch der Pflanzenanalyse*, Springer, Wien (1933).

⁶ T. A. HENRY, *The Plant Alkaloids*, Churchill, London (1949).

⁷ R. H. F. MANSKE and H. L. HOLMES, *The Alkaloids, Chemistry and Physiology*, Academic Press, N.Y. (1950-1960).

⁸ V. S. SOKOLOV, *Alkaloidnocyne Rasteniya SSSR*, Izdatel'stvo Akad. Nauk SSSR, Moscow (1952).

⁹ H.-G. BOIT, *Ergebnisse der Alkaloid-Chemie bis 1960*, Akademie Verlag, Berlin (1961).

¹⁰ J. J. WILLAMAN and B. G. SCHUBERT, *U.S. Dept. Agr. Tech. Bul.* No. 1234 (1961).

well-known for their alkaloid content, such as Leguminosae and Solanaceae, were not included. For systematic reasons we extended the screening to include some small plants not easily available in quantities. A few plants were investigated because of contradictory reports in the literature or because an early report has neither been confirmed nor denied.

Almost all wild plants were collected in the vicinity of Stockholm or on the Swedish west coast near Fiskebäckskil. A few were collected in the province of Härjedalen. Horticultural plants were grown in Stockholm. The names used for the wild plants are those given by Hylander.¹¹ The dried plant material was extracted with methanol. An aqueous solution of the acid soluble portion of the methanol extract was made basic with ammonia and subjected to differential extraction with chloroform followed by chloroform-ethanol. The two extracts so obtained were then tested with six alkaloid reagents: Mayer's reagent (mercuric chloride and potassium iodide), Wagner's reagent (potassium triiodide), Dragendorff's reagent (bismuth nitrate and potassium iodide) Sonnenschein's reagent (phosphomolybdic acid), silicotungstic acid, and Hager's reagent (picric acid).

The precipitates formed by alkaloid reagents vary in amount with different alkaloids.¹² Hence, any estimate of alkaloid concentration from the amount of the precipitate with one reagent is only approximate. The accuracy can be improved by using several reagents. A semi-quantitative method for estimating the alkaloid concentration in dried plant material was worked out for the present screening. The method is based on comparing the amount of the precipitates obtained with six different alkaloid reagents, as compared with the precipitates with strychnine solutions of known concentrations. Abisch and Reichstein¹³ have also published a micromethod, using this principle for estimating the alkaloid concentration in a dried methanolic extract of plant material.

RESULTS

The presence of alkaloids was considered to be demonstrated only if the reaction was positive with the six reagents.¹³ However, one of the reagents, picric acid, has so much lower sensitivity than the others¹² that if the reactions with all other reagents used was weak but positive, this was considered to indicate the presence of alkaloids even if no precipitate was obtained with picric acid. Nevertheless, picric acid was included because it appeared to be one of the most discriminating reagents for the assay. Sonnenschein's reagent sometimes gave strong precipitates when borderline reactions were obtained with the other reagents, as was also the case to a lesser extent with silicotungstic acid.

The efficiency of the method was tested in a few experiments. Known amounts of gentianine, pyridine, and strychnine were added to plant material (*Knautia arvensis*) which in previous analyses had given no alkaloid reactions. The amounts of gentianine and strychnine added were recovered, but the pyridine could not be detected. It may be concluded that volatile alkaloids are not detected by our method.

Some substances give false-positive reactions with alkaloid reagents,¹⁴⁻¹⁹ and this pro-

¹¹ N. HYLANDER, *Förteckning över Nordens växter utgiven av Lunds botaniska förening*, Gleerups, Lund (1955).

¹² R. MARTELLO and N. R. FARNSWORTH, *Lloydia* **25**, 176 (1962).

¹³ E. ABISCH and T. REICHSTEIN, *Helv. Chim. Acta* **43**, 1844 (1960).

¹⁴ R. F. RAFFAUF, *Econ. Botany* **14**, 276 (1960).

¹⁵ O. SCHMIEDEBERG, *Arch. Exp. Pathol. Pharmacol.* **16**, 149 (1883).

¹⁶ W. MARMÉ, *Ztschr. f. rat. Med.* [3] **26**, 1 (1866).

¹⁷ L. H. BRIGGS and R. H. LOCKER, *J. Chem. Soc.* 2157 (1949).

¹⁸ N. R. FARNSWORTH and K. L. EULER, *Lloydia* **25**, 186 (1962).

blem has recently been investigated by Farnsworth, Pilewski and Draus.¹⁹ Mayer's and Hager's reagents appear to us to be particularly discriminating for alkaloids. Choline²⁰ does not give a positive reaction with all of the reagents used, and hence does not interfere in this analysis. Repeated analyses of the same plant material indicated that our estimate of alkaloid concentrations was reproducible within the accuracy noted.

The results from the screening of the plants chosen are presented in Table 1 together with references to earlier investigations. Because of our planned selection of plants, the fraction giving a positive alkaloid reaction was considerably higher than usual. Almost one-quarter of these plants gave a precipitation reaction corresponding to at least 0.01 per cent; work on plants with less concentration is considered impractical.¹⁴ Twenty-seven of these are apparently new alkaloid sources. Traces of alkaloids were found in a second quarter of the plants. Almost one-sixth of the plants gave a positive reaction for such alkaloids only which are not extractable with chloroform from alkaline solution.

A general conclusion from this and earlier investigations is that the alkaloid concentration in most Nordic plants is low, and that relatively few plants have alkaloids in sufficient concentrations to warrant further investigation.

TABLE 1. SPECIES TESTED FOR ALKALOID CONTENT, AND REACTION OBTAINED

Family	Species	Plant* part	Fraction†		Reference‡
			A	B	
Acanthaceae	<i>Thunbergia alata</i> Hook.	w	0	1	+ ²¹
Adoxaceae	<i>Adoxa moschatellina</i> L.	w	0	3	
Alismataceae	<i>Alisma plantago-aquatica</i> L.	w	0	0	— ²² , — ^{23§}
	<i>Sagittaria sagittifolia</i> L.	w	1	1	(24)
Araceae	<i>Calla palustris</i> L.	w	0	0	+ ²²
Aristolochiaceae	<i>Asarum europaeum</i> L.	w	10	30	— ²² , + ²⁶ , + ²⁷
Asclepiadaceae	<i>Cynanchum vincetoxicum</i> (L.) Pers.	w	10	0	+ ²² (23, 28, 29)

* Part of plant: b = bark, f = fruit, l = leaf, r = root, rb = root bark, s = stem or twig, t = tuber, and w = whole plant.

† Fraction A: extracted with chloroform from an ammoniacal solution; fraction B: after addition of sodium sulfate, subsequently extracted with chloroform:ethanol (3:2). The reaction was graded by comparison with the intensity of the reaction between strychnine and the reagents used. 0 designates less than 1 mg per 100 g of dried material; other figures give the order of magnitude expressed in mg per cent.

‡ References for earlier investigations: + and — designate positive and negative reaction, respectively, reported for the same species; parentheses show that a previous investigation was run on a closely related alkaloid-bearing plant.

§ Massagetov²³ got a positive alkaloid reaction from the seeds.

|| This may be a false-positive reaction.²⁵

¹⁹ N. R. FARNSWORTH, N. A. PILEWSKI and F. J. DRAUS, *Lloydia* **25**, 312 (1962).

²⁰ G. KLEIN and A. ZELLER, *Österr. botan. Z.* **79**, 40 (1930).

²¹ H. R. ARTHUR, *J. Pharm. Pharmacol.* **6**, 66 (1954).

²² A. I. BANKOVSKII, M. P. ZARUBINA and L. A. SERGEEVA, *Trudy Vsesoyuz. Nauchn-Issledovatel. Inst. Lekarstv. Rast.* **9**, 119 (1947).

²³ P. S. MASSAGETOV, *Trudy Vsesoyuz. Nauchn-Issledovatel. Inst. Lekarstv. Rast.* **9**, 3 (1947).

²⁴ M. E. WALL, J. W. GARVIN, J. J. WILLAMAN, Q. JONES and B. G. SCHUBERT, *J. Pharm. Sci.* **50**, 1001 (1961).

²⁵ M. PAILER, Personal communication.

²⁶ A. ORECHOFF, *Arch. Pharm.* **272/44**, 673 (1934).

²⁷ M. A. ABDUL'MENEV, *Farmatsiya* **8**, No. 4, 39 (1945).

²⁸ L. J. WEBB, *Australia, Commonwealth Sci. Ind. Res. Organization Bull.* No. 241 (1949).

²⁹ L. J. WEBB, *Australia, Commonwealth Sci. Ind. Res. Organization Bull.* No. 268 (1952).

TABLE 1—continued

Family	Species	Plant part	Fraction		Reference
			A	B	
Betulaceae	<i>Alnus glutinosa</i> (L.) Gaertn.	b, rb	0	0	+ ²²
	<i>Alnus incana</i> (L.) Moench	b, rb	0	1	+ ²²
	<i>Betula nana</i> L.	l	0	0	
	<i>Betula verrucosa</i> Erh.	rb	3	1	+ ²² , + ³⁰ , + ³¹
Butomaceae	<i>Butomus umbellatus</i> L.	w	0	0	+ ³¹
Campanulaceae	<i>Campanula latifolia</i> L.	w	0	0	— ²⁶
	<i>Campanula persicifolia</i> L.	w	0	0	
	<i>Campanula rapunculoides</i> L.	w	0	0	— ²² , — ³⁵
	<i>Campanula rotundifolia</i> L.	w	3	0	+ ³²
	<i>Campanula trachelium</i> L.	w	0	0	
	<i>Jasione montana</i> L.	w	10	3	+ ²² , + ³²
	<i>Platycodon grandiflorum</i> A. DC.	r	3	10	
	<i>Platycodon grandiflorum</i> A. DC.	s, l	0	3	+ ³²
Caprifoliaceae	<i>Linnea borealis</i> L.	w	30	30	
	<i>Lonicera periclymenum</i> L.	b	10	10	(29, 33, 34)
	<i>Viburnum opulus</i> L.	b	3	3	+ ³¹ , — ³⁵
Caryophyllaceae	<i>Cerastium holosteoides</i> Fr.	w	1	1	
	<i>Dianthus deltoideus</i> L.	w	1	3	— ²² , (26, 33, 36)
	<i>Herniaria glabra</i> L.	w	0	0	+ ³⁷
	<i>Lychnis flos-cuculi</i> L.	w	—	3	— ²² , + ²⁶ , + ³⁸
	<i>Melandrium rubrum</i> (Weig.) Garcke	w	0	3	(33)
	<i>Minuartia peploides</i> (L.) Hiern	w	0	3	
	<i>Saponaria officinalis</i> L.	r	0	0	
	<i>Saponaria officinalis</i> L.	s, l	0	3	+ ²² , — ³⁵
	<i>Scleranthus annuus</i> L.	w	0	0	
	<i>Silene acaulis</i> (L.) Jacq.	w	0	0	(33)
	<i>Silene maritima</i> With.	s, l	1	1	(33)
	<i>Silene maritima</i> With.	r	3	3	
	<i>Silene rupestris</i> L.	w	10	10	(33)
	<i>Spergula arvensis</i> L.	w	3	10	
	<i>Spergula marginata</i> (DC.) Murb.	w	10	30	
	<i>Spergula rubra</i> (L.) D. Dietr.	w	0	1	— ³⁶
	<i>Stellaria graminea</i> L.	w	0	0	(34)
	<i>Stellaria media</i> (L.) Vill.	w	1	3	(29)
Chenopodiaceae	<i>Atriplex litoralis</i> L.	w	0	3	+ ³³
	<i>Salicornia europaea</i> L.	w	0	0	
	<i>Salsola kali</i> L.	w	0	10	+ ²⁸ , + ³¹ , + ⁴⁰ , + ⁴¹
	<i>Suaeda maritima</i> (L.) Dum.	w	0	0	(28, 33, 35)

³⁰ FROMME; from CAESAR and LORETZ, *Just's Botanischer Jahresbericht*, **25** II, 19 (1897).³¹ P. S. MASSAGETOV, *Farmatsiya* **9** No. 3, 22 (1946).³² H. GERTIG, *Dissertationes Pharm.* **14**, 527 (1962).³³ S. Y. ZOLOTNITSKAYA, *Izvest. Akad. Nauk Armyan. SSR, Biol. i Sel'skokhoz. Nauki* **7**, 27 (1954).³⁴ G. V. LAZUR'EVSKII and A. S. SADYKOV, *Tr. SAGU, nov. ser.* **2** No. 1 (1945), from V. S. SOKOLOV, *loc. cit.*, p. 263.³⁵ M. E. WALL, C. S. FENSKE, J. W. GARVIN, J. J. WILLAMAN, Q. JONES, B. G. SCHUBERT and H. S. GENTRY, *J. Am. Pharm. Assoc. Sci. Ed.* **48**, 695 (1959).³⁶ M. N. VARLAKOV, *Khim.-Farm. Prom.* (1932) No. 2, from V. S. SOKOLOV, *loc. cit.*, p. 196.³⁷ SCHNEEGANS, *J. Pharm. Alsace-Lorraine* **206** (1890), from C. WEHMER, *loc. cit.*, p. 305.³⁸ O. STEPPUHN, *Arch. Exp. Pathol. Pharmacol.* **147**, 79 (1930).³⁹ M. A. NAUMENKO, *Nekotorye Voprosy Farm. (Kiev) Sbornik* **242** (1956) from *Chem. Abstr.* **52**, 3044e (1958).⁴⁰ B. BORKOWSKI, K. DROST and B. PASICHOWA, *Acta Polon. Pharm.* **16**, 57 (1959).⁴¹ K. DROST, *Dissertationes Pharm.* **13**, 167 (1961).

TABLE 1—continued

Family	Species	Plant part	Fraction		References
			A	B	
Compositae	<i>Antennaria dioeca</i> (L.) Gaertn.	w	10	10	—22, +26
	<i>Anthemis arvensis</i> L.	w	3	3	—35, +42*
	<i>Anthemis tinctoria</i> L.	w	0	0	+26
	<i>Centaurea cyanus</i> L.	w	3	3	+22
	<i>Centaurea jacea</i> L.	s, l	10	30	+22, +26, +43
	<i>Centaurea jacea</i> L.	r	0	0	+22
	<i>Centaurea scabiosa</i> L.	s, l	10	10	+22, +44
	<i>Chrysanthemum segetum</i> L.	w	0	0	(26, 45)
	<i>Cirsium palustre</i> (L.) Scop.	w	3	3	(35, 46)
	<i>Cirsium vulgare</i> (Savi) Ten.	w	1	0	—35
Convolvulaceae	<i>Calystegia sepium</i> (L.) R. Br. (<i>Convolvulus sepium</i> L.)	w	1	1	+22, ±23, —35
	<i>Convolvulus arvensis</i> L.	s, l	3	1	+23, —26, —35
	<i>Cuscuta europaea</i> L.	w	1	0	(28)
Cornaceae	<i>Cornus suecica</i> L.	w	0	0	(35)
Corylaceae	<i>Corylus avellana</i> L.	rb	0	0	+22
Cupressaceae	<i>Juniperus communis</i> L.	rb	0	3	(23, 47)
Cyperaceae	<i>Carex acuta</i> L.	w	1	0	(33, 48)
	<i>Carex echinata</i> Murr. (<i>C. stellulata</i> Good.)	w	0	0	(33, 48)
	<i>Carex nigra</i> (L.) Reich. (<i>C.</i> <i>Goodenowii</i> Gay.)	w	3	0	(33, 48)
	<i>Eleocharis uniglumis</i> (Link) Schult.	w	1	0	
	<i>Eriophorum angustifolium</i> Honck.	w	0	0	
	<i>Scirpus maritimus</i> L.	w	1	1	
	<i>Scirpus sylvaticus</i> L.	w	0	0	
	<i>Scirpus Tabernaemontani</i> C. C. Gmel.	r	0	0	+23
	<i>Knautia arvensis</i> (L.) Coult.	w	0	0	(49)
	<i>Succisa pratensis</i> Moench (<i>Scabiosa succisa</i> L.)	w	100	10	+50, +51
Droseraceae	<i>Drosera rotundifolia</i> L.	w	0	0	
Elaeagnaceae	<i>Hippophaë rhamnoides</i> L.	l	0	0	
	<i>Hippophaë rhamnoides</i> L.	b	0	3	+52, +23
	<i>Hippophaë rhamnoides</i> L.	rb	0	30	
Empetraceae	<i>Empetrum nigrum</i> L.	w	0	0	
Ericaceae	<i>Andromeda polifolia</i> L.	w	0	0	

* Pattone's⁴² alkaloid can hardly be identical with the alkaloid detected here because his alkaloid was insoluble in alcohol.

⁴² PATTONE, *J. pharm. chim.* 35, 198 (1859).

⁴³ D. E. DIONIS'EV and E. E. CHERNOMAZ, *Uchenye Zapiski Rostovsk. na Donu Gos. Univ.* 9 (1938), from V. S. SOKOLOV, *loc. cit.*, p. 272.

⁴⁴ B. V. KURMAZ and V. K. YASHCHENKO, *Sbornik Nauch. Trudov Dnepropetrovsk. Med. Inst.* 6, 333 (1958), from *Chem. Abstr.* 55, 8769i (1961).

⁴⁵ A. F. GAMMERMAN and M. D. SHUPINSKAYA, *Farmatsiya i Farmakol.* No. 3-4 (1937), from V. S. SOKOLOV, *loc. cit.*, p. 273.

⁴⁶ N. M. ISMAILOV, *Izvest. Akad. Nauk Azerbaidzhan. SSR. Ser. Biol. i Sel'skokhoz. Nauk* No. 4, 11 (1958), from *Chem. Abstr.* 53, 3597a (1959).

⁴⁷ G. V. LAZUR'EVSKII and A. S. SADYKOV, *Trudy Uzbeksk. Gos. Univ.* 15 (1939), from V. S. SOKOLOV, *loc. cit.*, p. 162.

⁴⁸ I. V. TERENT'EVA and G. V. LAZUR'EVSKII, *Zh. Obshch. Khim.* 27, 3170 (1957).

⁴⁹ N. M. ISMAILOV and R. YA. RZAZADE, *Dokl. Akad. Nauk. Azerb. SSR* 10, 197 (1954).

⁵⁰ V. S. SOKOLOV, *loc. cit.*, p. 132.

⁵¹ K. TORSSSELL, *Arkiv Kemi* 21, 93 (1963).

⁵² P. S. MASSAGETOV, *Zh. Obshch. Khim.* 16, 775 (1946).

TABLE 1—continued

Family	Species	Plant part	Fraction		References
			A	B	
Ericaceae	<i>Arctostaphylos uva-ursi</i> (L.) Spreng.	w	0	0	
	<i>Erica tetralix</i> L.	w	0	0	
	<i>Ledum palustre</i> L.	w	0	0	
	<i>Vaccinium myrtillus</i> L.	w	0	10	+ ⁵¹
	<i>Vaccinium oxycoccus</i> L.	w	0	0	
	<i>Vaccinium uliginosum</i> L.	w	0	0	
	<i>Vaccinium vitis-idaea</i> L.	w	1	0	— ⁵³
	<i>Euphorbia cyparissias</i> L.	w	0	0	+ ⁵³
Euphorbiaceae	<i>Euphorbia palustris</i> L.	s, l	0	0	
	<i>Euphorbia palustris</i> L.	rb	0	0	
	<i>Euphorbia pepus</i> L.	w	0	0	+ ²⁵ , + ⁵⁴
	<i>Euphorbia polychroma</i> A. Kern	w	0	0	
Fagaceae	<i>Mercurialis perennis</i> L.	w	0	1	+ ²²
	<i>Fagus sylvatica</i> L.	rb	0	0	(⁵⁵)
	<i>Quercus robur</i> L.	rb	0	0	
Geraniaceae	<i>Quercus petraea</i> (Matt.) Liebl.	rb	0	0	
	<i>Geranium lucidum</i> L.	w	1	0	
	<i>Geranium molle</i> L.	w	0	0	+ ⁵⁶
	<i>Geranium Robertianum</i> L.	w	3	3	
Gramineae	<i>Geranium silvaticum</i> L.	w	3	0	+ ²² , + ⁵³
	<i>Bromus hordeaceus</i> L. (<i>B. mollis</i> L.)	w	3	3	
	<i>Bromus secalinus</i> L.	w	3	0	
	<i>Dactylis glomerata</i> L.	w	3	3	
	<i>Holcus mollis</i> L.	w	1	3	
	<i>Phragmites communis</i> Trin.	r	10	3	— ⁵⁵
Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	rb	0	0	
Hippuridaceae	<i>Hippuris vulgaris</i> (L.) Hiern	s, l	3	10	+ ²³
(Halorrhagaceae)					
Hydrophyllaceae	<i>Phacelia tanacetifolia</i> Benth.	w	1	3	
Isoëtaceae	<i>Isoëtes echinospora</i> Dur.	w	1	0	
	<i>Isoëtes lacustris</i> L.	w	0	0	
Juncaceae	<i>Juncus articulatus</i> L.	w	0	0	
	<i>Juncus conglomeratus</i> L.	w	3	—	
	<i>Juncus effusus</i> L.	w	0	1	
	<i>Juncus squarrosus</i> L.	w	3	0	
	<i>Juncus subnodulosus</i> Schrank	w	0	0	
	<i>Juncus tenuis</i> Willd.	w	0	0	
	<i>Luzula multiflora</i> (Retz.) Lej.	w	0	0	
	<i>Luzula pilosa</i> (L.) Willd.	w	0	0	
	<i>Triglochin maritimum</i> L.	w	0	1	
Juncaginaceae	<i>Lemna minor</i> L.	w	0	0	
Lemnaceae	<i>Pinguicula vulgaris</i> L.	w	10	3	
Lentibulariaceae	<i>Utricularia minor</i> L.	w	3	3	
Liliaceae	" <i>Hemerocallis conspicua</i> "†	r	3	10	(²² ⁵⁶)
Loasaceae	<i>Bartonia aurea</i> Lindl.	w	3	30	
Loganiaceae	<i>Buddleia Davidii</i> Franch.	b	0	3	(²⁹)

* Klein⁵ erroneously states that Laland found an alkaloid; but Laland⁵³ only reported that he did not find narcotine in lingonberries.

† Originating from Messrs. Perry's Hardy Plant Farm, Enfield, Middlesex, England

⁵³ P. LALAND, *Z. Physiol. Chem.* **204**, 112 (1932).

⁵⁴ A. E. A. SHARAF, *Brit. Vet. J.* **105**, 128 (1949).

⁵⁵ J. L. VAN EIK, *Pharm. Weekblad* **87**, 70 (1952).

⁵⁶ G. KLEIN and G. POLLAU, *Österr. Botan. Z.* **78**, 251 (1929).

TABLE 1—continued

Family	Species	Plant part	Fraction		Reference
			A	B	
Lythraceae	<i>Lythrum salicaria</i> L.	s, l	3	0	— 22, + 23, — 24
Myricaceae	<i>Myrica gale</i> L.	l, rb	3	0	
Oleaceae	<i>Fraxinus excelsior</i> L.	rb	0	1	— 57, (23, 26, 33, 35)
	<i>Ligustrum vulgare</i> L.	b	100	3	
	<i>Ligustrum vulgare</i> L.	l	30	30	+ 23
Onagraceae	<i>Clarkia</i> sp.	w	0	0	
	<i>Chamaenerion angustifolium</i> (L.) Scop.	w	0	0	+ 22, + 26, — 35
	<i>Epilobium Hornemannii</i> Rchb.	w	0	0	
	<i>Epilobium montanum</i> L.	w	0	0	
	<i>Epilobium roseum</i> Schreb.	w	0	0	+ 23
Orchidaceae	<i>Orchis maculata</i> L.	r	0	3	
	<i>Platanthera bifolia</i> (L.) L. C. Rich	w	3	10	
Pinaceae	<i>Larix decidua</i> Mill.	b, l	0	0	(22)
	<i>Picea abies</i> (L. H. Karst.	l	30	10	(58)
	<i>Picea abies</i> (L.) H. Karst.	rb	3	0	
	<i>Pinus silvestris</i> L.	l	3	3	+ 22, + 31
	<i>Pinus silvestris</i> L.	rb	0	0	
Plantaginaceae	<i>Plantago lanceolata</i> L.	w	3	3	+ 23
	<i>Plantago maritima</i> L.	w	3	3	(59, 60, 61)
	<i>Plantago media</i> L.	w	1	10	(59, 60, 61)
Plumbaginaceae	<i>Armeria maritima</i> (Mill.) Willd.				
	(<i>Statice armeria</i> L.)	w	10	10	(23, 26, 62)
Polemoniaceae	<i>Limonium vulgare</i> Mill.	s, l, r	0	0	(33)
	<i>Cobaea scandens</i> Cav.*	s, l	0	10	
	<i>Phlox paniculata</i> hybr.	s, l	1	1	— 22
Polygalaceae	<i>Polygala vulgaris</i> L.	w	10	3	(24)
Polygonaceae	<i>Polygonum aviculare</i> L.	w	0	0	± 61
	<i>Polygonum hydropiper</i> L.	w	0	1	+ 22, — 24, + 29
	<i>Polygonum viviparum</i> L.	w	0	10	
	<i>Rumex acetosa</i> L.	w	0	0	(29, 64 †)
	<i>Rumex longifolius</i> DC	w	0	0	
Polypodiaceae	<i>Pteridium aquilinum</i> Kuhn	l	0	0	+ 65
	<i>Pteridium aquilinum</i> Kuhn	r	1	0	
Portulacaceae	<i>Montia fontana</i> L.	w	0	0	
	<i>Portulaca grandiflora</i> Lindl.	w	1	1	(29)
Potamogetonaceae	<i>Potamogeton natans</i> L.	f	1	1	
	<i>Potamogeton polygonifolius</i> Pourr.	w	3	0	
Primulaceae	<i>Glaux maritima</i> L.	w	0	0	+ 23
	<i>Lysimachia thyrsiflora</i> L.	w	0	0	
	<i>Lysimachia vulgaris</i> L.	w	0	0	— 22, — 26, — 35
	<i>Primula veris</i> L.	w	3	0	
	<i>Trientalis europaea</i> L.	w	0	0	
Pyrolaceae	<i>Pyrola rotundifolia</i> L.	w	0	0	+ 22, — 26

* Hutchinson⁶³ lists *Cobaea* in the family Cobaeaceae.

† *Rumex obtusifolius* contains α -picoline¹⁰ which is not detected by our method.

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TABLE 1—continued

Family	Species	Plant part	Fraction		Reference
			A	B	
Ranunculaceae	<i>Actaea spicata</i> L.	s, l	1	0	+ ²⁶
	<i>Actaea spicata</i> L.	r	0	0	— ²²
	<i>Caltha palustris</i> L.	r	3	0	+ ²² , + ²⁶ , + ⁶⁶ , + ⁶⁷
Rhamnaceae	<i>Rhamnus cathartica</i> L.	rb	1	10	— ²² (49)
	<i>Rhamnus frangula</i> L.	rb	10	0	— ⁶⁸ (49)
Rosaceae	<i>Cotoneaster intergerrimus</i> Med.	b, l	0	0	(23)
	<i>Crataegus monogyna</i> Jacq.	rb	0	3	⁶⁹
	<i>Potentilla plaustris</i> (L.) Scop. (<i>Comarum palustre</i> L.)	w	0	0	
	<i>Sorbus aucuparia</i> L.	rb	3	0	
	<i>Sorbus intermedia</i> (Erh.) Pers. (<i>S. suecica</i> (L.) Krok)	rb.	10	0	
Rubiaceae	<i>Galium aparine</i> L.	w	0	30	
	<i>Galium mollugo</i> L.	w	0	3	+ ²² , — ²⁶
	<i>Galium verum</i> L.	w	1	30	+ ²² , + ²³ , — ²⁶
Salicaceae	<i>Populus tremula</i> L.	rb	1	0	
Saxifragaceae	<i>Hydrangea petiolaris</i> Sieb et Zucc.	b, r	0	0	(70, 71)
	<i>Parnassia palustris</i> L.	r	1	0	
	<i>Ribes alpinum</i> L.	b	0	0	
	<i>Ribes alpinum</i> L.	rb	1	0	
	<i>Saxifraga granulata</i> L.	w	0	0	
Scheuchzeriaceae	<i>Scheuchzeria palustris</i> L.	w	1	3	
Scrophulariaceae	<i>Euphrasia officinalis</i> L.	w	3	3	(23)
	<i>Euphrasia frigida</i> Pusgl.	w	10	10	
	<i>Linaria vulgaris</i> Mill.	w	10	0	+ ²² , + ²⁶
	<i>Melampyrum cristatum</i> L.	w	10	30	+ ²⁶
	<i>Melampyrum nemorosum</i> L.	2	3	3	+ ²⁶
	<i>Melampyrum pratense</i> L.	w	10	10	
	<i>Odontites litoralis</i> Fr.	w	10	30	
	<i>Odontites verna</i> (Bell.) Dum. (<i>Odontites serotina</i> (Lam.) Rchb.)	w	0	0	+ ²³
	<i>Pedicularis palustris</i> L.	w	10	30	(33)
	<i>Pedicularis silvatica</i> L.	w	10	10	(23)
	<i>Rhinanthus minor</i> L.	w	3	30	+ ^{72*}
	<i>Rhinanthus serotinus</i> (Schönh.) Sch. et Th.	w	1	10	+ ^{72*}
	<i>Scrophularia nodosa</i> L.	s, l	1	1	⁷³
	<i>Scrophularia nodosa</i> L.	t	0	0	+ ⁷⁴
	<i>Verbascum nigrum</i> L.	r	3	1	(23)
	<i>Verbascum thapsus</i> L.	s, l†	1	3	— ⁶⁸
	<i>Verbascum thapsus</i> L.	rb	10	10	
	<i>Veronica beccabunga</i> L.	w	3	3	(22, 23, 50)
	<i>Veronica officinalis</i> L.	w	0	10	

* *Rhinanthus crista-galli* L.† Green parts peeled off from supporting woody structure. This plant may give a false-positive reaction.⁶⁸⁶⁶ O. KELLER, *Arch. Pharm.* **248**, 463 (1910).⁶⁷ E. POULSSON, *Arch. Exp. Pathol. Pharmacol.* **80**, 173 (1917).⁶⁸ K. L. EULER and N. R. FARNSWORTH, *Lloydia* **25**, 296 (1962).⁶⁹ R. NEU and P. HAGEDORN, *Deut. Apoth. Ztg.* **96**, 19 (1956).⁷⁰ C. S. JANG, F. Y. FU, K. C. HUANG and C. Y. WANG, *Nature* **161**, 401 (1948).⁷¹ F. ABLONDI, S. GORDON, J. MORTON, II, and J. H. WILLIAMS, *J. Org. Chem.* **17**, 14 (1952).⁷² A. P. OREKHOV, *Khim. farm. prom.* **1** (1935), from V. S. SOKOLOV, *loc. cit.*, p. 261.⁷³ F. KOCH, *Arch. Pharm.* **233**, 48 (1895).⁷⁴ V. D. MOER, *Ned. Tijdschr. Pharm.* **1**, (1896), from C. WEHMER, *loc. cit.*, p. 1122.

TABLE 1—continued

Family	Species	Plant part	Fraction		Reference
			A	B	
Scrophulariaceae	<i>Veronica scutellata</i> L.	w	3	3	
	<i>Veronica spicata</i> L.	w	1	0	— 22
Sparganiaceae	<i>Sparganium ramosum</i> Huds.	w	1	0	+ 33
Tamaricaceae	<i>Myricaria germanica</i> (L.) Desv.	rb	0	0	
Typhaceae	<i>Typha latifolia</i> L.	w	0	0	— 33, — 35, (35)
Ulmaceae	<i>Ulmus glabra</i> Huds.	rb	1	0	(22)
Umbelliferae	<i>Heracleum spondylium</i> L.	r	0	0	(23)
	<i>Ligusticum scoticum</i> L.	s, l	0	0	(33, 75)
Valerianaceae	<i>Valeriana officinalis</i> L.	r	30	30	+ 76, + 77
	<i>Valeriana sambucifolia</i> Mikan	s, l, r	10	100	
Violaceae	<i>Viola riviniana</i> Rchb.	w	0	0	(78)
	<i>Viola tricolor</i> L.	w	1	3	— 22, + 79
Zosteraceae	<i>Zostera marina</i> L.	w	0	0	

EXPERIMENTAL

A 4 g sample of carefully dried (under 50°), ground plant material was allowed to stand overnight with 40 ml of methanol and was then warmed for 4 hr at 50°. The mixture was filtered, the residue washed with 20 ml of methanol and the combined extracts evaporated *in vacuo*. The residue was suspended in methanol (2 ml), and 12 ml of 1% HCl added. The mixture was shaken and filtered, using an additional 8 ml of 1% HCl to wash the residue. The filtrate was made basic with conc. NH₃ and extracted with three 20 ml portions of chloroform (fraction A). The aqueous solution was next made half-saturated with sodium sulfate and extracted three times with 20 ml of chloroform: ethanol (3:2 v/v) (fraction B). The organic phases were washed with 5 ml of half-saturated sodium sulfate solution and dried with anhydrous sodium sulfate.

The two extracts were evaporated separately *in vacuo*, and 1.0 ml of HCl and 1.0 ml of chloroform were added to each with vigorous shaking. The aqueous phase from each was pipetted off, filtered through cotton, and divided into six portions. These samples were tested with the following alkaloid reagents, prepared according to Cromwell⁸⁰ except where indicated: Mayer's, Wagner's, Dragendorff's, Sonnenschein's (prepared as 10% solution of phosphomolybdic acid in dilute nitric acid (1:9 v/v)), silicotungstic acid, and Hager's reagents. The amounts of precipitate formed were compared to those resulting from strychnine solutions of known concentrations.

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