

STRUCTURE AND BIOLOGICAL ACTIVITY OF THE FURAN-DITERPENOID FROM THE GENERA *LENOTIS* AND *LEONURUS*

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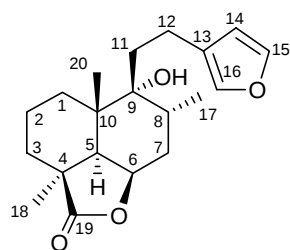
Abstract – The present review, covering the literature up to 2006, reports the chemistry and the biological activities of the diterpenoids occurring in the aerial parts of species belonging to the genera *Leonotis* and *Leonurus*, family Lamiaceae.

Leonotis and *Leonurus*, family Lamiaceae (Labiatae), tribe Stachyoideae, are two small genera, including about forty and eighty species respectively.¹

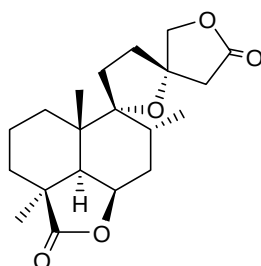
During the last sixty years, several species were investigated for the search of diterpenoids. The present review is an updated report on the researches on this class of natural products isolated from these genera. Concerning the genus *Leonotis*, it occurs in the tropical belt: Caribbean Islands, South America, India, Africa (specially South Africa). Indeed, a large contribution to the investigations on this genus was given by SouthAfrican researchers.

The first results on the chemistry of the diterpenes from the genus *Leonotis* appeared in 1962:² two products were isolated from the aerial parts of *Leonotis leonurus* R. Br. collected in South Africa and provisionally indicated as compound X and compound Y. Two years later the extraction of the same species yielded³ the well known marrubiin, previously isolated from *Marrubium vulgare* L. and whose labdanic structure **1** had been elucidated just in those years after one century of investigations. The compounds X and Y were isolated again, and their structures were elucidated some years later⁴ as **2** and **3** respectively: the labdane skeleton and some details of the functional groups clearly indicate that they are closely related to marrubiin, and are new natural products.

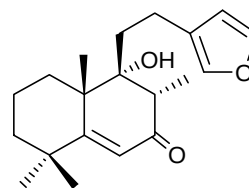
The structure **2** of compound X was also confirmed by X-ray analysis.⁵ In a paper concerning diterpenoids from a *Solidago* (Compositae),⁶ the structure of compound Y was proved to be correct by formal total synthesis starting by a derivative of marrubiin.



1 marrubiin



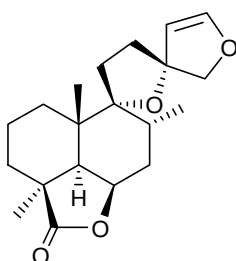
2 compound X



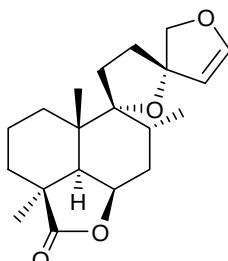
3 compound Y

Some years after, the two stereoisomeric premarrubiins (**4**) (13*R*) and (**5**) (13*S*) were also isolated⁷ from the same species on a sample collected in Italy: no other diterpenes were detected.

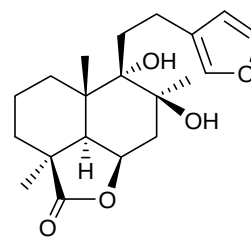
A species particularly rich in diterpenoids is *Leonotis nepetaefolia* R. Br. In 1969 a new product, leonotin, was isolated⁸ and proved to have the structure **6** of 8β-hydroxy-marrubiin. The same substance was found in *Leonotis leonitis* R. Br.⁹ and in *Leonotis dysophylla* Benth.¹⁰



4 13*R*-premarrubiin

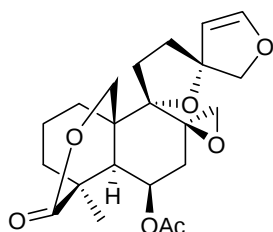


5 13*S*-premarrubiin

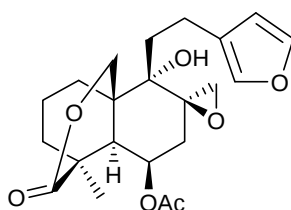


6 leonotin

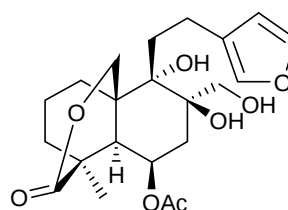
Continuing the investigations on *Leonotis nepetaefolia*, other diterpenoids were found. Nepetaefolin (**7**) is a new prefuranic compound, characterized by the occurrence of an 8,17-epoxide and a 18,20-lactone.^{11,12} Its structure was confirmed by X-ray analysis¹³ In the previous paper¹² two new products were reported, nepetaefuran (**8**) and nepetaefuranol (**9**). The former is the product of furanization of nepetaefolin, whereas in the latter the 8,17-epoxide has changed into a 8β,17-diol.



7 nepetaefolin



8 nepetaefuran

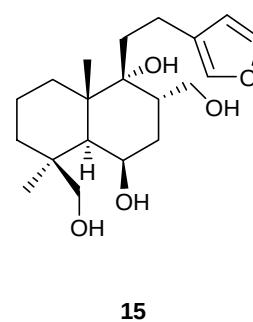
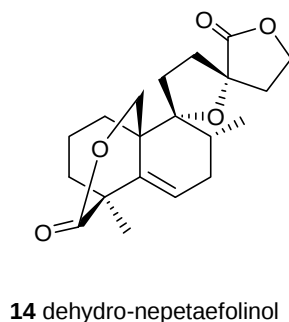
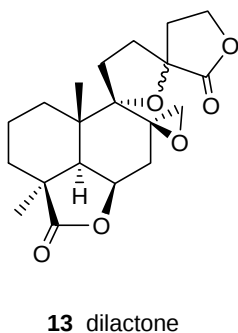
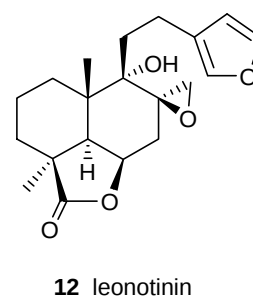
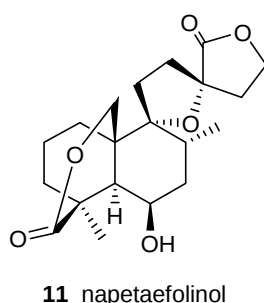
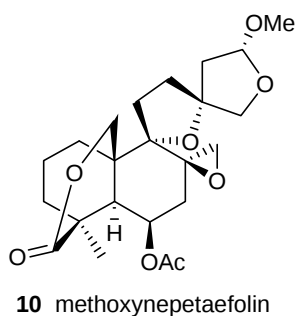


9 nepetaefuranol

Always from *Leonotis nepetaefolia* another compound was isolated,¹⁴ methoxynepetaefolin (**10**): it is the product of formal addition of MeOH on the 14,15 double bond of nepetaefolin; its structure was confirmed by X-ray crystallographic analysis.¹⁵

Three more diterpenoids were found¹⁶ in *Leonotis nepetaefolia*: nepetaefolinol (**11**), leonotinin (**12**) and the dilactone (**13**); the last two products show the 19,20-lactone group. Also the structure of nepetaefolinol was confirmed by X-ray analysis.¹⁵

Many years after, a paper¹⁷ reported further investigations on *L. nepetaefolia*: besides the already known nepetaefolinol (**11**), two more natural diterpenoids were isolated. The first is the product of dehydration of nepetaefolinol, resulting in the forming of a 5,6 double bond (dehydronepetaefolinol, **14**), the last is a furanic tetrol (**15**) (no trivial name given) indicated as 15,16-epoxy-labda-13(16),14-diene-6 β ,9,17,19-tetrol, arising from the reduction of leonotinin (**12**). The structures were established by X-ray analysis.



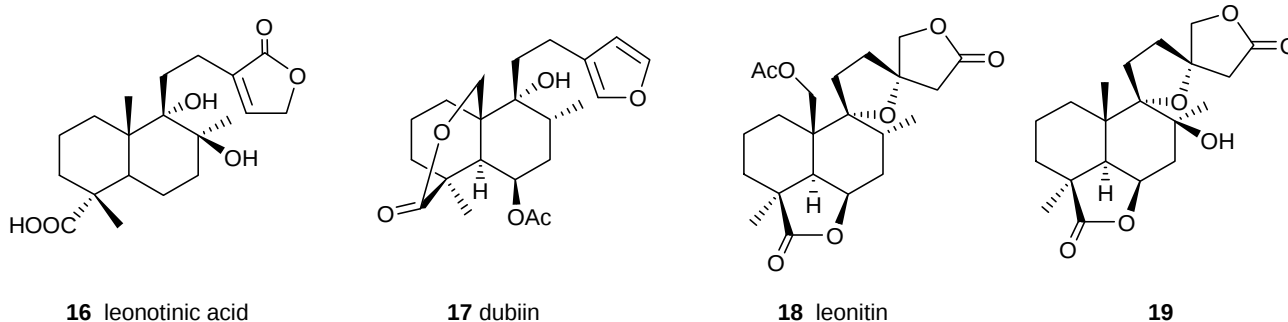
The most recent study on *Leonotis nepetaefolia*¹⁸ led to isolation of a new labdane diterpene, leonotinic acid (**16**). The 4 α equatorial carboxyl group is quite unusual.

Another species, *Leonotis dubia* E. Mey, now classified as *L. ocymifolia* var. *ocymifolia*, yielded¹⁹ the furolabdane dubiin (**17**): characteristics are the 9 α -hydroxy group and the 19,20-lactone. The structure and absolute stereochemistry were confirmed²⁰ by X-ray and CD determinations.

The species *Leonotis leonitis* R. Br. contained²¹ the dilactone leonitin (**18**), in which the occurrence of the 20-acetoxy group is remarkable. The product is quite similar to product X (**2**), from which differs for

having the carbon atom 20 as a CH_2OAc group instead of CH_3 . The complete stereochemistry of leonitin as **18** was ascertained by X-ray analysis.²² The occurrence also of leonotin (**6**) in this species had been signalled in an old communication.⁹

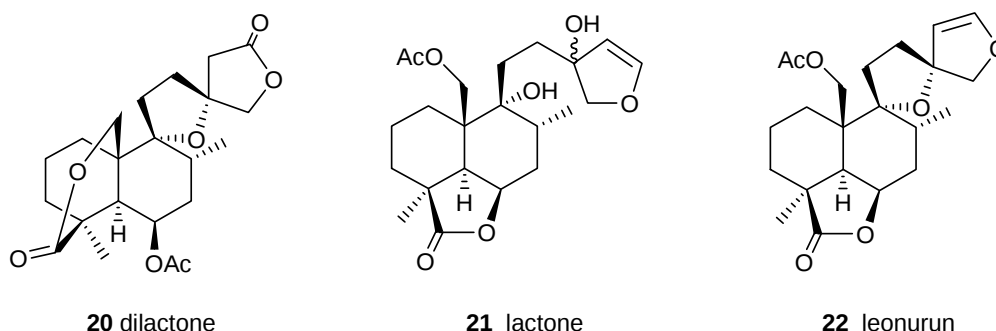
From the species *Leonotis leonitis* var. *hirtiflora* (Benth.) Skan another diterpenoid was isolated²³ and elucidated as $9\alpha,13(S)$ -epoxy- 8β -hydroxylabdane- $6\beta,19;16,15$ -diolide (**19**) (no trivial name given).



Finally, from the species *Leonotis ocymifolia* (Burm. f) Iwarsson var. *raineriana* (Visiani) Iwarsson four products were isolated:²⁴ the already known leonitin (**18**) and compound X (**2**), and two new diterpenic natural products. The first is the dilactone (**20**), 6β -acetoxy- $9\alpha,13\alpha$ -epoxylabda- $20(19),16(15)$ -diol-dilactone. The second was assigned the structure **21**, 20 -acetoxy- $9\alpha,13$ -dihydroxy- $15(16)$ -epoxylabd- 14 -en- $6\beta(19)$ -lactone (no trivial names given to both products).

A recent paper²⁵ re-examined the same plant and showed the occurrence of leonotin (**6**), leonotinin (**12**) and nepetaefolin (**7**). The paper reported also the complete NMR data of these three diterpenoids and of six related diterpenoidic compounds.

Several informations on the researches in progress in 1983 had been reviewed by Rivett in a lecture.²⁶ Quite recently,²⁷ from a new sample of *Leonotis leonurus* a new labdane diterpenoid, leonurun (**22**) was isolated in South Africa. Its structure differs from $13R$ -premarrubiin **4** only for having C-20 as $\text{CH}_2\text{-O-CO-CH}_3$ instead as CH_3 .

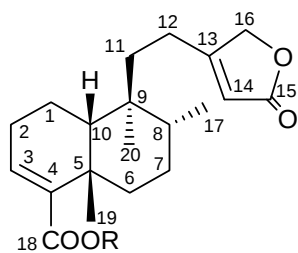


In total, from the genus *Leonotis* 22 diterpenoids have been isolated: of them, 19 are new natural products whereas three (**1**, **4**, **5**) were already known as occurring in *Marrubium vulgare* L. The labdane skeleton is present in all these diterpenoids, and is therefore a marker of the genus. The fourth isoprenic unit is always in the form of an oxygenated pentatomic ring, as a furan, prefuran, saturated or unsaturated γ -lactone system. The occurrence of 19,6 or 18,20 lactones is frequent (nineteen out of twenty-two). It is remarkable that only few species of the genus have been investigated.

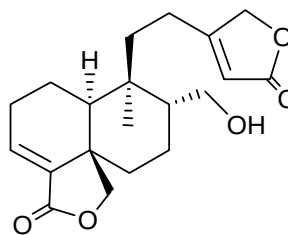
The genus *Leonurus* is widespread in Eurasia, from Western Europe to China.

The first paper on the chemistry of terpenoids from this genus was published in 1972: it reported the occurrence of several products, probably bicyclic diterpenoids with furan and lactone groups²⁸ in *Leonurus cardiaca* L. Their structures were not identified.

In 1973 a paper reported²⁹ the isolation of two new products from *Leonurus marrubiastrum* L., marrubiaside and marrubialactone. Their structures were elucidated by classical chemical degradation and spectroscopic investigations. Marrubiaside (**23**) is the β -D-glucopyranosyl derivative of the aglycone marrubiagenin (**24**): the last was obtained by acid or enzymatic hydrolysis. Marrubialactone is represented by structure **25**. Both products show an oxidized furan ring forming an unsaturated γ -lactone system. Such structures are worthy of an important remark: whereas all the diterpenoids occurring in *Leonotis* do show a labdane backbone, on the contrary, these two products isolated from *Leonurus marrubiastrum* have a labdane-rearranged skeleton; this result indicates a certain difference from the quite similar *Leonotis* genus; moreover, the occurrence of a glycosidic product is rather rare in these genera.



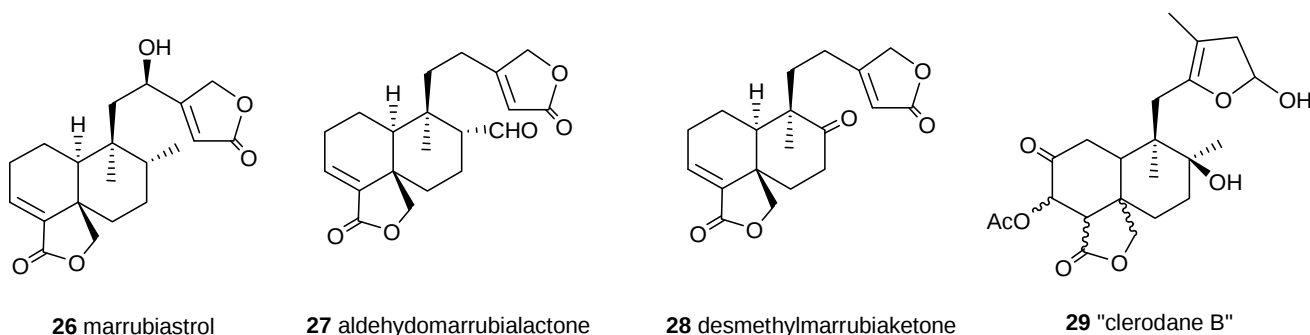
23 R = β -D-Glu marrubiaside
24 R = H marrubiagenin



25 marrubialactone

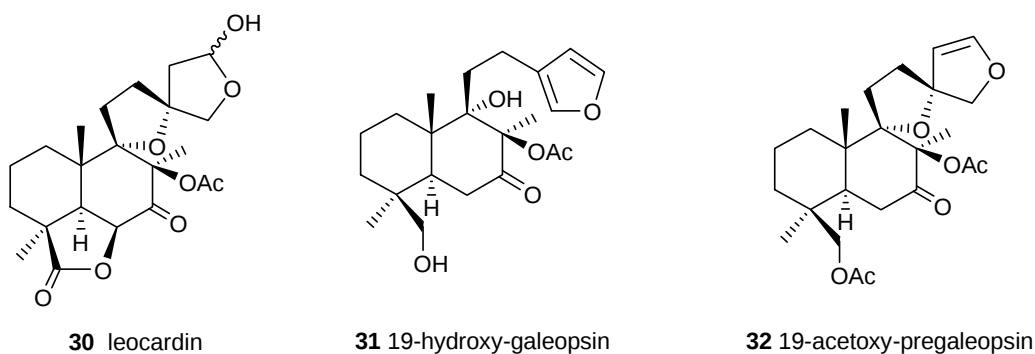
Five years later, a reinvestigation of *Leonurus marrubiastrum* led to the isolation of three new products, again with the rearranged labdane skeleton:³⁰ marrubiastrol (**26**), aldehydo-marrubialactone (**27**) and desmethyilmarrubiaketone (**28**). Also in these products the oxidized furan ring occurs. The norditerpene (**28**) is also remarkable for the loss of C-17. In the original paper the indication of some carbon atoms is different from the usual numbering.

The investigation of *Leonurus cardiaca* L. was taken again³¹ by the first group: one of the products previously isolated²⁸ was identified as a new derivative, indicated as “clerodane B”, and formed by a mixture of two epimers, maybe at C-4 and C-5. In the provisional structure **29** the configurations at C-3, C-4 and C-5 were not elucidated; no other papers on this substance appeared later.



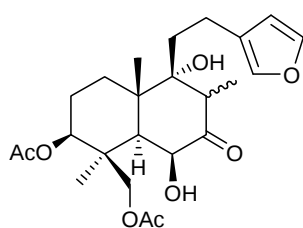
Some years after, other authors³² reported the isolation of leocardin, an epimeric mixture at C-15, from *Leonurus cardiaca*: the structure **30** was firmly ascertained. No other products were found. It is very interesting to note that leocardin has the labdane skeleton.

Only many years after, a new labdane diterpenoid, 19-hydroxygaleopsin (**31**) was found in *Leonurus cardiaca*.³³ A labdane prefuranic compound, 19-acetoxypregaleopsin (**32**) was isolated from the same species.³⁴

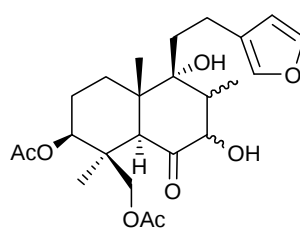


Another species, *Leonurus sibiricus* L., yielded three new labdane derivatives:³⁵ leosibirin (**33**), isoleosibirin (**34**) and leosibiricin (**35**). The first and second product have the typical furano-labdanic structure, while the third is a prefuranic derivative.

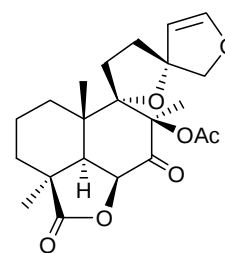
A paper³⁶ concerning the accumulation of furanic labdanes in *Leonurus cardiaca* in different stages of its growth reported the occurrence of leosibiricin (**35**) as the major component of the diterpenic fraction: this labdane had been previously isolated from *Leonurus sibiricus*.³⁵ The same paper³⁶ proved that the labdanes occur only in the aerial part of the plant. Further investigations are desirable to ascertain which diterpenoids really occur in the samples of *L. cardiaca* collected in different geographical areas.^{28, 31-34, 36}



33 leosibirin



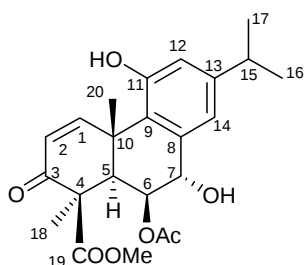
34 isoleosibirin



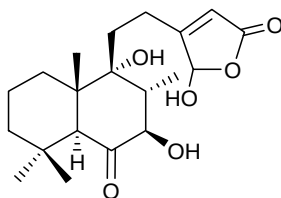
35 leosibiricin

Coming back to *Leonurus marrubiastrum*, a more recent paper³⁷ reported the isolation of an abietane diterpenoid, leonubiastrin (**36**). The occurrence of another skeleton, quite different from labdane and rearranged labdane, is rather singular and could put some questions about the taxonomy of the genus *Leonurus*.

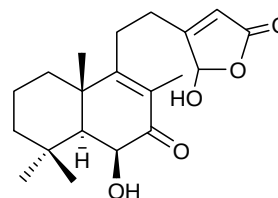
Quite recently, seven new labdane diterpenes were isolated³⁸ from *Leonurus sibiricus*: sibiricinone A (**37**), sibiricinone B (**38**), sibiricinone C (**39**), sibiricinone D (**40**), sibiricinone E (**41**), 15-*epi*-sibiricinone D (**42**) and 15-*epi*-sibiricinone E (**43**). In all the products the oxidized furanic system occur. It is remarkable that products **39**, **40**, **41**, **42**, **43** have a 15-OCH₃ substituent; **40** and **41** are a C-15 epimeric pair with 13*R* configuration, while **42** and **43** are a C-15 epimeric pair with 13*S* configuration.



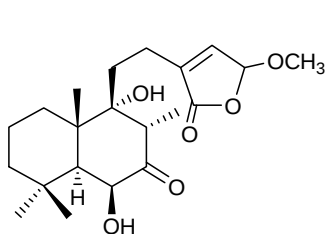
36 leonubiastrin



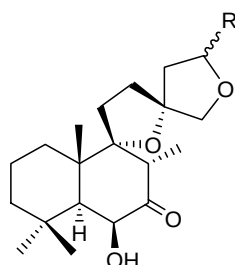
37 sibiricinone A



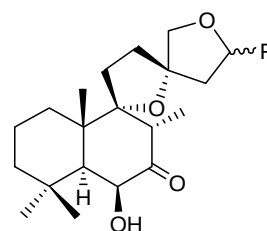
38 sibiricinone B



39 sibiricinone C



40 R = α OCH₃ sibiricinone D
41 R = β OCH₃ *epi*-sibiricinone D

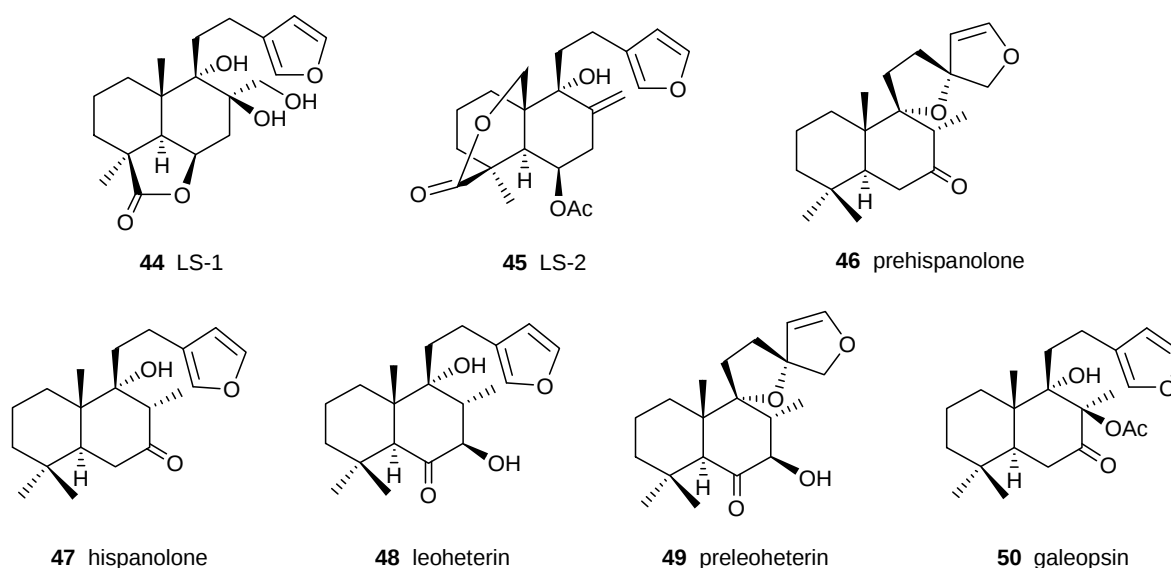


42 R = α OCH₃ sibiricinone E
43 R = β OCH₃ *epi*-sibiricinone E

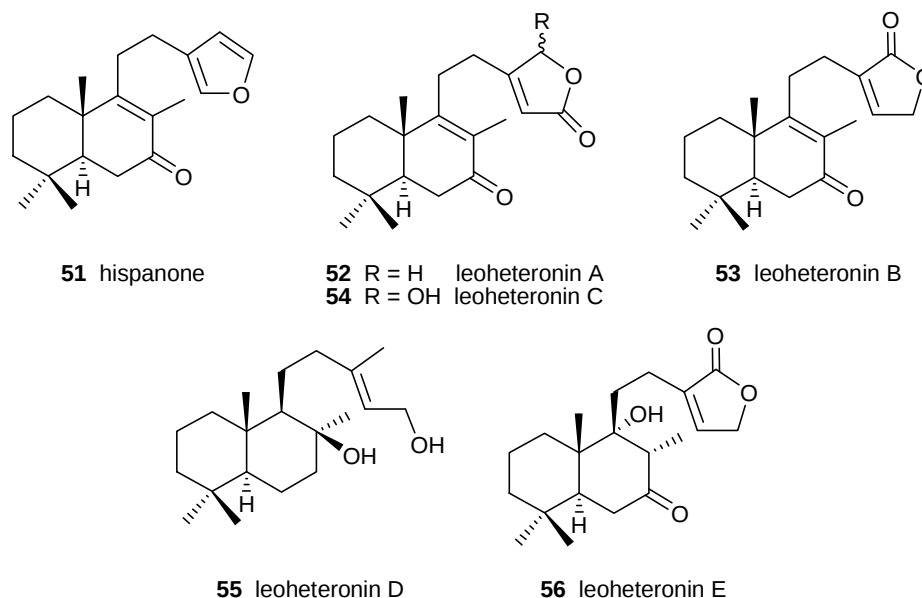
Another recent paper³⁹ reported the isolation from *L. sibiricus* of two new furolabdanes, whose structures were elucidated as **44** and **45**; the products were indicated as LS-1 and LS-2 respectively and no trivial names were given. The extract contained also four known diterpenoids, leonotinin **12**,¹⁶ leonotin **6**,⁸ dubiin **17**¹⁹ and nepetaefuran **8**.¹² These four products had been isolated from species of the *Leonotis*

genus, and not of the *Leonurus* genus, as erroneously indicated in this paper.

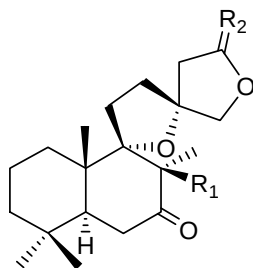
The species *Leonurus heterophyllus* Sweet is rich in furolabdane diterpenoids. A first paper⁴⁰ reported the isolation of a new product, prehispanolone (**46**); this prefuranic compound was converted into the known hispanolone (**47**), previously isolated from *Ballota hispanica*⁴¹ and *Galeopsis angustifolia*.⁴² In a following investigation, two new compounds were found,⁴³ leoheterin (**48**) and preleoheterin (**49**), together with the known hispanolone (**47**) and galeopsin (**50**).⁴²



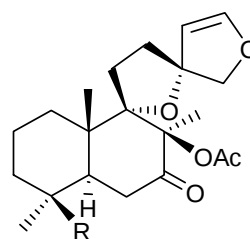
A quite recent paper⁴⁴ reported the isolation, together with the previously found compounds, of the known hispanone (**51**) (occurring in *Galeopsis angustifolia*⁴⁵), and of five new furolabdanes: leoheteronin A (**52**), leoheteronin B (**53**), leoheteronin C (**54**), leoheteronin D (**55**) and leoheteronin E (**56**). The synthesis of prehispanolone was reported.^{46,47}



Also *Leonurus persicus* Boiss. is very rich in diterpenoids. A first paper⁴⁸ reported the isolation of five new labdane compounds: leopersin A (**57**), 8-deacetoxyleopersin A (**58**), leopersin B (**59**), 15-*epi*-leopersin B (**60**) and 4 β -hydroxymethylpregaleopsin (**61**) (name corrected⁴⁹ to 19-hydroxypregaleopsin), together with the known products pregaleopsin **62**,⁴² galeopsin (**50**)⁴² and leosibiricin (**35**).³⁵ Improved NMR data of these last three compounds were reported.



- 57** R₁ = OAc, R₂ = O leopersin A
58 R₁ = OH, R₂ = O 8-deacetoxy-leopersin A
59 R₁ = OAc, R₂ = α H, β OH leopersin B
60 R₁ = OAc, R₂ = β H, α OH 15-*epi*-leopersin B

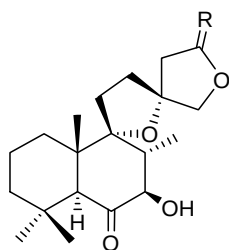


- 61** R = CH₂OH 19-hydroxypregaleopsin
62 R = CH₃ pregaleopsin

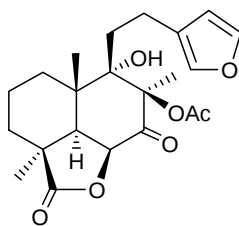
A remark about leosibiricin (**35**): the product isolated in 1995 by Tasdemir et al.⁴⁸ was reported to have a negative rotatory power, hypothesizing that it could be the enantiomer of leosibiricin isolated in 1982 by Savona et al.³⁵ and reported to have a positive rotatory power. Actually, the two products have identical spectroscopic data and are identical. Indeed, an unfortunate misprint in the 1982 paper quoted a positive value instead of the negative value: (+) instead of (-). Therefore leosibiricin is represented by the structure and stereochemistry **35**.

In a second paper⁴⁹ the same authors described six new furolabdane derivatives from *L. persicus*: leopersin C (**63**), 15-*epi*-leopersin C (**64**), leopersin D (**65**), leopersin E (**66**), leopersin F (**67**) and 7-*epi*-leopersin F (**68**). The last two products show the interesting structure of 8,9-*seco*-labdane.

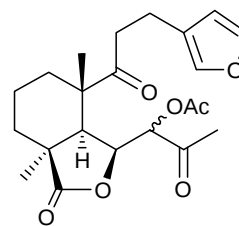
Further labdane diterpenoids were isolated from *L. persicus*.⁵⁰ Seven compounds are new: leopersin G (**69**), leopersin H (**70**), leopersin I (**71**), leopersin J (**72**), 15-*epi*-leopersin J (**73**), leopersin K (**74**), leopersin L (**75**). Also two known diterpenoids occurred: 13-hydroxyballonigrinolide (**76**), previously isolated from *Ballota lanata*⁵¹ and ballotenol (**77**), previously found in *Ballota nigra*.⁵² The configuration at C-8 of ballotenol was revised and assigned as 8 α -CH₃. These results seem to indicate a close relationship between the genera *Ballota* and *Leonurus*.



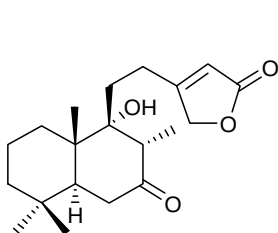
63 R = α H, β OH leopersin C
64 R = β H, α OH 15-*epi*-leopersin C
65 R = O leopersin D



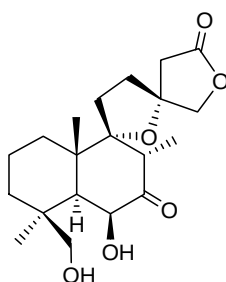
66 leopersin E



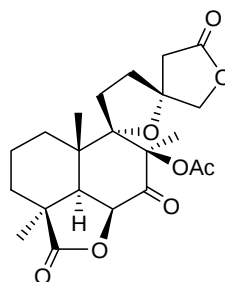
67 / 68 leopersin F / 7-*epi*-leopersin F



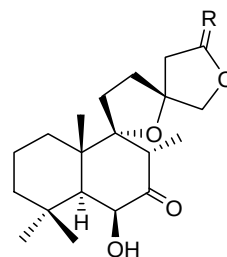
69 leopersin G



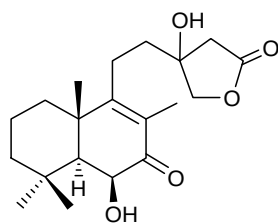
70 leopersin H



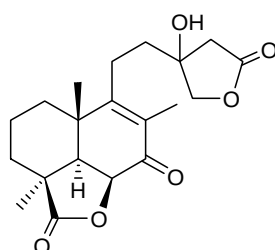
71 leopersin I



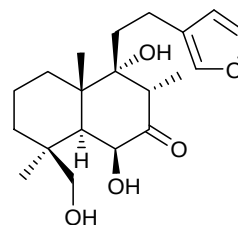
72 R = α H, β OH leopersin J
73 R = β H, α OH 15-*epi*-leopersin J
74 R = O leopersin K



75 lepersin L

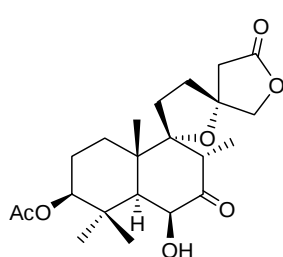


76 13-hydroxy-ballonigrinolide

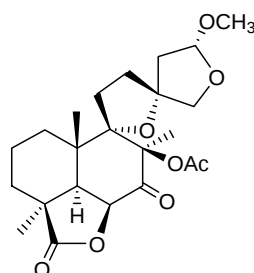


77 ballotenolo

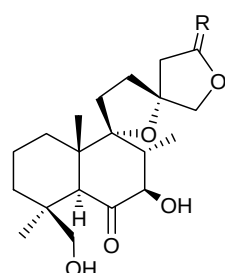
Another paper on *L. persicus*⁵³ reported seven new diterpenoids: leopersin M (**78**), leopersin N (**79**), leopersin O (**80**), 15-*epi*-leopersin O (**81**), leopersin P (**82**), leopersin Q (**83**), 15-*epi*-leopersin Q (**84**). Also 19-hydroxygaleopsin (**31**) was isolated and described as a new product, but it had been described few months before³³.



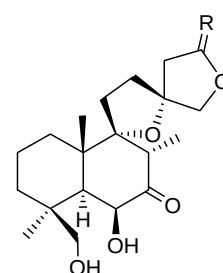
78 leopersin M



79 leopersin N



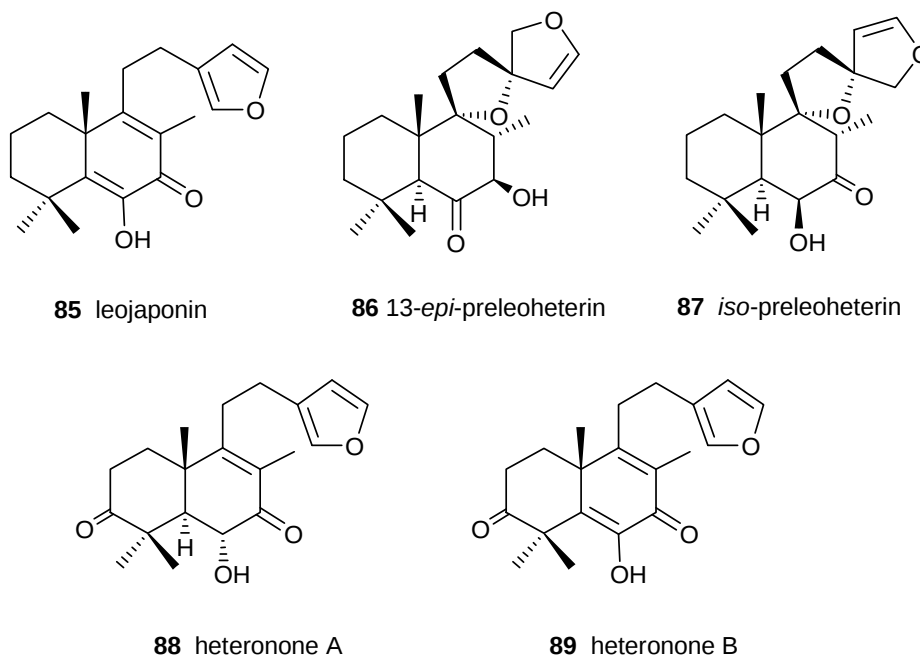
80 R = α H, β OH leopersin O
81 R = β H, α OH 15-*epi*-leopersin O
82 R = O leopersin P



83 R = α H, β OH leopersin Q
84 R = β H, α OH 15-*epi*-leopersin Q

A quite recent paper⁵⁴ reported the occurrence of three new labdanes in *L. japonicus* Houtt., considered as synonymous of *L. heterophyllus* Sweet: leojaponin (**85**), 13-*epi*-preleoheterin (**86**), *iso*-preleoheterin (**87**), together with the known preleoheterin (**49**).

Again from *L. heterophyllus*, two new furolabdane were isolated very recently, and attributed the structures **88** for heteronone A^{55, 56, 57} and **89** for heteronone B.^{56,57}



It is clear that the genus *Leonurus* is much richer in diterpenoids than the genus *Leonotis*. Indeed, from the only six species investigated until now, a total of 71 products was isolated: 61 of them are new natural products, whereas 10 had been isolated previously from other plants: in particular from species of the genera *Ballota*, *Galeopsis* and *Leonotis*.

As for the taxonomic aspect, the Stachyoideae tribe of the Lamiaceae family contains many genera rich in diterpenoids. Chemotaxonomic results show a certain closeness between the genera *Galeopsis*, *Ballota*, *Marrubium*, *Leonurus* and *Leonotis*: indeed the same compound can be found in more than one genus. This is for instance the case of marrubiin occurring in *Marrubium* and *Leonotis*, galeopsin in *Galeopsis* and *Leonurus*, hispanolone in *Ballota*, *Galeopsis* and *Leonurus*, ballotenol in *Leonurus* and *Ballota*. The skeletal structures can be markers to distinguish the genera: in the case of the two genera subject of the present review, it is evident that *Leonotis* contains only labdane derivatives, therefore they are typical of the genus. On the contrary, in *Leonurus* there are mainly diterpenoids with the labdane backbone, but in *L. marrubiastrum* there are also some products with rearranged labdane and abietane skeleta.

Biological activity

A number of informations and results has been reported concerning the biological activities of species belonging to the *Leonotis* and *Leonurus* genera.

Many species were used in folk medicine: this the case of *Leonotis leonurus* in Southern Africa, where it is called “wild dagga”² or “wild hemp”:⁵⁸ it is used as anticonvulsant,⁵⁹ antinociceptive, antiinflammatory, antidiabetic,⁶⁰ antiarthritic, antidote for snake bite,⁵⁸ antibacterial.⁶¹ Aqueous or ethanolic extracts are usually prepared. Effects on prostaglandin-synthesis inhibition⁶² and on fibroblast growth stimulation⁶¹ were investigated.

Leonotis dubia is used in Africa against whooping cough.¹⁹ *Leonotis ocymifolia*, Eastern and Southern Africa, is quoted to have ascaricide and anticancer activity and to cure ulcers and wounds;²³ it is also reported to be a narcotic and habit forming drug.⁶³

Probably the most used species is *Leonotis nepetaefolia*, in Africa, India, Caribbean countries, South America, that has attributed a variety of salutary physiological effects.⁵⁶ It is called “molinillo” in Puerto Rico, “chandelier” in Trinidad, “Christmas candle stick” in Jamaica, “dagga” in Africa. In India it is an ancient Ayurvedic drug.¹⁶ Smoking of dried leaves is a common practice in many countries as a narcotic drug.¹⁴ Folk medicine used extracts as antitumour, antifungal, antimalarial, hypotensive, tonic, laxative, sedative, insecticide, antiviral, antibacteric, to cure coughs, fever, stomach ache, head ache, kidney diseases, rheumatism, dysmenorrhea, asthma, burns. Pharmacological investigations regarded anticancer activity,⁶⁴ antibacterial,⁶⁵ antifungine.⁶⁶ Also the activity on smooth muscle and cardiac muscle was studied.⁶⁷ It was ascertained that in Central Mexico *Leonotis nepetaefolia* is a reservoir for several viruses.⁶⁸

Also the species of *Leonurus* are reported to have interesting biological activities and a very large use in folk medicine, specially in China. The most used species are *L. japonicus* (syn. *L. heterophyllus*, *L. artemisia*) and *L. sibiricus*. There are many hundreds Chinese patents for commercial preparations, usually in mixtures with other plants or animal parts: such preparations are claimed to be active against any human or animal disease. In Central America *L. sibiricus* is called “marihuanilla” and used to replace marihuana.

Extracts of the aerial parts of several species were reported as heart antiarrhythmic,⁶⁹ sedative,⁷⁰ antibacterial,^{71, 72} anticoagulant,⁷³ antioxidant,^{74, 75} antitumoral,⁷⁶ booster of the immuno response.⁷⁷ The anticoagulant activity of *L. japonicus* was attributed⁷⁸ to hispanolone (48) and prehispanolone (47). Anti-oxidative stress effects on ischemic rat hearts was reported.⁷⁹

In Bulgaria *Leonurus cardiaca* is used³³ against tachycardia, hypertonia and nervous disorders, while in Turkey is used⁸⁰ for the cardiotonic, expectorant, astringent and euphoric effects.

Table 1. *Leonotis* species content

Taxa	Compound	N° and Ref.
<i>Leonotis leonurus</i>	marrubiin	1 ³
	compound X	2 ^{2, 4, 5}
	compound Y	3 ^{2, 4, 6}
	premarrubiin (13R)	4 ⁷
	premarrubiin (13S)	5 ⁷
	leonurun	22 ²⁷
<i>Leonotis nepetaefolia</i>	leonotin	6 ⁸
	nepetaefolin	7 ^{11, 12, 13}
	nepetaefuran	8 ¹²
	nepetaefuranol	9 ¹²
	methoxynepetaefolin	10 ^{14, 15}
	nepetaefolinol	11 ^{15, 16, 17}
	leonotinin	12 ¹⁶
	dilactone	13 ¹⁶
	dehydronepetaefolinol	14 ¹⁷
	tetrol	15 ¹⁷
	leonotinic acid	16 ¹⁸
<i>Leonotis dysophylla</i>	leonotin	6 ¹⁰
<i>Leonotis dubia</i>	dubiin	17 ^{19, 20}
<i>Leonotis ocymifolia raineriana</i>	leonotin	18 ²⁴
	compound X	2 ²⁴
	dilactone	20 ²⁴
	lactone	21 ²⁴
	leonotin	6 ²⁵
	leonotinin	12 ²⁵
	nepetaefolin	7 ²⁵
<i>Leonotis leonitis</i>	leonitin	18 ^{21, 22}
	leonotin	6 ⁹
<i>Leonotis leonitis hirtiflora</i>	diolide	19 ²³

Table 2. *Leonurus* species content

Taxa	Compound	N° and Ref
<i>Leonurus marrubiastrum</i>	marrubiaside	23 ²⁹
	marrubialactone	25 ²⁹
	marrubiastron	26 ³⁰
	aldehydo-marrubialactone	27 ³⁰
	desmethyalmarrubiaketone	28 ³⁰
	leonubiastrin	36 ³⁷
<i>Leonurus cardiaca</i>	“clerodane B”	29 ^{28, 31}
	leocardin	30 ³²
	19-hydroxygaleopsin	31 ³³
	19-acetoxypregaleopsin	32 ³⁴
	leosibiricin	35 ³⁵
<i>Leonurus sibiricus</i>	leosibirin	33 ³⁵
	isoleosibirin	34 ³⁵
	leosibiricin	35 ³⁵
	sibiricinone A	37 ³⁸
	sibiricinone B	38 ³⁸
	sibiricinone C	39 ³⁸
	sibiricinone D	40 ³⁸
	sibiricinone E	41 ³⁸
	15- <i>epi</i> -sibiricinone D	42 ³⁸
	15- <i>epi</i> -sibiricinone E	43 ³⁸
	compound LS-1	44 ³⁹
	compound LS-2	45 ³⁹
	leonotinin	12 ³⁹
	leonotin	6 ³⁹
	dubiin	17 ³⁹
	nepetaefuran	8 ³⁹
<i>Leonurus heterophyllus</i>	prehispanolone	46 ⁴⁰
	hispanolone	47 ⁴³
	leoheterin	48 ⁴³
	preleoheterin	49 ⁴³
	galeopsin	50 ⁴³
	hispanone	51 ⁴⁴
	leoheteronin A	52 ⁴⁴
	leoheteronin B	53 ⁴⁴
	leoheteronin C	54 ⁴⁴

	leoheteronin D	55 ⁴⁴
	leoheteronin E	56 ⁴⁴
	heteronone A	88 ⁵⁵⁻⁵⁷
	heteronone B	89 ^{56, 57}
<i>Leonurus japonicus</i>	preleoheterin	49 ⁵⁴
	leojaponin	85 ⁵⁴
	13- <i>epi</i> -preleoheterin	86 ⁵⁴
	<i>iso</i> -preleoheterin	87 ⁵⁴
<i>Leonurus persicus</i>	leopersin A	57 ⁴⁸
	8-deacetoxyleopersin A	58 ⁴⁸
	leopersin B	59 ⁴⁸
	15- <i>epi</i> -leopersin B	60 ⁴⁸
	19-hydroxypregaleopsin	61 ^{48, 49}
	pregaleopsin	62 ⁴⁸
	galeopsin	50 ⁴⁸
	leosibiricin	35 ⁴⁸
	leopersin C	63 ⁴⁹
	15- <i>epi</i> -leopersin C	64 ⁴⁹
	leopersin D	65 ⁴⁹
	leopersin E	66 ⁴⁹
	leopersin F	67 ⁴⁹
	7- <i>epi</i> -leopersin F	68 ⁴⁹
	leopersin G	69 ⁵⁰
	leopersin H	70 ⁵⁰
	leopersin I	71 ⁵⁰
	leopersin J	72 ⁵⁰
	15- <i>epi</i> -leopersin J	73 ⁵⁰
	leopersin K	74 ⁵⁰
	leopersin L	75 ⁵⁰
	13-hydroxyballonigrinolide	76 ⁵⁰
	ballotenol	77 ⁵⁰
	leopersin M	78 ⁵³
	leopersin N	79 ⁵³
	leopersin O	80 ⁵³
	15- <i>epi</i> -leopersin O	81 ⁵³
	leopersin P	82 ⁵³
	leopersin Q	83 ⁵³
	15- <i>epi</i> -leopersin Q	84 ⁵³
	19-hydroxygaleopsin	31 ⁵³

Table 3. Diterpenes in *Leonotis* species

Compound	Species
marrubiin (1)	<i>leonurus</i> ³
compound X (2)	<i>leonurus</i> , ^{2, 4, 5} <i>ocymifolia raineriana</i> ²⁴
compound Y (3)	<i>leonurus</i> ^{2, 4, 6}
13(<i>R</i>)-premarrubiin (4)	<i>leonurus</i> ⁷
13(<i>S</i>)-premarrubiin (5)	<i>leonurus</i> ⁷
leonotin (6)	<i>nepetaefolia</i> , ⁸ <i>leonitis</i> , ⁹ <i>dysophylla</i> , ¹⁰ <i>ocymifolia</i> , <i>raineriana</i> ²⁵
nepetaefolin (7)	<i>nepetaefolia</i> , ^{11, 12, 13} <i>ocymifolia raineriana</i> ²⁵
nepetaefuran (8)	<i>nepetaefolia</i> ¹²
nepetaefuranol (9)	<i>nepetaefolia</i> ¹²
methoxynepetaefolin (10)	<i>nepetaefolia</i> ^{14, 15}
nepetaefolinol (11)	<i>nepetaefolia</i> ^{15, 16}
leonotinin (12)	<i>nepetaefolia</i> , ¹⁶ <i>ocymifolia raineriana</i> ²⁵
dilactone (13)	<i>nepetaefolia</i> ¹⁶
dehydronepetaefolinol (14)	<i>nepetaefolia</i> ¹⁷
tetrol (15)	<i>nepetaefolia</i> ¹⁷
leonotinic acid (16)	<i>nepetaefolia</i> ¹⁸
dubiin (17)	<i>dubia</i> ^{19, 20}
leonitin (18)	<i>leonitis</i> , ^{21,22} <i>ocymifolia raineriana</i> ²⁴
diolide (19)	<i>leonitis hirtiflora</i> ²³
dilactone (20)	<i>ocymifolia raineriana</i> ²⁴
lactone (21)	<i>ocymifolia raineriana</i> ²⁴
leonurun (22)	<i>leonitis</i> ²⁷

Table 4. Diterpenes in the genus *Leonurus*

Compound	Species
leonotin (6)	<i>sibiricus</i> ³⁹
nepetaefuran (8)	<i>sibiricus</i> ³⁹
leonotinin (12)	<i>sibiricus</i> ³⁹
dubiin (17)	<i>sibiricus</i> ³⁹
marrubiaside (23)	<i>marrubiastrum</i> ²⁹
marrubialactone (25)	<i>marrubiastrum</i> ²⁹
marrubiastronol (26)	<i>marrubiastrum</i> ³⁰
aldehydomarrubialactone (27)	<i>marrubiastrum</i> ³⁰
desmethylnarrubiastronol (28)	<i>marrubiastrum</i> ³⁰
“clerodane B” (29)	<i>cardiaca</i> ³¹
leocardin (30)	<i>cardiaca</i> ³²
19-hydroxy-galeopsin (31)	<i>cardiaca</i> , ³³ <i>persicus</i> ⁵³
19-acetoxy-pregaleopsin (32)	<i>cardiaca</i> ³⁴
leosibirin (33)	<i>sibiricus</i> ³⁵
isoleosibirin (34)	<i>sibiricus</i> ³⁵
leosibiricin (35)	<i>cardiaca</i> , ³⁶ <i>sibiricus</i> , ³⁵ <i>persicus</i> ⁴⁸
leonubiastronol (36)	<i>marrubiastrum</i> ³⁷
sibiricinone A (37)	<i>sibiricus</i> ³⁸
sibiricinone B (38)	<i>sibiricus</i> ³⁸
sibiricinone C (39)	<i>sibiricus</i> ³⁸
sibiricinone D (40)	<i>sibiricus</i> ³⁸
sibiricinone E (41)	<i>sibiricus</i> ³⁸
15- <i>epi</i> -sibiricinone D (42)	<i>sibiricus</i> ³⁸
15- <i>epi</i> -sibiricinone E (43)	<i>sibiricus</i> ³⁸
compound LS-1 (44)	<i>sibiricus</i> ³⁹
compound LS-2 (45)	<i>sibiricus</i> ³⁹
prehispanolone (46)	<i>heterophyllus</i> ⁴⁰
hispanolone (47)	<i>heterophyllus</i> ⁴³
leoheterin (48)	<i>heterophyllus</i> ⁴³
preleoheterin (49)	<i>heterophyllus</i> , ⁴³ <i>japonicus</i> ⁵⁴
galeopsin (50)	<i>heterophyllus</i> , ⁴³ <i>persicus</i> ⁴⁸
hispanone (51)	<i>heterophyllus</i> ⁴⁴
leoheteronin A (52)	<i>heterophyllus</i> ⁴⁴
leoheteronin B (53)	<i>heterophyllus</i> ⁴⁴
leoheteronin C (54)	<i>heterophyllus</i> ⁴⁴
leoheteronin D (55)	<i>heterophyllus</i> ⁴⁴
leoheteronin E (56)	<i>heterophyllus</i> ⁴⁴

leopersin A (57)	<i>persicus</i> ⁴⁸
8-deacetoxy-leopersin A (58)	<i>persicus</i> ⁴⁸
leopersin B (59)	<i>persicus</i> ⁴⁸
15- <i>epi</i> -leopersin B (60)	<i>persicus</i> ⁴⁸
19-hydroxypregaleopsin (61)	<i>persicus</i> ^{48, 49}
pregaleopsin (62)	<i>persicus</i> ⁴⁸
leopersin C (63)	<i>persicus</i> ⁴⁹
15- <i>epi</i> -leopersin C (64)	<i>persicus</i> ⁴⁹
leopersin D (65)	<i>persicus</i> ⁴⁹
leopersin E (66)	<i>persicus</i> ⁴⁹
leopersin F (67)	<i>persicus</i> ⁴⁹
7- <i>epi</i> -leopersin F (68)	<i>persicus</i> ⁴⁹
leopersin G (69)	<i>persicus</i> ⁵⁰
leopersin H (70)	<i>persicus</i> ⁵⁰
leopersin I (71)	<i>persicus</i> ⁵⁰
leopersin J (72)	<i>persicus</i> ⁵⁰
15- <i>epi</i> -leopersin J (73)	<i>persicus</i> ⁵⁰
leopersin K (74)	<i>persicus</i> ⁵⁰
leopersin L (75)	<i>persicus</i> ⁵⁰
13-hydroxyballonigrinolide (76)	<i>persicus</i> ⁵⁰
ballotenol (77)	<i>persicus</i> ⁵⁰
leopersin M (78)	<i>persicus</i> ⁵³
leopersin N (79)	<i>persicus</i> ⁵³
leopersin O (80)	<i>persicus</i> ⁵³
15- <i>epi</i> -leopersin O (81)	<i>persicus</i> ⁵³
leopersin P (82)	<i>persicus</i> ⁵³
leopersin Q (83)	<i>persicus</i> ⁵³
15- <i>epi</i> -leopersin Q (84)	<i>persicus</i> ⁵³
leojaponin (85)	<i>japonicus</i> ⁵⁴
13- <i>epi</i> -preleoheterin (86)	<i>japonicus</i> ⁵⁴
iso-preleoheterin (87)	<i>japonicus</i> ⁵⁴
heteronone A (88)	<i>heterophyllus</i> ^{55, 56, 57}
heteronone B (89)	<i>heterophyllus</i> ^{56, 57}

REFERENCES

1. J. C. Willis, A dictionary of the flowering plants and ferns, Cambridge University Press, 7th edition, 1966.
2. G. M. L. Cragg and G. E. Little, *J. South Afr. Chem. Inst.*, 1962, **15**, 29.

3. D. E. A. Rivett, *J. Chem. Soc.*, 1964, 1857.
4. E. R. Kaplan and D. E. A. Rivett, *J. Chem. Soc. (C)*, 1968, 262.
5. G. J. Kruger and D. E. A. Rivett, *S. Afr. J. Chem.*, 1988, **41**, 124.
6. M. S. Henderson, R. McCrindle, and D. McMaster, *Canad. J. Chem.*, 1973, **51**, 1346.
7. G. Laonigro, R. Lanzetta, M. Parrilli, M. Adinolfi, and L. Mangoni, *Gazz. Chim. Ital.*, 1979, **109**, 145.
8. J. D. White, P. S. Manchand, and W. B. Whalley, *Chem. Commun.*, 1969, 1315.
9. D. E. A. Rivett, 1969, personal communication in ref. 8.
10. E. R. Kaplan, K. Naidu, and D. E. A. Rivett, *J. Chem. Soc. (C)*, 1970, 1656.
11. J. D. White and P. S. Manchand, *J. Am. Chem. Soc.*, 1970, **92**, 5527.
12. J. D. White and P. S. Manchand, *J. Org. Chem.*, 1973, **38**, 720.
13. R. B. Von Dreele, G. R. Pettit, R. H. Ode, R. E. Perdue Jr, J. D. White, and P. S. Manchand, *J. Am. Chem. Soc.*, 1975, **97**, 6236.
14. P. S. Manchand, *Tetrahedron Lett.*, 1973, 1907.
15. J. F. Blount and P. S. Manchand, *J. Chem. Soc., Perkin Trans. 1*, 1980, 264.
16. K. K. Purushothaman, S. Vasanth, and J. D. Connolly, *J. Chem. Soc., Perkin Trans. 1*, 1974, 2661.
17. L. Govindasamy, V. Rajakannan, D. Velmurugan, S. Banumathi, and S. Vasanth, *Cryst. Res. Technol.*, 2002, **37**, 896.
18. D. M. Boalino and W. F. Tinto, *Heterocycles*, 2004, **63**, 383.
19. G. A. Eagle and D. E. A. Rivett, *J. Chem. Soc., Perkin Trans. 1*, 1973, 1701.
20. M. T. Davies-Coleman, R. B. English, and D. E. A. Rivett, *S. Afr. J. Chem.*, 1991, **44**, 80.
21. G. A. Eagle, E. R. Kaplan, K. Naidu, and D. E. A. Rivett, *J. Chem. Soc., Perkin Trans. 1*, 1978, 994.
22. G. J. Kruger, and D. E. A. Rivett, *S. Afr. J. Chem.*, 1979, **32**, 59.
23. T. G. Dekker, T. G. Fourie, E. Matthee, F. O. Snyckers, J. C. A. Boeyens, and L. Denner, *S. Afr. J. Chem.*, 1987, **40**, 228.
24. S. Habtemariam, A. I. Gray, and P. G. Waterman, *J. Nat. Prod.*, 1994, **57**, 1570.
25. A. A. Hussein, M. J. J. Meyer, and B. Rodriguez, *Magn. Reson. Chem.*, 2003, **41**, 147.
26. D. E. A. Rivett, *Chem. S. A.*, 1984, 368.
27. J. M. McKenzie, I. R. Green, and P. Mugabo, *S. Afr. J. Chem.*, 2006, **59**, 114.
28. C. H. Brieskorn and W. Broschek, *Pharmac. Acta Helvetiae*, 1972, **47**, 123.
29. R. Tschesche and H.-U. Plenio, *Chem. Ber.*, 1973, **106**, 2929.
30. R. Tschesche and B. Streuff, *Chem. Ber.*, 1978, **111**, 2130.
31. C. H. Brieskorn and R. Hofmann, *Tetrahedron Lett.*, 1979, 2511.
32. P. Malakov, G. Papanov, J. Jakupovic, M. Grenz, and F. Bohlmann, *Phytochemistry*, 1985, **24**, 2341.

33. G. Papanov, P. Malakov, and K. Tomova, *Phytochemistry*, 1998, **47**, 139.
34. G. Y. Papanov, P. Y. Malakov, B. Rodriguez B, and M. C. de la Torre, *Phytochemistry*, 1998, **47**, 1149.
35. G. Savona, F. Piozzi, M. Bruno, and B. Rodriguez, *Phytochemistry*, 1982, **21**, 2699.
36. W. Knöss and J. Zapp, *Planta Med.*, 1998, **64**, 357.
37. P. Y. Malakov, G. Y. Papanov, K. N. Tomova, B. Rodriguez, M. C. de la Torre, *Phytochemistry*, 1998, **48**, 557.
38. D. M. Boalino, S. McLean, W. F. Reynolds, and W. F. Tinto, *J. Nat. Prod.*, 2004, **67**, 714.
39. M. Satoh, Y. Satoh, K. Isobe, and Y. Fujimoto, *Chem. Pharm. Bull.*, 2003, **51**, 341.
40. P. M. Hon, C. M. Lee, H. S. Shang, Y. X. Cui, H. N. C. Wong , and H. M. Chang, *Phytochemistry*, 1991, **30**, 354.
41. G. Savona, F. Piozzi, and B. Rodriguez, *Heterocycles*, 1978, **9**, 257.
42. B. Rodriguez and G. Savona, *Phytochemistry*, 1980, **19**, 1805.
43. P. M. Hon, E. S. Wang, S. K. M. Lam, Y. M. Choy, C. M. Lee, and H. N. C. Wong, *Phytochemistry*, 1993, **33**, 639.
44. P. M. Giang, P. T. Son, K. Matsunami, and H. Otsuka, *Chem. Pharm. Bull.*, 2005, **53**, 938.
45. L. Perez-Sirvent, B. Rodriguez, G. Savona, and O. Servettaz, *Phytochemistry*, 1983, **22**, 527.
46. E. S. Wang, B. S. Luo, T. C. W. Mak, Y. M. Choy, and H. N. C. Wong, *Tetrahedron Lett.*, 1994, **35**, 7401.
47. E. S. Wang, Y. M. Choy, and H. N. C. Wong, *Tetrahedron*, 1996, **52**, 12137.
48. D. Tasdemir, A. D. Wright, O. Sticher, I. Çalis, and A. Linden, *J. Nat. Prod.*, 1995, **58**, 1543.
49. D. Tasdemir, A. D. Wright, O. Sticher, and I. Çalis, *J. Nat. Prod.*, 1996, **59**, 131.
50. D. Tasdemir, O. Sticher, I. Çalis , and A. Linden, *J. Nat. Prod.*, 1997, **60**, 874.
51. G. Savona, F. Piozzi, and J. R. Hanson, *Phytochemistry*, 1978, **17**, 2132.
52. G. Savona, F. Piozzi, J. R. Hanson, and M. Siverns, *J. Chem. Soc. Perkin Trans. 1*, 1977, 497.
53. D. Tasdemir, I. Çalis, and O. Sticher, *Phytochemistry*, 1998, **49**, 137.
54. R. R. Romero-Gonzalez, J. L. Avila-Nunez, L. Aubert, and M. E. Alonso-Amelot, *Phytochemistry*, 2006, **67**, 965.
55. X. Zhang and G. Peng, *Tianran Chanwu Yanjiu Yu Kaifa*, 2004, **16**, 104 (**144**:34055).
56. X. H. Cai, C. T. Che, C. K. Lam, T. C. W. Mak, and L. J. Wu, *J. Asian Nat. Prod. Res.*, 2006, **8**, 599.
57. X. Zhang and G. P. Peng, *Chinese Chem. Lett.*, 2006, **17**, 1321.
58. W. J. Speight, *Pharmaceutical Journal*, 1931, **126**, 478.
59. E. Bienvenu, G. J. Amabeoku, P. K. Eages, and E. P. Springfield, *Phytomedicine, Internat. J. Phytother. Phytopharmacol.*, 2002, **9**, 217 (**138**:100799).

60. J. A. O. Ojewole, *Methods and findings in experimental and clinical pharmacology*, 2005, **27**, 257.
61. V. Steenkamp, E. Mathivha, M. C. Gouws, and C. E. J. van Rensburg, *J. Ethnopharmacol.*, 2004, **95**, 353.
62. A. K. Jager, A. Hutchings, and J. van Staden, *J. Ethnopharmacol.*, 1996, **52**, 95.
63. J. Watt and M. G. Breyer-Brandwijk, *The medicinal and poisonous plants of Southern and Eastern Africa*, Livingstone Ltd. London, 2nd edition, 1962, p. 516.
64. R. I. Geran, N. H. Greenberg, M. M. Macdonald, A. M. Schumacher, and B. J. Abbott, *Cancer Chemother. Rep. Part 3*, 1972, **3**, 1-88.
65. R. H. Gopal, S. Vasanth, K. E. Vinnarasi, and S. Govindarajan, *Fitoterapia*, 1995, **66**, 83.
66. M. N. Abubacker and R. Ramanathan, *Indian J. Exp. Biol.*, 2003, **41**, 1473.
67. J. B. Calixto, R. A. Yunes, and G. A. Rae, *J. Pharm. Pharmacol.*, 1991, **43**, 529.
68. E. Piedra-Ibarra, R. de La Torre-Almaraz, G. Zuniga, B. Xoconostle-Cazares, and R. Ruiz-Medrano, *Phytoparasitica*, 2005, **33**, 480.
69. K. Horita, Y. Noguchi, M. Matsunaga, M. Y. Uchida, K. Shimizu, T. Kohno, A. Tsunoo, and S. Nishibe, *Natural Medicines*, 2002, **56**, 212 (CAN **138**:382071).
70. E. Widy-Tyszkiewicz, and R. Schminda, *Herba Pol.*, 1997, **43**, 154.
71. C. De Souza, A. P. Haas, G. L. Von Poser, E. E. Schapoval, and E. Elisabetsky, *J. Ethnopharmacol.*, 2004, **90**, 135.
72. F. Ahmed, M. Amirul Islam, and M. M. Rahman, *Fitoterapia*, 2006, **77**, 316.
73. C. M. Lee, L. M. Jiang, H. S. Shang, P. M. Hon, Y. He, and H. N. Wong, *Br. J. Pharmacol.*, 1991, **103**, 1719.
74. K. Sugaya, F. Hashimoto, M. Ono, Y. Ito, C. Masuoka, and T. Nohara, *Food Sci. Technol. Int. Tokyo*, 1998, **4**, 278.
75. A. Matkowski and M. Piotrowska, *Fitoterapia*, 2006, **77**, 346.
76. G. Chinwala Maimoona, M. Gao, J. Dai, and J. Shao, *J. Chinese Med. Mat.*, 2002, **25**, 71.
77. G. Chinwala Maimoona, M. Gao, J. Dai, and J. Shao, *J. Altern. Complement. Medicine*, 2003, **9**, 511.
78. H. M. Xu, C. M. Lee, P. M. Hon, and H. M. Chang, *Yaoxue Xuebao*, 1992, **27**, 812 (**118**:94046).
79. J. Sun, S. H. Huang, Y. C. Zhu, M. Whiteman, M. J. Wang, B. K. H. Tan, and Y. Z. Zhu, *Life Sciences*, 2005, **76**, 3043.
80. E. Ràcz-Kotilla, G. Ràcz, R. Bartha, *Rev. Med.*, 1981, **27**, 32.



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