E-ISSN: 2378-654X

Recent Advances in Biology and Medicine

Review Article

Goniothalamus: Phytochemical and Ethnobotanical Review

HATASO, USA

Goniothalamus: Phytochemical and Ethnobotanical Review

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Received: Jun 20, 2016; Accepted: Jul 19, 2016; Published: Jul 28, 2016

Abstract

Goniothalamus species are used in widespread medicines for abortion, anti-aging, body pains, rheumatism, skin complaints, typhoid fever, tympanites, stomach ache and fever. The present study reviews the distribution of species along with their synonyms, their traditional usage, and correlated chemical compounds of *Goniothalamus* species with stress on the authentication of their ethnobotanical uses. The findings in some *Goniothalamus* species suggest that the chemical nature of their derivatives, such as acetogenins and styryl-lactones, may justify the use of these species against cancer in Asian traditional medicines due to their cytotoxic potential.

Keywords: *Goniothalamus*; Ethnobotanical; Acetogenins; Styryl-lactones; Cytotoxic.

1. INTRODUCTION

Medicinal plants have been traditionally used in Southeast Asian countries for centuries, and in their usage, they have proven to be useful to humans as pharmaceutical drugs [1, 125]. The specific plants to be used and the methods of application for particular ailments were passed down through history by word. Many tropical plants have also been reported to possess interesting biological activities with potential therapeutic applications. In the more recent history, the use of plants as medicines has involved the isolation and characterization of pharmacologically active compounds [2, 126].

2. BOTANY

In Malaysia, there are about 14,500 species of flowering plants [3, 123] out of which about 1,300 are assumed to be medicinal [4, 124]. *Goniothalamus* (family: Annonaceae) is a genus of about 160 species of trees and shrubs mostly found in tropical Southeast Asia throughout Indochina and Malaysia [5, 32]. In Table 1, we have listed the *Goniothalamus* species along with its synonyms. We have also listed the distribution of *Goniothalamus* species in Table 2.

3. TRADITIONAL USES OF *GONIOTHALAMUS*

The leaves of *G. macrophyllus* Hook.f & Thoms. are used to allay fever [8, 9, 106, 116]. The decoction of its roots are also used in postpartum remedy and for abortion. Its root decoction is used for anti-aging purposes. Mixed with *Eurycoma longifolia*, it is used as a male tonic. Different parts of *Goniothalamus macrophyllus* are used by the Temuan in Peninsular Malaysia to treat various ailments such as body pains, rheumatism, and skin complaints. The decoction of the root is used to eliminate excessive gas in the body. The decoction is used as a lotion to treat body pains and rheumatism. Pounded leaves and bark are used for skin complaints [8-11, 106, 113, 115, 116]. The roots of *G. giganteus* Hook.f & Thoms. are used in abortion and for the treatment of cold. Heated leaves of *G. giganteus* Hook.f & Thoms. are applied onto the swelling [12, 13, 107, 117]. A decoction of *G. scortechinii* is given as a postpartum protective remedy [8, 106]. The roots of *G. tapis* Miq. are used as an abortifacient during early months of pregnancy. In Java, Indonesia, an infusion of the roots are used to treat typhoid fever [14, 15, 108, 118]. In Taiwan, the roots of *G. amuyon* Merr. are used to treat scabies. In the Philippines, the seeds are used to treat rheumatism and tympanites [16-18] [109, 110, 119]. The fruit is used to treat stomachache [18, 110]. *Goniothalamus uvaroides* King parts are used traditionally as postpartum protective remedies and abortifacients and to treat typhoid fever, rheumatism, and headache [19, 114]. There is a list of *Goniothalamus* species with their common names, part used, and their traditional uses in Table 3.

4. CHEMICAL CONSTITUENTS OF GENUS *GONIOTHALAMUS*

Goniothalamus is a huge genus containing several species. The most well-known species are *Goniothalamus giganteus, Goniothalamus gardneri, Goniothalamus macrophyllus, Goniothalamus amuyon, Goniothalamus griffithii, Goniothalamus tamirensis,* and

Table 1: *Goniothalamus* species with synonyms [6, 104].

Species	Synonyms
Goniothalamus amuyon (Blanco) Merr.	*Goniothalamus amuyon var. ramosii Bân* *Polyalthia sasakii Yamam.* *Uvaria amuyon Blanco*
Goniothalamus aruensis Scheff	*Goniothalamus rhynchocarpus Diels*
Goniothalamus brunneus Merr.	*Goniothalamus elmeri Merr.*
Goniothalamus cardiopetalus (Dalzell) Hook.f. & Thomson	*Atrategia thomsonii Bedd. ex Hook.f.*
Goniothalamus caudifolius Ridl	*Goniothalamus tenuifolius King.*
Goniothalamus ceramensis Miq.	*Uvaria tripetala Lam.*
Goniothalamus costulatus Miq.	*Goniothalamus imbricatus (Blume) Koord.* *Goniothalamus kunstleri var. tomentosus Baker f.* *Goniothalamus opacus Bakh.f.*
Goniothalamus cylindrostigma Airy Shaw	*Goniothalamus suaveolens Becc.*
Goniothalamus desmoides Craib	*Friesodielsia desmoides (Craib) Steenis.*
Goniothalamus dispermus Miq.	*Goniothalamus malayanus Hook.f. & Thomson.*
Goniothalamus dolichopetalus Merr.	*Goniothalamus dolichopetalus var. basilensis Bân*
Goniothalamus fasciculatus Boerl.	*Goniothalamus ridleyi King.*
Goniothalamus forbesii Baker f.	*Goniothalamus macrophyllus (Blume) Hook.f. & Thomson.*
Goniothalamus gabriacianus (Baill.) Ast	*Goniothalamus gabriacianus var. coriaceifolius Bân* *Oxymitra gabriaciana Baill.*
Goniothalamus gabriacianus var. coriaceifolius Bân	*Goniothalamus gabriacianus (Baill.) Ast.*
Goniothalamus giganteus Hook.f. & Thomson	*Goniothalamus oxycarpus (Miq.) Miq.*
Goniothalamus grandiflorus (Warb.) Boerl	*Beccariodendron grandiflorum Warb.*
Goniothalamus kunstleri King i	*Goniothalamus tenuifolius King.* *Goniothalamus kunstleri var. macranthus King*
Goniothalamus laoticus (Finet & Gagnep.) Bân	*Mitrephora laotica Finet & Gagnep.*
Goniothalamus leiocarpus (W.T.Wang) P.T.Li	*Mitrephora leiocarpa W.T. Wang*
Goniothalamus longistipites Mat-Salleh	*Goniothalamus tapisoides Mat-Salleh.*
Goniothalamus macrophyllus (Blume) Hook.f. & Thomson	*Goniothalamus forbesii Baker f.* *Goniothalamus macrophyllus var. kerrii Bân* *Goniothalamus macrophyllus var. lanceolatus Bân* *Goniothalamus macrophyllus var. siamensis J.Sinclair* *Polyalthia macrophylla (Blume) Blume* *Unona macrophylla Blume*
Goniothalamus malayanus Hook.f. & Thomson	*Goniothalamus dispermus Miq.* *Goniothalamus malayanus var. slingerlandtianus (Scheff.) Boerl.* *Goniothalamus puncticulatus Boerl. & Koord.* *Goniothalamus slingerlandtianus Scheff.* *Goniothalamus ventristylus Boerl. & Koord.*
Goniothalamus philippinensis Merr.	*Goniothalamus mindanaensis Elmer*
Goniothalamus ridleyi King	*Goniothalamus fasciculatus Boerl.* *Goniothalamus prainianus King* *Goniothalamus prainianus var. angustipetalus*
Goniothalamus roseus Stapf	*Goniothalamus elmeri var. longipedicellatus Bân*
Goniothalamus sesquipedalis (Wall.) Hook.f. & Thomson	*Guatteria sesquipedalis Wall.*
Goniothalamus suaveolens Becc	*Goniothalamus cylindrostigma Airy Shaw*
Goniothalamus tamirensis Pierre ex Finet & Gagnep.	*Goniothalamus tamirensis var. kamputensis Finet & Gagnep.* *Goniothalamus marcanii Craib*
Goniothalamus tapis Miq.	*Goniothalamus umbrosus J.Sinclair*
Goniothalamus tapisoides Mat-Salleh	*Goniothalamus longistipites Mat-Salleh* *Goniothalamus sinclairianus Mat-Salleh*
Goniothalamus tenuifolius King	*Goniothalamus caudifolius Ridl* *Goniothalamus kunstleri King* *Goniothalamus kunstleri var. macranthus King* *Goniothalamus tenuifolius var. arborescens King*
Goniothalamus uvarioides King	*Goniothalamus pendulifolius Ridl.*
Goniothalamus viridiflorus K.Schum. & Lauterb.	*Goniothalamus myrmeciocarpa K.Schum. & Lauterb.*
Goniothalamus wynaadensis (Bedd.) Bedd.	*Atrutegia wynaadensis Bedd.*

Table 2: *Goniothalamus* species distributed in Malaysia [7, 105].

Species	Distribution
Goniothalamus kinabaluensis Bân	Sabah. Ridge below Camp-South.
Goniothalamus tortilipetalus M. R. Hend.	Pahang. Tembeling.
Goniothalamus nitidus Merr.	Sabah. Sandakan and vicinity.
Goniothalamus macrophyllus Hook. f. & Thomson var. lanceolatus (Blume) Bân	Sarawak. Mount Poi.
Goniothalamus bracteosus Bân	Sabah. Tenompok, Mount Kinabalu
Goniothalamus clemensii Bân	Sabah. Mount Nunkok, Mount Kinabalu.
Goniothalamus elmeri Merr. var. longipedicellatus Bân	Sabah. Tenompok, Mount Kinabalu.
Goniothalamus borneensis	Sarawak Semangon Arboretum, 12 1/2 mile Penrrisen road, Kuching
Goniothalamus calcareus	Mount Kinabalu, Penibukan Sabah; Mount Nunkok, G. Api limestone, Ulu Melinau
Goniothalamus calycinus	Terengganu, Kemaman, Bkt. Kajang Peninsular Malaysia Kemaman: Bukit Kajang
Goniothalamus crockerensis	malaysia
Goniothalamus curtisii	Peninsular Malaysia Near Ulu Kerling Kuala Lumpur. Perak
Goniothalamus cylindrostigma	Sarawak Near Long Kapa, Mount Dulit (Ulu Tinjar). IVth Division
Goniothalamus dolichocarpus	Sandakan
Goniothalamus elmeri	Mount Kinabalu, Tenompok,
Goniothalamus fulvus	Peninsular Malaysia
Goniothalamus holttumii	Peninsular Malaysia Fraser hill, S. Ridge. Pahang Pahang, Raub, Frasers Hill, Upon the Selangor Border
Goniothalamus kinabaluensis	Malaysia Sabah; Ridge below Camp-South
Goniothalamus kostermansii	Borneo. East Borneo, Berouw, Mt. Ilas Bungaan
Goniothalamus longistipites	Upstream from Melinau Gorge, Mulu National Park, 4th Division Sarawak, Marudi, Gn. Mulu N.P., Upstream from Melinau Gorge
Goniothalamus malayanus	Peninsular Malaysia
Goniothalamus montanus	Terengganu, Hulu Terengganu, Ulu Berang, Tersat
Goniothalamus parallelovenius	Sarawak
Goniothalamus prainianus	Peninsular Malaysia Perak, Larut. Chanderiang [Chenderiang]
Goniothalamus pendulifolius	Peninsular Malaysia Pahang. 6 miles N of Bentong
Goniothalamus ridleyi	Peninsular Malaysia [Sungei Murai]
Goniothalamus roseus	Mount Kinabalu Tenompok Kina Balu
Goniothalamus rostellatus	—
Goniothalamus rotundisepalus	Kelantan, Sg. Renang Sungei Renong
Goniothalamus scortechinii	Peninsular Malaysia Perak, Larut. Chanderiang [Chenderiang]
Goniothalamus stenophyllus	Sarawak
Goniothalamus suaveolens	Sarawak
Goniothalamus subevenius	Peninsular Malaysia Larut, Perak. Gopeng, Kinta.
Goniothalamus tapis	Peninsular Malaysia Jungle behind No.2 plant house Waterfall Gardens, Penang
Goniothalamus umbrosus	Peninsular Malaysia Jungle behind No.2 plant house Waterfall Gardens, Penang Jungle behing No.3 Plant house Walterfall Gardens, Penang
Goniothalamus uvarioide	Peninsular Malaysia Perak, Ulu Slim
Goniothalamus tapisoides	Sarawak Bt. Mersing, Anap
Goniothalamus tenuifolius	Peninsular Malaysia Larut, Perak Peninsular Malaysia [Snuki], Perak.
Goniothalamus kunstleri	Penang, Seberang Perai Tengah, Bkt. Juru, (Province Wellesley) Peninsular Malaysia Goping
Goniothalamus tomentosus	Ulu Endau Pahang/Johore border Bt. Peta. 1100 ft Pahang/Johor border, Ulu Endau, Bkt. Peta
Goniothalamus tortilipetalus	Pahang, Jerantut, Tembeling
Goniothalamus velutinus	Sarawak 4th Division, Near Long Kapa, Mount Dulit (Ulu Tinjar)
Goniothalamus woodii	Sabah Sandakan
Goniothalamus wrayi	Perak, G. Batu Puteh, Lower camp Peninsular Malaysia Perak Lower camp Gunong Batu Patch
Goniothalamus giganteus	Penang
Goniothalamus bygravei	Sarawak District: Miri. Locality: Gunong Lambir. Alt. low Sarawak Sg. Iban, Linau, Belaga, 7th Division.
Goniothalamus kamarudinii	Keebambang [Kibambangan] River, Mt Kinabalu, British North Borneo.
Goniothalamus megalocalyx	Sarawak Western slopes of Bukit Tibang, Indonesian Border, extreme head-waters of Balleh river, Kapit District. °35′N, 114°33′E.
Goniothalamus subvenius	Perak,
Goniothalamus bracteosu	Tenompok, B. N. Borneo, Mount Kinabalu

Table 3: *Goniothalamus* species with their common names, part used, and their traditional uses.

Species	Vernacular name	Part used	Traditional uses	References
G. macrophyllus Hook.f & Thoms	Selada, SelayarHitam Gajah Beranak, Penawar Hitam (Malaya) Ki Cantung (Indonesia), Limpanas Putih (Brunei), Chin Dok Diao (Thailand)	Leaves	The leaves of *G. macrophyllus* Hook.f & Thoms. are used to allay fever.	[8, 9, 106, 116]
G. macrophyllus Hook.f & Thoms; G.macrophyllus (Bl.)	Selada, SelayarHitam Gajah Beranak, Penawar Hitam (Malaya) Ki Cantung (Indonesia), Limpanas Putih (Brunei), Chin Dok Diao (Thailand)	Roots	Decoction of the roots are given as a postpartum remedy and for abortion. Root decoction is given for anti-aging purposes. Mixed with *Eurycoma longifolia*, it is used as a male tonic. Different parts of *Goniothalamus macrophyllus* are used by the Temuan in Peninsular Malaysia to treat various ailments such as body pains, rheumatism, and skin complaints. The decoction of the root is used to eliminate excessive gas in body. The decoction is used as a lotion to treat body pains and rheumatism Pounded leaves and bark are used for skin complaints.	[8-11, 106, 113, 115, 116]
G. giganteus	Penawar hitam (Malaya), Paanan Chaang(Thailand)	Roots	The roots of *G. giganteus* Hook.f & Thoms. are used in abortion and for the treatment of cold.	[12, 13, 107, 117]
G. giganteus	Penawar hitam (Malaya), Paanan Chaang(Thailand)	Leaves	Heated leaves are applied onto the swelling.	[12, 13, 107, 117]
G. scortechinii	–	–	A decoction of *G. scortechinii* is given as a postpartum protective remedy.	[8, 106]
G. tapis Miq.	Kenarak, gertimang(Malaya), Naara, Chi-no-koh (Thailand)	Roots	The roots of *G. tapis* Miq. are used as an abortifacient during early months of pregnancy. In Java, Indonesia, an infusion of the roots are used to treat typhoid fever.	[14, 15, 108, 118]
G. amuyon Merr.	Taiwan goniothalamus (Engl.) Tai wan ge na xiang (Chin.)	Seeds	In Taiwan, the seeds of *G. amuyon* Merr. are used to treat scabies. In the Philippines, the seeds are used to treat rheumatism and tympanites.	[16, 17, 18, 109, 110, 119]
G. amuyon Merr.	Taiwan goniothalamus (Engl.) Tai wan ge na xiang (Chin.)	Fruit	The fruit is used to treat stomachache.	[110]
G. laoticus	----------	Stem bark	*Goniothalamus laoticus* is being used traditionally as a tonic and a febrifuge by the local people in the northeastern part of Thailand.	[20, 111]
Goniothalamus uvaroides King	----------	Roots	They are used traditionally as postpartum protective remedies, abortifacients, and to treat typhoid fever, rheumatism, and headache.	[19, 114]

Goniothalamus cheliensis. The bark of *Goniothalamus giganteus* consist of Gigantrionenin **(2)**,4-Deoxyannomontacin **(3)**, Gonionenine **(4)**, (2,4-cis and trans)-annomontacinone **(5)**, annonacin **(6)**, 4-Acetylgigantetrocin **(7)**, Goniotrionin, Gigantransenin A **(9)**, Gigantransenin B, Gigantrasenin C **(10)**, Goniotetrocin, (2,4-cis and trans) Gonioneninone, Goniothalamicin **(11)**, Pyranicin **(12)**, Pyragonicin, (2,4-cis and trans)-gigantecinione, 4-deoxygigantecin, Giganin **(64)**, Giganenin, 4-deoxygigantecin, (−)-goniofupyrone, gigantetrocin, gigantriocin, gonioheptolides A, gonioheptolides B, Goniodenin, Goniocin, Gigantransenins A, B, C, Goniotriol, 2,4-cis and -trans)-xylomaticinones, Goniotricin, Goniothalenol, Goniotetracin, (2,4-cis and trans)-gonioneninone, goniobutenolides A and B, pyragonicin. Its stem bark consists of 9-deoxygoniopypyrone and 7-epi-Goniofufurone. Aerial part of *Goniothalamus gardneri* contains 2′-hydroxy-4,4′,6′-trimethoxychalcone (flavokawain A) **(13)**, 2′,4′-dihydroxy-4,6′-dimethoxydihydrochalcone **(14)**, 4,2′,4′-trihydroxy-6′-methoxydihydrochalcone, 5,7,4′-trimethoxyflavanone **(15)** (naringenin trimethyl ether), 7-hydroxy-5,4′-dimethoxyflavanone (tsugafolin) **(16)**, (rel)-1β,2α-di-(2,4-dihydroxy-6-methoxybenzoyl)-3β,4α-di-(4-methoxyphenyl)-cyclobutane, 2′,4′-dihydroxy-4,6′-dimethoxychalcone, 2′-hydroxy-4,4′,6′-trimethoxydihydrochalcone, whereas its roots consist of Gardnerilin A **(17)**, Gardnerilin B **(18)**. All remaining species along with their references are mentioned in Table 4.

Table 4: List of chemical constituents in genus *Goniothalamus*.

Species	Part used	Chemical constituents	References
Goniothalamus montanus	Leaves	Isoaltholactone **(1)**	[21, 1]
Goniothalamus tapis	Root	Isoaltholactone **(1)**, Goniothalamin A **(26)**	[21, 22, 1, 48]
Goniothalamus giganteus	Bark	Gigantrionenin **(2)**, 4-Deoxyannomontacin **(3)**, Gonionenine **(4)**, (2,4-cis and trans)-annomontacinone **(5)**, annonacin **(6)**, 4-Acetylgigantetrocin **(7)**, Goniotrionin, Gigantransenin A **(9)**, Gigantransenin B, Gigantrasenin C **(10)**, Goniotetrocin, (2,4-cis and trans) Gonioneninone, Goniothalamicin **(11)**, Pyranicin **(12)**, Pyragonicin, (2,4-cis and trans)-gigantecinone, 4-deoxygigantecin, Giganin **(64)**, Giganenin, 4-deoxygigantecin, (−)-goniofupyrone, gigantetrocin, gigantriocin, gonioheptolides A, gonioheptolides B, Goniodenin, Goniocin, Gigantransenins A, B, C, Goniotriol, (2,4-cis and -trans)-xylomaticinones, Goniotricin, Goniothalenol, Goniotetracin, (2,4-cis and trans)-gonioneninone. goniobutenolides A, B, pyragonicin	[23-25, 26-46] [2-10, 42, 57, 60, 62-67, 69-71, 79, 84, 101]
Goniothalamus giganteus	Stem bark	9-Deoxygoniopypyrone and 7-epi-Goniofufurone	[47, 94]
Goniothalamus gardneri	Aerial part	2′-hydroxy-4,4′,6′-trimethoxychalcone (flavokawain A)(13), 2′,4′-dihydroxy-4,6′-dimethoxydihydrochalcone **(14)**, 4,2′,4′-trihydroxy-6′-methoxydihydrochalcone, 5,7,4′-trimethoxyflavanone **(15)** (naringenin trimethyl ether), 7-hydroxy-5,4′-dimethoxyflavanone (tsugafolin) **(16)**, (rel)-1β,2α-di-(2,4-dihydroxy-6-methoxybenzoyl)-3β,4α-di-(4-methoxyphenyl)-cyclobutane, 2′,4′-dihydroxy-4,6′-dimethoxychalcone,2′-hydroxy-4,4′,6′-trimethoxydihydrochalcone	[48, 11]
Goniothalamus gardneri	Root	Gardnerilin A **(17)**, Gardnerilin B **(18)**	[49, 90]
Goniothalamus thwaitesii	Aerial part	Myricetin 4′-O-methyl ether-3-O-α-l-rhamnopyranoside (mearnsitrin) **(19)**, myricetin-3-O-methyl ether (annulatin) **(20)**, friedelinol **(21)**, friedelin **(22)**, betulinic acid **(23)**.	[48, 11]
Goniothalamus howii	Bark	Howiinol A **(24)**, Howiinin A **(25)**	[50-52, 12, 13]
Goniothalamus howii	Seed	Howiicin D, howiicin E, howiicins F, howiicins C.	[98]
Goniothalamus maewongensis	Leaves and twigs	Styryllactone	[53, 16]
Goniothalamus uvaroides	Roots	Styryl dihydropyrone, 5-acetyl goniothalamin terpinen-4-ol **(28)**, 1,8-cineole **(29)**	[54, 55, 17, 27]
Goniothalamus uvaroides	Leaf oils	β-cubebene **(30)**, β-selinene **(31)**	[55, 27]
Goniothalamus uvaroides	Bark oils	Eudesmols **(32)**	[55, 27]
Goniothalamus malayanus	Leaf oils	β-cubebene **(30)**, β-selinene **(31)**	[55, 27]
Goniothalamus malayanus	Bark oils	Eudesmols **(32)**	[55, 27]
Goniothalamus malayanus	Stem bark	(+)-Isoaltholactone **(1)**, altholactone	[21, 56, 1, 49]
Goniothalamus macrophyllus	Bark oil	Terpinen-4-ol **(28)**, β-ocimene, α-terpineol, 1,8-cineole (**29**), geranyl acetate **(34)**, geraniol **(33)**	[55, 57, 27, 99]
Goniothalamus macrophyllus	Twig	Geranyl acetate **(34)**, geraniol **(33)**, linalool, camphene **(35)**	[58, 31]
Goniothalamus macrophyllus	Roots	Cyperene **(36)**, geranyl acetate **(34)**, geraniol **(33)**, linalool **(37)**, pinene, benzaldehyde	[58, 31]
Goniothalamus macrophyllus	Stem	3-Amino-5-hydroxy-2-methoxynaphthalene-1,4-dione, 3-hydroxymethyl-1-methyl-1-1H-benzo[f]indole-4,9-dione, 2-acetyl-3-amino-5-hydroxy-6-methoxynaphthalene-1,4-dione, 10-amino-3,4-methylenedioxyphenyl-N-methoxy-9,10-dihydrophenanthrene-1-carboxylic acid lactam, 10-amino-3,4-dimethoxy-N-methoxyl-9,10-dihydrophenanthrene-1-carboxylic acid lactam, 6-methylene-2-styryl-3,6-dihydro-2H-pyran, 2-methylnaphthalein-1,4dione, 6-(1-hydroxy-2-methoxy-2-phenylethyl)-5,6-dihydro-2H-pyran-2-one, 6-methylene-2-(3-phynyloxiranyl)-3, 6-dihydro-2H-pyran, 5-hydroxyl-3-amino-2-aceto-3,1,4-naphthoquinone, 3-methoxy-4-methylbenzo[f]quinoline-2,5,10-(1H)-trione, 10-amino-3,4-methylenedioxyphenylphenanthrene-1-carboxylic acid lactam, 1-(6-methylene-3,6-dihydro-2H-pyran-2-yl)2-phenyl-ethane-1,2,diol, 8-hydroxy-7-phenyl-2,6-dioxabicyclic[3.3.1]nonan-3one, 10-amino-3-hydroxy-4-methoxypheanthrene-1-carboxylic acid lactam, liriodenine **(38)**	[59, 36]
Goniothalamus macrophyllus	Root	Goniolandrene-A, B	[60, 43]
Goniothalamus macrocalyx	Fruits	Macrocalactone, 3-deoxycardiobutanolide, cetogenins, annonacin **(6)**, solamin, isoannonacin, trans-murisolinone **(39)**, 7-acetylaltholactone, beta-caryophyllene-8R,9R-oxide and 2-(2′-hydroxytetracosanoylamino)-octadecane-1,3,4-triol	[61, 95]

(*Continued*)

Table 4: *Continued*

Species	Part used	Chemical constituents	References
Goniothalamus andersonii	Leaf oil	Guaiol **(40)** and elemol **(41)**	[55, 27]
Goniothalamus andersonii	Bark	Goniothalamin **(26)**	[62, 14]
Goniothalamus gitingensis	Leaves	Isoaltholactone **(1)**, altholactone **(1)**, goniopypyrone **(42)**, liriodenine **(38)**	[63, 18]
Goniothalamus amuyon	Stem, leaves, seeds	Goniodiol-7-monoacetate, goniodiol 8-monoacetate, goniotriol, Digoniodiol, Deoxygoniopypyrone A, goniofupyrone A, gonodiol, goniothalamin **(26)**, goniothalamin epoxide, gonodiol-7-monoacetate, gonodiol-8-monoacetate, 8-chlorogonodiol,8-methoxygonodiol, 9-Deoxygoniopypyrone,goniobutenolide A **(43)**, goniobutenolide B, goniothalesacetate, goniothalesdiol A **(44)**, goniodiol-8-monoacetate, leiocarpin C, liriodenine **(38)**, griffithazanone A **(45)**, 4-methyl-2,9,10-(2H)-1-azaanthracencetrione, velutinam **(46)**, aristolactam BII, gigantriocin **(8)**, corossolin **(47)**, annonacin **(6)**, N-methylatherosperminium **(48)**, (−)-discretamine **(49)**, (−)-tetrahydropalmatine, palmatine **(50)**, (−)-asimilobine **(51)**, (−)-norannuradhapurine **(52)**, (−)-crebanine, (−)-calycinine **(53)**, fissoldine, fissistigine A, (−)-anolobine **(54)**, (−)-xylopine, oxocrebanine, atherosperminine, N-noratherosperminine, (+)-O-methylflavinantine (O-methylpallidine), Goniothalesdiol A,(6R,7R,8R)-8-methoxygoniodioland (6R,7R,8R)-8-chlorogoniodiol	[64-74] [19-25, 47, 61, 75, 97]
Goniothalamus griffithii	Rhizome	8-Acetylgoniofufurone, 7-acetylgonio-pypyrone, and 5-acetylgoniopypyrone, goniofufurone **(55)**, goniopypyrone **(42)**, goniothalamin **(26)**, goniothalenol, isoaltholactone **(1)**, goniodiol **(57)**, 7-acetylgoniodiol, goniotriol, 8-acetylgoniotriol, 9-deoxygoniopypyrone	[75, 93]
Goniothalamus griffithii	Stem	Goniothalamin **(26)**, 9-deoxygoniopypyrone, altholactone **(1)**, goniodiol **(57)**, goniotharvensin **(56)**, goniofufurone **(55)**, 8-acetylgoniotriol, squamolone **(58)**, pinocembrin **(59)**, succinic acid, beta-sitosterol, and stigmasterol	[76, 77, 28, 102]
Goniothalamus griffithii	Leaves and twigs	Goniodiol monoacetate, b-sitosterol, b-daucosterol, (−)-7-O-Acetylgoniodiol, goniothalamin **(26)**, pinocembrin **(27)**	[78, 79, 33, 15]
Goniothalamus griffithii	Roots	Griffithazanone A **(45)**, griffithdione, and griffithinam **(60)**	[80, 46]
Goniothalamus griffithii	Bark	6-Hydroxy-7-(α hydroxybenzyl) hydroxy tetrahydrofurofuran-2-one, 6-(7,8 acetoxy phenylethyl)5,6-2H-5-hydroxy-2-pyrone, 8 hydroxy-7-phenyl 2,6 dioxabicyclononan-3-one 10-amino-2,4-dimethoxyphenanthrene-1-carboxylic acid lactam, 3,4,5 trimethoxyphenyl-1-O-β-D-glucopyranoside, gonioffithine, 5, 7-dihydroxyflavanone, 5,6-2H-6-styryl-2-pyrone, (5R, 6S, 7R, 8R)-7-hydroxy-8-phenyl tetrahydrofuro(3,2-b) pyran-2-one, (6R, 7R, 8R)-6-(7, 8-dihydroxyphenylethyl)-5, 6-2H-pyran-2-one, (4S, 5R, 6S, 7S, 8R)-6-hydroxy-7-(alpha-acetoxybenzyl)-tetrahydrofuro (3, 2-b) furan-2-one	[81-83, 87, 96, 81]
Goniothalamus australis	Aerial	Goniothalines A **(61)**, goniothalines B **(62)**, aristolactam AII, enterocarpam II, caldensine, sauristolactam, anonaine **(63)**, asimilobine **(51)**, altholactone **(1)**, goniofufurone **(55)**	[84, 29]
Goniothalamus umbrosus	Leaves	1-Butyl-2-cyclohexen-1-ol, benzaldehyde and globulol	[85, 30]
Goniothalamus umbrosus	Root	Dehydrogoniothalamin, goniothalamin **(26)**, 5-acetoxy goniothalamin	[86, 73]
Goniothalamus leiocarpus	Stem bark	7-Epi-goniodiol , leiocarpin B and leiocarpin C, Annonacin **(6)**, Corossoline, gigantriocin, murisolin, gonothalamin	[87, 88, 34, 37]
Goniothalamus leiocarpus	Seed	Leiocyclocin A, leiocyclocin B, Leiocyclocin C and D	[89, 90, 38, 39]
Goniothalamus leiocarpus	Stereoselectively synthesized	7-Epi-goniodiol and leiocarpin A	[91, 92, 35, 40]
Goniothalamus laoticus	Stem	Laoticuzanone A,3-Methyl-1H-1-azaanthracene-2,9,10-trione, griffithazanone A **(45)**, methyl sinapate, methyl p-coumarate, p-hydroxyphenylethyl p-coumarate	[93, 41]
Goniothalamus albiflous Ban	Leaf oil	α-Pinene, caryophyllene oxide, and 1,8-cineole	[94, 44]

(*Continued*)

Table 4: *Continued*

Species	Part used	Chemical constituents	References
Goniothalamus tamirensis	Leaves	Goniotamirine, goniotamiric acid, 3,5-demethoxypiperolide, (−)-N-nornuciferine **(65)**, (−)-norisocorydine, (−)-isocorydine **(66)**, (−)-3-hydroxynornuceferine, (−)-O-methylisopiline, (−)-anonaine **(63)**, (−)-roemerine **(67)**, (−)-roemeroline, (−)-boldine, glaunine, liriodenine **(38)**, 9-deoxygoniopypyrone, 8-epi-9-deoxygoniopypyrone, 8-epi-9-deoxygoniopypyrone acetate, goniodiol **(57)** and goniothalamin **(26)**	[95, 45]
Goniothalamus Grandiflorous	Leaves	Isoaltholactone **(1)**	[96, 50]
Goniothalamus Tortilipetalus	Stem bark, leaves	Discretamine **(49)**, liriodenine **(38)**, asimilobine **(51)**, Lanuginosine, 6-styryl-2-pyrone and goniothalamin **(6)**	[97, 51]
Goniothalamus scortechinii	Roots and leaves	Goniothalaminone A and B, (−)-8-epi-9-deoxygoniopypyrone acetate, indolequinone, 1-aza-anthraquinone, scorazanone	[98, 99, 52, 120]
Goniothalamus cardiopetalus	Stem bark	Cardiobutanolide, goniothalamin **(26)**, goniodiol, goniofufurone **(55)**, goniofupyrone, squamocin **(68)** goniodonin and 34-epi-goniodonin	[100, 53]
Goniothalamus velutinus	Stem bark	goniothalamin **(26)**, pinocembrine **(27)**, naringenin **(69)**	[101, 55]
Goniothalamus velutinus	Bark	velutinam (10-amino-8-hydroxy-3,4-dimethoxyphenanthrene-1-carboxylic acid lactam) **(70)**, aristolactam-BII (10-amino-3, 4-dimethoxyphenanthrene-1-carboxylic acid lactam).	[102, 91]
Goniothalamus undulatus	Root	5-acetoxyisogoniothalamin oxide, O-acetylaltholactone, altholactone **(1)**, Annonacin **(6)**, goniothalamicin	[103, 56]
Goniothalamus tapisoides	Stem bark	goniomicin A, goniomicin B, goniomicin C, goniomicin D, tapisoidin, goniothalamin **(26),** 9-deoxygoniopypyrone, pterodondiol, liriodenine **(38)**, benzamide, and cinnamic acid	[104, 58]
Goniothalamus cheliensis	Bark	8-hydroxy-7-phenyl-2, 6-dioxybicyclo [3, 3, 1] nonan-3-one, 10-amino-3, 8-dimethoxy-4-hydroxyphenanthrene-1-carboxylic acid lactam, 10-amino-4, 8-dihydroxy-3-methoxyphenanthrene-1-carboxylic acid lactam, beta-sitosterol and beta-sitosterol-3-O-beta-D-glucopyranside	[105, 54]
Goniothalamus cheliensis	Roots	Goniolactones A−F, gonioquinone, and goniofufurone acetonide	[106, 107, 68, 100]
Goniothalamus cheliensis	Root bark	Goniolactones G−I	[108, 89]
Goniothalamus wightii	Leaves and stem	Pypyrones	[109, 74]
Goniothalamus donnaiensis	Roots	Donhepocin, 34-epi-donhepocin, donhexocin, donbutocin, goniodonin, 34-epi-goniodonin, cis-goniodonin, 34-epi-cis-goniodonin, donnaienin C, 34- EPI-donnaienin C, donnaienin D, 34- EPI-donnaienin D, donnaienin	[110-113] [59, 76, 78, 85]
Goniothalamus marcanii	Stem bark	Azaanthraquinones and 3-Aminonaphthoquinone	[114, 77]
Goniothalamus marcanii	Leaves and twigs	5-hydroxygoniothalamin, 5-acetylgoniothalamin, and goniopypyrone **(42)**.	[115, 80]
Goniothalamus arvensis	Stem bark	(+)-Garvensintriol, (+)-etharvendiol, (+)-goniofufurone **(55)**	[116, 82]
Goniothalamus tomentosus	Stem bark and roots	Aristololactam BII, ouregidione , stigmasterol	[117, 83]
Goniothalamus woodii	Root	Goniothalamin **(26)**, 5-acetoxygoniothalamin and goniotriol	[118, 86]
Goniothalamus borneensis	Bark	Goniothalesdiol and goniothalactam	[119, 88]
Goniothalamus dolichocarpus	Stem bark	(+)-5β-Hydroxygoniothalamin	[120, 92]
Goniothalamus ridleyi	Root	5-Hydroxy-6-[(E)-2-phenylethenyl]-5,6-dihydro-2H-pyran-2-one	[121, 103]
Goniothalamus dolichocarpus	Stem bark	5-Hydroxy-6-[(E)-2-phenylethenyl]-5,6-dihydro-2H-pyran-2-one	[121, 103]
Goniothalamus sesquipedalis	Leaves and twigs	Goniopedaline, aristololactam A-II, taliscanine, aurantiamide acetate, β-sitosterol, β-d-glucoside	[122, 121]
Goniothalamus sesquipedalis	Stem bark	6S-(5-S-acetoxy)-7S, 8R-epoxystyryl-5,6-dihydro-2-pyrone (5-acetoxyisogoniothalamin oxide)	[123, 122]

Figure 1: List of some important structures of chemical constituents in genus *Goniothalamus*.

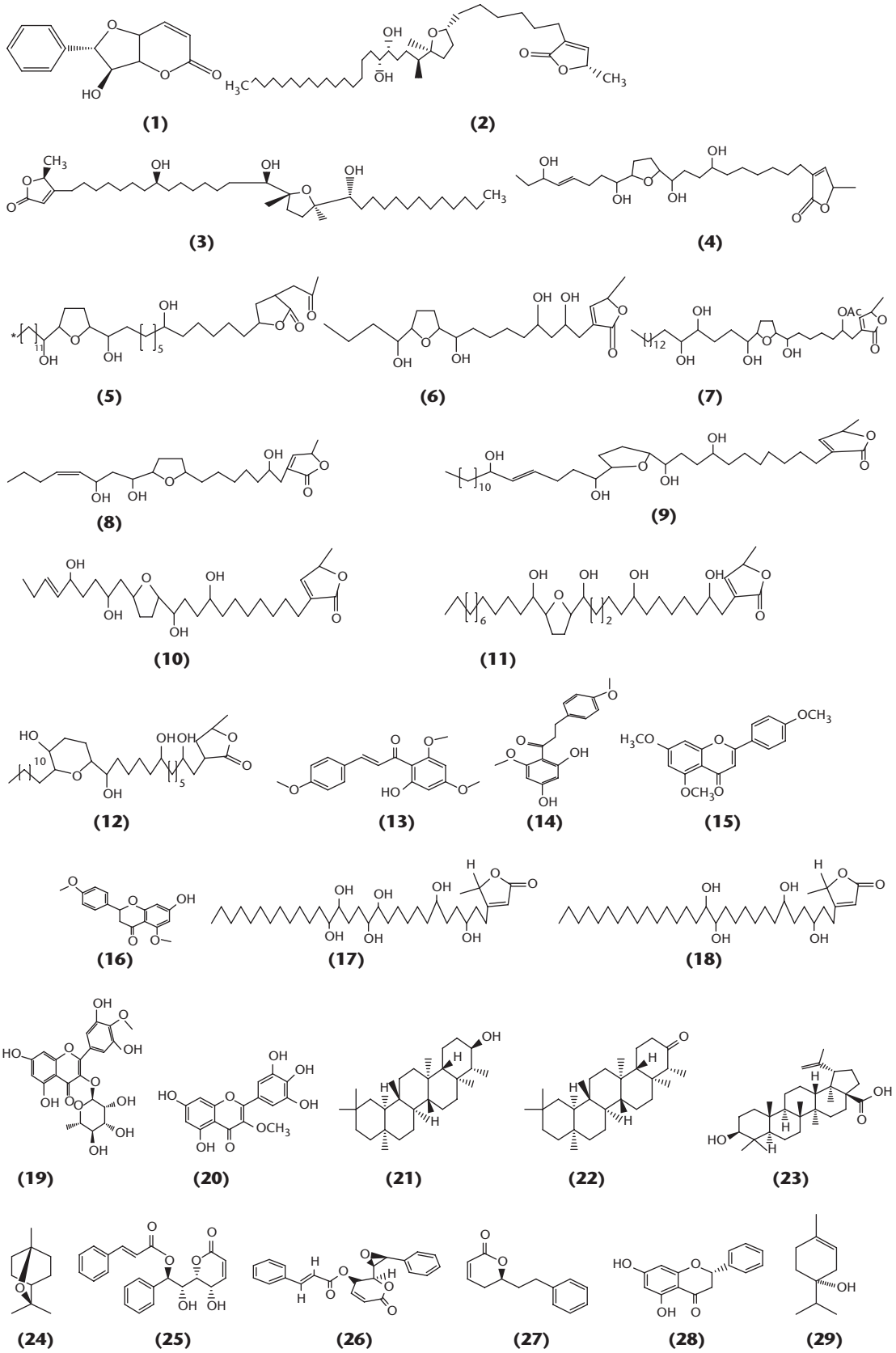

Figure 1: ***Continued***

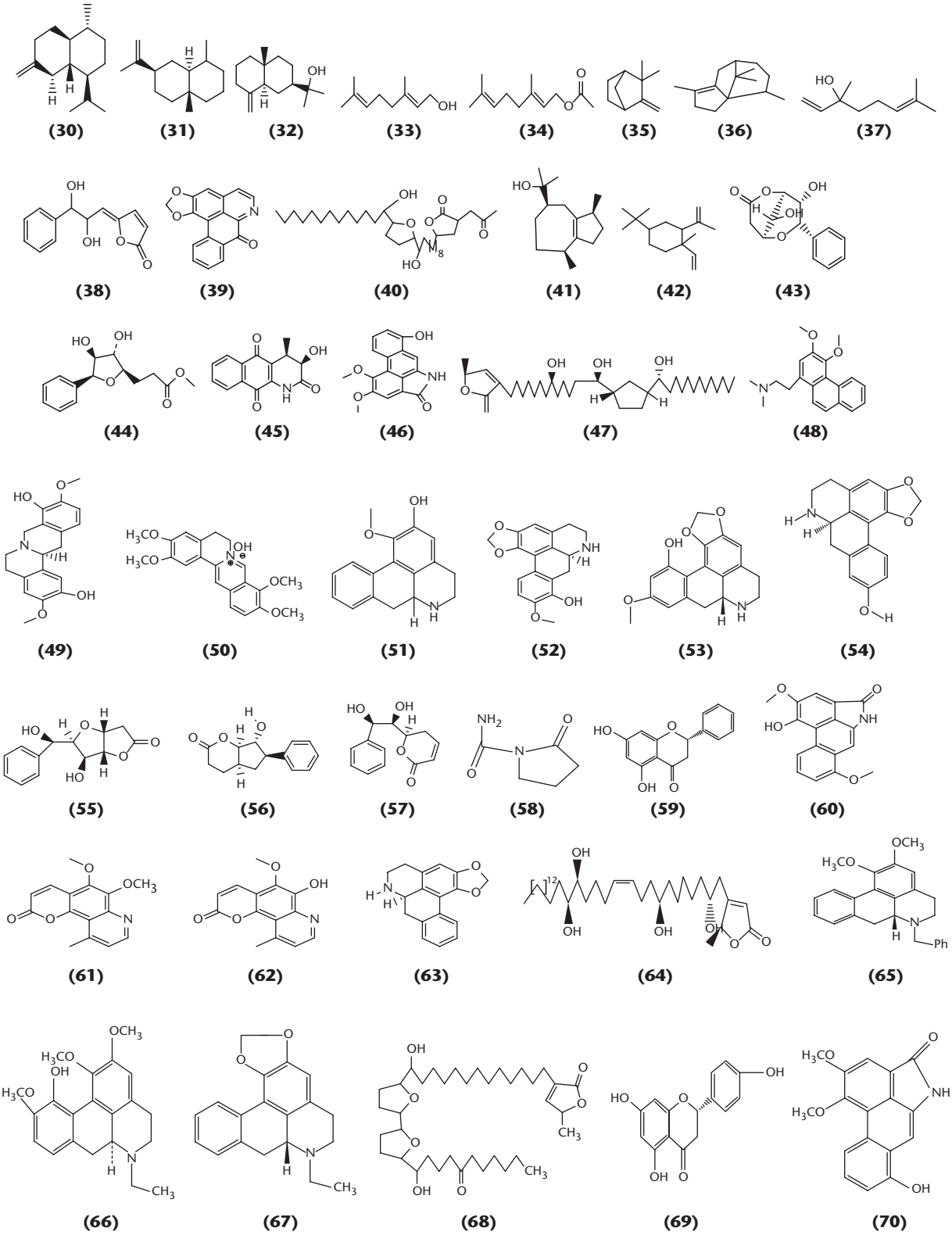

Table 5: Some important chemical natures of compounds isolated in genus *Goniothalamus*.

Chemical nature	List of compounds
Styryl lactones: phenolic compounds	*Goniothalamin,altholactone,ardiopetalolactone,goniopypyrone,goniodiol,goniofufurone, goniofupyrone, goniofufurone,goniopypyrone,goniothalamin,goniotriol,digoniodiol 8-acetylgoniotriol, deoxygoniopypyrone A, deoxygoniopypyrone A, howiinol, gonodiol-8-monoacetate,5-isogoniothalamin oxide. 5-Acetyl goniothalamin*
Acetogenins: unusual polyketides	*(2,4-cis and trans-)-Annomontacinones,annonacin,giganenin,gigantecin, 4-deoxygigantecin, (2,4-cis and trans)-gigantecinones, 4-acetylgigantetrocin A, goniotrionin, gigantransenin A,C, gigantrionenin,gigantetrocin,goniotetrocine, (2,4-cis and trans)-gigantetrocinones, gonionenin, (2,4-cis and trans)-gonioneninones, 4-deoxygigantenin,4-deoxyan nomontacin,goniothalamicin,pyranicin,gigantriocin, goniotriocin, (2,4-cis and trans)-isoannonacins, longicoricin,longifolicicin, longimicin C, cis-gigantrionenin,pyragoniocin, xylomaticin, and (2,4-cis and trans)-xylomaticinones,donhepocin, goniodin,donhexocin,donbutocin,Gardnerilins A and B*
Alkaloids	*Discretamine,tetrahydropalmatin,palmatine,asimilobine,norannuradhapurine,crebanine, calycinine,anolobine,xylopine,anonaine,oxocrebanine,liriodenine,atherosperminine, N-noratherosperminine,(+)-O-methylflavinantine,oxostaphanine,griffithazanone A, griffithdione,griffithinam, 4-methyl-2,9,10-(2H)-1-azaanthracenetrione,velutinam, aristololactam BI, aristololactam BII, aristololactam AII, and norcepharanone B, (3S)-2-Oxo-5,12-dimethoxy-3-hydroxy-3-methylbenz[f]indoline*

5. CONCLUSION

Literature actually reports chemical investigations of only forty species of *Goniothalamus* out of the 160 known species. There are no published data concerning either the toxicity of the whole remedies and the isolated compounds from new species of *Goniothalamus*. Despite the diversity of the genus and the numerous phytochemical constituents found, they have not been fully explored yet. Clinical investigation for new cytotoxic compounds is yet to be done. Further investigations on phytochemical discovery and subsequent screening are needed for opening new opportunities to develop pharmaceuticals based on *Goniothalamus* constituents.

Author Contributions
Every author has contributed equally during preparation of manuscript.

Source of Funding
None.

Conflict of Interest
None.

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Citation: Aslam MS, Ahmad MS, Mamat AS, Ahmad MZ, Salam F. *Goniothalamus*: phytochemical and ethnobotanical review. Recent Adv Biol Med. 2016; 2:34-47.