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ALKALOIDS OF THE LAURACEAE

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Summary

Alkaloids of the plant family Lauraceae are classified according to structure into fifteen groups, and arranged in tabular form. The genera and species in which they occur are also tabulated, and another table summarises the number of occurrences of each alkaloid group by genus. Incompletely characterised bases not included in these tables are listed separately. Occurrences of the main structural types are compared for the Lauraceae and certain other plant families in a further table. The possible mode of biogenesis of some less familiar bases is discussed, and references are given to the biosynthesis of well-known structural types.

Contents

1. Introduction

The family Lauraceae is most abundantly represented in the tropics of both hemispheres, with about 18 American and nearly as many Asian genera. Few of these are common to both regions, although the large genus *Cryptocarya* is widely spread, and *Sassafras* occurs in both Eastern Asia and in the Atlantic region of North America as far as Canada. On the whole, the family is sparsely distributed in tropical Africa, with the exception of Madagascar, which has one genus with about 18 species. There are several genera in Australasia[1,159,160]. A detailed study of the taxonomy of the Lauraceae has been made by Kostermans[96], and the chemotaxonomy[63] and chemosystematics[161] of the family have also been reviewed.

The great majority of alkaloids found in the Lauraceae are of the aporphine type. Table 1 shows the principal plant families which contain aporphine alkaloids. The Lauraceae includes examples of many of the other types of alkaloid structures found in nature which are considered to arise biogenetically from phenylalanine or tyrosine, and plant families containing the main types are also shown in Table 1; of these, the dibenzopyrrocolines have so far been found only in the Lauraceae. It can be seen from Table 1 that in general families such as the Monimiaceae and Hernandiaceae, which belong to the same natural order as the Lauraceae, show similarities in alkaloid distribution, but this similarity also extends to families such as the Anonaceae, Magnoliaceae, Ranunculaceae, Menispermaceae and Berberidaceae which are placed in related orders in Hutchinson's "Families of Flowering Plants"[158], although the last three are in herbaceous orders in contrast to the others, which are composed of woody types of plants.

Figures (I-XV) illustrate the general structural types of alkaloids found to date in the Lauraceae; they include a comparatively small number of alkaloids belonging to types which appear to be derived from amino acids other than tyrosine or phenylalanine. A number of reviews have been published discussing the chemistry of the more important alkaloid groups found in the Lauraceae, including aporphines[5], proaporphines[6], bisbenzylisoquinolines[7], and morphines[8], as well as general texts covering the various types of isoquinoline alkaloids[16,23].

The occurrence of alkaloids found in the various species of the Lauraceae is shown in Table 2, which includes 105 alkaloids of 15 structural types occurring in 103 species from 19 genera. The data are summarised in Table 3, in which the number of occurrences of alkaloids of the principal structural types is shown for each genus. The information contained in the tables has been drawn from reviews[2,3,4] and from Chemical Abstracts for the period 1967-1976.

2. Biosynthesis

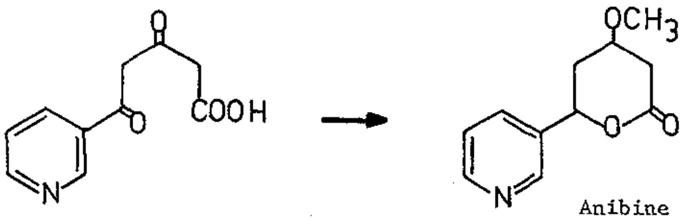
Comparatively few of the individual alkaloids found in the Lauraceae have been the subject of biosynthetic study, and such studies as have been made have for the most part been carried out using plants of other families in which the biosynthetic pathways may not be identical. However, the lauraceous alkaloids can be classified according to structure into a number of groups for which the general lines at any rate of the biosynthetic pathways have been largely established. The great majority of the bases may be considered to arise from tyrosine, some of them with only slight modification (group I)[145]. Others (groups II and IIa) have a benzylisoquinoline or benzyltetrahydroisoquinoline structure, in the biosynthesis of which two tyrosine units are involved[146,147].

The range of lauraceous alkaloids include examples of many of the metabolic modifications which the benzyltetrahydroisoquinoline structure can undergo, such as proaporphine (group III), aporphine (group IV) and phenanthrene (group VI). Several biosynthetic routes to the aporphines, the largest single group, have been established for individual alkaloids occurring in other plant families[148], and from the considerable variety in the pattern of substitution in the case of the aporphines of the Lauraceae, it would appear that their biogenesis involves more than one of these routes. The origin of the unique dibenzylamino substituent in variabiline (IV_{50}) is particularly intriguing. Oxoaporphines[149] (V) and phenanthrene alkaloids (VI) are probably formed in nature by oxidation or biological Hofmann-type degradation of the aporphine structure respectively. The reported occurrence of berberine in a lauraceous sp.[91] is not supported by later work on the same plant[95,121,126,127].

The pavine (group VII), dibenzopyrrocoline (group VIII), and sinomenine (group IX) types represent further modifications of the benzylisoquinoline structure in which extra rings have been formed; the last-named type is related structurally and biosynthetically to morphine[150]. On the other hand, cryptopleurospermine (group X) is the sole representative of a type with fewer rings, and it would seem to have been formed by oxidative ring-opening of a tetrahydroisoquinoline structure.

The Lauraceae contains several types of bisbenzylisoquinoline alkaloids (group XI) in which two simple benzylisoquinoline units appear to have been joined together head-to-head, tail-to-tail by phenol oxidative processes[156], and they include examples of a type with a diphenyl in place of the more usual diphenylether link. Group XI bases are confined to *Nectandra* and *Ocotea* spp., and botanical confusion in the earlier literature has led to some confusion regarding their alkaloid content[89, 92]. More recent work[95,121,126,127] has not substantiated the occurrence of bisbenzylisoquinoline alkaloids of the head-to-tail type, such as bebeerine, in these plants.

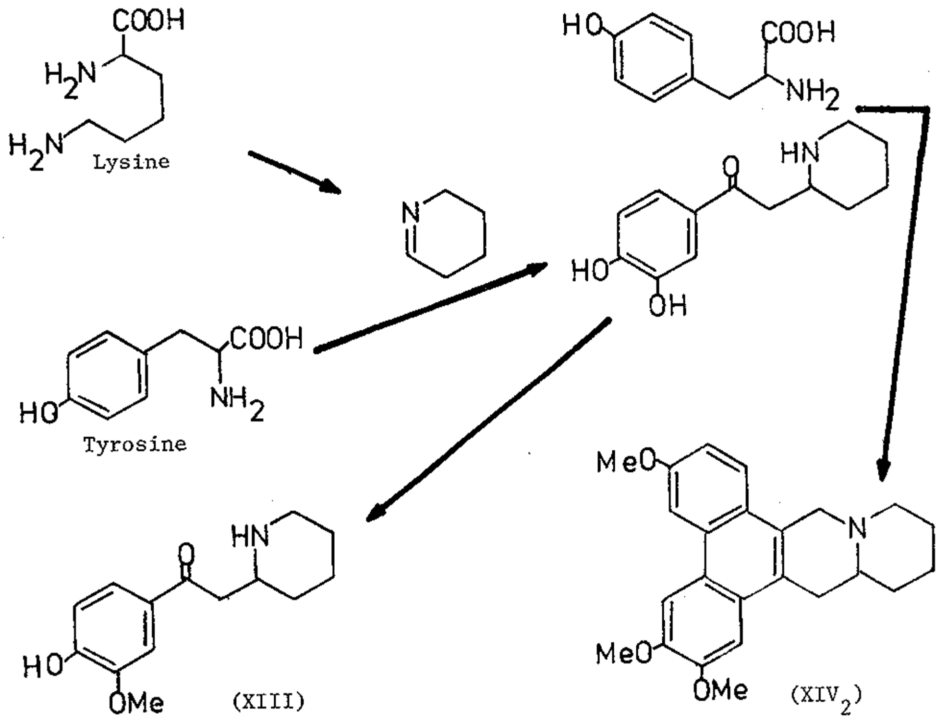
There is a miscellaneous group of pyridine alkaloids (group XII) which are confined to the genus *Aniba*, including anabasine, an alkaloid well-known from its occurrence in other plant families; in the case of solanaceous plants, it has been shown to be derived from the aminoacids lysine[152,153] and nicotinic acid[148,153]. The other pyridine alkaloids, anibine and duckeine, would appear from their structures to be made up of nicotinic acid condensed with two or three units of acetate respectively:



Anibine

Duckeine

Pleurospermine (XIII) is an alkaloid of the sedamine type, which may be formed from lysine[157] in a corresponding way to the latter except for the possible replacement of phenylalanine by tyrosine or dopa. The phenanthroquinolizidine type (group XIV) could be derived from the same source, with an additional dopa or tyrosine unit. No biosynthetic work has been done on these alkaloids to date, but they are structurally analogous to tylophorine, which has been shown to be built up from units of tyrosine, phenylalanine, and ornithine[154]. Cryptopleurine may be formed in a similar way with the substitution of lysine for ornithine.



The only occurrence of an indole alkaloid reported in the Lauraceae so far is the widely distributed serotonine (XV), which occurs in *Persea* spp. together with simple bases related to tyrosine[130].

3. Classification of alkaloids according to structure

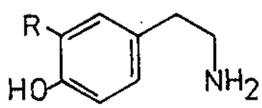


Fig. 1. Phenethylamines

Dopamine R=OH (I_1) Ref. 130

Tyramine R=H (I_2) Ref. 130

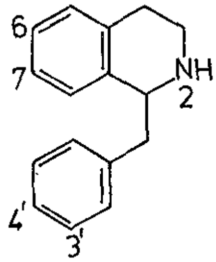


Fig. IIa. Benzyltetrahydroisoquinolines

Alkaloid		Substituent positions					
		2	6	7	3'	4'	Ref.
Cinnamolaurine	(IIa_1)	Me	$-OCH_2O-$		-	OH	44,45
Coclaurine (Machiline)	(IIa_2)	-	OMe	OH	-	OH	70
Laudanidine	(IIa_3)	Me	OMe	OMe	OH	OMe	81
Magnocurarine	(IIa_4)	Me_2^+	OMe	OH	-	OH	67
N-Norarmepavine	(IIa_5)	-	OMe	OMe	-	OH	81
Norcinnamolaurine	(IIa_6)	-	$-OCH_2O-$		-	OH	44,45
Reticuline	(IIa_7)	Me	OMe	OH	OH	OMe	19

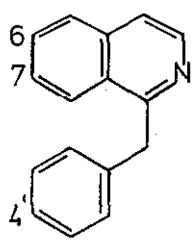


Fig. IIb. Benzylisoquinolines

Alkaloid		Substituent positions			
		6	7	4'	Ref.
Crykonisine	(IIb_1)	OMe	OMe	OH	80
1-(p-Methoxybenzyl)-6,7-dimethoxy-isoquinoline	(IIb_2)	OMe	OMe	OMe	123
1-(p-Methoxybenzyl)-6,7-methylenedioxy-isoquinoline	(IIb_3)	$-OCH_2O-$		OMe	123

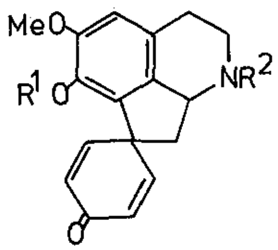
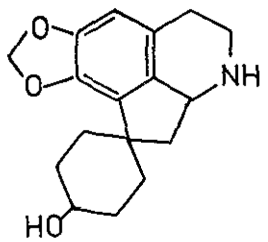


Fig. III. *Proaporphines*

			Ref.
Crotsparine	($IIIa_1$)	$R^1=R^2=H$	136
Glaziovine	($IIIa_2$)	$R^1=H$, $R^2=Me$	113
Pronuciferine	($IIIa_3$)	$R^1=R^2=Me$	137



Litsericine ($IIIb_1$), Ref. 102.

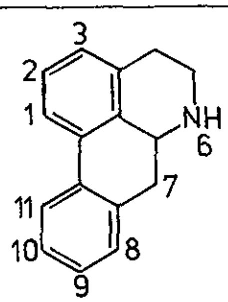
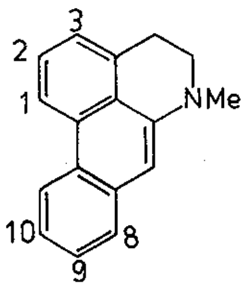


Fig. IV Aporphines

Alkaloid		Substituent positions 1	2	3	6	8	9	10	11	Ref.
Actinodaphnine	(IV_1)	$-OCH_2O-$		-	-	-	OH	OMe	-	39
Anonaine	(IV_2)	$-OCH_2O-$		-	-	-	-	-	-	98
Apoglaziovine	(IV_3)	OH	OMe	-	Me	-	-	OH	-	110,128

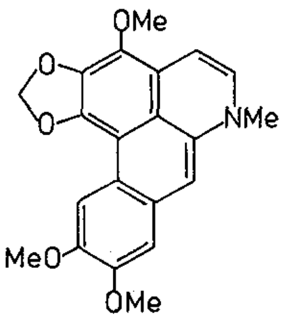
Alkaloid		Substituent positions								
		1	2	3	6	8	9	10	11	Ref.
Asimilobine	(IV_4)	OMe	OH	–	–	–	–	–	–	138
Boldine	(IV_5)	OMe	OH	–	Me	–	OH	OMe	–	73
Bulbocapnine	(IV_6)	$-OCH_2O-$		–	Me	–	–	OMe	OH	31
Caaverine	(IV_7)	OH	OMe	–	–	–	–	–	–	139
Cassyfiline (Cassythine)	(IV_8)	$-OCH_2O-$		OMe	–	–	OH	OMe	–	34,35,37
Cassythicine	(IV_9)	$-OCH_2O-$		–	Me	–	OH	OMe	–	39
Cassythidine	(IV_{10})	$-OCH_2O-$		OMe	–	–	$-OCH_2O-$		–	35
Corydine	(IV_{11})	OH	OMe	–	Me	–	–	OMe	OMe	45
Cryptodorine	(IV_{12})	$-OCH_2O-$		–	–	–	–	$-CH_2O-$		52
Dicentrine	(IV_{13})	$-OCH_2O-$		–	Me	–	OMe	OMe	–	27
2,11-Dihydroxy-1,10-dimethoxyaporphine	(IV_{14})	OMe	OH	–	Me	–	–	OMe	OH	20
1,10-Dihydroxy-2-methoxyaporphine	(IV_{15})	OH	OMe	–	Me	–	–	OH	–	109
Domesticine	(IV_{16})	OH	OMe	–	Me	–	$-CH_2O-$		–	34
Glaucine	(IV_{17})	OMe	OMe	–	Me	–	OMe	OMe	–	28
Hernovine	(IV_{18})	OMe	OH	–	–	–	–	OH	OMe	140
(±)-1-Hydroxy-2-methoxyaporphine	(IV_{19})	OH	OMe	–	Me	–	–	–	–	110
10-Hydroxy-1,2-methylenedioxy-aporphine	(IV_{20})	$-OCH_2O-$		–	Me	–	–	OH	–	20
2-Hydroxy-1,9,10-trimethoxynor-aporphine	(IV_{21})	OMe	OH	–	–	–	OMe	OMe	–	28
Isoboldine	(IV_{22})	OH	OMe	–	Me	–	OH	OMe	–	27,34,70
(+)-Isocorydine	(IV_{23})	OMe	OMe	–	Me	–	–	OMe	OH	52
Launobine	(IV_{24})	$-OCH_2O-$		–	–	–	–	OMe	OH	61
Laurelliptine (Norisoboldine)	(IV_{25})	OH	OMe	–	–	–	OH	OMe	–	27,79
Laurolitsine (Norboldine)	(IV_{26})	OMe	OH	–	–	–	OH	OMe	–	70

Alkaloid		Substituent positions								
		1	2	3	6	8	9	10	11	Ref.
Laurotetanine	(IV_{27})	OMe	OMe	–	–	–	OH	OMe	–	14,70
Lindcarpine	(IV_{28})	OMe	OH	–	–	–	–	OMe	OH	60
Litsedine	(IV_{29})	$-OCH_2O-$		–	–	–	–	OMe	OMe	76
N-Methylactinodaphnine	(IV_{30})	$-OCH_2O-$		–	Me	–	OH	OMe	–	72
O-Methylbulbocapnine	(IV_{31})	$-OCH_2O-$		–	Me	–	–	OMe	OMe	59
O-Methylcassyfiline (O-Methylcassythine)	(IV_{32})	$-OCH_2O-$		OMe	–	–	OMe	OMe	–	31,35
N-Methylhernangerine	(IV_{33})	$-OCH_2O-$		–	Me	–	–	OH	OMe	59
N-Methylhernovine	(IV_{34})	$-OCH_2O-$		–	Me	–	–	$-OCH_2O-$		59
N-Methylisocorydine	(IV_{35})	OMe	OMe	–	Me_2^+	–	–	OMe	OH	47
N-Methyllaurotetanine	(IV_{36})	OMe	OMe	–	Me	–	OH	OMe	–	67
Nandigerine	(IV_{37})	$-OCH_2O-$		–	–	–	–	OH	OMe	104
Nantenine	(IV_{38})	OMe	OMe	–	Me	–	$-OCH_2O-$		–	34
Neolitsine	(IV_{39})	$-OCH_2O-$		–	Me	–	$-OCH_2O-$		–	103
Nordomesticine	(IV_{40})	OH	OMe	–	–	–	$-OCH_2O-$		–	34
Nornantenine	(IV_{41})	OMe	OMe	–	–	–	$-OCH_2O-$		–	41
Nuciferine	(IV_{42})	OMe	OMe	–	Me	–	–	–	–	98
Ocokryptine	(IV_{43})	OMe	$-OCH_2O-$		Me	–	–	OMe	OH	116
Oconovine	(IV_{44})	OMe	OMe	OMe	Me	–	–	OMe	OH	116
Ocopodine	(IV_{45})	$-OCH_2O-$		–	Me	OMe	OMe	OMe	–	116
Ocoteine (O,N-dimethyl-cassyfiline, thalicmine)	(IV_{46})	$-OCH_2O-$		OMe	Me	–	OMe	OMe	–	94,125
Predicentrine	(IV_{47})	OMe	OH	–	Me	–	OMe	OMe	–	114,115, 128
Roemerine	(IV_{48})	$-OCH_2O-$		–	Me	–	–	–	–	47,132
Ushinsunine	(IV_{49})	$-OCH_2O-$		–	Me	– (OH group at 7)	–	–	–	132
Variabiline	(IV_{50})	OMe	OMe	–	Me	–	$-N(CH_2Ph)_2$		–	128



Dehydroaporphines

Alkaloid		Substituent positions						Ref.
		1	2	3	8	9	10	
Dehydrodicentrine	(IV_{51})	$-OCH_2O-$		–	–	OMe	OMe	116
Dehydronantenine	(IV_{52})	OMe	OMe	–	–	$-OCH_2O-$		123
Dehydroocopodine	(IV_{53})	$-OCH_2O-$		–	OMe	OMe	OMe	114
Dehydroocoteine	(IV_{54})	$-OCH_2O-$		OMe	–	OMe	OMe	117



Didehydroocoteine (IV_{55}) Ref. 117

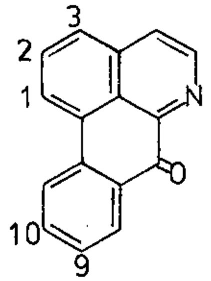


Fig. V. Oxoaporphines

Alkaloid		Substituent positions 1	2	3	9	10	Ref.
Cassamedine	(V_1)	$-OCH_2O-$		OMe	$-OCH_2O-$		31,32
Cassameridine	(V_2)	$-OCH_2O-$		-	$-OCH_2O-$		31
Dicentrinone	(V_3)	$-OCH_2O-$		-	OMe	OMe	114
1,2-Dimethoxy-9,10-methylenedioxy-7-oxodibenzo-[de,g]-quinoline	(V_4)	OMe	OMe	-	$-OCH_2O-$		41
Lirodenine (Oxoushinsunine)	(V_5)	$-OCH_2O-$		-	-	-	70,132
Thalicminine	(V_6)	$-OCH_2O-$		OMe	OMe	OMe	118

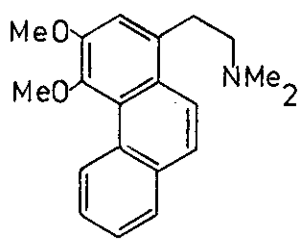


Fig. VI. Phenanthrene

Atherosperminine (3,4-Dimethoxy-1-dimethylaminoethyl-phenanthrene) (VI). Ref. 47, 134

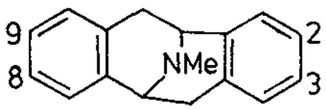


Fig. VII. Pavines

Alkaloid		Substituent positions			Ref.
		2	3	8 9	
Caryachine	(VII_1)	OH(OMe)	OMe(OH)	$-OCH_2O-$	50
Crychine	(VII_2)	$-OCH_2O-$		$-OCH_2O-$	50
O-Methylcaryachine	(VII_3)	OMe	OMe	$-OCH_2O-$	51

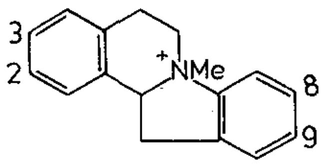


Fig. VIII. Dibenzopyrrocolines

Alkaloid		Substituent positions				Ref.
		2	3	8	9	
Cryptaustoline	($VIII_1$)	OH	OMe	OMe	OMe	49
Cryptowoline	($VIII_2$)	OH	OMe	$-OCH_2O-$		49

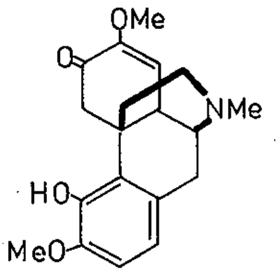
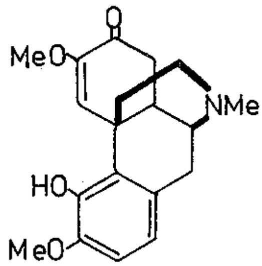
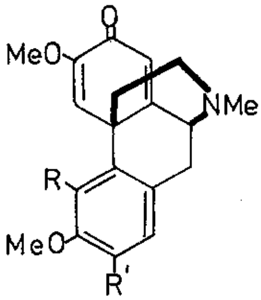


Fig. IX
Sinomenines
(Morphine group)

14-Episinomenine (IX_1) Ref. 141



Ocobotrine (IX_2) Ref. 141



Pallidine (R=H, R'=OH) (IX_3) Ref. 141,144

Sinoacutine (R=OH, R'=H) (IX_4) Ref. 34, 141

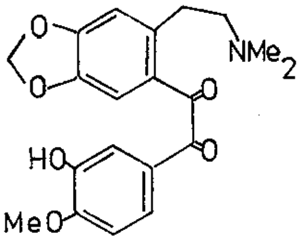


Fig. X. Cryptopleurospermine Ref. 53

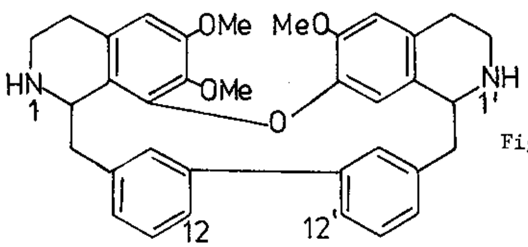
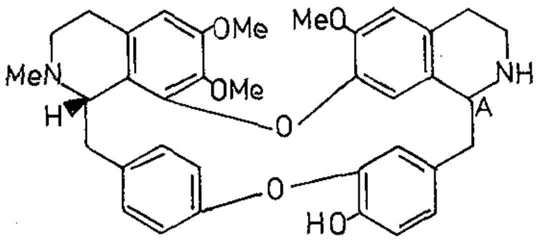


Fig. XI. Bisbenzylisoquinolines (head-to-head)

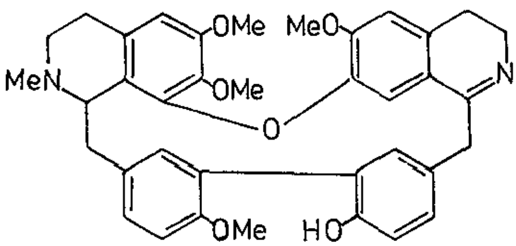
Alkaloid		Substituent positions 1	1'	12	12'	Ref.
Norrodiasine	(XI_1)	H(Me)	Me(H)	OMe	OH	121(126)
Ocotine	(XI_2)	Me	H	OMe	OH	126
Rodiasine	(XI_3)	Me	Me	OMe	OH	126,127



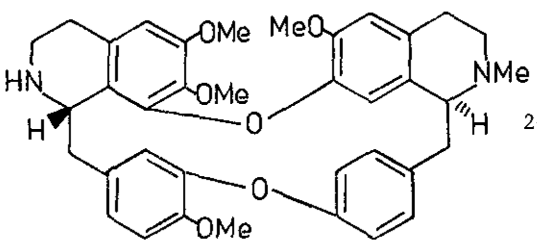
Ocoteamine (Sepeerine) (A=*R*)

(XI$_4$) Ref. 95

Demerarine (A=*S*) (XI$_5$) Ref. 95



Ocotosine (XI$_6$) Ref. 126



2-Nor-(+)-tetrandrine (XI$_7$)

Ref. 126

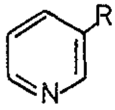
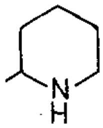
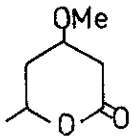
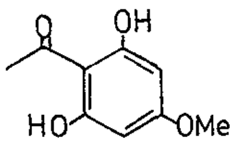


Fig. XII. Pyridines

Alkaloid			
Anabasine	(XII$_1$)	R = 	Ref. 21
Anibine	(XII$_2$)	R = 	Ref. 24
Duckeine	(XII$_3$)	R = 	Ref. 22

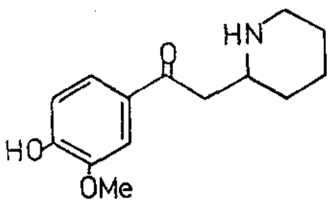


Fig. XIII. Sedamine type

Pleurospermine (XIII) Ref. 54,55,162.

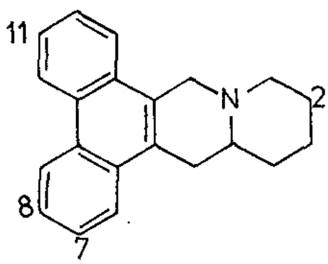


Fig. XIV. Phenanthroquinolizidines

Alkaloid		Substituent positions				
		2	7	8	11	Ref.
Cryptopleuridine	(XIV$_1$)	OH	$-OCH_2O-$		OMe	53
Cryptopleurine	(XIV$_2$)	-	OMe	OMe	OMe	54,142

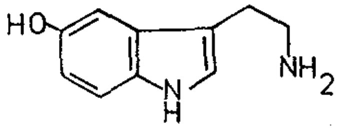


Fig. XV. Indole

Serotonine (5-Hydroxytryptamine) (XV) Ref. 130

Acknowledgements

We wish to thank Dr. Ryutaro Kishimoto for his kindness in translating some of the articles from Japanese. We are grateful also for the award of a Merle White Weaver Postgraduate Research Scholarship to one of us (W.S.).

4. Table 1

Occurrence in the Lauraceae of Alkaloid Types related to Isoquinoline. For comparison, other families containing one or more of the major alkaloid types are also shown.

	Aporphine	Benzyliso-quinoline	Bisbenzyliso-quinoline	Phenanthrene	Proaporphine	Morphine	Phenethylamine	Pavine	Dibenzo-pyrrocoline
Anonaceae	√	√	√	√					
Aristolochiaceae	√		√	√			√		
Berberidaceae	√	√	√				√		
Buxaceae			√						
Celastraceae	√						√		
Combretaceae		√	√				√		
Euphorbiaceae	√	√			√	√	√		
Eupomataceae	√								
Hernandiaceae	√	√	√				√		
Lauraceae	√	√	√	√	√	√	√	√	√
Liliaceae	√				√		√		
Magnoliaceae	√	√	√				√		
Menispermaceae	√	√	√	√	√	√			
Monimiaceae	√	√	√	√	√		√		
Myrisinaceae		√							
Nymphaceae	√	√	√		√				
Papaveraceae	√	√			√	√	√	√	
Ranunculaceae	√	√	√	√			√		
Rhamnaceae	√	√							
Rutaceae	√	√					√		
Symplocaceae	√								

5. Table 2

Alkaloids of the Lauraceae

Plant species	Alkaloids present	Formulae	Ref.
Actinodaphne ocutivena	laurolitsine	(IV_{26})	9
Actinodaphne hookeri Meissn.	actinodaphnine	(IV_1)	10,107
Actinodaphne nitida	boldine	(IV_5)	12
	laurolitsine	(IV_{26})	12
Actinodaphne obovata Bl.	actinodaphnine	(IV_1)	13
	laurotetanine	(IV_{27})	13
	N-methyllaurotetanine	(IV_{36})	13
Actinodaphne procera Nees	laurotetanine	(IV_{27})	14
Alseodaphne archboldiana (C.K. Allen) Kosterm.	(+), (-)-coclaurine	(IIa_2)	19
	(-)-N-norarmepavine	(IIa_5)	19
	(+)-reticuline	(IIa_7)	19
Aniba coto (Rusby) Kosterm.	anabasine	(XII_1)	21
Aniba duckeri	duckeine	(XII_3)	22
Aniba duckeri Kosterm.	anibine	(XII_2)	24
Aniba rosaeodora Ducke	anibine	(XII_2)	24
Beilschmiedia elliptica C.T. White	isoboldine	(IV_{22})	27
	laurelliptine	(IV_{25})	27
Beilschmiedia podagrica	(+)-2,11-dihydroxy-1,10-dimethoxyaporphine	(IV_{14})	28
	glaucine	(IV_{17})	28
	(+)-2-hydroxy-1,9,10-trimethoxynoraphorphine	(IV_{21})	28
	isoboldine	(IV_{22})	28
	laurelliptine	(IV_{25})	28
	predicentrine	(IV_{47})	28
Beilschmiedia tawa	isoboldine	(IV_{22})	30

Table 2 (continued)

Cassytha americana	actinodaphnine	(IV_1)	31
	bulbocapnine	(IV_6)	31
	cassamedine	(V_1)	31
	cassameridine	(V_2)	31
	cassyfiline (cassythine)	(IV_8)	31
	cassythicine	(IV_9)	31
	cassythidine	(IV_{10})	31
	dicentrine	(IV_{13})	31
	launobine	(IV_{24})	31
	N-methylactinodaphnine	(IV_{30})	31
	O-methylcassyfiline	(IV_{32})	31
	neolitsine	(IV_{39})	31
	nuciferine	(IV_{42})	31
Cassytha filiformis L.	cassyfiline (cassythine)	(IV_8)	35, 37
	cassythidine	(IV_{10})	35
	laurotetanine	(IV_{27})	36
	nantenine	(IV_{38})	33
	ocoteine (O,N-dimethylcassyfiline)	(IV_{46})	35,37
Cassytha glabella R.Br.	cassythicine	(IV_9)	39
Cassytha melantha R.Br.	actinodaphnine	(IV_1)	39
	cassythicine	(IV_9)	39
Cassytha pubescens R.Br.	domesticine	(IV_{16})	34
	isoboldine	(IV_{22})	34
	laurelliptine	(IV_{25})	34
	nantenine	(IV_{38})	34
	nordomesticine	(IV_{40})	34
	sinoacutine	(IX_4)	34
Cassytha racemosa	(+)-coclaurine	(IIa_2)	41
	1,2-dimethoxy-9,10-methylenedioxy-7-oxodibenzo (de,g)-quinoline	(V_4)	41
	isoboldine	(IV_{22})	41
	laurelliptine	(IV_{26})	41

Table 2 (continued)

Cassytha racemosa contd.	laurotetanine	(IV_{27})	41
	N-methyllaurotetanine	(IV_{36})	41
	nantenine	(IV_{38})	41
	nornantenine	(IV_{41})	41
Cinnamomum camphora (Linn.) Seib.	laurolitsine	(IV_{26})	88
	reticuline	(IIa_7)	88
Cinnamomum laubatii F. Muell.	(+)-reticuline	(IIa_7)	42
Cinnamomum sp.	cinnamolaurine	(IIa_1)	44
	(-)-cinnamolaurine	(IIa_1)	45
	(+)-corydine	(IV_{11})	45
	norcinnamolaurine	(IIa_6)	45
	(+)-reticuline	(IIa_7)	45
Cryptocarya alba	(+)-reticuline	(IIa_7)	46
Cryptocarya angulata C.T. White	3,4-dimethoxy-1-(dimethylaminoethyl)-phenanthrene (atherosperminine)	(VI)	47,134
	N-methylisocorydine	(IV_{35})	47
	roemerine	(IV_{48})	47
Cryptocarya bowiei Druce	cryptaustoline	($VIII_1$)	49
	cryptowoline	($VIII_2$)	49
Cryptocarya chinensis Hemsl.	(±),(-)-caryachine	(VII_1)	50
	crychine	(VII_2)	50,51
	(+)-O-methylcaryachine	(VII_3)	51
Cryptocarya konishii Hayata	(±)-coclaurine	(IIa_2)	51
	(±)-N-norarmepavine	(IIa_5)	51
	(-)-N-norarmepavine	(IIa_5)	51
	crykonisine	(IIb_1)	80
Cryptocarya odorata	cryptodorine	(IV_{12})	52
	isocorydine	(IV_{23})	52
	laurotetanine	(IV_{27})	52
	N-methyllaurotetanine	(IV_{36})	52
Cryptocarya pleurosperma White and Francis	cryptopleuridine	(XIV_1)	53
	cryptopleurine	(XIV_2)	54

Table 2 (continued)

Cryptocarya pleurosperma contd. White and Francis	cryptopleurospermine	(X)	53
	pleurospermine	(XIII)	55
Cryptocarya sp.	crykonisine	(IIb_1)	80
Cryptocarya tomentosa Blume	laurotetanine	(IV_{27})	135
Cryptocarya triplinervis R.Br.	N-methylisocorydine (menisperine)	(IV_{35})	47
Laurus nobilus L.	actinodaphnine	(IV_1)	57
	launobine	(IV_{24})	57
Lindera benzoin	laurotetanine	(IV_{27})	58
Lindera oldhamii	(+)-dicentrine	(IV_{13})	59
	dicentrinone	(V_3)	59
	O-methylbulbocapnine	(IV_{31})	59
	N-methylhernangerine (N-methylnandigerine)	(IV_{33})	59
	N-methylhernovine (N-methylovigerine)	(IV_{34})	59
Lindera pipericarpa Boerl	laurotetanine	(IV_{27})	68
	lindcarpine	(IV_{28})	60
Lindera strychnifolia (Sieb. et. Zucc.) F. Vill.	laurolitsine	(IV_{26})	61
Lindera umbellata	launobine	(IV_{24})	61
Litsea amara Blume	laurotetanine	(IV_{27})	62
Litsea chrysocoma Blume	laurotetanine	(IV_{27})	56
Litsea (Tetranthera) citrata Blume	laurotetanine	(IV_{27})	65
	N-methyllaurotetanine	(IV_{36})	64
Litsea cubeba Pers.	isocorydine	(IV_{23})	66
	laurotetanine	(IV_{27})	62,66
	(+)-magnocurarine	(IIa_4)	67
	N-methyllaurotetanine	(IV_{36})	66,67
Litsea deccanensis Gamble	actinodaphnine	(IV_1)	69
Litsea glutinosa (Lour.) C.B. Rob.	isoboldine	(IV_{22})	70
	laurelliptine	(IV_{25})	70

Table 2 (continued)

Litsea glutinosa contd. (Lour.) C.B. Rob.	laurolitsine	(IV_{26})	70
	laurotetanine	(IV_{27})	70
	liriodenine	(V_5)	70
Litsea glutinosa var. glabraria Hook	actinodaphnine	(IV_1)	72
	boldine	(IV_5)	72
	laurolitsine (norboldine)	(IV_{26})	72
	laurotetanine	(IV_{27})	72
	N-methylactinodaphnine	(IV_{30})	72
	N-methyllaurotetanine	(IV_{36})	72
Litsea hayatae	laurolitsine	(IV_{26})	9
	liriodenine (oxoushinsunine)	(V_5)	9
	ushinsunine	(IV_{49})	9
Litsea intermedia Boerl	laurotetanine	(IV_{27})	62
Litsea japonica Mirb.	laurolitsine	(IV_{26})	74
Litsea javanica Blume	laurotetanine	(IV_{27})	62
Litsea lancifolia Villar	laurotetanine	(IV_{27})	62
Litsea latifolia Blume	laurotetanine	(IV_{27})	65
Litsea leefeana	boldine	(IV_5)	75
	laurolitsine	(IV_{26})	75
	(+)-reticuline	(IIa_7)	75
Litsea lucida Blume	laurotetanine	(IV_{27})	62
Litsea nitida Roxb.	actinodaphnine	(IV_1)	76
	dicentrine	(IV_{13})	76
	litsedine	(IV_{29})	76
Litsea sebifera Pers.	actinodaphnine	(IV_1)	13
	boldine	(IV_5)	13
	laurotetanine	(IV_{27})	13
	N-methyllaurotetanine	(IV_{36})	13
Litsea solomensis Allen	laurolitsine	(IV_{26})	70
	reticuline	(IIa_7)	70

Table 2 (continued)

Litsea sp. (*Tetranthera intermedia* Blume)	laurotetanine	(IV_{27})	70
Litsea sp.	actinodaphnine	(IV_1)	69
	(+)-coclaurine	(IIa_2)	69,70
	(+)-isocorydine	(IV_{23})	66
	laurolitsine	(IV_{26})	70,74
	laurotetanine	(IV_{27})	70,77
	(-)-magnocurarine	(IIa_4)	67
	reticuline	(IIa_7)	70
Litsea turfosa	boldine	(IV_5)	78
	laurolitsine (norboldine)	(IV_{26})	78
Litsea wightiana Hook f.	boldine	(IV_5)	13
	laurolitsine (norboldine)	(IV_{26})	13
Litsea zeylanica	(+)-isoboldine	(IV_{22})	79
	(+)-N-norisoboldine	(IV_{25})	79
	(+)-reticuline	(IIa_7)	79
Machilus acuminatissima (Hay.) Kanehira	(±)-coclaurine (machiline)	(IIa_2)	80
	crykonisine	(IIb_1)	80
	(±)-N-norarmepavine	(IIa_5)	80
	(-)-N-norarmepavine	(IIa_5)	80
Machilus arisanensis Hayata.	(+)-laudanidine	(IIa_3)	81
	(±)-(-)-N-norarmepavine	(IIa_5)	81
	(-)-N-norarmepavine	(IIa_5)	81
Machilus kusanoi Hayata	coclaurine	(IIa_2)	82
	(-)-N-norarmepavine	(IIa_5)	82
Machilus macrantha Blume	(±)-coclaurine (machiline)	(IIa_2)	84
Machilus macrantha Nees.	(±)-coclaurine	(IIa_2)	86
Machilus obovatifolia (Hayata) Kanehira and Sasaki	(+)-laudanidine	(IIa_3)	81
	(±)-N-norarmepavine	(IIa_5)	81
	(-)-N-norarmepavine	(IIa_5)	81
Machilus pseudolongifolia Hayata	(±)-N-norarmepavine	(IIa_5)	85
	(-)-N-norarmepavine	(IIa_5)	85

Table 2 (continued)

Machilus thunbergii Sieb. and Zucc.	(±)-N-norarmepavine	(IIa_5)	81,87
	(-)-N-norarmepavine	(IIa_5)	87
	reticuline	(IIa_7)	87
Machilus zuihoensis Hayata	(±)-N-norarmepavine	(IIa_5)	81
	(-)-N-norarmepavine	(IIa_5)	81
Nectandra pichurim (H.B.K.) Mez. (*Ocotea pichurim* H.B.K.)	isoboldine	(IV_{22})	90
Nectandra rodioei Hook	ocotine	(XI_2)	93
	rodiasine	(XI_3)	93
	sepeerine	(XI_4)	93
Nectandra saligna (Nees et Mart.) Nees	dehydroocoteine	(IV_{54})	94
	ocoteine	(IV_{46})	94
Neolitsea acuminatissima Kanehira and Sasaki	(+)-laurotetanine	(IV_{27})	98
Neolitsea pubescens	boldine	(IV_5)	105
	laurolitsine	(IV_{26})	105
	N-methyllaurotetanine	(IV_{36})	105
	roemerine	(IV_{48})	105
Neolitsea pulchella	neolitsine	(IV_{39})	103
Neolitsea sericea (Blume) Koidzumi	actinodaphnine	(IV_1)	98
	anonaine	(IV_2)	98
	boldine	(IV_5)	98
	laurolitsine	(IV_{26})	101
	laurotetanine	(IV_{27})	98,101
	liriodenine (oxoushinsunine)	(V_5)	98
	litsericine	($IIIb_1$)	98,101
	N-methylactinodaphnine	(IV_{30})	98,101
	N-methyllaurotetanine	(IV_{36})	98,101
	nuciferine	(IV_{42})	98,101
	roemerine	(IV_{48})	98,101
	(-)-roemerine	(IV_{48})	100
Neolitsea variabillima	(-)-hernovine	(IV_{18})	104
	(-)-N-methylhernovine	(IV_{34})	104
	(-)-nandigerine	(IV_{37})	104

Table 2 (continued)

Notaphoebe konishii Hayata	(±)-N-norarmepavine	(IIa_5)	106
	(-)-N-norarmepavine	(IIa_5)	106
	(-)-laudanidine	(IIa_3)	106
Notaphoebe sp.	actinodaphnine	(IV_1)	107
Notaphoebe umbelliflora Blume	laurotetanine	(IV_{27})	108
Ocotea brachybotra (Meiss.) Mez.	14-episinomenine	(IX_1)	141
	ocobotrine	(IX_2)	141
	pallidine	(IX_2)	141
	sinoacutine	(IX_4)	141
Ocotea glaziovii	glaziovine	($IIIa_2$)	112
Ocotea glaziovii Mez.	(±)-apoglaziovine	(IV_3)	110
	asimilobine	(IV_4)	110
	caaverine	(IV_7)	110
	(±)-crotsparine	($IIIa_1$)	110
	1,10-dihydroxy-2-methoxyaporphine	(IV_{15})	109
	(±)-glaziovine	($IIIa_2$)	109
	(±)-1-hydroxy-2-methoxyaporphine	(IV_{19})	110
	isoboldine	(IV_{22})	110
	(-)-pronuciferine	($IIIa_3$)	110
Ocotea glaziovis (?)	glaziovine	($IIIa_2$)	113
Ocotea leucoxylon	dicentrine	(IV_{13})	18
Ocotea macrophylla	dehydroantenine	(IV_{52})	123
	(+)-glaucine	(IV_{17})	123
	(+)-isocorydine	(IV_{23})	123
	1-(p-methoxybenzyl)-6,7-dimethoxyisoquinoline	(IIb_2)	123
	1-(p-methoxybenzyl)-6,7-methylenedioxy-isoquinoline	(IIb_3)	123
	(+)-nantenine	(IV_{38})	123
Ocotea macropoda	dehydrodicentrine	(IV_{51})	114,116
	dehydroocopodine	(IV_{53})	114
	dicentrine	(IV_{13})	114,116
	dicentrinone	(V_3)	114

Table 2 (continued)

Ocotea macropoda contd.	*ocopodine*	*(IV_{45})*	*114,116*
	predicentrine	*(IV_{47})*	*114,115*
Ocotea puberula (Nees et Mart.) Nees	*dehydroocoteine*	*(IV_{54})*	*117*
	didehydroocoteine	*(IV_{55})*	*117*
	ocoteine	*(IV_{46})*	*118,125*
	thalicminine	*(V_6)*	*118*
Ocotea rodiaei (Nectandra rodioei)	*demerarine*	*(XI_5)*	*121*
	norrodiasine	*(XI_1)*	*121*
	2-(+)-nortetrandrine	*(XI_7)*	*126*
	ocoteamine (sepeerine)	*(XI_4)*	*121,122*
	ocotine	*(XI_2)*	*122,126*
	ocotosine	*(XI_6)*	*126*
	rodiasine	*(XI_3)*	*120,121, 126*
Ocotea sp.	*isocorydine*	*(IV_{23})*	*116*
	1-(p-methoxybenzyl)-6,7-dimethoxyisoquinoline	*(IIb_2)*	*123*
	1-(p-methoxybenzyl)-6,7-methylenedioxyisoquinoline	*(IIb_3)*	*123*
	ocokryptine	*(IV_{43})*	*116*
	oconovine	*(IV_{44})*	*116*
Ocotea variabilis	*(+)-apoglaziovine*	*(IV_3)*	*128*
	(+)-glaziovine	*($IIIa_2$)*	*128*
	(+)-nantenine	*(IV_{38})*	*128*
	variabiline	*(IV_{50})*	*128*
Ocotea venenosa	*rodiasine*	*(XI_3)*	*129*
Persea gratissima Gaertn. f.	*dopamine (hydroxytyramine)*	*(I_1)*	*130*
	serotonine (5-hydroxytryptamine)	*(XV)*	*130*
Persea sp.	*dopamine*	*(I_1)*	*130*
	serotonine	*(XV)*	*130*
	tyramine	*(I_2)*	*130*
Phobe clemensii C.K. Allen	*2,11-dihydroxy-1,10-dimethoxyaporphine*	*(IV_{14})*	*37*

Table 2 (continued)

Phobe clemensii C.K. Allen contd.	10-hydroxy-1,2-(methylene-dioxy)-aporphine	(IV_{20})	37
	isocorydine	(IV_{23})	37
	laurolitsine	(IV_{26})	37
Phobe formosana Hay.	laurolitsine	(IV_{26})	132
	liriodenine (oxoushinsunine)	(V_5)	132
	roemerine	(IV_{48})	132
	ushinsunine	(IV_{49})	132
Phobe porfiria	ocoteine	(IV_{46})	94
Ravensara aromatica	N-methylisocorydine (menisperine)	(IV_{35})	133

6. Table 3

Number of occurrences of each alkaloid group by genus

Genus (no. of species examined)		Phenethylamine I	Benzylisoquinoline II	Proaporphine III	Aporphine IV	Oxaporphine V	Phenanthrene VI	Pavine VII	Dibenzopyrrocoline VIII	Sinomenine IX	Cryptopleurospermine X	Bisbenzylisoquinoline XI	Pyrridine XII	Sedamine XIII	Phenanthroquinolizidine XIV	Indole XV
Actinodaphne	(5)				8											
Alseodaphne	(1)		3													
Aniba	(4)												4			
Beilschmiedia	(3)				9											
Cassytha	(6)		1		30	3				1						
Cinnamomum	(3)		6		2											
Cryotocarya	(10)		6		8		1	3	2		1			1	2	
Laurus	(1)				2											
Lindera	(5)				9	1										
Litsea	(23)		7		47	2										
Machilus	(9)		21													
Nectandra	(3)				3							3				
Neolitsea	(5)			1	19	1										
Notaphoebe	(3)		3		2											
Ocotea	(12)		4	6	25	2				4		8				
Persea	(2)														2	
Phobe	(3)				8	1										
Ravensara	(1)				1											

7. Uncharacterised and Partly Characterised Alkaloids

In addition to the alkaloids shown in Figs. I-XV, the following incompletely characterised bases have been described:

Actinodaphne montana Gamble[11]. Uncharacterised bases.

Actinodaphne sesquipedalis Hook f. and Thoms[15]. Uncharacterised bases.

Actinodaphne sp.[17]. Uncharacterised bases.

Andrographis paniculata Nees[15]. Uncharacterised bases.

Beilschmiedia bancroftii J.F. Bailey and C.T. White[25,26]. Uncharacterised bases.

Beilschmiedia obtus folia (?) Benth[25]. Uncharacterised bases.

Cassytha filiformis L[38]. Uncharacterised bases.

Cassytha pomiformis Nees[40]. 0.04% of crude alkaloids.

Cassytha spp.[25]. Uncharacterised bases.

Cinnamomum laubatii F. Muell.[25]. Uncharacterised bases.

Cinnamomum mercadoi Vidal.[43]. Uncharacterised bases.

Cinnamomum oliveri F.M. Bailey[25,26]. Uncharacterised bases.

Cryptocarya angulata C.T. White[26]. Uncharacterised bases.

Cryptocarya australis Benth[25]. Uncharacterised bases.

Cryptocarpine[48], needles, insoluble in water, soluble in alcohol, chloroform, ether, dilute acids.

Cryptocarya chinensis Hemsl.[50]. Base A, m.p. 210-211°; base C, picrate, yellow-orange needles, m.p. 164-168°.

Cryptocarya cinnamomifolia Benth.[25,26]. Uncharacterised bases.

Cryptocarya erythroxylon Maiden and Betche[25,26]. Uncharacterised bases.

Cryptocarya foveolata C.T. White[26]. Uncharacterised bases.

Cryptocarya glaucescens R.Br.[25]. Uncharacterised bases.

Uncharacterised and Partly Characterised Alkaloids continued.

Cryptocarya hypospodia F. Muell. (*C. obovata var. tropica*)[26]. Uncharacterised bases.

Cryptocarya konishii Hayata[51]. Base IV, small greyish-brown crystals (MeOH), m.p. 234-235°.

Cryptocarya mackinnoniana F. Muell[26]. Uncharacterised bases.

Cryptocarya meissneri F. Muell.[26]. Uncharacterised bases.

Cryptocarya obovata R. Br.[26]. Uncharacterised bases.

Cryptocarya pleurosperma C.T. White[25]. Uncharacterised bases.

Cryptocarya sp. nor. aff. *hypospodia*[26]. Uncharacterised bases.

Cryptocarya sp.[17]. Uncharacterised bases.

Dehaasia firma Java[65]. Uncharacterised bases.

Dehaasia incrassata (Jack) Kosterm[11]. Uncharacterised bases.

Dehaasia squarrosa Java[56]. Uncharacterised bases.

Endiandra glauca R.Br.[25]. Uncharacterised bases.

Endiandra palmerstonii C.T. White[25]. Uncharacterised bases.

Endiandra pubens Meissn.[26]. Uncharacterised bases.

Endiandra sieberi Nees.[25]. Uncharacterised bases.

Endiandra tooram (?) F.M. Bailey[26]. Uncharacterised bases.

Lindera pipericarpa Boerl[15]. Uncharacterised bases.

Lindera spathacea Gamble *tomentosa*[15]. Uncharacterised bases.

Litsea cubeba Pers.[15]. Uncharacterised bases.

Litsea dealbata Nees[25]. Uncharacterised bases.

Litsea glutinosa (Lour.) C.B. Rob (*L. chinensis* Lam.)[26]. Uncharacterised bases.

Litsea leefeana (*L. ferruginea* Blume)[26]. Uncharacterised bases.

Litsea reticulata (Benth and Hook f.)[25]. Uncharacterised bases.

Litsea spathacea Gamble[11,15]. Uncharacterised bases.

Uncharacterised and Partly Characterised Alkaloids continued.

Machilus acuminatissima (Hay.) Kanehira[80]. Unknown base, m.p. 254-255°.

Machilus macrantha[83]. Macranthine, crystalline hydrochloride m.p. 242-243°, $C_{13}H_{17}O_3N.HCl$, with a phenolic OH and an OCH_3 group.

Machilus obovatifolia (Hayata) Kanchira and Sasaki[81]. Unknown base. m.p. 258-259°.

Machilus pseudolongifolia Hayata[85]. Non-phenolic base, oxalate, m.p. 188-189°.

Machilus zuihoensis Hayata[81]. Unknown base, m.p. 258-259°.

Nectandra coto Rusby[97]. Parostemine (non-phenolic); parostemine (phenolic).

Neolitsea sericea (Blume) Koidzumi[101]. Base III, phenolic, m.p. 133°, $C_{19}H_{19}O_4,N$ $[\alpha]_D^{23}$ + 42.9°, with NCH_3, OCH_3, O_2CH_2 and phenolic OH groups; picrate m.p. 218-220°. Base V, hydrochloride, $C_{19}H_{17}O_4N.HCl$, m.p. 266°. Water-soluble bases:

Base VII - styphnate, $C_6H_{14(16)}ON.C_6H_2O_8N_3$, m.p. 165°.

Base VIII - styphnate, $C_9H_{18}ON.C_6H_2O_8N_3$, m.p. 182-183°.

Base IX - styphnate (choline styphnate), $C_5H_{14}ON.C_6H_2O_8N_3$, m.p. 203°.

Neolitsea pulchella[103]. Neolitsinine ($C_{18}H_{23}O_3N$), one OMe and one NMe group, two active Hs., one phenolic and one non-phenolic OH, m.p. 214-215°, $[\alpha]_D$ + 94.7°. Pulchelline ($C_{18}H_{23}O_3N$), one phenolic and one non-phenolic OH, m.p. 189°, $[\alpha]_D$ + 80.1°.

Neolitsea zeylanica (*Litsea zeylanica* C and T. Nees) Merrill[26]. Uncharacterised bases.

Notaphoebe konishii Hayata[106]. Unknown base, D, m.p. 180-181°. Unknown base E, m.p. 254-255°.

Notaphoebe pandiriformis Gamble[11]. Uncharacterised bases.

Uncharacterised and Partly Characterised Alkaloids continued.

Ocotea leucoxylon[18]. Leucoxine, $C_{20}H_{21}O_5N$, m.p. 213-217°, $[\alpha]_D^{23}$ + 81°, two OMe and an O_2CH_2 group. Leucoxylonine, $C_{22}H_{25}O_6N$, m.p. 54-58°, $[\alpha]_D^{24}$ + 52°, four OMe and an O_2CH_2 group.

Ocotea rodiaei[95]. Dirosine has a bisbenzylisoquinoline structure with one diphenyl ether linkage. Otocamine and ocodemerine have bisbenzylisoquinoline structures with two diphenyl ether linkages.

Ocotea rodioei[122]. Unknown base, insoluble methiodide, $C_{36}H_{38}N_2O_6.2CH_3I$, colourless cubes from MeOH, decomp. above 280°.

Ocotea sp.[124]. Uncharacterised bases.

Ocotea venenosa[129]. Demethylrodiasine is a bisbenzylisoquinoline alkaloid related to d-tubocurarine.

Phobe macrophylla Blume[11]. Uncharacterised bases.

Phobe opaca Blume[15]. Uncharacterised bases.

Phobe sp.[56]. Uncharacterised bases.

Sassafras albidum Nees[38]. Uncharacterised bases.

Stemmatodaphne perakensis Gamble[11,15]. Uncharacterised bases.

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