Chemistry and Biology of Novel Meliaceae Limonoids

Fayaj A. Mulani [1, 2 †], Sharvani S. Nandikol [1, 2 †] and Hirekodathakallu V. Thulasiram [1, 2, 3 *]

[1] Chemical Biology Unit, Division of Organic Chemistry, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune - 411008, India

[2] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad – 201002, India

[3] CSIR-Institute of Genomics and Integrative Biology, Mall Road, New Delhi - 110007, India

* Corresponding author: Hirekodathakallu V. Thulasiram

Email address: hv.thulasiram@ncl.res.in

Ph.: +91-20-2590 2478

[†]These authors contributed equally to this work.

***Correspondence:**

Dr. Hirekodathakallu V. Thulasiram

Professor / Senior Principal Scientist

Chemical Biology Unit,

Division of Organic Chemistry,

CSIR-National Chemical Laboratory,

Dr. Homi Bhabha Road, Pune - 411008, India.

Fax: +91 2025902629

Tel: +91 2025902478

E-mail: hv.thulasiram@ncl.res.in

Email addresses of authors

hv.thulasiram@ncl.res.in

fa.mulani@ncl.res.in

ss.nandikol@ncl.res.in

Abstract

Nature has bestowed us with abundant bioactive/drug molecules for various uses in our everyday life. One such group of plant specialized molecules is limonoids, which are structurally characterized as 4,4,8-trimethyl-17-furanyl steroidal skeleton. Limonoids are well known for their various biological activities such as potent anti-feedent, anti-cancer, anti-inflammatory, insecticidal, anti-diabetic, anti-viral, anti-microbial etc. These tetranortriterpenes are highly oxygenated and structurally diversified molecules majorly found in *Meliaceae* and *Rutaceae* and less frequently in the *Cneoraceae* families in the plant kingdom. Many of these plants have been used in traditional medicine from ages. One of the well-known limonoid, azadirachtin A is highly valued and widely popular for its outstanding insecticidal properties. Till date, nearly 2500 limonoids with over 35 unique carbon frameworks have been observed. In recent times, these molecules have dig a great interest among researchers due to their myriad biological properties. With the advancement of analytical techniques, the limonoid research is aced to explore more different molecules from their sources. In our review we cover all the Meliaceous limonoids isolated during July 2010 to Dec 2020. We found over 1502 new limonoids, which are reported from various Meliaceae plants after Jun 2010. We have classified them based on their skeletal structure rearrangements and functional groups into various classes such as protolimonoids, Apoprotolionoid, Azadirone, Vilasinin, Cedrelone, Havanensin, Trichilin, Nimbin, Salannin, Azadirachtin, Nimbolidin, Nimbolinin, Obacunol, Evodulone, Trijugin, Cipadesin, Andirobin, Mexicanolide, Phragmalin, Khayanolide, Preieurianin, Aphanamixoid, Nor Limonoid and N-containing derivatives. Further we have discussed their biological activities in detail.

Contents		

1. Introduction

Nature has always amazed us with its vast engineering of natural products from different sources. Limonoids are a class of plant specialized metabolites with innumerable biological effects. The first limonoid was isolated from citrus in 1841, called as limonin which was responsible for the bitterness of the lemon[1]. Limonoids belong to class of tetracyclic triterpenoids which are formed by loss of four terminal carbons of the side chain in the apotirucallane (C30) skeleton and then cyclized to form the 17α-furan ring, also known as tetranortriterpenoids (C26). Limonoids are structurally diversified oxygenated compounds found in ring intact or highly rearranged *seco*-ring forms. They are distributed in Ptaeroxylaceae, Rutaceae, Cneoraceae, Simaroubaceae and Meliaceae families of plants[2]. Some of the other plant families reported to contain limonoids are Burseraceae[3], Flacourtiaceae[4], Boraginaceae[5] and Euphorbiaceae[6,7,8,9]. However the abundance of these limonoids is mainly restricted to Meliaceae and Rutaceae families.

The Meliaceae family is comprised of 58 genera and 534 known species as listed in National Center for Biotechnology Information database [https://www.ncbi.nlm.nih.gov]. The Meliaceae family is also called as Mahogany family with pantropical distribution. This family mainly consists of woody plants and rarely shrubs. Since ages the Meliaceae family plants are used for various purposes like in folk medicine, as insecticides and their highly priced wood. Across the globe, Meliaceae plants are of great economic importance. The limonoids from Meliaceae family are called as meliacins displaying a wide array of biological activities like antimicrobial, cytotoxic, antimalarial, antifeedant, insecticidal etc. The most noted limonoid Azadirachtin isolated from seed kernel of *Azadirachta indica* is well known for its anti-feedant activity against more than 600 species of insects[10]. It is one of the most promising limonoid in developing biopesticides for integrated pest management. Apart from their application in agriculture, these limonoids are also good applicants in the field of medicine. For instance, Gedunin, Azadiradione, Nimbolide, Epoxyazadiradione have shown to exert cytotoxic activity against various human cancer cell lines[11,12,13,14]. Owing to their limitless capability in the field of agriculture, human diseases and medicine, the research on discovery of novel meliacins is under way.

In the recent times, these molecules have dig a great interest among researchers due to their myriad biological properties. With the advancement of analytical techniques, the limonoid research aced to explore more different molecules from their sources. Q. Tan *et. al*. classified all the Meliaceae limonoids isolated between 1942 to 30 June 2010 in the review entitled 'Meliaceous limonoids: Chemistry and biological activities'[12]. In this review, Qin-Gang Tan and Xiao-Dong Luo have enlisted 1159 limonoids which are isolated and characterized in six decades. Based on their skeletal structure, they have classified them in to seventeen different classes and discussed their bioactivities. After this some reviews have been published on chemical synthesis of limonoids[15], limonoid chemistry[2], genus specific reviews covering the limonoids from a single genus[16–24], genus based classification of limonoids[25], phytochemistry and bioactivity based reviews[26,27] structure activity relationship based bioactivity of natural and synthesized limonoids[28] and novel triterpenoids isolated from different plants[29–34]. Although numerous reviews are published there is no systematic study discussing chemical and biological aspects of Meliaceae limonoids after the year 2010. This review highlights the classification of limonoids based on structure, covering their sources and various biological activities of novel limonoids. Overall this review describes the chemistry and biology of novel limonoids isolated from Meliaceae in the last ten years (1 July 2010 to 31 Dec. 2020). However this review doesn't address total/chemical synthetic efforts of new limonoids.

Limonoids biosynthesis in vivo remains elusive. The isoprene units derived from Mevalonate (MVA) or Methylerithritol (MEP) pathway undergo sequential condensation forming 30-carbon triterpene scaffold which then forms protolimonoid skeleton under the influence of oxidosqualene cyclases (Figure 1). Previously, based on the stereochemistry of protolimonoids in Meliaceae plants, Euphol, Tirucallol, or their Δ^7-isomers i.e. butyrospermol and Tiruculla-7,24-dien-3β-ol were believed to be biogenetic precursor of limonoids[35,36]. The major structural markers to differentiate between Euphol and Tirucallol are C20 configuration and bond rotation at (C17, C20). In Euphol, the C20 configuration is 20R and in Tirucallol it is 20S. The orientation of C22 with respect to C13 is *cis* in Euphol and *trans* in Tirucallol[37]. The labeling studies did not confirm the biogenetic precursor of limonoids in the previous studies[36,38]. The isotope labeled feeding experiments demonstrated the involvement of MVA pathway in limonoid biosynthesis[39,40]. Over the years with the development of genomic technology and resources, the mystery of limonoid biosynthesis is partially revealed. Very recently through genome mining and transcriptome sequence resources, an oxidosqualene cyclase producing Tiruculla-7,24-dien-3β-ol was identified in different limonoid producing plants like *Azadirachta indica*[41,42], *Melia azedarach* and *Citrus sinensis*[41]. Also the cytochrome P450

enzymes when coexpressed with this oxidosqualene cyclase produced Dihydroniloticin, Tirucalla-7,24-dien-21,3β-diol and Melianol which are protolimonoids[41]. These protolimonoids are formed by scaffold rearrangement and furan ring formation along with loss of four carbon atoms (Figure 1). These recent studies conclude Tirucalla-7,24-dien-3β-ol as a biogenetic precursor of limonoid biosynthesis. Also from these studies the initial steps involved in protolimonoid formation from isoprene units is nearly perspicuous.

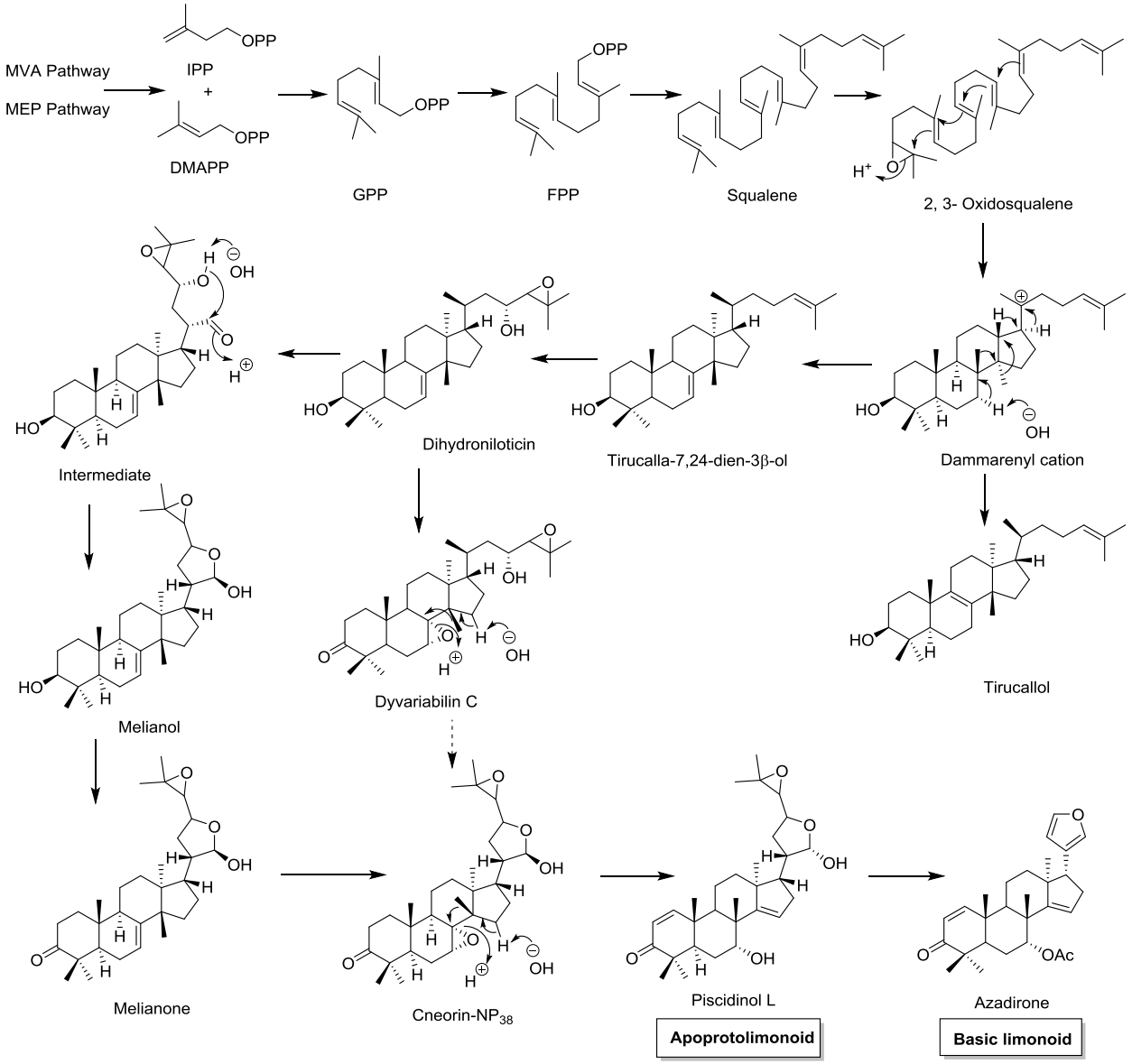


Figure 1. Limonoid biosynthetic pathway.

2. Classification of Meliaceae limonoids

Based on their chemical skeletons, 1502 Meliaceae limonoids were classified into 57 groups (Figure 2A/B) as Protolimonoid/Tirucallanetriterpenoid, Ring A-seco Protolimonoids, Nor Protolimonoids, Apoprotolimonoid/Apotirucallanetriterpenoid, Ring A-seco Apoprotolimonoid, Azadirone class limonoids, Cedrelone class limonoid, 18(13→14) abeo class limonoid, Havanensin class limonoid, Trichilin class limonoid, Vilasinin class limonoid, Other ring intact class limonoid, Evodulone class limonoid, Other ring A-seco class limonoid, Ring B-seco class limonoid, Azadirachtin/Meliacarpin class limonoid, Salannin class limonoid, Nimbolinin class limonoid, Nimbin class limonoid, Nimbolidin class limonoid, Gedunin class limonoid, other ring

D-seco class limonoid, Ring E-seco class limonoid, Prieurianin class limonoid, Aphanamixoid class limonoid, Other rings A,B-seco class limonoid, Obacunol class limonoid, Chukrasone class limonoid, other rings A,D-seco class limonoid, Andirobin class limonoid, Other rings B,D-seco class limonoid, Rings B,C-seco class limonoid, Rings A,E-seco class limonoid, Rings A,B,D-seco class limonoid, Mexicanolide class limonoid, 9,10-seco-Mexicanolide class limonoid, [1-8-9] Phragmalin orthoester class limonoid, [8-9-11] Phragmalin orthoester class limonoid, [8-9-12] Phragmalin orthoester class limonoid, [8-9-14] Phragmalin orthoester class limonoid, [8,9,30] Phragmalin orthoester class limonoid, Polyoxyphragmalin class limonoid, 1,2-seco Phragmalin class limonoid, 1,10-seco Phragmalin class limonoid, 16-Nor Phragmalin class limonoid, Khayanolide class limonoid, Trijugin class limonoid, Cipadesin class limonoid, Other linkage class limonoid, Pentanor triterpenoids class limonoid, Hexanor triterpenoids class limonoid, Heptanor triterpenoid, Octanor triterpenoids class limonoid, Enneanor triterpenoids class limonoid, Degraded derivatives class limonoid, N-containing derivatives class limonoid. Other derivatives class limonoid. The basic limonoid (azadiradione) skeleton is extensively modified/functionalized to produce variety of ring intact, ring seco and rearranged limonoids (Figure 2B). Most of the novel limonoids were isolated majorly from seeds (22.17 %) followed by twig (19.71 %), bark/stem (19.44 %), fruit (16.18 %), leaf (12.72 %) root (6.26 %) and flower (1.73 %) which is represented in Figure 2C. The highest number of novel limonoids were isolated in the year 2020 followed by 2014 (Figure 2D).

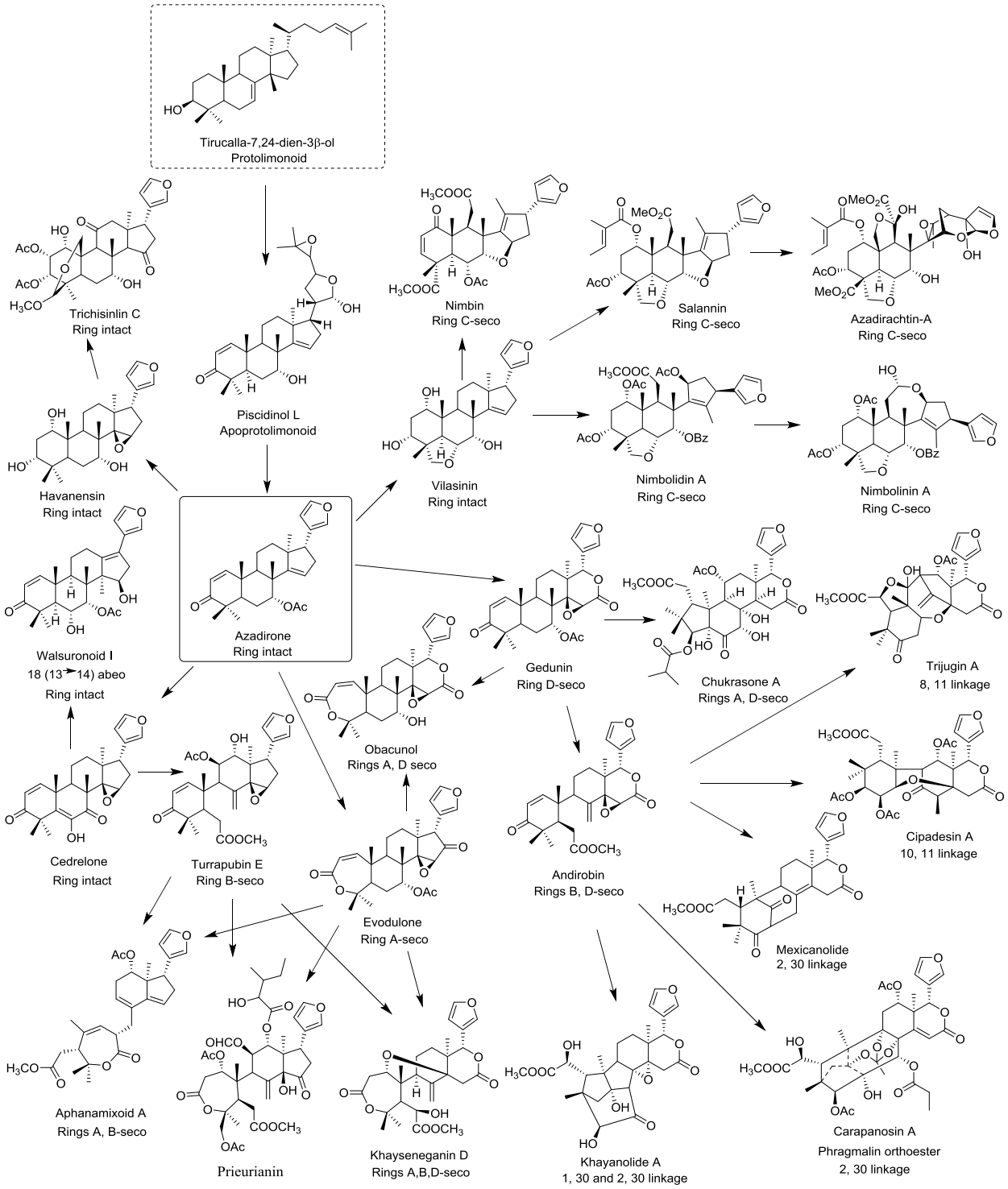


Figure 2A. Classification of limonoids and their tentative pathway of origin.

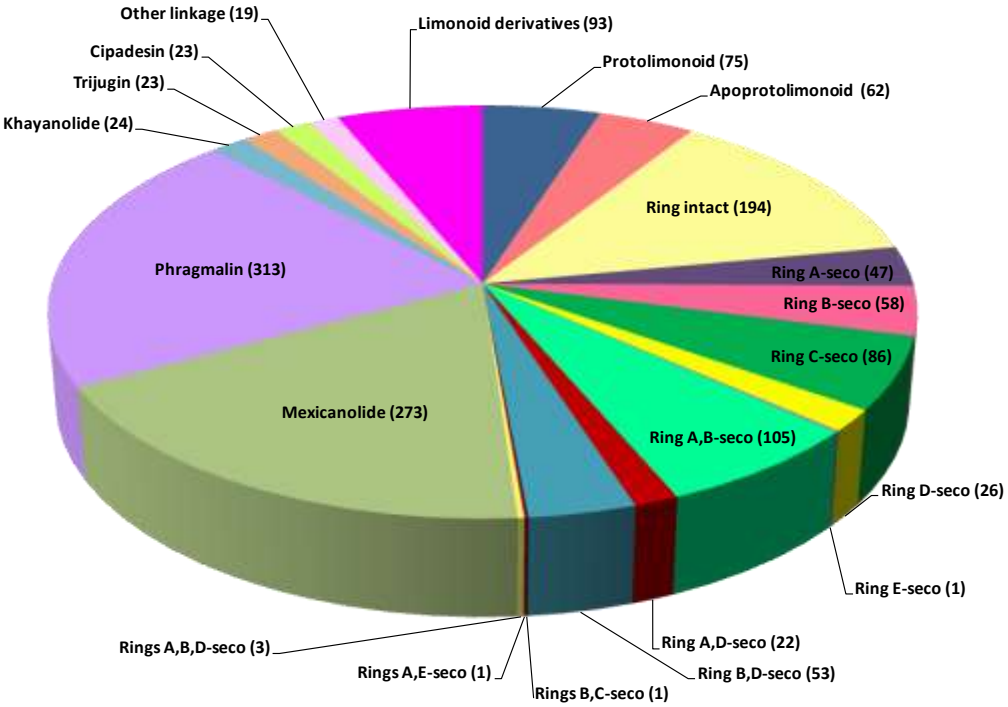


Figure 2B. Summary of major classes of Meliaceae limonoids

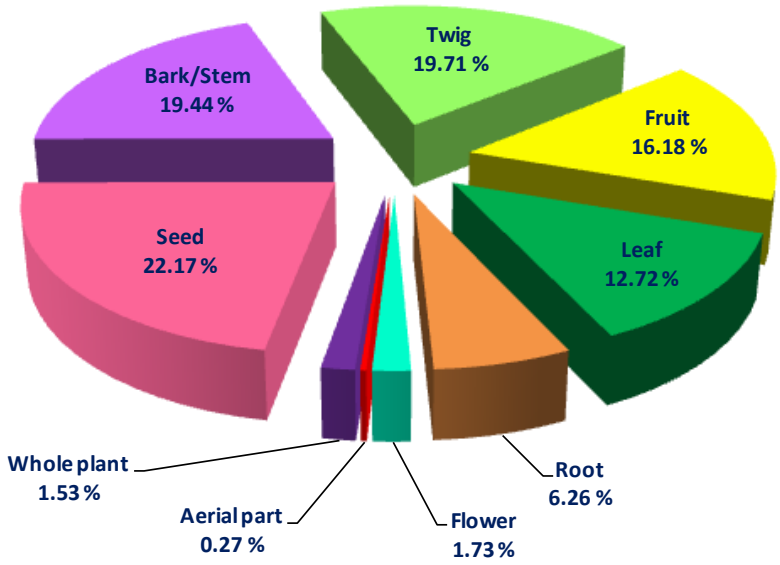


Figure 2C. Distribution plot showing the tissue specific isolation of novel limonoids

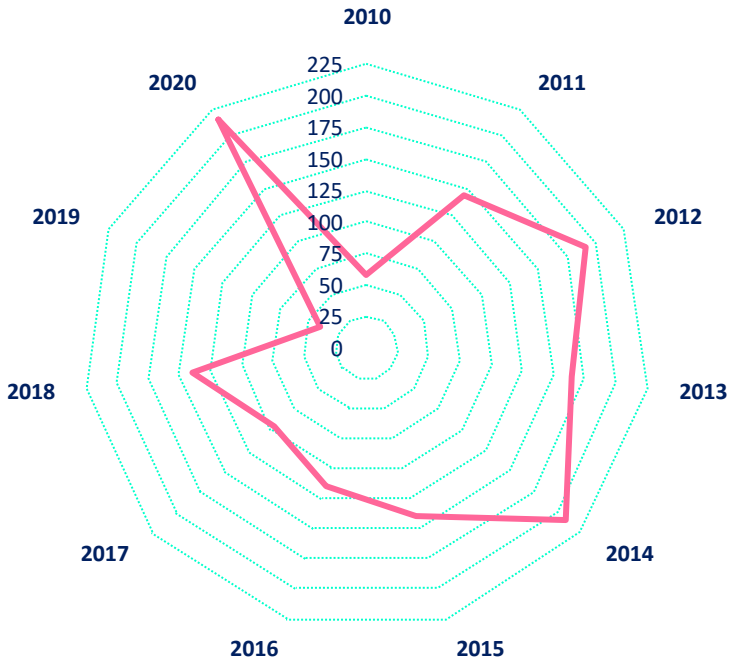


Figure 2D. Radar plot of all novel limonoids isolated from Meliaceae plants year wise.

2.1. Limonoid precursor

2.1.1. Protolimonoid/Tirucallanetriterpenoid

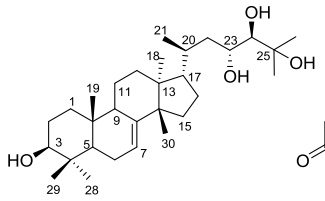
Protolimonoids are C30 tetracyclic triterpenes characterized by the presence of a steroidal skeleton containing $\Delta^{7,8}$ olefinic double bond. This class of limonoids are the precursor molecules for generation of variety of structurally diversified limonoids. A total of fifty five new protolimonoids were isolated from *Xylocarpus moluccensis*, *Toona ciliata*, *Dysoxylum hainanense*, *Aphanamixis grandifolia*, *Dysoxylum lukii*, *Dysoxylum lenticellatum, Azadirachta indica, Capuronianthus mahafalensis, Melia azedarach, Guarea kunthiana, Aphanamixis polystachya, Walsura cochinchinensis, Dysoxylum binectariferum and Melia toosendan* (Table 1/S1, Figure 3). The 3β-hydroxy-3-decarbonyl-24-epi-piscidinol A (**1**) is structurally similar to previously reported 24-epi-piscidinol[43] except at C3 carbonyl reduction. Toonamicrocarpavarin (**2**) has an additional double bond at $\Delta^{1,2}$ when compared to previously reported Piscidinol A[44]. Toonapubesin D (**3**) is C21 hydroxy analog of compound (**2**). Toonapubesin E (**4**) differed from previously reported Hispidol A[45] at C29 hydroxylation. The C3 hydroxyl group in compound (**4**) is oxidized in Toonapubesin F (**5**). Dysoxyhaine D (**6**) is distinguished from compound (**5**) at C1 containing additional hydroxyl moiety and enol group at side chain. In Dysohainanin F (**7**) $\Delta^{23,24}$ double bond is formed and hydroxyl moiety is shifted from C21 to C26 when compared to compound (**3**). Aphanamgrandin K (**8**) and Toonapubesin G (**10**) are structurally similar to previously reported Dyvariabilin A[46] and Piscidinol A[44] respectively except at the side chain. Aphagranin F (**9**) is the C25 ethoxy analog of Piscidinol A reported previously[44]. Xylocarpol C (**11**) differed from previously reported xylocarpol B[47] at C24 hydroxylation and C20 configuration. Aphagranin E (**12**) is a C25 methoxy analog of compound (**11**). The presence of two additional methoxy groups at C21 in Aphagranin A (**13**) is the only difference in comparison to compound (**12**). Aphagranin B (**14**) is a C25 ethoxy analog of compound (**13**). Aphagranin C (**15**) varied from compound (**14**) at C21 substitution. Compound (**16**) is C3 carbonyl reduced analog of Dymacrin D reported previously[48]. In comparison to compound (**16**), Congoensin B **(17)** is oxidized at C21 and 3β-hydroxytirucalla-7,24-diene-6,23-dione (**18**) has keto carbonyl group at C6. 3β,26-dihydroxytirucalla-7,24-diene-6,23-dione (**19**) is a C26 hydroxy analog of compound (**18**). Methyl 6-oxomasticadienolate (**20**) varied from compound (**18**) at C26 methyl group esterification and loss of carbonyl moiety at C23. The hydroxyl group at C3 in previously reported (23Z)-3β,25-dihydroxytirucalla-7,23-diene[49] is oxidized in compound (**21**). The C21 methyl group in previously reported 24,25-epoxytirucall-7-ene-3,23-dione[50] is replaced by acid in Dysolenticin H **(22)** and ester moiety in Dysolenticin I **(23)** respectively. Dysoxyhaine C (**24**) is a C6 hydroxy analog of 24,25-epoxytirucall-7-ene-3,23-dione[50]. The carbonyl group at C23 in 24,25-epoxy-3β,23-dihydroxy-7-tirucallene[49] is

reduced in compound (**25**). Capulin (**26**) is a very unique protolimonoid containing four membered ring in its side chain. Compound (**27**) is C25 methoxy analog of previously reported Melianodiol[51,52]. Compound (**28**) is C3 epimer of previously reported Paramignyol A[53]. Compounds (**29** and **30**) are C21 methoxy, C25 dehydroxy $\Delta^{25,26}$ and C25 dehydroxy $\Delta^{25,26}$ analogs of Melianodiol respectively. The C21 methoxy and C25 hydroxy groups in previously reported Agladupol E[54] are removed in Dysolenticin E (**31**) along with additional hydroxyl group at C23 and oxidation at C24. Dysolenticin D (**32**) is a C3 oxidised analog of compound (**31**). Compound (**33**) is the C23 ethoxy analog of compound (**31**). The epoxide ring formation at C24,25 in compounds (**34** and **47**) makes them structurally different from compounds (**33** and **44**) respectively. Compound (**35**) has methoxy groups at C21 and C23 when compared to compound (**34**). Compound (**36**) is C3 oxidised analog of compound (**35**). Compound (**37**) is C3 tigloyl derivative of previously reported Melianol[55]. Polystanin C (**38**) is C3 acetyl and C21 methoxy analog of Meliantriol reported previously[56]. Polystanin D (**39**) is a C21 epimer of compound (**38**). Indicalilacol C (**40**) is the C21 methoxy analog of Meliantriol with an additional double bond at $\Delta^{9,11}$. Cochinchinoid K (**41**) is structurally similar to previously reported 24-epi-melianodiol[43] except at C3 reduction and C21 oxidation. Indicalilacol B (**42**) is C21 epimer of compound (**41**). Mesendanin M (**43**) is a C29 hydroxyl derivative of compound (**42**). Compound (**44**) is C21 methylated and C24 acetylated derivative of Melianodiol. The C24 acetoxyl group in compound (**44**) is replaced by keto carbonyl group in compound (**45**). Compound (**46**) is a C25 methoxy analog of compound (**45**). Dysolenticin B (**51**) is $\Delta^{20,22}$ analog of Nimolinone reported previously[57]. Compound (**49**) is $\Delta^{23,24}$ $\Delta^{25,26}$ analog of compound (**48**). Compound (**50**) is a C25 methoxy analog of compound (**49**). Compounds (**51**-**54**) contain six membered lactone ring at C17 and vary among each other in lactone ring substituents. Toonaciliatavarin D (**55**) is C3 epimer of Sapelin B reported previously[58].

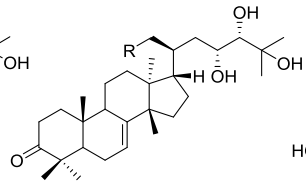
Table 1. Protolimonoid/Tirucallanetriterpenoid 1-55

No.	Limonoid	Substituent	Source
1	3β-hydroxy-3-decarbonyl-24-epi-piscidinol A		*Xylocarpus moluccensis*[59]
2	Toonamicrocarpavarin	R = H; $\Delta^{1,2}$	*Toona Ciliata*[60]
3	Toonapubesin D		*Toona ciliata*[61]
4	Toonapubesin E		*Toona ciliata*[61]
5	Toonapubesin F		*Toona ciliata*[61]
6	Dysoxyhaine D		*Dysoxylum hainanense*[62]
7	Dysohainanin F		*Dysoxylum hainanense*[63]
8	Aphanamgrandin K		*Aphanamixis grandifolia*[64]
9	Aphagranin F		*Aphanamixis grandifolia*[65]
10	Toonapubesin G		*Toona ciliata*[61]
11	Xylocarpol C	R_1 = OH; R_2 = H	*Xylocarpus moluccensis*[47]
12	Aphagranin E	R_1 = β-OH; R_2 = OCH_3	*Aphanamixis grandifolia*[65]
13	Aphagranin A	R = CH_3	*Aphanamixis grandifolia*[65]
14	Aphagranin B	R = CH_2CH_3	*Aphanamixis grandifolia*[65]
15	Aphagranin C		*Aphanamixis grandifolia*[65]
16	3β-hydroxytirucalla-7,24-dien-23-one	R_1 = β-OH; R_2 = CH_3	*Dysoxylum lukii*[66]
17	Congoensin B	R_1 = α-OH; R_2 = COOH	*Entandrophragma congoënse*[67]
18	3β-hydroxytirucalla-7,24-diene-6,23-dione	R = H	*Dysoxylum lukii*[66]
19	3β,26-dihydroxytirucalla-7,24-diene-6,23-dione	R = OH	*Dysoxylum lukii*[66]
20	Methyl 6-oxomasticadienolate		*Dysoxylum lukii*[66]
21	(23Z)-25-hydroxy-tirucalla-7,23- diene-3-one		*Aphanamixis grandifolia*[64]
22	Dysolenticin H	R_1 = H; R_2 = COOH	*Dysoxylum lenticellatum*[68]
23	Dysolenticin I	R_1 = H; R_2 = $COOCH_3$	*Dysoxylum lenticellatum*[68]
24	Dysoxyhaine C	R_1 = OH; R_2 = CH_3	*Dysoxylum hainanense*[62]
25	24,25-epoxy-3β-hydroxy-20- oxo-7-tirucallene		*Azadirachta indica*[69]
26	Capulin		*Capuronianthus mahafalensis*[70]
27	(21S,23R,24R)-21,23-epoxy-21,24-dihydroxy-25-methoxytirucall-7-en-3-one		*Melia azedarach*[71]
28	(3S,21S,23R,24S)-21,23-epoxy-21,25-dimethoxytirucall-7-ene-3,24-diol		*Melia azedarach*[71]
29	(21S,23R,24R)-21,23-epoxy-24-hydroxy-21- methoxytirucalla-7,25-dien-3-one	R = CH_3	*Melia azedarach*[71]
30	(21S,23R,24R)-21,23-epoxy-21,24-dihydroxytirucalla-7,25-dien-3-one	R = H	*Melia azedarach*[71]
31	Dysolenticin E		*Dysoxylum lenticellatum*[68]
32	Dysolenticin D		*Dysoxylum lenticellatum*[68]
33	(3α,13α,14 β,17α,20S,23R)-23-ethoxy-3-hydroxy-21,23-epoxylanost-7-en-24-one		*Aphanamixis grandifolia*[72]

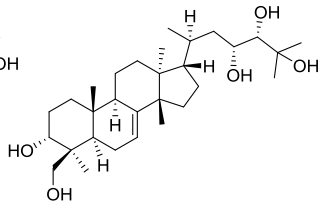
34	Dysolenticin F		*Dysoxylum lenticellatum*[68]
35	(3R,5R, 9R,10R,13S,14S,17S)-17-{(2R,3S,5R)-5-[(2S)-3,3-dimethyloxiran-2-yl]-2,3,4,5-tetrahydro-2,5-dimethoxyfuran- 3-yl}-4,4,10,13,14-pentamethyl-2,3,4,5,6,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta- [α]phenanthren-3-ol		*Aphanamixis grandifolia*[72]
36	(5R,9R,10R,13S,14S,17S)-17-{(2R,3S,5R)-5-[(2S)-3,3-dimethyloxiran-2-yl]-2,5- dimethoxytetrahydrofuran-3-yl}-1,2,4,5,6,9,10,11,12,13,14,15,16,17-tetradecahydro-4,4,10,13,14-pentamethyl- 3H-cyclopenta[α]phenanthren-3-one		*Aphanamixis grandifolia*[72]
37	3β-*O*-tigloylmelianol		*Guarea kunthiana*[73]
38	Polystanin C	R_1 = α-OAc; R_2 = α-OCH_3; R_3 = α-OH	*Aphanamixis polystachya*[74]
39	Polystanin D	R_1 = α-OAc; R_2 = β-OCH_3; R_3 = α-OH	*Aphanamixis polystachya*[74]
40	Indicalilacol C	R_1 = β-OH; R_2 = α-OCH_3; R_3 = OH; $\Delta^{9,11}$	*Azadirachta indica*[75]
41	Cochinchinoid K	R_1 = β-OH; R_2 = H	*Walsura cochinchinensis*[76]
42	Indicalilacol B	R_1 = α-OH; R_2 = H	*Azadirachta indica*[75]
43	Mesendanin M	R_1 = α-OH; R_2 = OH	*Melia azedarach*[77]
44	(+)-21R*,23R*-epoxy-21α-methoxy-24S*,25-dihydroxyapotirucall-7-en-3-one		*Dysoxylum binectariferum*[78]
45	(+)-21R*,23R*-epoxy-21α- methoxy-25-hydroxyapotirucall-7-en-3,24-dione	R = H	*Dysoxylum binectariferum*[78]
46	(+)- 21R*,23R*-epoxy-21α,25-dimethoxyapotirucall-7-en-3,24-dione	R = CH_3	*Dysoxylum binectariferum*[78]
47	(+)-21R*,23R*-epoxy-21α-methoxy-24S*,25- oxidoapotirucall-7-en-3-one		*Dysoxylum binectariferum*[78]
48	Dysolenticin B		*Dysoxylum lenticellatum*[68]
49	(13α,14 β,17α,23Z)-21,23-epoxylanosta-7,20(22),23,25-tetraene-3,21-dione		*Aphanamixis grandifolia*[72]
50	(13α,14β,17 α,23Z)-25-methoxy-21,23-epoxylanosta-7,20(22),23-triene- 3,21-dione		*Aphanamixis grandifolia*[72]
51	Dysolenticin A		*Dysoxylum lenticellatum*[68]
52	Mesendanin Q		*Melia toosendan*[79]
53	Dysoxylumstatin A		*Dysoxylum lukii*[66]
54	Dysoxylumstatin B		*Dysoxylum lukii*[66]
55	Toonaciliatavarin D		*Toona ciliata*[80]



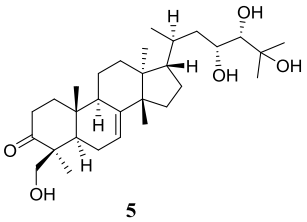
1



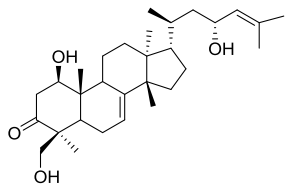
2-3



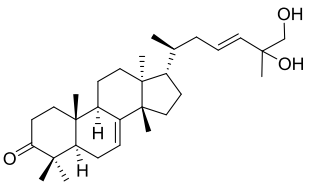
4



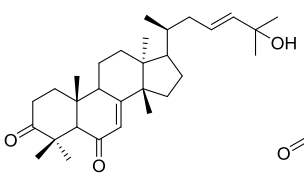
5



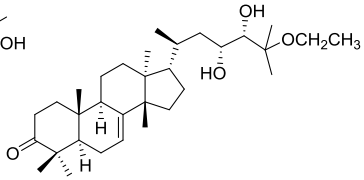
6



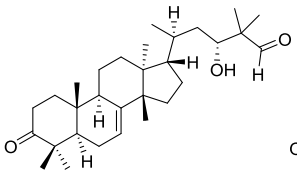
7



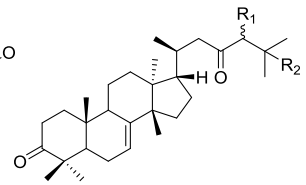
8



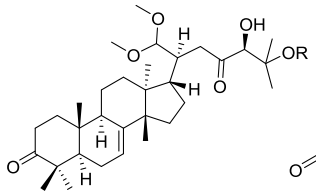
9



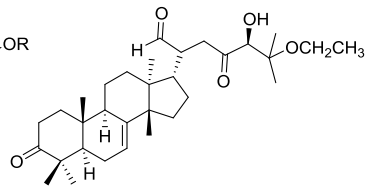
10



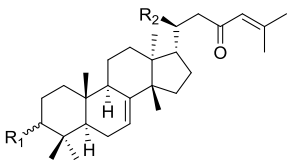
11-12



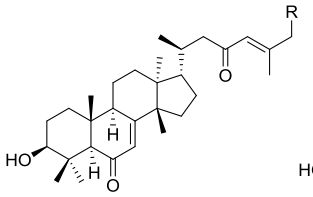
13-14



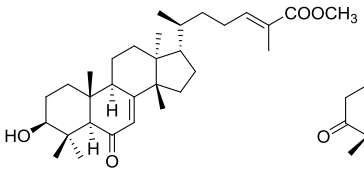
15



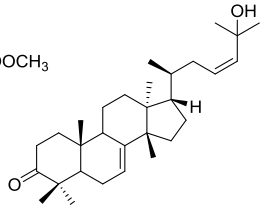
16-17



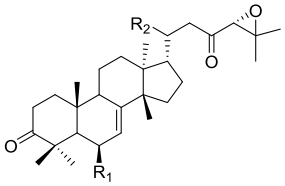
18-19



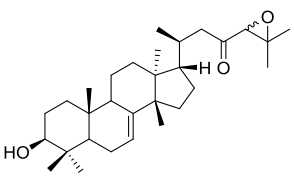
20



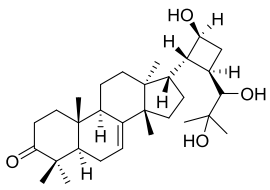
21



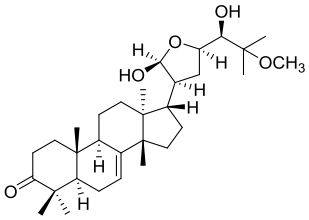
22-24



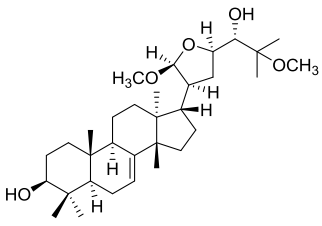
25



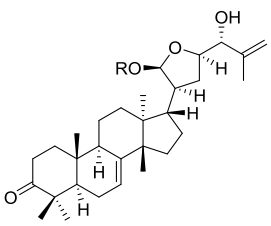
26



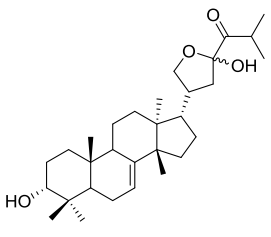
27



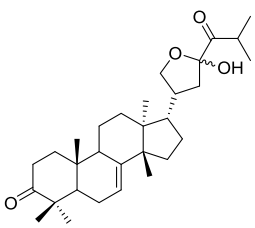
28



29-30



31



32

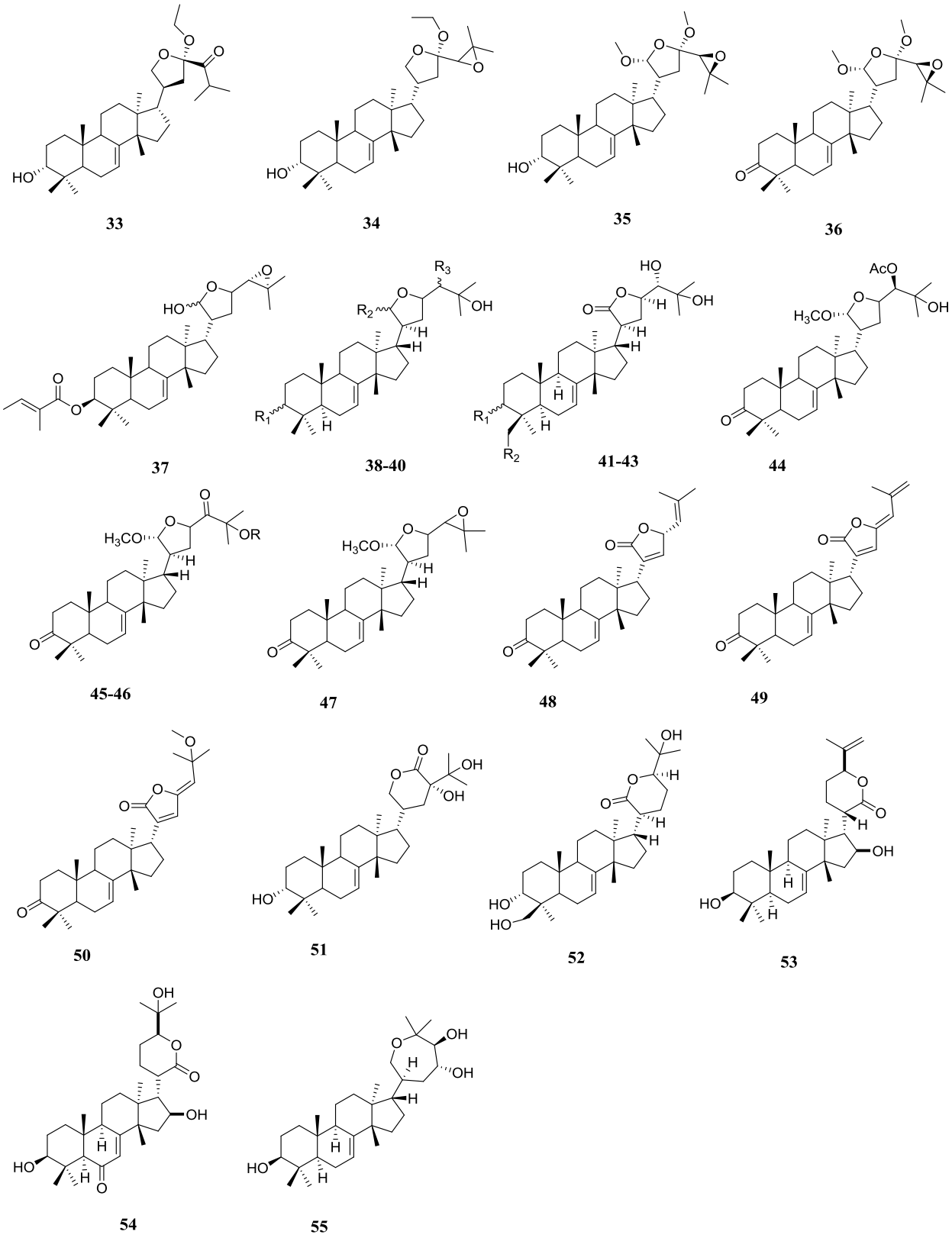


Figure 3. Structures of protolimonoid/tirucallanetriterpenoid **1-55**.

2.1.2. Ring A-seco Protolimonoid

This class of limonoids is characterized by open, rearranged ring A. A total of eleven new ring A seco protolimonoids were isolated from *Guarea guidonia and Aphanamixis grandifolia* (Table 2/S2, Figure 4). Guareoic acid B (**56**) contains substituted tetrahydrofuran ring with cleaved A ring. Guareoic acid A (**57**) is a C21 hydroxy analog of compound (**56**). The formation of ether bridge between C3 and C11 in Guareolide (**58**) is the only structural difference in comparison to compound (**56**). Aphanamgrandin H and I (**60** and **61**) are methyl ester and $\Delta^{24,25}$ analogs of Aphanamgrandin G (**59**) respectively. Aphanamgrandin J (**62**) is C21 methyl analog of 3,4-secotirucalla-23-oxo-4(28), 7,24-trien-21-al-3-oic acid reported previously[81]. Compounds (**63**, **64**) contain A ring with ether linkage and compounds (**65**, **66**) contain both ether linkage and lactone moiety in A ring. In Aphanamgrandin B (**66**) epoxide is formed at C7,8 when compared to Aphanamgrandin A (**65**).

Table 2. Ring A-seco Protolimonoid 56-66

No.	Limonoid	Substituent	Source
56	Guareoic acid B	R = H	*Guarea guidonia*[82]
57	Guareoic acid A	R = OH	*Guarea guidonia*[82]
58	Guareolide		*Guarea guidonia*[82]
59	Aphanamgrandin G	R = H	*Aphanamixis grandifolia*[64]
60	Aphanamgrandin H	R = CH_3	*Aphanamixis grandifolia*[64]
61	Aphanamgrandin I	R = CH_3 $\Delta^{24,25}$	*Aphanamixis grandifolia*[64]
62	Aphanamgrandin J		*Aphanamixis grandifolia*[64]
63	Aphanamgrandin C		*Aphanamixis grandifolia*[64]
64	Aphanamgrandin D	$\Delta^{24,25}$	*Aphanamixis grandifolia*[64]
65	Aphanamgrandin A		*Aphanamixis grandifolia*[64]
66	Aphanamgrandin B		*Aphanamixis grandifolia*[64]

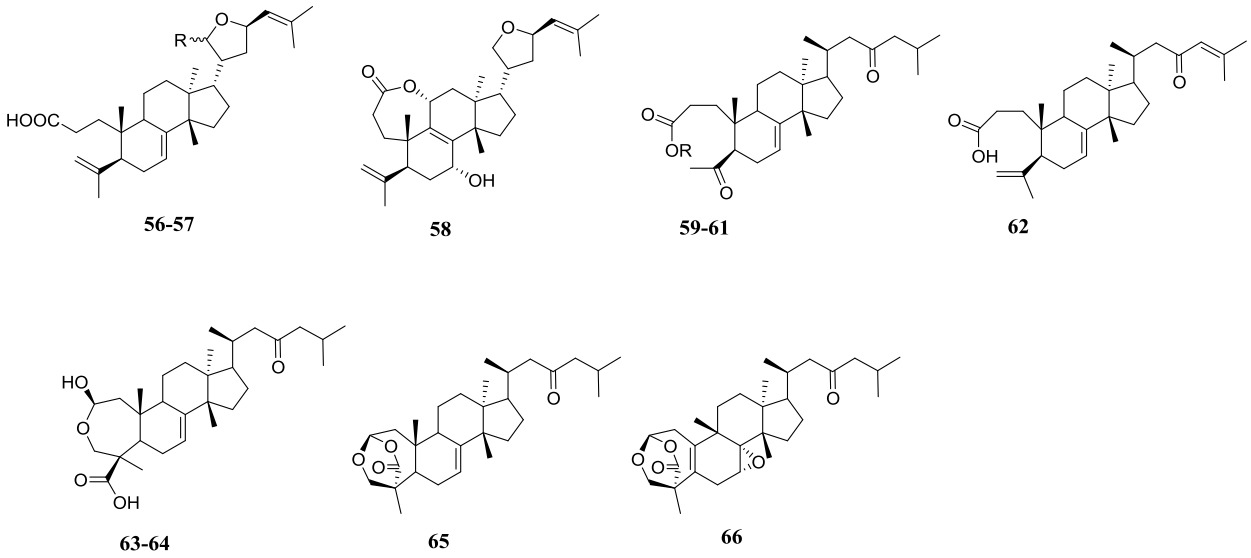


Figure 4. Structures of ring A-seco protolimonoid **56-66**.

2.1.3. Nor Protolimonoid

The loss of carbon units from the side chain is a peculiar characteristic of this class. A total of nine new nor protolimonoids were isolated from *Toona sinensis, Dysoxylum lenticellatum and Aphanamixis grandifolia* (Table 3/S3, Figure 5). Compound (**67**) is trinor protolimonoid differing at side chain in additional methylene group in comparison with previously reported (4,4,14-trimethyl-3-oxo-24-nor-5*α*,13*α*,14*β*,17*α*,20*S*-chol-7-en-23-oic acid)[83]. The shift in double bond at $\Delta^{6,7}$ to $\Delta^{7,8}$ with peroxide bridge formation between C5-C8 and additional olefinic bond at $\Delta^{9,11}$ in Compound (**68**) are the structural differences when compared to previously reported (4,4,14-trimethyl-3-oxo-24-nor-5*α*,13*α*,14*β*,17*α*,20*S*-chol-7-en-23-oic acid)[83]. Dysolenticin C (**69**) is the trinor analog of compound (**48**). Compound (**70**) is C3 carbonyl reduced and C21 methoxy analog of 24, 25, 26, 27-tetranortirucall-7-ene-3-oxo-23

(21)-lactone reported previously[50]. Compound (**71**) is the C21 epimer of compound (**70**). Compounds (**72** and **73**) are C3 carbonyl analogs of compounds (**70** and **71**) respectively. The methoxy group in (**72**) is replaced by the ethoxy group in compound (**74**). Dysolenticin G (**75**) is hexanor protolimonoid.

Table 3. Nor Protolimonoid 67-75

No.	Limonoid	Substituent	Source
67	(20S)-3-oxo-tirucalla-25-nor-7-en-24-oic acid		*Toona sinensis*[84]
68	(20S)-5α,8α-epidioxy-3-oxo-24-nor-6,9(11)-dien-23-oic acid		*Toona sinensis*[84]
69	Dysolenticin C		*Dysoxylum lenticellatum*[68]
70	3α-Hydroxy-21α-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone	R = α-OCH_3	*Aphanamixis grandifolia*[85]
71	3α-Hydroxy-21β-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone	R = β-OCH_3	*Aphanamixis grandifolia*[85]
72	3-Oxo-21α-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone	R = α-OCH_3	*Aphanamixis grandifolia*[85]
73	3-Oxo-21β-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone	R = β-OCH_3	*Aphanamixis grandifolia*[85]
74	3-Oxo-21α-ethoxy-24,25,26,27-tetranortirucall-7-ene-23(21)- lactone	R = α-OCH_2CH_3	*Aphanamixis grandifolia*[85]
75	Dysolenticin G		*Dysoxylum lenticellatum*[68]

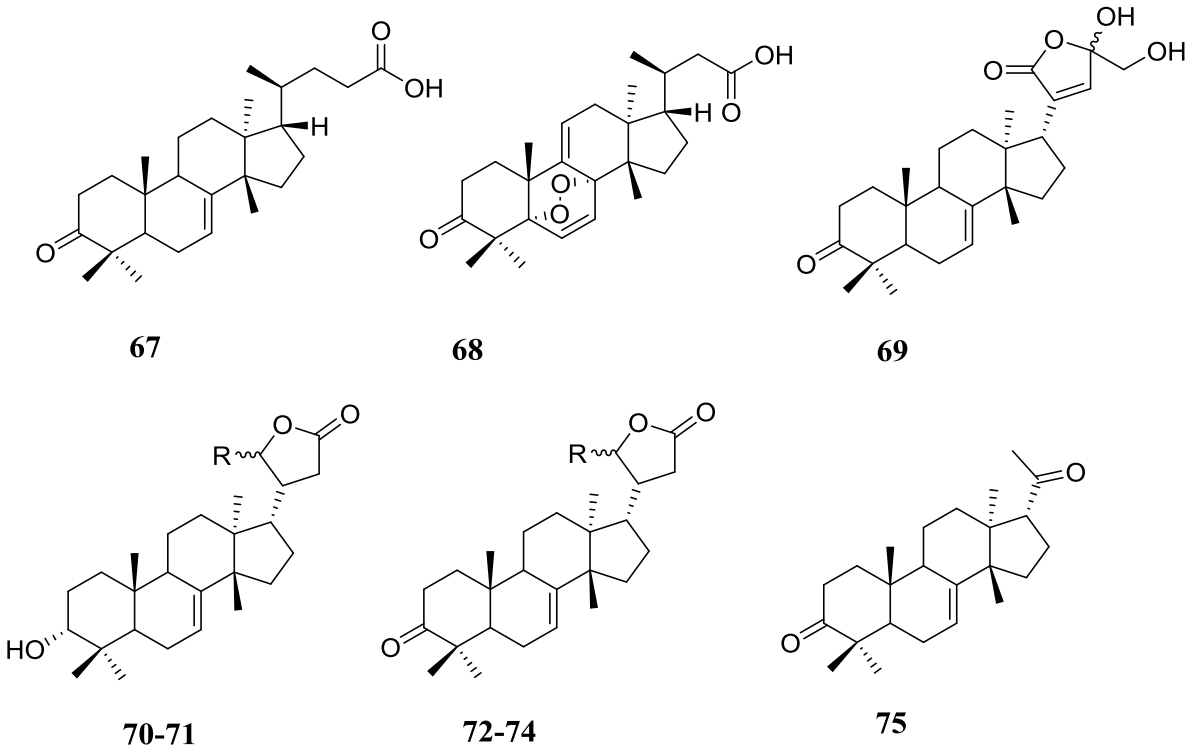


Figure 5. Structures of Nor protolimonoid **67-75**.

2.1.4. Apoprotolimonoid/Apotirucallanetriterpenoid

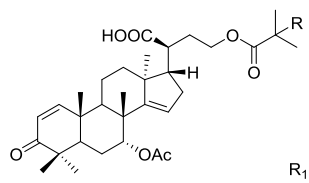
The shift in methyl group from C14 to C8 and $\Delta^{7,8}$ olefinic double bond to $\Delta^{14,15}$ distinguishes the apoprotolimonoid skeleton from protolimonoids. A total of fifty four new apoprotolimonoids from *Xylocarpus moluccensis, Xylocarpus granatum, Aglaia odorata, Melia Toosendan, Chisocheton paniculatus, Walsura trichostemon, Walsura trifoliata, Azadirachta indica, Trichilia lepidota, Melia azedarach, Cedrela odorata, Dysoxylum hainanense, Toona ciliata, Swietenia macrophylla, Walsura trifoliata*, *Toona sinensis* and *Entandrophragma utile* were isolated (Table 4/S4, Figure 6). Compound (**76**) is the C25 dehydroxy analog of Protoxylogranatin B (**77**)[86]. The reduction of $\Delta^{1,2}$ and C3 carbonyl moiety followed by C3 acetylation in Agladoral A (**78**) is the only difference from previously reported Senegalene C[87]. Agladoral B (**79**) is C25 methoxy, C3, C7 deacetyl analog of compound (**78**). Agladoral E (**80**) is C7 acetyl, C21 methoxy analog of compound (**79**). Toosendine H (**81**) and Chisopanin G (**85**) are C21 ethoxy C25 hydroxy analaogs of compounds (**79**) and (**83**) respectively. Toosendine I (**82**), Chisopanin F (**84**), Chisopanin H (**86**) and Xylogranatumine A (**106**) are C21

epimer of compounds (**81**), (**83**), (**85**) and Protoxylogranatin A reported previously[88] respectively. Chisopanin E (**83**) is C3 acetyl, C7 deacetyl analog of compound (**80**). Chisopanin I (**87**) is a C25 methoxy analog of compound (**85**). Chisopanin J (**88**) is a C25 ethoxy analog of compound (**84**). Xylogranatumine F (**89**) is C3 tigloyl and C21 ethoxy derivative of compound (**81**). Toonasinensin A (**90**) is C21 ethoxy, C26 hydroxy analog of previously reported Dictamnin A[89]. The hemiacetal group at C17 in previously reported 3α-acetoxy-21,23-epoxyapotirucall-14- ene-7α,21R,24,25-tetrol[90] is replaced by lactone ring in Chisiamol G (**91**) making it a C21 carbonyl analog. Chisopanin K (**92**) is $\Delta^{20,22}$ analog of compound (**91**). Agladoral C (**93**) is C3, C21 dihydroxy analog of Toonaciliatine A reported previously[91]. Chisopanin C and A (**94** and **110**) are C3 acetyl analog of previously reported Toonaciliatine A and 7α-acetoxyl- 17α-20S-21,24-epoxy-apotirucall-14-ene-3α,23R,24S,25-tetraol respectively[92]. Chisopanin D (**95**) is a C21 ethoxy analog of compound (**94**). Agladoral D (**96**) is $\Delta^{1,2}$ and C3 carbonyl reduced analog of previously reported Bruceajavanin A[93]. Chisiamol H (**97**) is a C24,25 epoxy analog of compound (**91**). Xylogranatumine D (**98**) is $\Delta^{1,2}$ double bond reduced analog of Holstinone A reported previously[94]. 7-deacetylbrujavanone E (**99**), Chisopanin B (**111**) and Cedrodorol B (**114**) are C7 deacetyl analog of previously reported Brujavanone E[95], compound (**110**) and Mesendanin U[79] respectively. Compound (**100**) is C6 hydroxy, C21, C24, C25 tri acetyl analog of compound (**99**). Xylogranatumine B (**101**) is C7 acetyl, C11 dehydroxy, C21 methoxy analog of compound (**99**). Xylogranatumine C (**102**) is C7 deacetyl, C24 acetyl analog of compound (**101**). Xylogranatumine E (**103**) is C11 acetyl, C24 deacetyl C25 methoxy analog of compound (**102**). Xylogranatumine G (**104**) is C21 methoxy analog of Senegalene C reported previously[87]. 2-methyl butyrate moiety at C11 in previously reported Gentinone A[96] is removed in the formation of Piscidinol L (**105**). Neemfruitin B (**106**) is a C21 acetyl analog of compound (**105**). Lepidotrichilin B (**108**) is $\Delta^{1,2}$ double bond reduced, C21 carbonyl analog of Dysorone D reported previously[97]. Lepidotrichilin A (**109**) is C21 carbonyl analog of Dysorone D. Compound (**112**) is C3 tigloyl analog of previously reported Sapelin D[98]. The tigloyl group at C3 in compound (**112**) is displaced by the benzoyl group in 3*α*-benzoate triterpenoid A (**113**). Dysohainanin E/Mesendanin U (**115**) is C7 acetyl analog of compound (**114**). Compound (**115**) was also isolated by another research group from *Melia toosendan* but trivially named differently as Mesendanin U[79]. Toonaciliatavarin B (**116**) is C11 hydroxy $\Delta^{1,2}$ analog of compound (**115**). Entanutilin U (**117**) is C23, C24 epimer of previously reported Diepoxyazadirol[99]. Acetoxyl group at C7 in compound (**116**) is replaced by ketocarbonyl group in Toonaciliatavarin A (**118**). Swietesenin (**119**) differed from Spicatin reported previously[100] with presence of glucose moiety at C7 and hydroxylation at C28. Piscidinol K (**120**) is C21 hydroxyl, $\Delta^{1,2}$ analog of compound (**114**). Piscidinol I (**121**) is C11 hydroxyl, C21 acetyl analog of compound (**120**). 11,25-dideacetyltrichostemonate (**122**) is C7 acetyl analog of compound (**121**) with oxidation at C23. Trichostemonate (**123**) is C11, C25 acetyl analog of Compound (**122**). Piscidinol J (**124**) is C7 deacetyl, C11 tigloyl analog of compound (**122**). The acetyl group at C7 in (**122**) is replaced by the carbonyl group in Piscidinol H (**125**). Piscidinone A (**126**) differed from compound (**125**) at C11 and C17 substitution. The tiglate group at C11 in compound (**126**) is replaced by 2-methylbutanoate in Piscidinone B (**127**). In Azadirahemiacetal (**128**) there is formation of four membered ring at C24,25 which contains ether bridge when compared with 1α,7a-diacetoxyl-17α-20S-21,24-epoxy-apotirucall-14-ene-3α,23R,24S,25-tetraol reported previously[92]. Toonaciliatavarin C (**129**) differed from previously reported Chisiamol C[101] with presence of enone system in A ring and hydroxylation at C11.

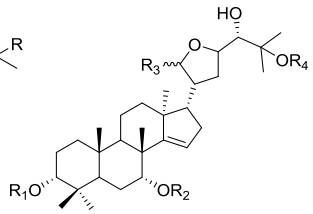
Table 4. Apoprotolimonoid/Apotirucallanetriterpenoid 76-129

No.	Limonoid	Substituent	Source
76	25-dehydroxy protoxylogranatin B	R = H	*Xylocarpus moluccensis*[47]
77	Protoxylogranatin B	R = OH	*Xylocarpus granatum*[86]
78	Agladoral A	$R_1 = R_2 = Ac$; $R_3 = \beta$-OH; $R_4 = H$	*Aglaia odorata*[102]
79	Agladoral B	$R_1 = R_2 = H$; $R_3 = \beta$-OH; $R_4 = CH_3$	*Aglaia odorata*[102]
80	Agladoral E	$R_1 = H$; $R_2 = Ac$; $R_3 = \alpha$-OCH_3; $R_4 = CH_3$	*Aglaia odorata*[102]
81	Toosendine H	$R_1 = R_2 = H$; $R_3 = \alpha$-OCH_2CH_3; $R_4 = H$	*Melia Toosendan*[103]
82	Toosendine I	$R_1 = R_2 = H$; $R_3 = \beta$-OCH_2CH_3; $R_4 = H$	*Melia Toosendan*[103]
83	Chisopanin E	$R_1 = Ac$; $R_2 = H$; $R_3 = \alpha$-OCH_3; $R_4 = CH_3$	*Chisocheton paniculatus*[104]
84	Chisopanin F	$R_1 = Ac$; $R_2 = H$; $R_3 = \beta$-OCH_3; $R_4 = CH_3$	*Chisocheton paniculatus*[104]
85	Chisopanin G	$R_1 = Ac$; $R_2 = H$; $R_3 = \alpha$-OCH_2CH_3; $R_4 = H$	*Chisocheton paniculatus*[104]
86	Chisopanin H	$R_1 = Ac$; $R_2 = H$; $R_3 = \beta$-OCH_2CH_3; $R_4 = H$	*Chisocheton paniculatus*[104]
87	Chisopanin I	$R_1 = Ac$; $R_2 = H$; $R_3 = \alpha$-OCH_3; $R_4 = CH_2CH_3$	*Chisocheton paniculatus*[104]
88	Chisopanin J	$R_1 = Ac$; $R_2 = H$; $R_3 = \beta$-OCH_3; $R_4 = CH_2CH_3$	*Chisocheton paniculatus*[104]
89	Xylogranatumine F	R_1 = Tig; $R_2 = H$; $R_3 = \alpha$-OCH_3; $R_4 = H$	*Xylocarpus granatum*[105]
90	Toonasinensin A		*Toona sinensis*[106]
91	Chisiamol G		*Chisocheton paniculatus*[107]
92	Chisopanin K		*Chisocheton paniculatus*[104]
93	Agladoral C	$R_1 = H$; $R_2 = Ac$; $R_3 = \beta$-OH	*Aglaia odorata*[102]
94	Chisopanin C	$R_1 = Ac$; $R_2 = H$; $R_3 = \alpha$-OCH_3	*Chisocheton paniculatus*[104]
95	Chisopanin D	$R_1 = Ac$; $R_2 = H$; $R_3 = \alpha$-OCH_2CH_3	*Chisocheton paniculatus*[104]

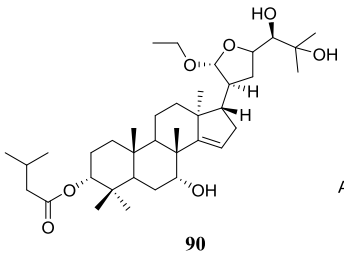
96	Agladoral D		*Aglaia odorata*[102]
97	Chisiamol H		*Chisocheton paniculatus*[107]
98	Xylogranatumine D		*Xylocarpus granatum*[105]
99	7-deacetylbrujavanone E	$R_1 = R_2 = H$; $R_3 = OH$; $R_4 = \beta$-OH; $R_5 = \alpha$-OH; $R_6 = H$	*Walsura trichostemon*[108]
100	21,24,25- triacetyl-7-deacetyl-6-hydroxylbrujavanone E	$R_1 = OH$; $R_2 = H$; $R_3 = OH$; $R_4 = \beta$-OAc; $R_5 = OAc$; $R_6 = Ac$	*Walsura trichostemon*[108]
101	Xylogranatumine B	$R_1 = H$; $R_2 = Ac$; $R_3 = H$; $R_4 = \alpha$-OCH_3; $R_5 = \beta$-OH; $R_6 = H$	*Xylocarpus granatum*[105]
102	Xylogranatumine C	$R_1 = R_2 = R_3 = H$; $R_4 = \alpha$-OCH_3; $R_5 = \alpha$-OAc; $R_6 = H$	*Xylocarpus granatum*[105]
103	Xylogranatumine E	$R_1 = R_2 = H$; $R_3 = OAc$; $R_4 = \alpha$-OCH_3; $R_5 = \alpha$-OH; $R_6 = CH_3$	*Xylocarpus granatum*[105]
104	Xylogranatumine G	$R_1 = H$; $R_2 = Ac$; $R_3 = H$; $R_4 = \beta$-OCH_3; $R_5 = \alpha$-OH; $R_6 = H$	*Xylocarpus granatum*[105]
105	Piscidinol L		*Walsura trifoliata*[109]
106	Neemfruitin B		*Azadirachta indica*[110]
107	Xylogranatumine A		*Xylocarpus granatum*[105]
108	Lepidotrichilin B		*Trichilia lepidota*[111]
109	Lepidotrichilin A	$\Delta^{1,2}$	*Trichilia lepidota*[111]
110	Chisopanin A	R = Ac	*Chisocheton paniculatus*[104]
111	Chisopanin B	R = H	*Chisocheton paniculatus*[104]
112	3α-tigloylsapelin D	R = Tig	*Melia azedarach*[112]
113	3*α*-benzoate triterpenoid A	R = Bz	*Melia azedarach*[113]
114	Cedrodorol B		*Cedrela odorata*[114]
115	Dysohainanin E/Mesendanin U		*Dysoxylum hainanense*[63], *Melia toosendan*[79]
116	Toonaciliatavarin B		*Toona ciliata*[80]
117	Entanutilin U		*Entandrophragma utile*[115]
118	Toonaciliatavarin A		*Toona ciliata*[80]
119	Swietesenin	R = Glucose	*Swietenia macrophylla*[116]
120	Piscidinol K	$R_1 = R_2 = H$	*Walsura trifoliata*[109]
121	Piscidinol I	$R_1 = OH$; $R_2 = Ac$	*Walsura trifoliata*[109]
122	11,25-dideacetyltrichostemonate	$R_1 = Ac$; $R_2 = R_3 = H$	*Walsura trichostemon*[108]
123	Trichostemonate	$R_1 = R_2 = R_3 = Ac$	*Walsura trichostemon*[117]
124	Piscidinol J	$R_1 = H$; $R_2 = Tig$; $R_3 = H$	*Walsura trifoliata*[109]
125	Piscidinol H		*Walsura trifoliata*[109]
126	Piscidinone A	$\Delta^{2',3'}$	*Walsura trifoliata*[118]
127	Piscidinone B		*Walsura trifoliata*[118]
128	Azadirahemiacetal		*Azadirachta indica*[119]
129	Toonaciliatavarin C		*Toona ciliata*[80]



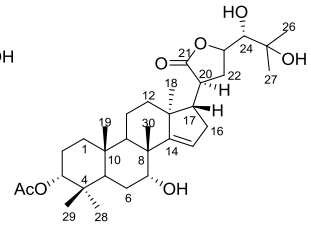
76-77



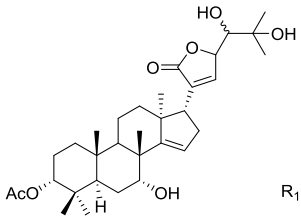
78-89



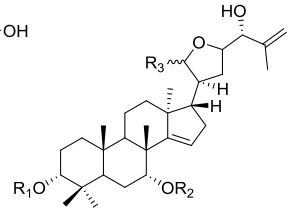
90



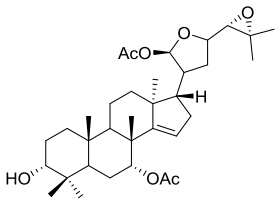
91



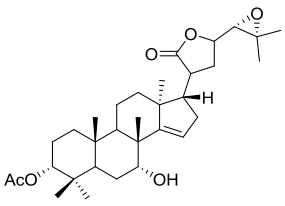
92



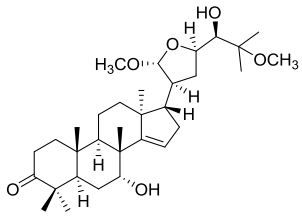
93-95



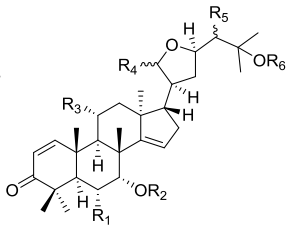
96



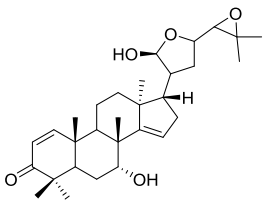
97



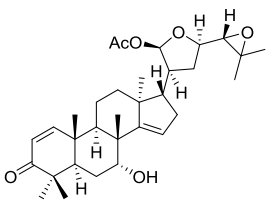
98



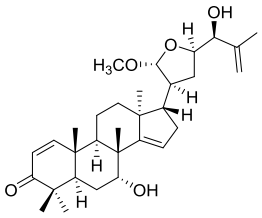
99-104



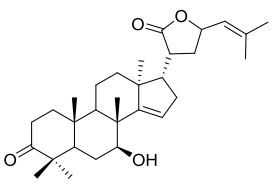
105



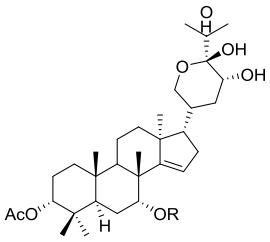
106



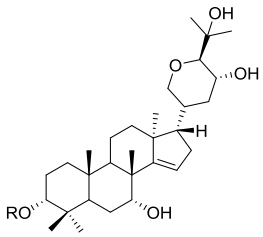
107



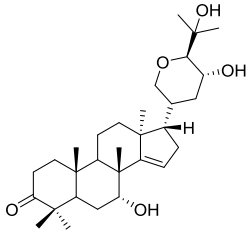
108-109



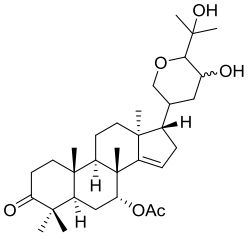
110-111



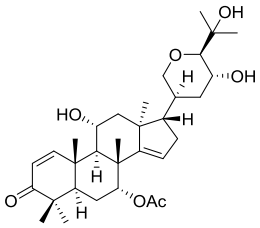
112-113



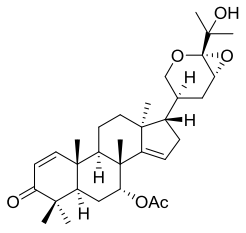
114



115



116



117

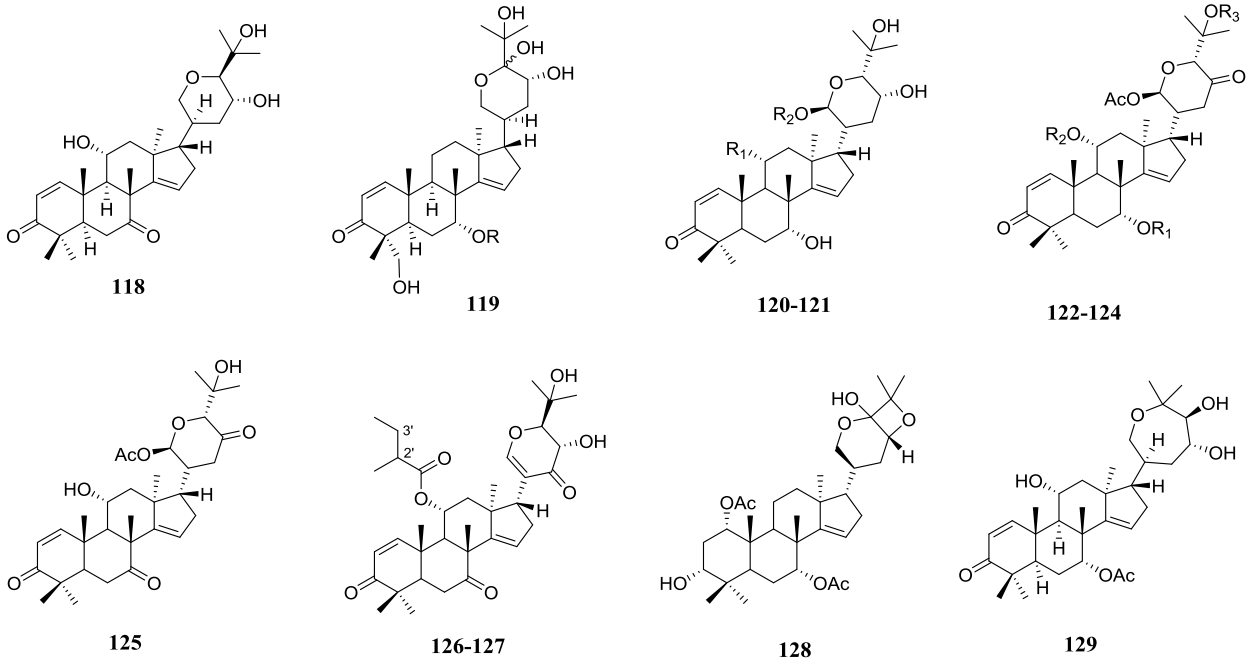


Figure 6. Structures of apoprotolimonoid/apotirucallanetriterpenoids **76-129**.

2.1.5. Ring A-seco Apoprotolimonoid

This class is characterized by a modified A ring. A total of eight ring A-seco apoprotolimonoids were isolated from *Aphanamixis polystachya*, *Walsura chrysogyne*, *Aglaia argentea* and *Aphanamixis grandifolia* (Table 5/S5, Figure 7). Compounds (**130** and **131**) isolated from *Aphanamixis polystachya* were reported as Aphataiwanin C and D respectively. Same compounds were isolated from *Walsura chrysogyne* by another research group which named them as Apowalsogyne B and A (**130** and **131**)[120,121]. Aphataiwanin A (**132**) is a C25 dehydro analog of compound (**130**). Aphataiwanin B (**133**) is C21 epimer of compound (**132**). Polystanin A (**134**) is C7 deacetyl analog of Methyl- 1*E*,7R-diacetoxy- 23R,24,25 - trihydroxy- 20S- 21,24-epoxy- 3,4- seco-apotirucall- 4(28), 14(15)-diene- 3-oate reported previously[122]. The acetoxyl group at C7 in methyl-1*E*,7R-diacetoxy-23R,25-dihydroxy-20S,24R-21,24-epoxy-3,4-seco-apotirucall-4(28),14(15)-diene-3-oate reported previously[122] is replaced by carbonyl group in Argentinin B (**135**). Polystanin E (**136**) differed from 7α-acetoxyl-17α-20S-21,24-epoxy-apotirucall-14-en-3-one- 23R,24S,25-triol reported previously[92] in presence of acetoxyl group at C1 and formation of ester functionality with cleavage/rearrangement of A ring. Polystanin B (**137**) is derived from compound (**136**) with removal of acetic acid.

Table 5. Ring A-seco Apoprotolimonoid 130-137

No.	Limonoid	Substituent	Source
130	Aphataiwanin C/Apowalsogyne B	R = β-OCH_3	*Aphanamixis polystachya*[120], *Walsura chrysogyne*[121]
131	Aphataiwanin D/Apowalsogyne A	R = α-OCH_3	*Aphanamixis polystachya*[120], *Walsura chrysogyne*[121]
132	Aphataiwanin A	R = β-OCH_3	*Aphanamixis polystachya*[120]
133	Aphataiwanin B	R = α-OCH_3	*Aphanamixis polystachya*[120]
134	Polystanin A		*Aphanamixis polystachya*[74]
135	Argentinin B		*Aglaia argentea*[123]
136	Polystanin E		*Aphanamixis grandifolia*[124]
137	Polystanin B		*Aphanamixis polystachya*[74]

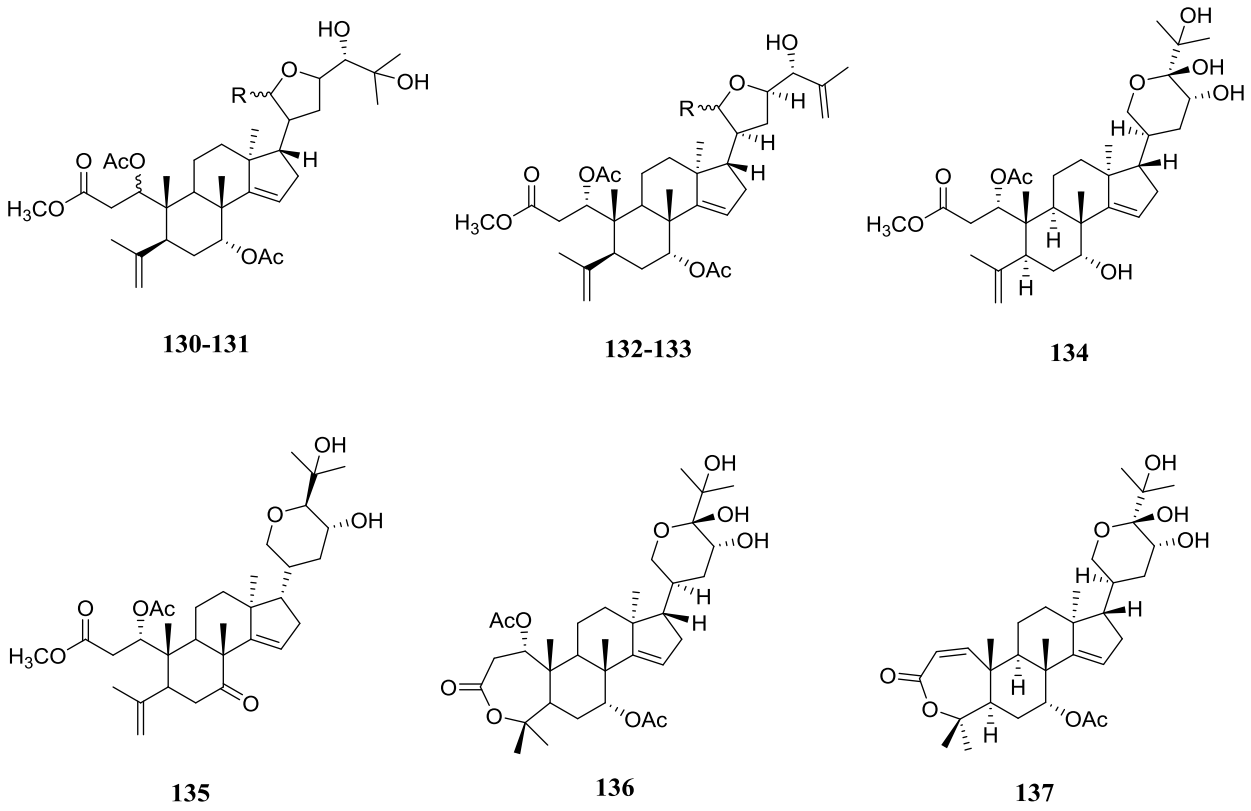


Figure 7. Structures of ring A-seco apoprotolimonoids **130-137**.

2.2. Ring intact limonoids

2.2.1. Azadirone-Class

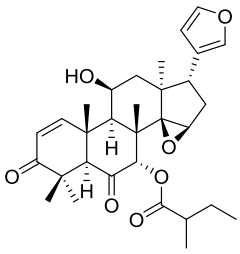
Presence of carbonyl group at C3 and substituted oxygen at C7 are the signature features of the Azadirone skeleton. A total of fifty nine azadirone class Limonoids were isolated from *Walsura robusta*, *Dysoxylum mollissimum*, *Toona ciliata*, *Azadirachta indica*, *Walsura cochinchinensis*, *Chisocheton macrophyllus*, *Entandrophragma angolense*, *Xylocarpus moluccensis*, *Walsura yunnanensis*, *Carapa guianensis*, *Trichilia gilgiana*, *Munronia unifoliolata*, *Xylocarpus granatum*, *Dysoxylum lukii Toona sinensis* and *Chisocheton pentandrus* (Table 6/S6, Figure 8). Prior to this eighty different Azadirone class limonoids were reported from Meliaceae family[12]. As assigned by HMBC spectrum, Walsurin A (**138**) has an epoxide ring at C13/14 and in compounds (**138-141**) carbonyl group at C6 is in keto form. Dysoxylumosin J and K (**143** and **144**) have the same molecular formula which later were differentiated by the position of acetyl functionality using NMR. Dysomollide F and G (**161** and **162**) are structucrally similar to previously reported turranolide[125] and lenticellatumin[126] respectively, but differ in functionality at C1 and C20. Toonayunnanin B (**145**) is structurally similar to previously reported 12α-acetoxyneotrichilinone[127]. Compounds (**146** and **147**) are structurally similar to previously reported toonaciliatone A[91] and 17-epiazadiradione[128] respectively. Cochinchinoid H (**148**) differs from compound (**147**) in substitution at C7 and C11. The acetyl group at C11 in compound (**148**) is shifted to C12 in Cochinchinoid I (**149**). The $\Delta^{1,2}$ olefinic double bond in compound (**149**) is reduced in Cochinchinoid J (**150**). Toonayunnanin A (**152**) has carbonyl group at C7 along with α,β-unsaturated carbonyl group at A ring with additional olefinic double bond at C9 and absence of acetyl group with respect to Toonaciliatone B (**151**). Ciliatasecone Y (**153**) is C6 hydroxy analog of compound (**152**). The epoxide ring in compound (**151**) is opened in Dysobinol (**154**). Compounds (**155-157**) are structurally similar to compound (**151**) but differ in substituents at B and C rings. Toonasinenoid E (**158**) is C16 hydroxy analogs of previously reported Trichilenone acetate[99]. Ciliatasecone X (**159**) is C7 acetoxy analog of compound (**150**). The furan ring at C17 in compound (**148**) is replaced by γ-lactone ring in Xylomolin M (**160**). Compounds (**163**, **169-173**) differ in functionality at C17 as determined by ROESY correlations. The olefinic group

in compound (**160**) is replaced by epoxide group in Azadiraindin E (**164**). Azadiraindin F (**165**) and Andirolide Q (**174**) are structurally similar to compound (**160**) and Yunnanolide B (**166**) is structurally similar to compound (**164**) but both of them differ in substitution at γ-lactone ring. The furan ring at C17 in compound (**152**) is replaced by substituted γ-lactone ring in Toonaciliatavarin F and G (**167** and **168**). The carbonyl group at γ-lactone ring in compound (**163**) is reduced in Neemfruitin A (**175**) along with C1 acetylation. Trigilgianin (**176**) has carbonyl and hydroxyl groups at C7 and C12 respectively. Munronoid I (**177**) possess acetyl functionality at C6 and C7 with α orientation. Hainanxylogranin V (**178**) is C11 hydroxy epimer of previously reported 20,21,22,23-tetrahydro-23-oxoazadirone[129]. Hainanxylogranin W (**179**) is C11 hydroxy epimer of previously reported 20,21,22,23-tetrahydro-23-oxoazadirone[129]. Thaigranatin S (**180**) is C3 carbonyl reduced analog of previously reported 6- de(acetyloxy)-7-deacetylchisocheton compound E[130]. The A and D rings in Munronoid I (**177**) are reduced in compound (**181**). The acetyl group at C7 in compound (**172**) is converted to carbonyl group in Dysoxylumstatin C (**182**). Ciliatasecone S (**183**) differs from compound (**154**) with presence of $\Delta^{9,11}$ double bond and formation of ether linkage between C7,C14. Toonayunnanae F (**184**) is C6 deacetoxyl analog of compound (**183**). Furan ring in compound (**183**) is replaced by butenolide moiety in Ciliatasecone T (**185**). Compound (**186**) is C6 hydroxy, $\Delta^{1,2}$ analog of compound (**162**). Pentandricine B (**187**) is C17 butanolide analog of previously reported Azadirone[131]. Pentandricine C (**188**) is C7 deacetyl analog of compound (**187**). Pentandricine D (**189**) is C6 acetoxyl analog of compound (**187**). Ciliatasecone V (**190**) is C7 acetyl derivative of previously reported 7-deacetyl-23-hydroxyneotrichilenonelide[132]. Ciliatasecone U (**191**) is C23 dehydroxy analog of compound (**190**). Ciliatasecone W (**192**) is C11, C12 dihydroxy analog of previously reported 7-acetylneotrichilenone[133]. Toonayunnanae G (**193**) is C6 acetoxyl analog of compound (**142**). Hainanxylogranin X (**194**) is C16 acetoxy analog of 7-acetoxyneotrichilenone[133]. Toonasinenoid D (**195**) is C11 carbonyl analogs of previously reported Trichilenone acetate[99]. Toonayunnanae H (**196**) is C11, C12 dihydroxy derivative of previously reported Azadirone[131]. Walsurin E isolated from *Walsura robusta*[134] and 7-acetoxyneotrichilenone isolated from *Azadirachta indica*[133] reported previously are same but trivially named differently.

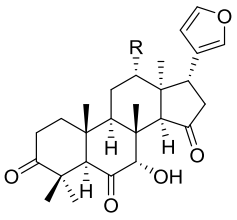
Table 6. Azadirone class limonoids 138-196

No.	Limonoid	Substituent	Source
138	Walsurin A		*Walsura robusta*[134]
139	Walsurin B	R = H	*Walsura robusta*[134]
140	Walsurin C	R = OAc; $\Delta^{1,2}$	*Walsura robusta*[134]
141	Dysoxylumosin L	R = $OCOCH(CH_3)CH_2CH_3$; $\Delta^{1,2}$	*Dysoxylum mollissimum*[135]
142	Walsurin D	$R_1 = R_2 = R_3 = H$	*Walsura robusta*[134]
143	Dysoxylumosin J	R_1 = OAc; $R_2 = R_3 = H$; $\Delta^{1,2}$	*Dysoxylum mollissimum*[135]
144	Dysoxylumosin K	R_1 = OH; R_2 = Ac; R_3 = H; $\Delta^{1,2}$	*Dysoxylum mollissimum*[135]
145	Toonayunnanin B	$R_1 = R_2$ = H; $R_3 = OCOCH(CH_3)_2$; $\Delta^{1,2}$	*Toona ciliata*[136]
146	Toonaciliatone F	R_1 = OAc; R_2 = Ac; R_3 = H; $\Delta^{1,2}$	*Toona ciliata*[137]
147	7-benzoyl-17-epinimbocinol		*Azadirachta indica*[138]
148	Cochinchinoid H	R_1 = OAc; R_2 = H; $\Delta^{1,2}$	*Walsura cochinchinensis*[76]
149	Cochinchinoid I	R_1 = H; R_2 = OAc; $\Delta^{1,2}$	*Walsura cochinchinensis*[76]
150	Cochinchinoid J	R_1 = H; R_2 = OAc	*Walsura cochinchinensis*[76]
151	Toonaciliatone B	R = OAc	*Toona ciliata*[137]
152	Toonayunnanin A	R = H; $\Delta^{9,11}$	*Toona ciliata*[136]
153	Ciliatasecone Y	R = OH; $\Delta^{9,11}$	*Toona ciliata*[139]
154	Dysobinol		*Chisocheton macrophyllus*[140]
155	Entangolensin O	R_1 = H; R_2 = β-OAc; R_3 = H; R_4 = β-OH	*Entandrophragma angolense*[141]
156	Toonaciliatone D	R_1 = OAc; R_2 = α-OH; $R_3 = R_4$ = H	*Toona ciliata*[137]
157	Toonaciliatone E	R_1 = OAc; R_2 = H; R_3 = OH; R_4 = H	*Toona ciliata*[137]
158	Toonasinenoid E	$R_1 = R_2 = R_3$ = H; R_4 = OH	*Toona sinensis*[142]
159	Ciliatasecone X	$R_1 = R_2 = R_3 = R_4$ = H; $\Delta^{9,11}$	*Toona ciliata*[139]
160	Xylomolin M		*Xylocarpus moluccensis*[143]
161	Dysomollide F		*Dysoxylum mollissimum*[144]
162	Dysomollide G	R_1 = H; R_2 = Bz; $\Delta^{20,22}$	*Dysoxylum mollissimum*[144]
163	24,25,26,27-tetranorapotirucall- 6α-hydroxy-7α-acetoxy-14-en-3-one-21,23-olide	R_1 = OH; R_2 = Ac	*Azadirachta indica*[145]
164	Azadiraindin E		*Azadirachta indica*[146]
165	Azadiraindin F		*Azadirachta indica*[146]
166	Yunnanolide B		*Walsura yunnanensis*[147]
167	Toonaciliatavarin F		*Toona ciliata*[80]
168	Toonaciliatavarin G		*Toona ciliata*[80]
169	24,25,26,27-tetranor-apotirucall-6α-hydroxy-7α-acetoxy-1,14-dien-3-one-21,24-anhydride	$\Delta^{1,2}$	*Azadirachta indica*[145]
170	24,25,26,27-tetranor-apotirucall-6α-hydroxy- 7α-acetoxy-14-en-3-one-21,24-anhydride		*Azadirachta indica*[145]

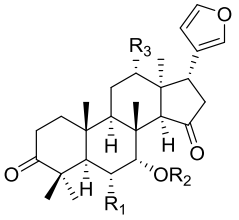
171	24,25,26,27-tetranor-apotirucall-6α,22-dihydroxy-7α-acetoxy- 1,14,20(21)-trien-3-one-21,23-olide	$\Delta^{1,2}$	*Azadirachta indica*[145]
172	24,25,26,27-tetranorapotirucall- 6α,22-dihydroxy-7α-acetoxy-14,20(21)-dien-3-one- 21,23-olide		*Azadirachta indica*[145]
173	7-O-acetyl-7-O-debenzoyl-22-hydroxy-21-methoxylimocinin		*Azadirachta indica*[148]
174	Andirolide Q		*Carapa guianensis*[149]
175	Neemfruitin A		*Azadirachta indica*[110]
176	Trigilgianin		*Trichilia gilgiana*[150]
177	Munronoid I	R_1 = OAc; R_2 = H	*Munronia unifoliolata*[151]
178	Hainanxylogranin V	R_1 = H; R_2 = α-OH	*Xylocarpus granatum*[152]
179	Hainanxylogranin W	R_1 = H; R_2 = β-OH	*Xylocarpus granatum*[152]
180	Thaigranatin S		*Xylocarpus granatum*[153]
181	1,2-dihydro-3α-hydroxy-turranolide		*Xylocarpus granatum*[154]
182	Dysoxylumstatin C		*Dysoxylum lukii*[66]
183	Ciliatasecone S	R_1 = OAc; R_2 = α-OH	*Toona ciliata*[139]
184	Toonayunnanae F	R_1 = H; R_2 = β-OH	*Toona ciliata*[155]
185	Ciliatasecone T		*Toona ciliata*[139]
186	(5R,6R,7S,13S,17R)-6-hydroxy-7-(benzoyloxy)-21,23-epoxy- 4,4,8-trimethyl-24-norchola-1,14,20,22-tetraene-3-one		*Azadirachta indica*[156]
187	Pentandricine B	R_1 = H; R_2 = Ac	*Chisocheton pentandrus*[157]
188	Pentandricine C	R_1 = R_2 = H	*Chisocheton pentandrus*[157]
189	Pentandricine D	R_1 = OAc; R_2 = Ac	*Chisocheton pentandrus*[157]
190	Ciliatasecone V	R = OH	*Toona ciliata*[139]
191	Ciliatasecone U	R = H	*Toona ciliata*[139]
192	Ciliatasecone W	R_1 = H; R_2 = Ac; R_3 = R_4 = OH; R_5 = H	*Toona ciliata*[139]
193	Toonayunnanae G	R_1 = OAc; R_2 = R_3 = R_4 = R_5 = H	*Toona ciliata*[155]
194	Hainanxylogranin X	R_1 = H; R_2 = Ac; R_3 = R_4 = H; R_5 = OAc	*Xylocarpus granatum*[152]
195	Toonasinenoid D		*Toona sinensis*[142]
196	Toonayunnanae H		*Toona ciliata*[155]



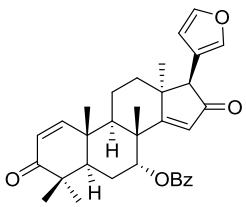
138



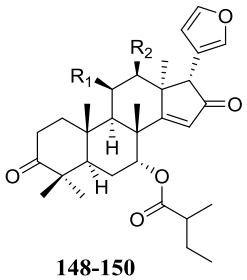
139-141



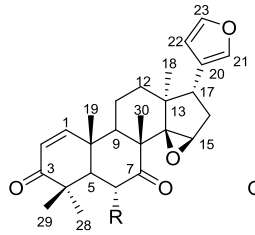
142-146



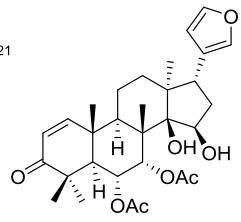
147



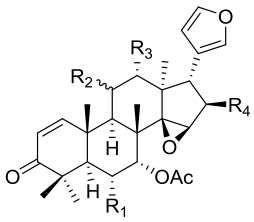
148-150



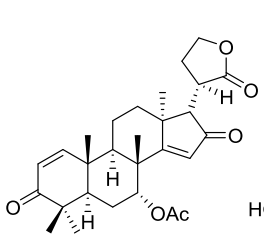
151-153



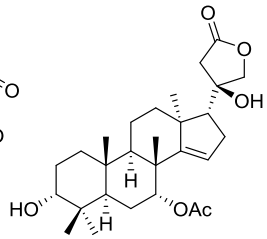
154



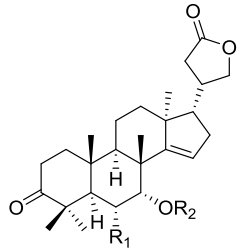
155-159



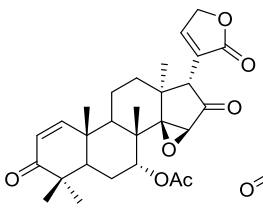
160



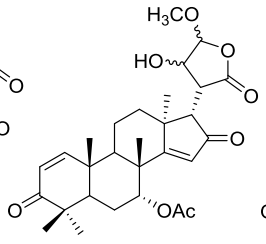
161



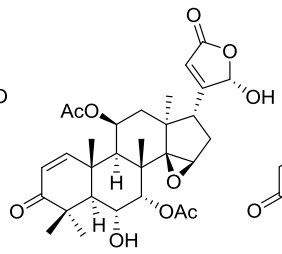
162-163



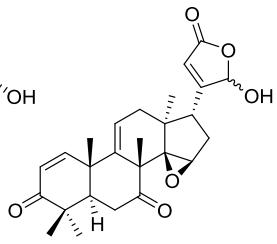
164



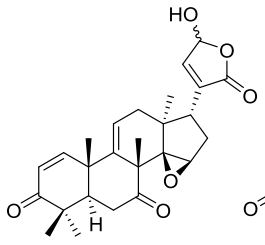
165



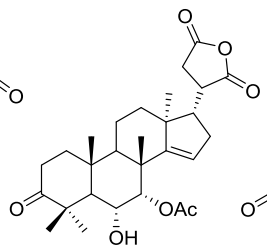
166



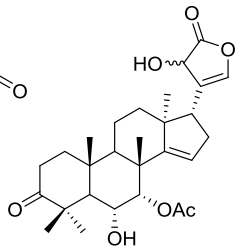
167



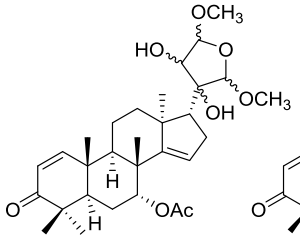
168



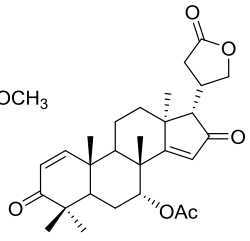
169-170



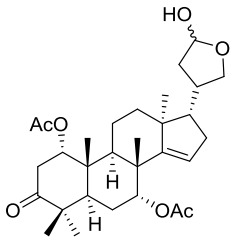
171-172



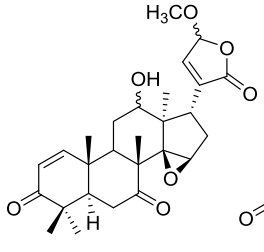
173



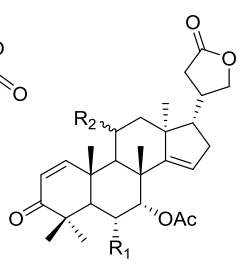
174



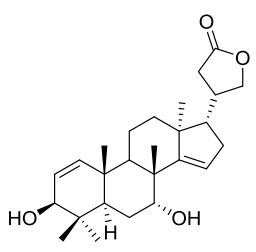
175



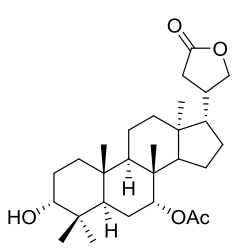
176



177-179



180



181

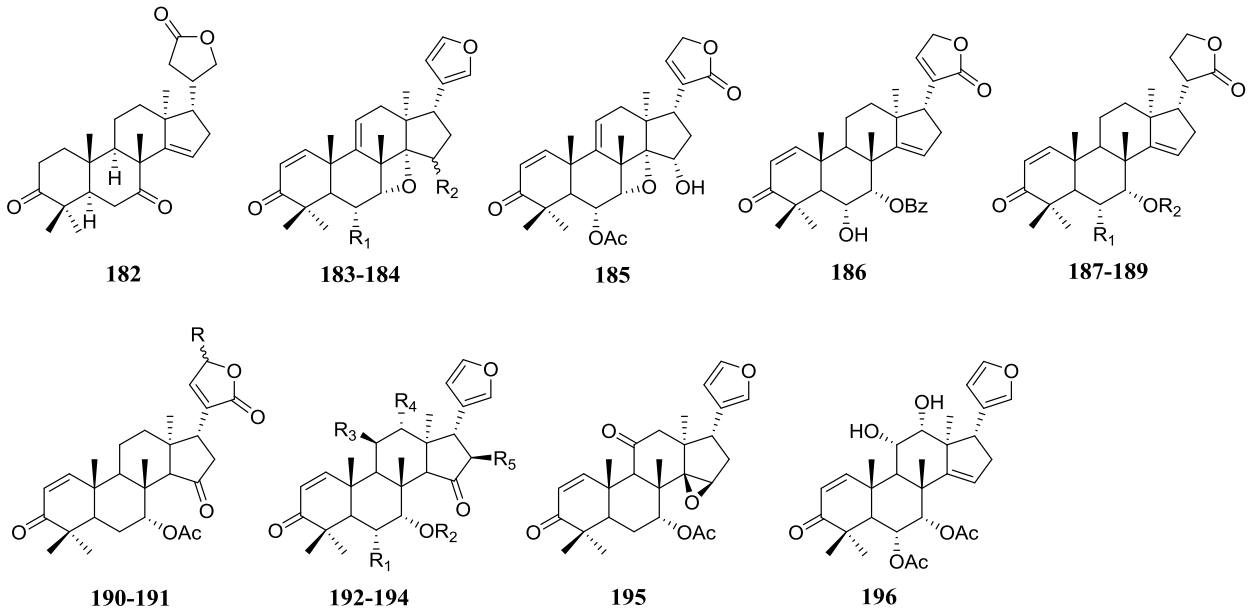


Figure 8. Structures of azadirone class limonoids **138-196**.

2.2.2. Cedrelone Class

This class of limonoids are identified by attendance of the carbonyl group at C3, C7 along with presence of $\Delta^{5,6}$ olefinic double bond and hydroxyl group at C6. A total of thirty six Limonoids were isolated from *Walsura robusta*, *Trichilia Americana*, *Dysoxylum mollissimum*, *Walsura yunnanensis*, *Turraea abyssinica* and *Toona sinensis* (Table 7/S7, Figure 9). Previously twenty five Cedrelone class limonoids were reported from the Meliaceae family[12]. Compound (**197**) has methoxy and acetoxy moiety at C1 and C12 respectively on cedrelone skeleton. Compounds (**198**, **199**) differ only at C1 substitution as confirmed by downfield shift observed in proton NMR. The methoxy group at C1 in compound (**198**) is replaced by hydroxyl group in compound (**200**). In Dysoxylumosin G (**201**), C11 is acetylated as compared to compound (**198**). Toonasinenoid C (**202**) is C11 acetyl analog of compound (**200**). Compounds (**203-207**) differ in substitution at C1, C11 and C12 with respect to compound (**200**). Compounds (**208-212**) differ at C11, C12 when compared to compound (**203**) with presence of additional olefinic double bond at $\Delta^{1,2}$. The furan ring in compound (**209**) is replaced by γ-lactone ring in compounds (**213-218**). In compounds (**219-229**) there is change in orientation of the γ-lactone ring. The olefinic double bond in substituted tetrahydrofuran ring of compound (**230**) is hydroxylated in Yunnanol A (**231**). The C14/15 oxirane and acetyl moiety in compound (**201**) are absent in Dysoxylumosin M (**232**) as indicated by NMR spectrum.

Table 7. Cedrelone class limonoid 197-232

No.	Limonoid	Substituent	Source
197	1α-methoxy-12 α -acetoxydihydrocedrelone	$R_1 = CH_3$; $R_2 = H$; $R_3 = OAc$	*Walsura robusta*[134]
198	1 α -methoxy-11β-hydroxydihydrocedrelone	$R_1 = CH_3$; $R_2 = OH$; $R_3 = H$	*Walsura robusta*[134]
199	1 α -ethoxy-11 β -hydroxydihydrocedrelone	$R_1 = CH_2CH_3$; $R_2 = OH$; $R_3 = H$	*Walsura robusta*[134]
200	1 α,11β-dihydroxy-1,2-dihydrocedrelone	$R_1 = H$; $R_2 = OH$; $R_3 = H$	*Trichilia americana*[158]
201	Dysoxylumosin G	$R_1 = CH_3$; $R_2 = OAc$; $R_3 = H$	*Dysoxylum mollissimum*[135]
202	Toonasinenoid C	$R_1 = H$; $R_2 = OAc$; $R_3 = H$	*Toona sinensis*[142]
203	11-oxo-dihydrocedrelone		*Walsura robusta*[134]
204	1,2-dihydrodeacetylhirtin	$R_1 = H$; $R_2 = OH$	*Trichilia americana*[158]
205	1α-hydroxy-1,2-dihydrodeacetylhirtin	$R_1 = R_2 = OH$	*Trichilia americana*[158]
206	1 α -hydroxy- 1,2-dihydrohirtin	$R_1 = OH$; $R_2 = OAc$	*Trichilia americana*[158]
207	1 α -methoxy-1,2-dihydrodeacetylhirtin	$R_1 = OCH_3$; $R_2 = OH$	*Trichilia americana*[158]
208	12 α -acetoxycedrelone	$R_1 = H$; $R_2 = OAc$	*Walsura robusta*[134]
209	Walsunoid H	$R_1 = β$-OAc; $R_2 = H$	*Walsura robusta*[159]
210	11β-hydroxy-12 α -propanoyloxycedrelone	$R_1 = β$ -OH; $R_2 = OCOCH_2CH_3$	*Trichilia americana*[158]
211	Dysoxylumosin H	$R_1 = α$-OH; $R_2 = OCOCH(CH_3)CH_2CH_3$; 2'S	*Dysoxylum mollissimum*[135]
212	Dysoxylumosin I	$R_1 = α$ -OH; $R_2 =$	*Dysoxylum mollissimum*[135]

		$OCOCH(CH_3)CH_2CH_3$; 2'R	
213	Walsunoid F		*Walsura robusta*[159]
214	Walsunoid G		*Walsura robusta*[159]
215	11β-hydroxyisowalsuranolide		*Walsura yunnanensis*[147]
216	11β-hydroxy-1,2-dihydroisowalsuranolide	$R_1 = H$	*Walsura yunnanensis*[147]
217	1α,11β-dihydroxy-1,2-dihydroisowalsuranolide	$R_1 = OH$	*Walsura yunnanensis*[147]
218	11β-hydroxy- 1α-methoxy-1,2-dihydroisowalsuranolide	$R_1 = OCH_3$	*Walsura yunnanensis*[147]
219	Americanolide A	$R_1 = H$; $R_2 = CH_3$	*Trichilia americana*[158]
220	Americanolide B	$R_1 = R_2 = CH_3$	*Trichilia americana*[158]
221	Americanolide D	$R_1 = R_2 = H$	*Trichilia americana*[158]
222	Americanolide C		*Trichilia americana*[158]
223	Walsunoid D	$R = OCH_3$	*Walsura robusta*[159]
224	Walsunoid E	$R = H$	*Walsura robusta*[159]
225	Walsunoid B	$R_1 = R_2 = H$; $R_3 = \beta\text{-}OCH_3$	*Walsura robusta*[159]
226	Walsunoid C	$R_1 = R_2 = H$; $R_3 = OH$	*Walsura robusta*[159]
227	Walsuranolide B	$R_1 = R_2 = R_3 = H$	*Walsura yunnanensis*[147]
228	11β-hydroxy-23-O-methylwalsuranolide	$R_1 = R_2 = H$; $R_3 = OCH_3$	*Walsura yunnanensis*[147]
229	11β, 12α-diacetoxywalsuranolide	$R_1 = Ac$; $R_2 = OAc$; $R_3 = OH$	*Turraea abyssinica*[160]
230	Yunnanolide A		*Walsura yunnanensis*[147]
231	Yunnanol A		*Walsura yunnanensis*[147]
232	Dysoxylumosin M		*Dysoxylum mollissimum*[135]

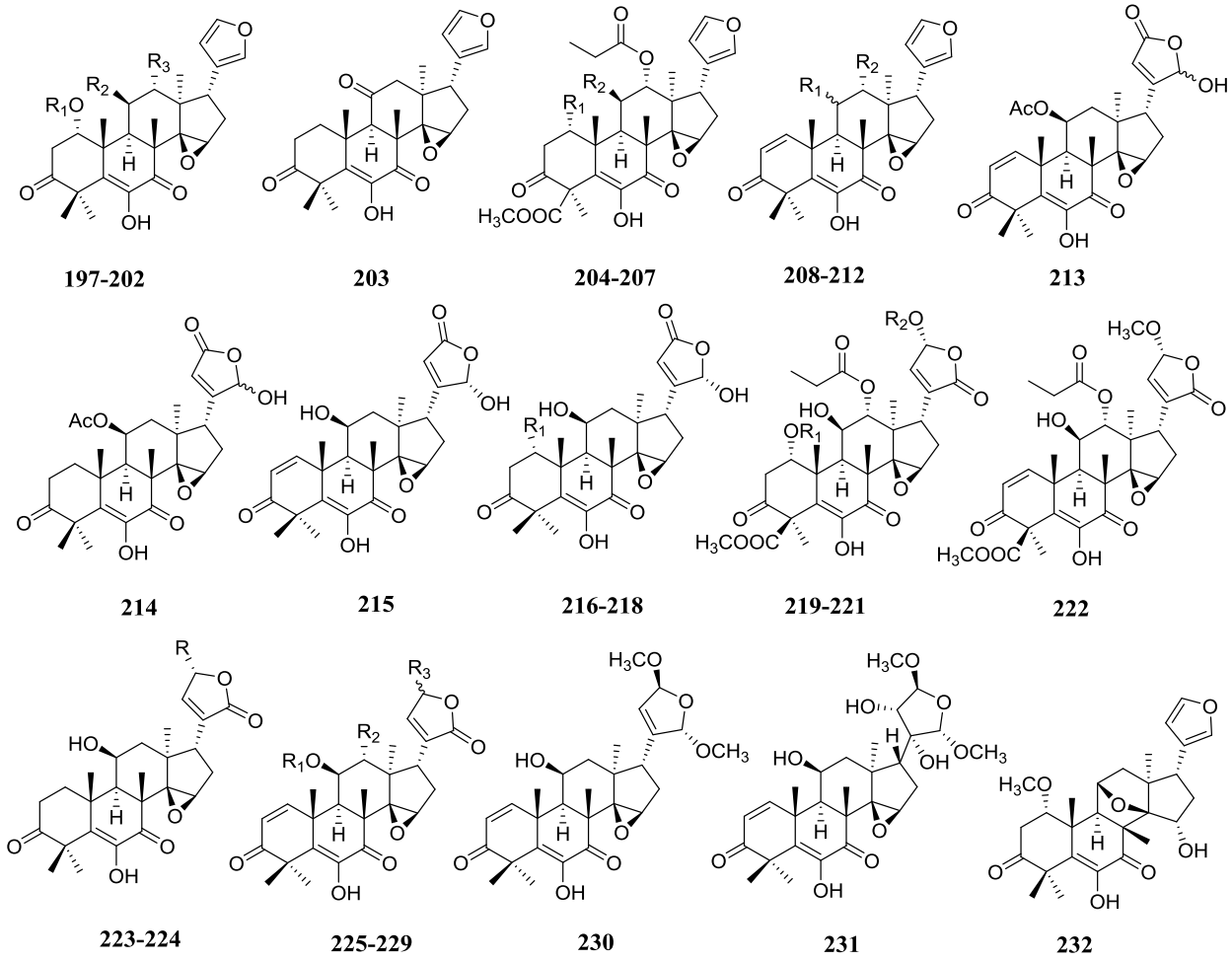


Figure 9. Structures of cedrelone class limonoids **197-232**.

2.2.3. 18 (13→14) abeo-Class

In this class of Limonoids, there is a shift in the C18 methyl group from C13 to C14. Eleven compounds belonging to 18(13→14) abeo-Class were isolated from *Walsura robusta*, *Dysoxylum mollissimum* and *Toona ciliata* (Table 8/S8, Figure 10). Only two limonoids belonging to this class were reported earlier from Meliaceae family[12]. Walsuronoid F (**233**) is structurally similar to previously isolated compound walsuronoid B[161]. From the NMR data, Dysoxylumosin A (**234**) is also structurally similar to walsuronoid B but has a rare 18(13→14) abeo limonoid skeleton. Toonaciliatone C (**236**) is C6 acetyl form of Walsuronoid I (**235**) and contain two α oriented acetyl groups at C6 and C7 as determined by NOE interactions between H7 and β-oriented methyl group at C8. The $\Delta^{1,2}$ double bond in compound (**235**) is reduced in compounds (**237-241**) and varies in substitutions at C1 and C11. The $\Delta^{12,13}$ olefinic double bond in compound (**234**) is shifted to $\Delta^{13,17}$ in Dysoxylumosin C and D (**242** and **243**) along with additional olefinic double bond at $\Delta^{11,12}$.

Table 8. 18 (13→14) abeo class limonoid 233-243

No.	Limonoid	Substituent	Source
233	Walsuronoid F	R = OH	*Walsura robusta*[134]
234	Dysoxylumosin A	R = H	*Dysoxylum mollissimum*[135]
235	Walsuronoid I	R = H	*Walsura robusta*[134]
236	Toonaciliatone C	R = Ac	*Toona ciliata*[137]
237	Walsuronoid G	$R_1 = OCH_2CH_3$; R_2 = OH	*Walsura robusta*[134]
238	Walsuronoid H	$R_1 = R_2$ = H	*Walsura robusta*[134]
239	Dysoxylumosin B	$R_1 = OCH_3$; R_2 = OH	*Dysoxylum mollissimum*[135]
240	Dysoxylumosin E	$R_1 = OCH_3$; R_2 = OAc	*Dysoxylum mollissimum*[135]
241	Dysoxylumosin F	R_1 = H; R_2 = OAc	*Dysoxylum mollissimum*[135]
242	Dysoxylumosin C		*Dysoxylum mollissimum*[135]
243	Dysoxylumosin D		*Dysoxylum mollissimum*[135]

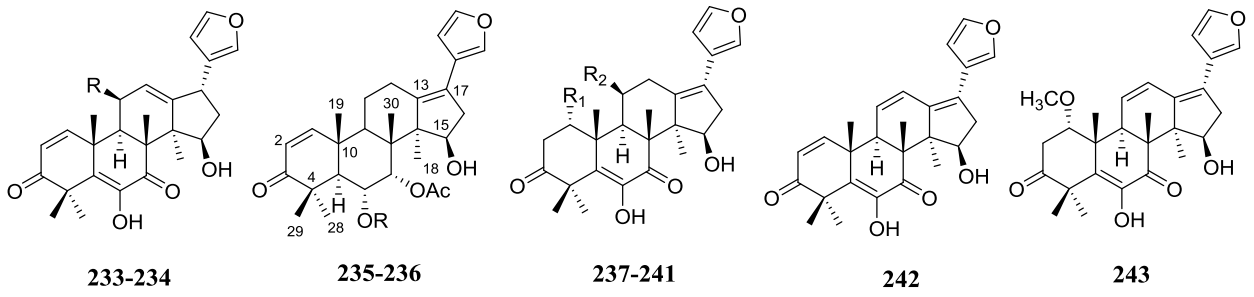


Figure 10. Structures of 18 (13→14) abeo class limonoids **233-243**.

2.2.4. Havanensin

In this class of Limonoids, substituted oxygen is present at C1, C3 and C7 positions. nineteen compounds were isolated from *Munronia henryi*, *Turraea pubescens*, *Melia toosendan*, *Entandrophragma angolense*, *Trichilia sinensis*, *Melia azedarach* and *Toona sinensis* (Table 9/S9, Figure 11). Previously twenty nine Havanensin class limonoids were reported from Meliaceae family[12]. The acetyl group in previously reported 6α-acetoxydeoxyhavanensin[162] is replaced by hydroxyl group in Munronin N (**244**) as confirmed by NMR data. The acetyl group in previously reported mesendanin B[163] is replaced by propanoyl group in Turrapubin I (**245**). Mesendanin B (**246**), Mesendanin A (**254**), Entangolensin P (**255**), Meliarachin A (**257**) and Trisinlin A (**258**) are structurally similar to previously isolated compounds 14,15-deoxyhavanensin triacetate[164], sendanal[165] meliatoosenin B[166], neohavanensin[167] and mesendanin D[163] respectively. Compound (**247**) resembles compound (**246**) except in an additional acetoxyl group at C12 and deacetylation at C3, C7 with conversion of C28 methyl group to aldehyde group. Meliazedarine I (**248**) is C6 acetyl and C7 benzoyl analog of previously reported Sendanal[168]. 6-Acetylsendanal and Sendanal B (**249**) are same but trivially named differently and C6 acetyl analog of previously reported Sendanal[168]. Trichilinin M (**250**) is the C6 deacetyl analog of compound (**248**).The $\Delta^{14,15}$ olefinic double bond in compound (**244**) is hydroxylated in compounds (**251**, **252**) which also have carbonyl group at C11. Mesendanin I (**253**) differs from Mesendanin J (**252**) in ether linkage formed between C7/14. Meliatoosenin F (**256**)

is the C3 deacetyl form of Meliarachin A (**257**). Mesendanin C and D (**259** and **260**) are acetyl derivatives of Trisinlin A (**258**) but differ in acetyl position. Toonasinenoid A (**261**) is C6 deactoxyl C11 hydroxy analog of compound (**259**). Toonasinenoid B (**262**) is C11 carbonyl analog of compound (**258**).

Table 9. Havanensin class limonoid 244-262

No.	Limonoid	Substituent	Source
244	Munronin N	R_1 = H; R_2 = R_3 = Ac	*Munronia henryi*[169]
245	Turrapubin I	R_1 = Ac; R_2 = $OCOCH_2CH_3$; R_3 = Ac	*Turraea pubescens*[170]
246	Mesendanin B	R_1 = R_2 = R_3 = Ac	*Melia toosendan*[163]
247	24,25,26,27- tetra-norapotirucalla-(apoeupha)-1α,6α,12α-triacetoxyl-3α, 7α-dihydroxyl - 28-aldehyde-14, 20, 22 - trien-21,23-epoxy	R_1 = Ac; R_2 = H; R_3 = α-OAc; R_4 = H	*Melia toosendan*[168]
248	Meliazedarine I	R_1 = H; R_2 = Ac; R_3 = α-OAc; R_4 = Bz	*Melia azedarach*[171]
249	6-Acetylsendanal/ Sendanal B	R_1 = H; R_2 = Ac; R_3 = α-OAc; R_4 = H	*Melia toosendan*[172,173]
250	Trichilinin M	R_1 = H; R_2 = Ac; R_3 = β-OH; R_4 = Bz	*Melia azedarach*[174]
251	14,15-deoxy-11-oxohavanensin 3,12-diacetate	R_1 = Ac; R_2 = H	*Melia toosendan*[175]
252	Mesendanin J	R_1 = H; R_2 = OAc	*Melia toosendan*[163]
253	Mesendanin I		*Melia toosendan*[163]
254	Mesendanin A		*Melia toosendan*[163]
255	Entangolensin P		*Entandrophragma angolense*[141]
256	Meliatoosenin F	R = H	*Melia toosendan*[176]
257	Meliarachin A	R = Ac	*Melia azedarach*[177]
258	Trisinlin A	R_1 = H; R_2 = Ac; R_3 = R_4 = R_5 =H	*Trichilia sinensis*[178]
259	Mesendanin C	R_1 = R_2 = Ac; R_3 = OAc; R_4 = R_5 = H	*Melia toosendan*[163]
260	Mesendanin D	R_1 = Ac; R_2 = R_3 = H; R_4 = Ac; R_5 = H	*Melia toosendan*[163]
261	Toonasinenoid A	R_1 = R_2 = Ac; R_3 = H; R_4 = R_5 = OH	*Toona sinensis*[142]
262	Toonasinenoid B		*Toona sinensis*[142]

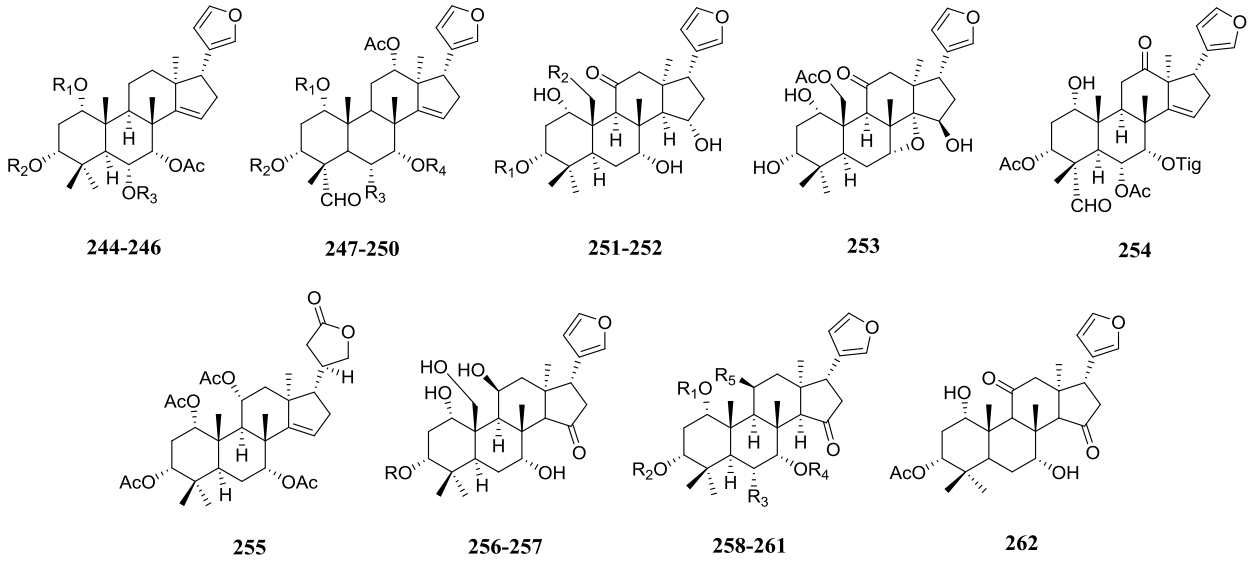


Figure 11. Structures of havanensin class limonoids **244-262**.

2.2.5. Trichilin

This class of limonoids consists of oxygen either in hydroxyl or acetoxyl form at C1, C3, C7, epoxide moiety at C14/15 or oxygen at C15, keto carbonyl at C11 and ether bridge between C19/29. Thirty three trichilin class limonoids were isolated from *Melia toosendan*, *Melia azedarach* and *Trichilia sinensis* (Table 10/S10, Figure 12). Prior to this fifty one Trichilin class limonoids were reported from Meliaceae family[12]. Compounds (**263**, **264**) are structurally identical with previously reported meliatoxin B1[179] and compounds (**265**, **275**) are congener of previously reported toosendanin[180]. Compound (**266**) is structurally similar to compound (**265**) except in position of methoxy group. Meliatoosenin G and H (**267** and **268**) share same skeleton with previously reported neoazedarachin D[181] except in variation of methoxy substitution and additional acetyl group. Trichisinlin A (**269**) and 12α-

hydroxymeliatoxin B_2 (**270**) are structurally similar to previously reported Meliatoxin B_1 and Meliatoxin B_2 respectively[182,179] except the variation of hydroxyl and acetoxyl group in compound (**269**) and hydroxyl group at C12 in compound (**270**). Trichisinlin B and C (**271** and **272**) are analogs of compound (**268**). Meliarachin L (**273**) is C29 ethoxy analog of previously reported Isochuanliansu[183]. In comparison to previously reported 12-hydroxyamoorastatone,[184] Meliatoosenin E (**274**) has $\Delta^{9,11}$ double bond with varied position of hydroxyl and carbonyl groups. 7-benzoyltoosendanin (**276**) and 7-cinnamoyltoosendanin (**277**) are benzoyl and cinnamoyl derivatives of toosendanin respectively. Trichisinlin F (**278**) and Meliarachin C (**279**) are structurally similar to previously reported trichilin D[185] except in the substitution at A ring. Compound (**280**) is C15 reduced form of previously reported isochuanliansu[183]. Meliarachin G (**281**) structurally resemble neoazedarachin D[181] with additional acetyl group at C12. Meliarachin H (**282**) is 3-deacetyl analog of compound (**281**) and Meliarachin I (**283**) is 12-deacetyl derivative of compound (**282**). From chemical shift value it was confirmed that Meliarachin J (**284**) is 29-epimer of neoazedarachin D. Meliarachin K (**285**) is 12 acetyl derivative of compound (**284**). With respect to meliatoosenin I (**287**) at C12 there is additional α oriented hydroxyl group and β orientated acetoxyl group in 12α-hydroxymeliatoosenin I (**286**) and Meliatoosenin J (**288**) respectively as determined by HMBC and NOESY correlation. The isobutyrate moiety in previously reported 7,14-epoxyazedarachin B[186] is absent in Mesendanin H (**289**) which has an additional -OAc group at C12. The 2-methyl-butyryl group at C29 in compound (**287**) is replaced by isobutyryl group in Trichisinlin E (**290**). Meliarachin D (**291**) is a C29 methoxy analog of compound (**289**). Meliarachin E (**292**) is C12 deacetyl analog of compound (**289**). Meliarachin F (**293**) is C29 epimer of compound (**292**). The furan ring at C17 in previously reported trichilin D[187] is replaced by 21-hydroxybutenolide moiety in Meliazedalide B (**294**) with altered C17 configuration. Toosendalactonin A/B (**295**) was obtained as a mixture of C29 epimers.

Table 10. Trichilin class limonoid 263-295

No.	Limonoid	Substituent	Source
263	12 α-hydroxymeliatoxin B_1	R_1 = H; R_2 = OAc; R_3 = Ac; R_4 = $OCOCH(CH_3)CH_2CH_3$; R_5 = H; R_6 = OH	*Melia toosendan*[175]
264	12α-acetoxylmeliatoxin B_2	R_1 = H; R_2 = OAc; R_3 = Ac; R_4 = $OCOCH(CH_3)_2$; R_5 = H; R_6 = OAc	*Melia toosendan*[175]
265	12- dehydroneoazedarachin D	R_1 = R_2 = H; R_3 = Ac; R_4 = H; R_5 = OCH_3; R_6 = H	*Melia azedarach*[188]
266	12-dehydro- 29-exo-neoazedarachin D	R_1 = R_2 = H; R_3 = Ac; R_4 = OCH_3; R_5 = R_6 = H	*Melia azedarach*[188]
267	Meliatoosenin G	R_1 = R_2 = H; R_3 = Ac; R_4 = OCH_3; R_5 = H; R_6 = OAc	*Melia toosendan*[176]
268	Meliatoosenin H	R_1 = R_2 = H; R_3 = Ac; R_4 = H; R_5 = OCH_3; R_6 = OAc	*Melia toosendan*[176]
269	Trichisinlin A	R_1 = Ac; R_2 = OH; R_3 = Ac; R_4 =$OCOCH(CH_3)CH_2CH_3$; R_5 = R_6 = H	*Trichilia sinensis*[189]
270	12α-hydroxymeliatoxin B_2	R_1 = H; R_2 = OAc; R_3 = Ac; R_4 = $OCOCH(CH_3)_2$; R_5 = H; R_6 = OH	*Trichilia sinensis*[189]
271	Trichisinlin B	R_1 = Ac; R_2 = OAc; R_3 = R_4 = H; R_5 = OCH_3; R_6 = H	*Trichilia sinensis*[189]
272	Trichisinlin C	R_1 = H; R_2 = OAc; R_3 = Ac; R_4 = OCH_3; R_5 = R_6 = H	*Trichilia sinensis*[189]
273	Meliarachin L	R_1 = R_2 = H; R_3 = Ac; R_4 = H; R_5 = OCH_2CH_3; R_6 = OAc	*Melia toosendan*[173]
274	Meliatoosenin E		*Melia toosendan*[176]
275	Meliarachin B		*Melia azedarach*[177]
276	7-benzoyltoosendanin	R_1 = R_2 = R_3 = H; R_4 = Bz	*Melia azedarach*[190]
277	7- cinnamoyltoosendanin	R_1 = R_2 = R_3 = H; R_4 = Cin	*Melia azedarach*[190]
278	Trichisinlin F	R_1 = Ac; R_2 = OH; R_3 = $COCH(CH_3)CH_2CH_3$; R_4 = H	*Trichilia sinensis*[189]
279	Meliarachin C	R_1 = R_2 = H; R_3 = CH_3; R_4 = H	*Melia azedarach*[177]
280	Mesendanin G	R_1 = Ac; R_2 = OH; R_3 = H; R_4 = Ac	*Melia toosendan*[163]
281	Meliarachin G	R_1 = Ac; R_2 = OCH_3; R_3 = H; R_4 = Ac;	*Melia azedarach*[177]
282	Meliarachin H	R_1 = H; R_2 = OCH_3; R_3 = H; R_4 =Ac	*Melia azedarach*[177]
283	Meliarachin I	R_1 = H; R_2 = OCH_3; R_3 = R_4 =H	*Melia azedarach*[177]
284	Meliarachin J	R_1 = Ac; R_2 = H; R_3 = OCH_3; R_4 = H	*Melia azedarach*[177]
285	Meliarachin K	R_1 = Ac; R_2 = H; R_3 = OCH_3; R_4 = Ac	*Melia azedarach*[177]
286	12a-hydroxymeliatoosenin I	R_1 = OAc; R_2 = $OCOCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = OH	*Melia toosendan*[175]
287	Meliatoosenin I	R_1 = OAc; R_2 = $OCOCH(CH_3)CH_2CH_3$; R_3 = R_4 = H	*Melia toosendan*[176]
288	Meliatoosenin J	R_1 = OAc; R_2 = $OCOCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = OAc	*Melia toosendan*[176]
289	Mesendanin H	R_1 = H; R_2 = OH; R_3 = H; R_4 = OAc	*Melia toosendan*[163]
290	Trichisinlin E	R_1 = OAc; R_2 = $OCOCH(CH_3)_2$; R_3 = R_4 = H	*Trichilia sinensis*[189]
291	Meliarachin D	R_1 = H; R_2 = OCH_3; R_3 = H; R_4 = OAc	*Melia azedarach*[177]
292	Meliarachin E	R_1 = R_2 = H; R_3 = R_4 = OH	*Melia azedarach*[177]
293	Meliarachin F	R_1 = H; R_2 = OH; R_3 = H; R_4 = OH	*Melia azedarach*[177]
294	Meliazedalide B	R = $COCH(CH_3)CH_2CH_3$	*Melia azedarach*[191]
295	Toosendalactonin A/B	R = $COCH(CH_3)CH_2CH_3$	*Melia azedarach*[192]

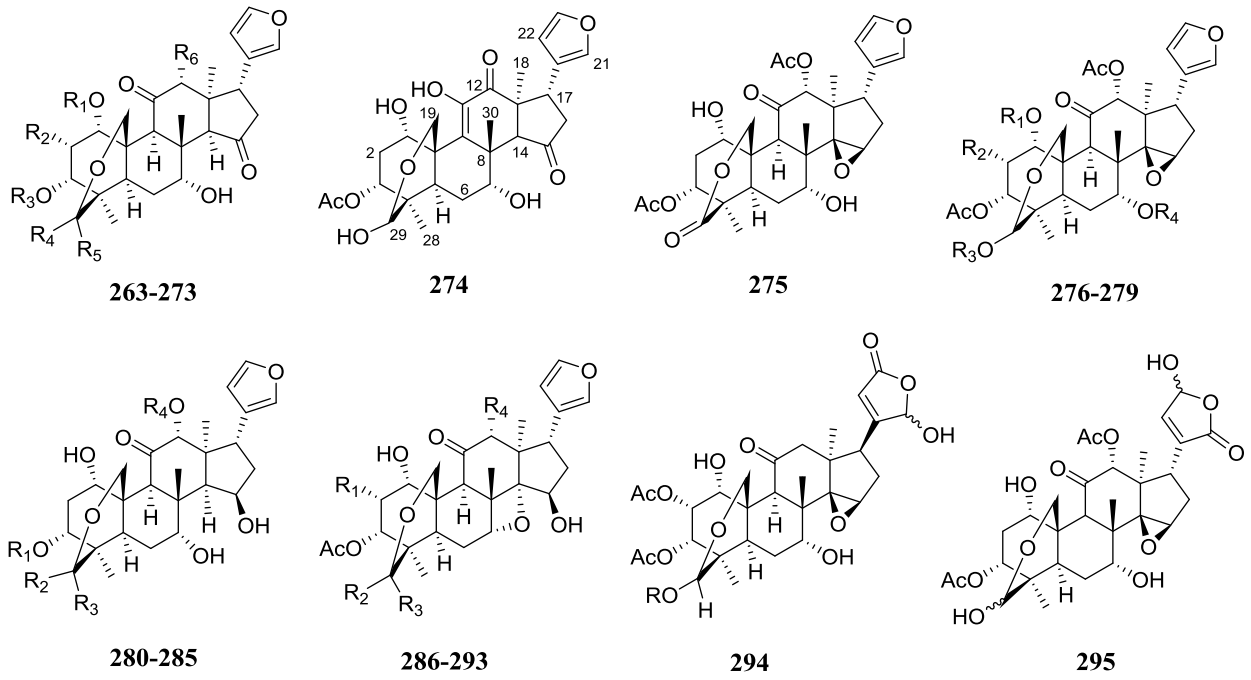


Figure 12. Structures of trichilin class limonoids **263-295**.

2.2.6. Vilasinin

This class of limonoids possess α,β-unsaturated keto carbonyl at C1 or oxygen functionality at C1, C3 and C7 with ether linkage between C6 and C29. Thirty four Limonoids belonging to this class were isolated from *Trichilia rubescens, Chisocheton ceramicus, Munronia unifoliolata, Melia toosendan, Walsura robusta, Walsura cochinchinensis, Cipadessa baccifera, Azadirachta indica* and *Chisocheton pentandrus* (Table 11/S11, Figure 13). Previously forty four Vilasinin class limonoids were reported from Meliaceae family[12]. Rubescin B (**296**) resembles previously reported ceramicine B[193] except in an extra $\Delta^{9,11}$ double bond. Ceramicine H and I (**297** and **298**) have additional tiglate and acetate group at C12 respectively, as compared to NMR data of previously isolated ceramicine B. Compounds (**299-301**) are structurally similar to previously reported meliavolkinin[194] except the substitutions at C1, C3 and C12. Ceramicine N (**302**) is structurally similar to previously reported ceramicine B except in the epoxidation at C14 and C15[193]. Walsuronoid D (**303**) is structurally similar to compound (**302**) with additional hydroxyl at C11 and tigloyl moiety at C12. Cochinchinoid A and B (**304** and **305**) show the same molecular formula as obtained by using HRESI (-) MS but differ at stereochemistry of two ester substituents at C3 and C7. The ester moieties at C3 and C7 in compound (**305**) are replaced by tigloyl group in Cochinchinoid C (**306)** and it is displaced only at C3 in Cochinchinoid D (**307**). In Cipadesin L (**308**) hydroxyl group at C1 is acetylated and ester moiety at C3 is replaced by tigloyl group with absence of hydroxyl group at C17, when compared to compound (**304**). The olefinic double bond at $\Delta^{14,15}$ in compound (**308**) is replaced by an epoxide ring in Cipadesin M (**309**). From the spectral data, the presence of carbonyl functionalities at C11 and C15 in compound (**310**) was confirmed. Ceramicine J (**311**) is analog of previously reported ceramicine B[193] except in the substituent variation at C14 and C15. There is an additional hydroxyl and tigloyl group at C11 and C12 respectively in Walsuronoid E (**312**) when compared to compound (**311**). Limonoid (**313**) closely resembles previously reported toosendone[195] but differs in ether linkage between C6/28. 7-tigloyl-12-oxo vilasini (**314**) is a deacetylated analog of compound (**313**). Toosendansin H (**315**) is C1 cinnamoyl analog of previously reported Nimbidinin[196]. Toosendansin I (**316**) is C1 benzoyl analog of previously reported Azadirachtolide[197]. The hydroxyl group at C7 in compound (**296**) is replaced by tigloyl moiety in Rubescin D (**317**) along with epoxidation of olefinic double bond at C9/11 and additional epoxide group is formed at C14/15. The epoxide ring in compound (**317**) is opened with ether bridge and C-C bond formation between C7 and C14 in Rubescin F and H (**319** and **320**) respectively. Pentendricine (**321**) differs from previously isolated ceramicine D[193] at C23, which has an additional hydroxyl group as determined by the NOESY experiment. Rubescin G (**322**) share similar skeletal structure with compounds (**318**, **321**) but differ at modification of furan ring and presence of two epoxide rings respectively. The olefinic double bond at $\Delta^{9,11}$ in Rubescin B (**296**) is reduced in Ceramicine O (**323**) along with oxidation at C7. Ceramicine O (**323**) isolated from bark of *Chisocheton*

ceramicus in Aug 2017 is published in journal of natural medicines and Rubescin I isolated from stem bark extract of *Trichilia rubescens* in March 2018 is published in Natural product research journal, have same structure but are trivially named different. Rubescin C (**324**) is like compound (**323**) except in the additional acetoxyl group at C11. With respect to compound (**323**), there is an additional $\Delta^{5,6}$ double bond in Rubescin A (**325**). Rubescin J (**326**) is acetoxyl analog of compound (**325**). Walsucochinone B (**327**) is structurally similar to compound (**323**) except in the additional epoxide group at $\Delta^{14,15}$ and substitutions at C11 and C12. Walsucochinone A (**328**) and Walsucochinone C (**329**) share a similar skeleton with compound (**327**) except in the presence of olefinic double bond at $\Delta^{5,6}$ and variation at C12 substitution.

Table 11. Vilasinin class limonoid 296-329

No.	Limonoid	Substituent	Source
296	Rubescin B		*Trichilia rubescens*[198]
297	Ceramicine H	R = Tig	*Chisocheton ceramicus*[199]
298	Ceramicine I	R = Ac	*Chisocheton ceramicus*[199]
299	Munronoid N	R_1 = α-OTig; R_2 = α-OAc; R_3 = α-OCH_3	*Munronia unifoliolata*[200]
300	Meliatoosenin K	R_1 = α-OTig; R_2 = α-OH; R_3 = α-OAc	*Melia toosendan*[176]
301	Munronoid J	$R_1 = R_2 = R_3$ = OAc	*Munronia unifoliolata*[151]
302	Ceramicine N		*Chisocheton ceramicus*[201]
303	Walsuronoid D		*Walsura robusta*[202]
304	Cochinchinoid A	R_1 = H; $R_2 = R_3$ = $COCH(CH_3)CH_2CH_3$ 2'R; R_4 = H; R_5 = OH	*Walsura cochinchinensis*[76]
305	Cochinchinoid B	R_1 = H; $R_2 = R_3$ = $COCH(CH_3)CH_2CH_3$ 2'S; R_4 = H; R_5 = OH	*Walsura cochinchinensis*[76]
306	Cochinchinoid C	R_1 = H; $R_2 = R_3$ = Tig; $R_4 = R_5$ = H	*Walsura cochinchinensis*[76]
307	Cochinchinoid D	R_1 = H; R_2 = Tig; R_3 = $COCH(CH_3)CH_2CH_3$; R_4 = OAc; R_5 = H	*Walsura cochinchinensis*[76]
308	Cipadesin L	$R_1 = R_2$ = Ac; R_3 = $COCH(CH_3)CH_2CH_3$; $R_4 = R_5$= H	*Cipadessa baccifera*[203]
309	Cipadesin M		*Cipadessa baccifera*[203]
310	11,15-dioxotrichilinin		*Melia toosendan*[175]
311	Ceramicine J	$R_1 = R_2$ = H	*Chisocheton ceramicus*[204]
312	Walsuronoid E	R_1 = OH; R_2 = OTig	*Walsura robusta*[202]
313	3-acetyl-7-tigloylnimbidinin	R_1 = H; R_1 = Ac; R_3 = Tig	*Azadirachta indica*[138]
314	7-tigloyl-12-oxo vilasini	$R_1 = R_2$ = H; R_3 = Tig	*Azadirachta indica*[119]
315	Toosendansin H	R_1 = Cin; $R_2 = R_3$ = H	*Melia toosendan*[205]
316	Toosendansin I		*Melia toosendan*[205]
317	Rubescin D		*Trichilia rubescens*[206]
318	Rubescin E		*Trichilia rubescens*[206]
319	Rubescin F		*Trichilia rubescens*[207]
320	Rubescin H		*Trichilia rubescens*[207]
321	Pentendricine		*Chisocheton pentandrus*[208]
322	Rubescin G		*Trichilia rubescens*[207]
323	Ceramicine O/ Rubescin I		*Chisocheton ceramicus*[201]/ *Trichilia rubescens*[209]
324	Rubescin C		*Trichilia rubescens*[198]
325	Rubescin A	R = H	*Trichilia rubescens*[198]
326	Rubescin J	R = OAc	*Trichilia rubescens*[209]
327	Walsucochinone B		*Walsura cochinchinensis*[210]
328	Walsucochinone A	R = $COCH(CH_3)CH_2CH_3$	*Walsura cochinchinensis*[210]
329	Walsucochinone C	R = Ac	*Walsura cochinchinensis*[210]

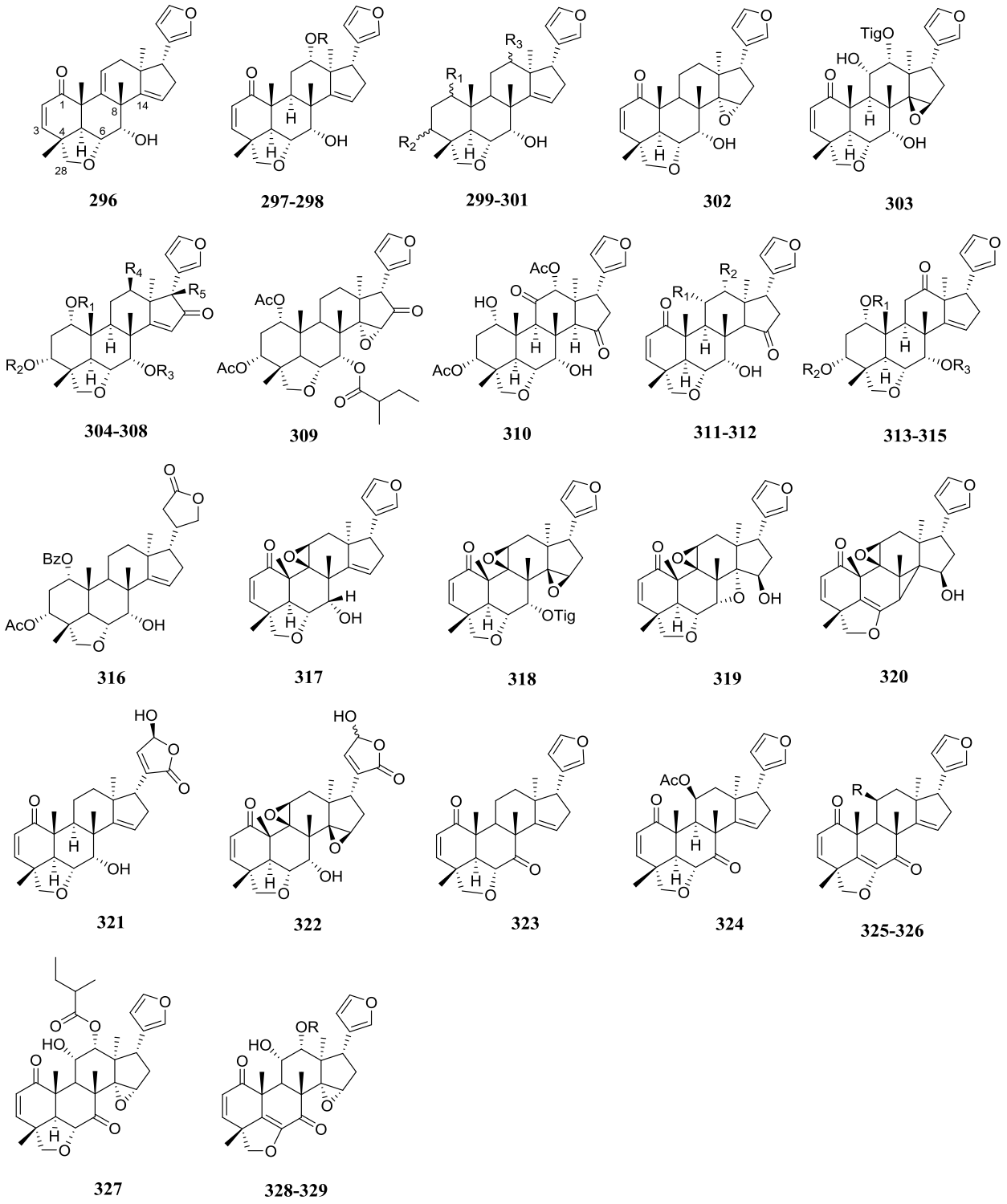


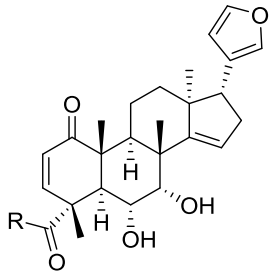
Figure 13. Structures of vilasinin class limonoids **296-329**.

2.2.7. Other ring intact

Ceramicine F and G (**330** and **331**) are analogs, isolated from *Chisocheton ceramicus* (Table 12/S12, Figure 14). Nineteen Meliaceae limonoids belonging to this class were reported earlier[12]. They differ in substitution at C4, where there is an aldehyde group in compound (**330**) and ester group in compound (**331**).

Table 12. Other class ring intact limonoid 330-331

No.	Limonoid	Substituent	Source
330	Ceramicine F	R = H	*Chisocheton ceramicus*[199]
331	Ceramicine G	R = OCH_3	*Chisocheton ceramicus*[199]



330-331

Figure 14. Structures of other ring intact class limonoids **330-331**.

2.3. Ring seco limonoids

2.3.1. Demolition of single ring

2.3.1.1. Ring A-seco

2.3.1.1.1. Evodulone

This class of limonoid is identified by the presence of an A ring in the form of a seven membered lactone ring and oxygen at C7. Forty two Limonoids were isolated belonging to this class from *Munronia henryi, Toona ciliata, Toona sinensis, Munronia delavayi, Aphanamixis grandifolia, Aphanamixis polystachya* and *Munronia unifoliolata* (Table 13/S13, Figure 15). Previously sixteen Evodulone class limonoids were reported from Meliaceae family[12]. Munronin H (**332**) is structurally similar to previously isolated surenone[211] except in additional two acetyl groups at C11, C12 and absence of hydroxyl group at C6. The hydroxyl group is absent in Toonayunnanin D (**333**) at C6 and an additional isobutyryloxy group is present at C12 in Toonasinenine J (**334**) with respect to surenone. The NMR spectroscopic data of Munronin I (**335**) is similar to compound (**332**) but has acetyl group at C1 and $\Delta^{1,2}$ double bond is absent. The acetyl group at C12 in compound (**335**) is replaced by tigloyl group in Mulavanin E (**336**). The carbonyl group at C7 in compound (**335**) is reduced to hydroxyl group in Toonin B (**337**) along with absence of acetoxyl groups at C11 and C12. Aphanalide L (**338**) has additional hydroxyl groups at C11, C12 in comparison to compound (**337**). Aphanalide E and H (**339** and **342**) are analogs of Toonin B with variation in substitution pattern at C7, C11 and C12. Aphanalide F **340**) is acetyl derivative of Aphanalide E (**339**). The C14/15-oxirane in Toonayunnanin D (**333**) is absent in Aphanalide I (**343**) along with carbonylated C15 and hydroxylation at C7 and C11 as confirmed by X-ray crystallography. Toonayunnanin C (**344**) is analog of compound (**343**) but differs in substitution at C11 and C12. The $\Delta^{1,2}$ double bond in Aphanalide I is absent in Aphanalide K (**345**) which also has an additional acetoxyl group at C1 as determined by the ROESY experiment. Aphanalide D (**346**) is a structural analog of compound (**345**) but differs at C12 substitution. The NMR spectral data of Munronoid K (**347**) is similar to previously reported carapolide I[212] except in the addition of 2-hydroxy-3-methylpentanoate at C12. Based on NMR data, Munronoid L (**348**) is structurally similar to compound (**347**) but differs only in acetylation at C12. The 2-hydroxy-3-methylpentanoate group at C7 in compound (**347**) is replaced by 3-methylbut-2-enoate in Munronoid L (**349**). The chemical shift difference i.e, shift in acetoxyl group from C7 to C12 in Munronin J (**350**) was confirmed by comparing spectroscopic data of previously reported carapolide I. Aphanagranin A (**351**) resemble Aphanalide L (**338**) but differ at C15 hydroxyl moiety and oxetane ring moiety between C7/C14 formed by opening of epoxide ring at $\Delta^{14,15}$. Aphanalide A-C (**352-354**) are structural analogs of compound (**351**) but differ in substitution at C11 and C12. Aphanalide J (**355**) differs structurally from compound (**351**) in formation of α,β-unsaturated double bond by removal of acetoxyl group from C1. Munronoid C (**356**) is structurally similar to Toonayunnanin D except in presence of two additional acetoxyl groups at C6, C7, missing carbonyl group at C7 and replaced furan ring by γ-lactone ring at C17. In comparison with compound (**356**), $\Delta^{14,15}$ double bond are formed in Munronoid D (**357**). Munronoid E and F (**358** and **359**) have additional keto group and hydrogen peroxide group at C16 respectively, in comparison to compound (**357**). The NMR spectral data of Munronoid G (**360**) is similar to previously reported rubralin C[213] except the conversion of tiglate group to keto carbonyl at C7. Munronoid H (**361**)

is detiglylated form of rubralin C. Toonaolide N (**362**) is C21 hydroxy butenolide analog of compound (**357**). Toonaolide M (**363**) is C6 deacetyl analog of compound (**362**). Toonaolide L (**364**) is C6 deacetoxyl analog of compound (**362**). Toonaolide J (**365**) is C7 deacetyl analog of compound (**364**). Toonaolide K (**366**) is oxidized at C7 compared with compound (**365**). Furan ring in compound (**333**) is replaced by C21 hydroxy butenolide moiety in Toonaolide D (**367**). Toonaolide E (**368**) is $\Delta^{9,11}$ analog of compound (**367**). Furan ring in previously reported Surenin[211] is replaced by C21 hydroxy butenolide moiety in Toonaolide F (**369**). Toonaolide P (**370**) and Toonaolide Q (**371**) are derived from compound (**365**) and compound (**364**) respectively with presence of carbonyl at C15. Toonaolide O (**372**) is C23 hydroxy butenolide analog of compound (**365**). Furan ring in compound (**333**) is replaced by C23 hydroxy butenolide moiety in Toonaolide G (**373**).

Table 13. Evodulone class limonoid 332-373

No.	Limonoid	Substituent	Source
332	Munronin H	$R_1 = R_2 = OAc$	*Munronia henryi*[169]
333	Toonayunnanin D	$R_1 = R_2 = H$	*Toona ciliata*[136]
334	Toonasinenine J	$R_1 = H$; $R_2 = OCOCH(CH_3)_2$	*Toona sinensis*[214]
335	Munronin I	R = Ac	*Munronia henryi*[169]
336	Mulavanin E	R = Tig	*Munronia delavayi*[215]
337	Toonin B	$R_1 = Ac$; $R_2 = R_3 = H$	*Toona sinensis*[216]
338	Aphanalide L	$R_1 = Ac$; $R_2 = R_3 = OH$	*Aphanamixis grandifolia*[124]
339	Aphanalide E	$R_1 = H$; $R_2 = OH$; $R_3 = OCOCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[217]
340	Aphanalide F	$R_1 = Ac$; $R_2 = OH$; $R_3 = OCOCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[217]
341	Aphanalide G	$R_1 = H$; $R_2 = OCHO$; $R_3 = OCOCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[217]
342	Aphanalide H	$R_1 = H$; $R_2 = OCHO$; $R_3 = OCOCH_2CH(CH_3)_2$	*Aphanamixis polystachya*[217]
343	Aphanalide I	$R_1 = OH$; $R_2 = H$	*Aphanamixis grandifolia*[124]
344	Toonayunnanin C	$R_1 = H$; $R_2 = COCH(CH_3)_2$	*Toona ciliata*[136]
345	Aphanalide K	R = H	*Aphanamixis grandifolia*[124]
346	Aphanalide D	$R = COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[217]
347	Munronoid K	$R_1 = Ac$; $R_2 = OAc$; $R_3 = COCH(OH)CH(CH_3)CH_2CH_3$	*Munronia unifoliolata*[200]
348	Munronoid L	$R_1 = R_3 = Ac$; $R_2 = OAc$	*Munronia unifoliolata*[200]
349	Munronoid M	$R_1 = R_3 = Ac$; $R_2 = OCOCHC(CH_3)_2$	*Munronia unifoliolata*[200]
350	Munronin J	$R_1 = R_3 = Ac$; $R_2 = H$	*Munronia henryi*[169]
351	Aphanagranin A	$R_1 = R_2 = H$	*Aphanamixis grandifolia*[218]
352	Aphanalide A	$R_1 = CHO$; $R_2 = COCH_2CH(CH_3)_2$	*Aphanamixis polystachya*[217]
353	Aphanalide B	$R_1 = H$; $R_2 = COCH_2CH(CH_3)_2$	*Aphanamixis polystachya*[217]
354	Aphanalide C	$R_1 = H$; $R_2 = COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[217]
355	Aphanalide J		*Aphanamixis grandifolia*[124]
356	Munronoid C		*Munronia unifoliolata*[151]
357	Munronoid D		*Munronia unifoliolata*[151]
358	Munronoid E		*Munronia unifoliolata*[151]
359	Munronoid F		*Munronia unifoliolata*[151]
360	Munronoid G		*Munronia unifoliolata*[151]
361	Munronoid H		*Munronia unifoliolata*[151]
362	Toonaolide N	$R_1 = R_2 = OAc$	*Toona ciliata*[219]
363	Toonaolide M	$R_1 = OH$; $R_2 = OAc$	*Toona ciliata*[219]
364	Toonaolide L	$R_1 = H$; $R_2 = OAc$	*Toona ciliata*[219]
365	Toonaolide J	$R_1 = H$; $R_2 = OH$	*Toona ciliata*[219]
366	Toonaolide K		*Toona ciliata*[219]
367	Toonaolide D		*Toona ciliata*[219]
368	Toonaolide E	$\Delta^{9,11}$	*Toona ciliata*[219]
369	Toonaolide F		*Toona ciliata*[219]
370	Toonaolide P	R = OH	*Toona ciliata*[219]
371	Toonaolide Q	R = OAc	*Toona ciliata*[219]
372	Toonaolide O		*Toona ciliata*[219]
373	Toonaolide G		*Toona ciliata*[219]

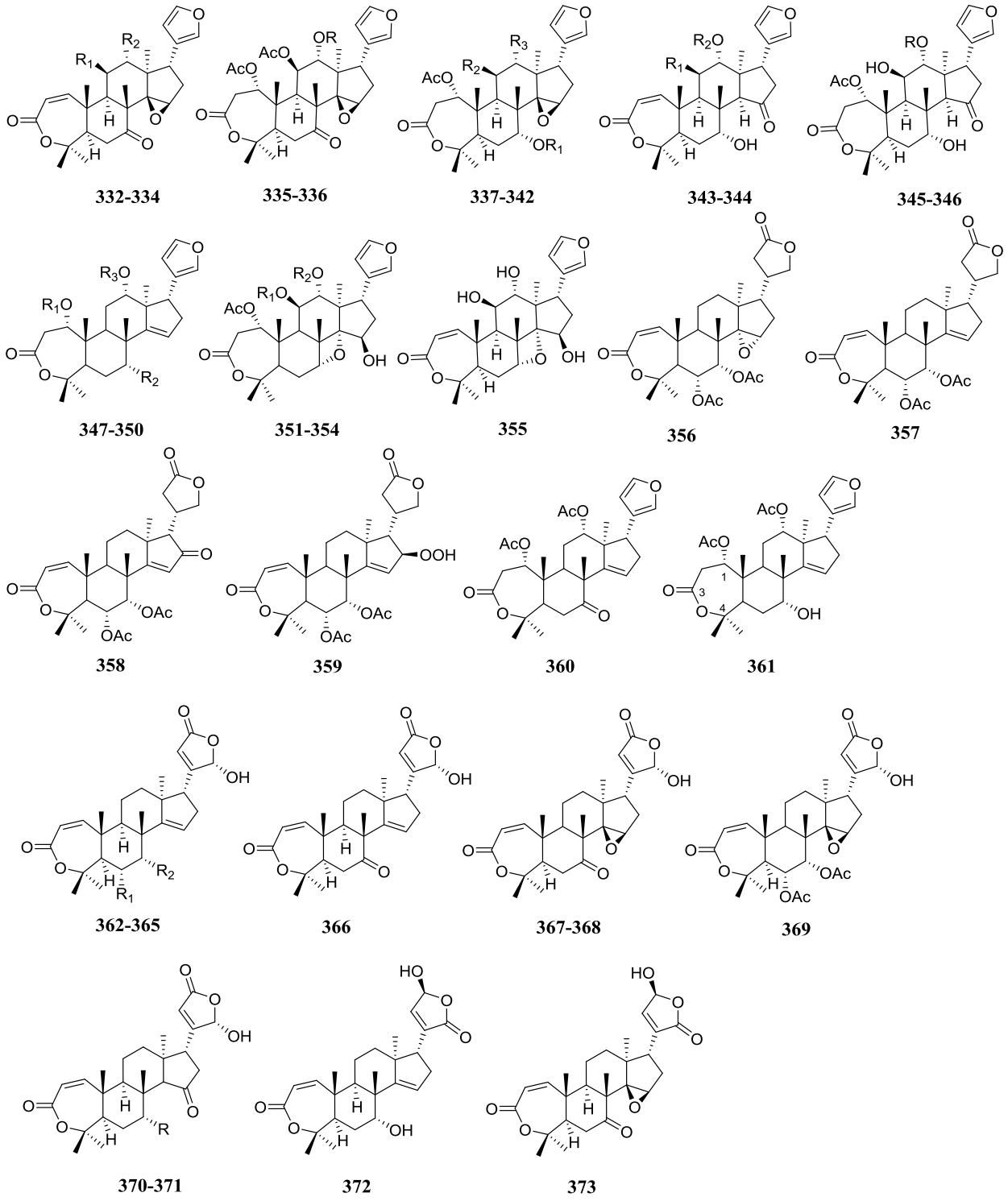


Figure 15. Structures of evodulone class limonoids **332-373**.

2.3.1.1.2. Other ring A-seco

Structural analogs Walrobsin A and B (**374** and **375**) were isolated from *Walsura robusta* which differ from each other in substitution at C2 and contain a unique 5-oxatricyclo [5.4.1] undecane ring system (Table 14/S14, Figure 16). The skeletal structure of Dysomollide E (**376**) isolated from *Dysoxylum mollissimum* was similar to

previously reported nymania 2[220] except in displacement of γ-substituted butyrolactone ring by furan ring, deacetylation at C1, C7 and presence of acetoxyl group at C16. Angustifolianin (**377**) is C7 deacetyl analog of previously reported Nymania 2[220]. Toonaolide C (**378**) is C6 acetoxyl C4, C21 dihydroxy, $\Delta^{20,22}$ analog of previously reported Nymania 2[220].

Table 14. Other ring A-seco class limonoid 374-378

No.	Limonoid	Substituent	Source
374	Walrobsin A	R = Tig	*Walsura robusta*[221]
375	Walrobsin B	R = $COCH(CH_3)CH_2CH_3$	*Walsura robusta*[221]
376	Dysomollide E		*Dysoxylum mollissimum*[144]
377	Angustifolianin		*Aglaia angustifolia*[222]
378	Toonaolide C		*Toona ciliata*[219]

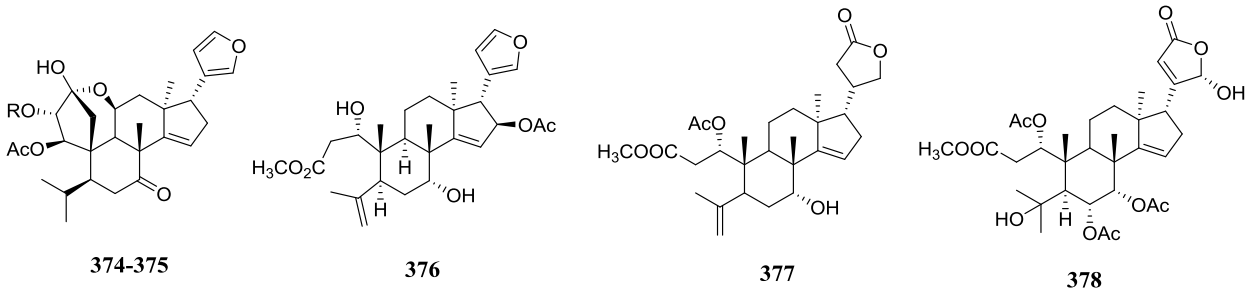


Figure 16. Structures of other ring (A-seco) class limonoids **374-378**.

2.3.1.2. Ring B-seco

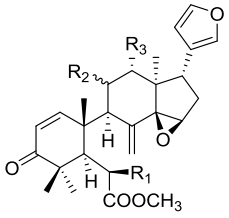
Ring B-seco class limonoids are characterized by modification of the B ring. Fifty eight compounds belonging to this class were isolated from *Turraea pubescens*, *Toona ciliata* and *Toona sinensis* (Table 15/S15, Figure 17). Previously twenty six ring B-seco class limonoids were reported from Meliaceae family[12]. Turrapubin E (**379**) shares similar skeletal structure with previously reported 11-epi-toonacilin[127] except deacetylation at C12. The C12 acetoxyl group in 11-epi-toonacilin is replaced by isobutanoyloxy and 2-methylbutanoxy moiety in Turrapubin F and G (**380** and **381**) respectively. Toonacilianin E (**382**) is C6 hydroxyl analog of 11-epi-toonacilin and Toonasinenine E (**383**) is C12 deacetoxyl analog of compound (**382**). The $\Delta^{1,2}$ double bond in 11-epi-toonacilin is absent in Turrapubin A (**384**) which also has acetoxyl group at C1. The acetyl group at C12 in Turrapubin A is replaced by Isobutanoyloxy and 2-methylbutanoxy groups in Turrapubin B and C (**385** and **386**) respectively. Toonayunnanin F (**387**) is structurally similar to Toonasinenine E but differ at C8 hydroxylation and acetoxyl group at C11 is absent; in addition to this, Toonasinenine G (**388**) has hydroxyl group at C12. Toonayunnanin I (**389**) is acetylated at C6 with C1, C11 ether linkage when compared to Toonayunnanin F. Limonoids (**390-393**) vary at C6 and C12 in acetylation and hydroxylation as compared to compound (**389**). Ciliatasecone L (**394**) is C11 dehydroxy analog of compound (**390**). The methyl group in Toonayunnanin I (**389**) at C29 is replaced by the formyl group in Toonayunnanin J (**395**). Whereas in Toonacilianin H (**396**), the acetyl group from C6 to C12 are shuffled and C29 is acetylated. The acetyl group at C6 in Toonayunnanin J is deacetylated in Toonasinenine B (**397**). Ciliatasecone M (**398**) is a C12 hydroxy analog of compound (**395**). Toonaciliatone G (**399**) possesses additional keto carbonyl at C12 when compared to Toonayunnanin I. Toonaciliatone E (**400**) is acetylated form of previously reported toonaciliatin B[223]. The double bond at $\Delta^{14,15}$ in previously isolated Turraflorin G[224] is replaced by an oxirane ring in Turrapubin D (**401**). Toonayunnanin G (**402**) differs from Toonayunnanin I in reduction of $\Delta^{1,2}$ double bond and Toonacilianin I (**403**) is a C12 hydroxyl form of compound (**402**). Toonacilianin J (**404**) is a C29 acetoxyl derivative of compound (**403**). Toonayunnanin H (**405**), Toonasinenine A (**406**) and Toonasinenine C (**407**) are dehydroxyl and deacetoxyl analogs of compound (**404**). The epoxide ring and hydroxyl group in compound (**402**) are shuffled from C14/15 to C8/14 and C8 to C15 respectively, in Toonayunnanin K and L (**408** and **409**). The carbonyl group at C3 in Toonasinenine G (**388**) is reduced with oxirane ring formation at C1/2 in Toonacilianin D (**410**) and Toonasinenine F (**411**). Toonacilianin B, C (**412**, **413**) and Toonaciliatone H (**414**) share the same skeleton as compound (**409**) except the cleavage of C1/11 ether bridge and formation of $\Delta^{1,2}$ double bond. Ciliatasecone G (**415**) is C15 acetyl analog of compound (**412**). Toonacilianin A (**416**) and Toonasinenine H (**417**) are C3 keto carbonyl group reduced analogs of compounds (**412**, **414**) respectively. Ciliatasecone F (**418**) is C15 acetyl analog of compound (**416**).

Ciliatonoid B (**420**) is a carbonyl reduced analog of Ciliatonoid A (**419**). The absolute configuration of Turrapubin H (**421**) was assigned by comparing the CD spectrum of previously isolated Turrapubesin D[225]. The hydroxyl group at γ-lactone ring in compound (**421**) is absent in Toonaciliatavarin H (**422**). The structure of Tooniliatone A (**423**) was confirmed by Cu Kα X-ray crystallographic analysis. Toonayunnanae A (**424**) differs from previously reported Toonafolin[214] with absence of C1, C11 ether linkage and additional $\Delta^{1,2}$ double bond. Toonayunnanae C (**425**) and Toonayunnanae D (**426**) are C6 dehydroxy and C6 acetyl analog of compound (**387**) respectively. Toonayunnanae E (**427**) is C8 hydroxy analog of previously reported Turraflorin G[224]. The epoxide ring at C14, C15 in compound (**390**) and compound (**393**) is replaced by $\Delta^{14,15}$ double bond in Ciliatasecone O (**428**) and Ciliatasecone P (**429**) respectively. Ciliatasecone D (**430**) differs from compound (**413**) with presence of hydroxyl group at C14 and $\Delta^{8,9}$ double bond with cleavage of C8,C14 epoxide ring. Ciliatasecone E (**431**) differs from compound (**430**) with reduction of C3 carbonyl and shifting of double bond from $\Delta^{8,9}$ to $\Delta^{8,30}$. Ciliatasecone H (**432**) and Ciliatasecone I (**433**) are C30 methoxy and ethoxy analogs of previously reported Turrapubesin A[226] respectively. Ciliatasecone K (**434**) is C15 oxidized and C30 dechlorinated analog of previously reported Turrapubesin A[226]. Ciliatasecone J (**435**) is C15 acetyl analog of previously reported Turrapubesin C[225]. Ciliatasecone Q (**436**) differs from compound (**409**) with C12 hydroxylation, C15 acetylation and cleavage of C8, C14 epoxide ring with presence of $\Delta^{8,9}$ double bond.

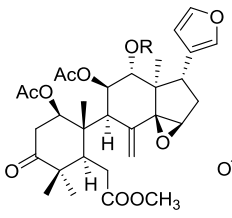
Table 15. Ring B-seco class limonoid 379-436

No.	Limonoid	Substituent	Source
379	Turrapubin E	R_1 = H; R_2 = β-OAc; R_3 = OH	*Turraea pubescens*[170]
380	Turrapubin F	R_1 = H; R_2 = β-OAc; R_3 = $OCOCH(CH_3)_2$	*Turraea pubescens*[170]
381	Turrapubin G	R_1 = H; R_2 = β-OAc; R_3 = $OCOCH(CH_3)CH_2CH_3$	*Turraea pubescens*[170]
382	Toonacilianin E	R_1 = OH; R_2 = α-OAc; R_3 = OAc	*Toona ciliata*[227]
383	Toonasinenine E	R_1 = OH; R_2 = α-OAc; R_3 = H	*Toona sinensis*[214]
384	Turrapubin A	R = Ac	*Turraea pubescens*[170]
385	Turrapubin B	R = $COCH(CH_3)_2$	*Turraea pubescens*[170]
386	Turrapubin C	R = $COCH(CH_3)CH_2CH_3$	*Turraea pubescens*[170]
387	Toonayunnanin F	R = H	*Toona ciliata*[136]
388	Toonasinenine G	R = OH	*Toona sinensis*[214]
389	Toonayunnanin I	R_1 = OAc; R_2 = H	*Toona ciliata*[136]
390	Toonacilianin F	R_1 = H; R_2 = OH	*Toona ciliata*[227]
391	Toonacilianin G	R_1 = OAc; R_2 = OH	*Toona ciliata*[227]
392	Toonaciliatin P	R_1 = OAc; R_2 = H	*Toona ciliata*[228]
393	Toonaciliatone-F	R_1 = R_2 = OH	*Toona ciliata*[229]
394	Ciliatasecone L	R_1 = R_2 = H	*Toona ciliata*[139]
395	Toonayunnanin J	R_1 = CHO; R_2 = OAc; R_3 = H	*Toona ciliata*[136]
396	Toonacilianin H	R_1 = CH_2OAc; R_2 = H; R_3 = OAc	*Toona ciliata*[227]
397	Toonasinenine B	R_1 = CHO; R_2 = R_3 = H	*Toona sinensis*[214]
398	Ciliatasecone M	R_1 = Ac; R_2 = OAc; R_3 = OH	*Toona ciliata*[139]
399	Toonaciliatone-G		*Toona ciliata*[229]
400	Toonaciliatone-E		*Toona ciliata*[229]
401	Turrapubin D		*Turraea pubescens*[170]
402	Toonayunnanin G	R = H	*Toona ciliata*[136]
403	Toonacilianin I	R = OH	*Toona ciliata*[227]
404	Toonacilianin J	R_1 = OAc; R_2 = OH	*Toona ciliata*[227]
405	Toonayunnanin H	R_1 = OAc; R_2 = H	*Toona ciliata*[136]
406	Toonasinenine A	R_1 = R_2 = H	*Toona sinensis*[214]
407	Toonasinenine C	R_1 = R_2 = OAc	*Toona sinensis*[214]
408	Toonayunnanin K	R = OAc	*Toona ciliata*[136]
409	Toonayunnanin L	R = H	*Toona ciliata*[136]
410	Toonacilianin D	R = H	*Toona ciliata*[227]
411	Toonasinenine F	R = OH	*Toona sinensis*[214]
412	Toonacilianin B	R_1 = OH; R_2 = H	*Toona ciliata*[227]
413	Toonacilianin C	R_1 = R_2 = H	*Toona ciliata*[227]
414	Toonaciliatone H	R_1 = OAc; R_2 = H	*Toona ciliata*[229]
415	Ciliatasecone G	R_1 = OH; R_2 = Ac	*Toona ciliata*[139]
416	Toonacilianin A	R_1 = α-OH; R_2 = OH; R_3 = H	*Toona ciliata*[227]
417	Toonasinenine H	R_1 = α-OH; R_2 = R_3 = H	*Toona sinensis*[214]
418	Ciliatasecone F	R_1 = β-OH; R_2 = OH; R_3 = Ac	*Toona ciliata*[139]
419	Ciliatonoid A		*Toona ciliata*[230]
420	Ciliatonoid B		*Toona ciliata*[230]
421	Turrapubin H	R_1 = β-OAc; R_2 = $COCH(CH_3)_2$; R_3 = OH	*Turraea pubescens*[170]
422	Toonaciliatavarin H	R_1 = α-OAc; R_2 = Ac; R_3 = H	*Toona ciliata*[80]
423	Tooniliatone A		*Toona ciliata*[231]
424	Toonayunnanae A		*Toona ciliata*[232]
425	Toonayunnanae C	R = H	*Toona ciliata*[232]

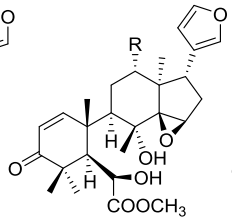
426	Toonayunnanae D	R = OAc	*Toona ciliata*[232]
427	Toonayunnanae E		*Toona ciliata*[232]
428	Ciliatasecone O	R = H	*Toona ciliata*[139]
429	Ciliatasecone P	R = OH	*Toona ciliata*[139]
430	Ciliatasecone D		*Toona ciliata*[139]
431	Ciliatasecone E		*Toona ciliata*[139]
432	Ciliatasecone H	R = CH_3	*Toona ciliata*[139]
433	Ciliatasecone I	R = CH_2CH_3	*Toona ciliata*[139]
434	Ciliatasecone K		*Toona ciliata*[139]
435	Ciliatasecone J		*Toona ciliata*[139]
436	Ciliatasecone Q		*Toona ciliata*[139]



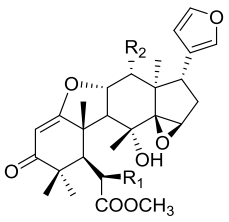
379-383



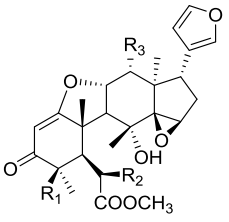
384-386



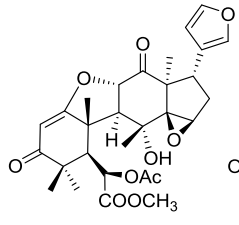
387-388



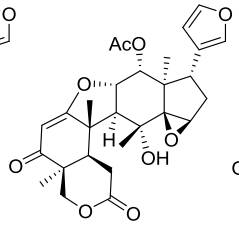
389-394



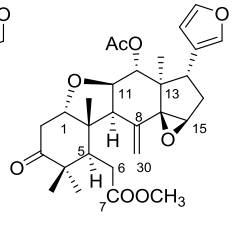
395-398



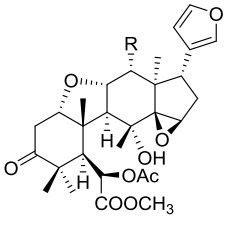
399



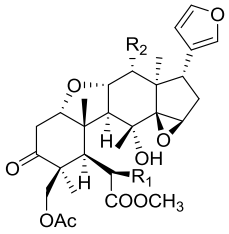
400



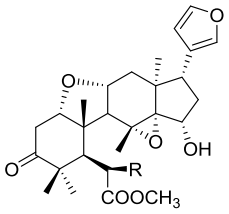
401



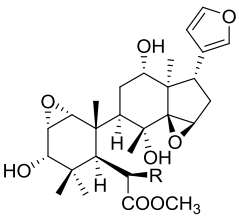
402-403



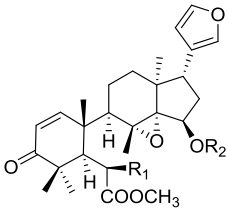
404-407



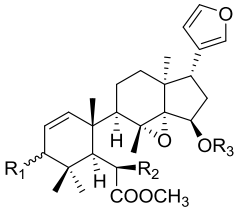
408-409



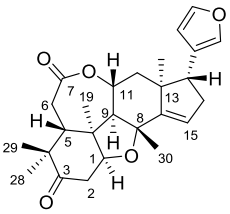
410-411



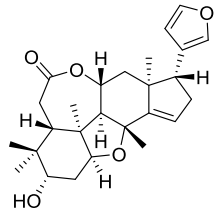
412-415



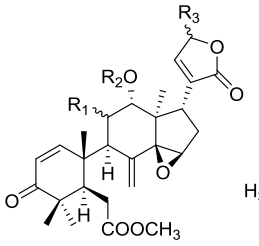
416-418



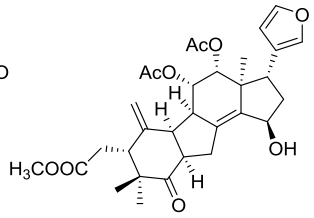
419



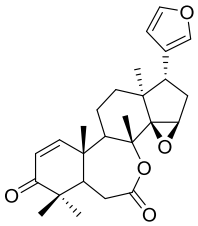
420



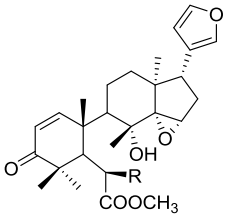
421-422



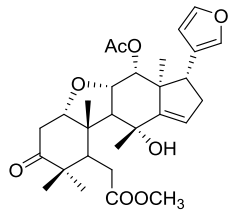
423



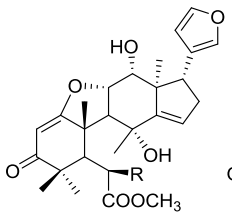
424



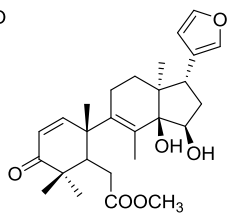
425-426



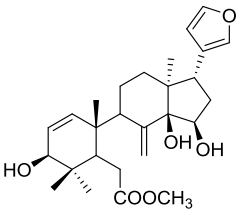
427



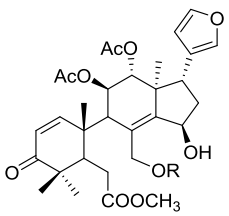
428-429



430



431



432-433

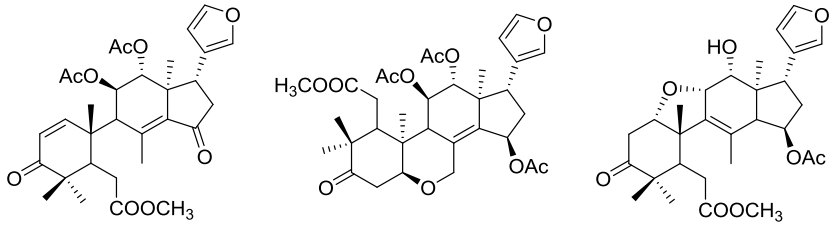


Figure 17. Structures of ring B-seco class limonoids **379-436**.

2.3.1.3. Ring C-seco

2.3.1.3.1. Azadirachtin/Meliacarpin

Ring C-seco Limonoids are characterized by modifications of the C ring. The only structural difference between Azadirachtin and Meliacarpin skeletons is the additional C7, C13 ether bridge in Meliacarpins. Nine Limonoids belonging to this class were isolated from *Azadirachta indica*, *Turraea pubescens* and *Melia toosendan* (Table 16/S16, Figure 18). A total of forty Azadirachtin/Meliacarpin class limonoids were reported from Meliaceae family[12]. 1-tigloylazadirachtol (**437**) is derivative of previously reported Azadirachtol[233]. Turrapubin K (**438**) also known as 3-deacetyl-3-propanoylazadirachtin-A is analog of azadirachtin-A. Turrapubin J (**439**) is structurally similar to previously reported 1-tigloyl-3-acetylazadirachtinin[234]. Toosendane A-C (**440-442**) are structural analogs of 1-tigloyl-3,20-diacetyl-11-methoxymeliacarpinin reported earlier[235]. Azadirachtin J (**443**) is C23 methoxy analog of previously reported Azdirachtin O[236]. Toosendansin E (**444**) is C23 ethoxy analog of previously reported 1,3-dicinnamoyl-11-hydroxymeliacarpin[237]. Toosendansin F (**445**) is C23 epimer of compound (**444**).

Table 16. Azadirachtin/Meliacarpin class limonoid 437-445

No.	Limonoid	Substituent	Source
437	1-tigloylazadirachtol		*Azadirachta indica*[145]
438	Turrapubin K		*Turraea pubescens*[170]
439	Turrapubin J		*Turraea pubescens*[170]
440	Toosendane A	R_1 = OTig; R_2 = H	*Melia toosendan*[238]
441	Toosendane B	R_1 = H; R_2 = Tig	*Melia toosendan*[238]
442	Toosendane C	R_1 = H; R_2 = $COC(CH_3)CH_2$	*Melia toosendan*[238]
443	Azadirachtin J		*Azadirachta indica*[239]
444	Toosendansin E	R = β-OCH_2CH_3	*Melia toosendan*[205]
445	Toosendansin F	R = α-OCH_2CH_3	*Melia toosendan*[205]

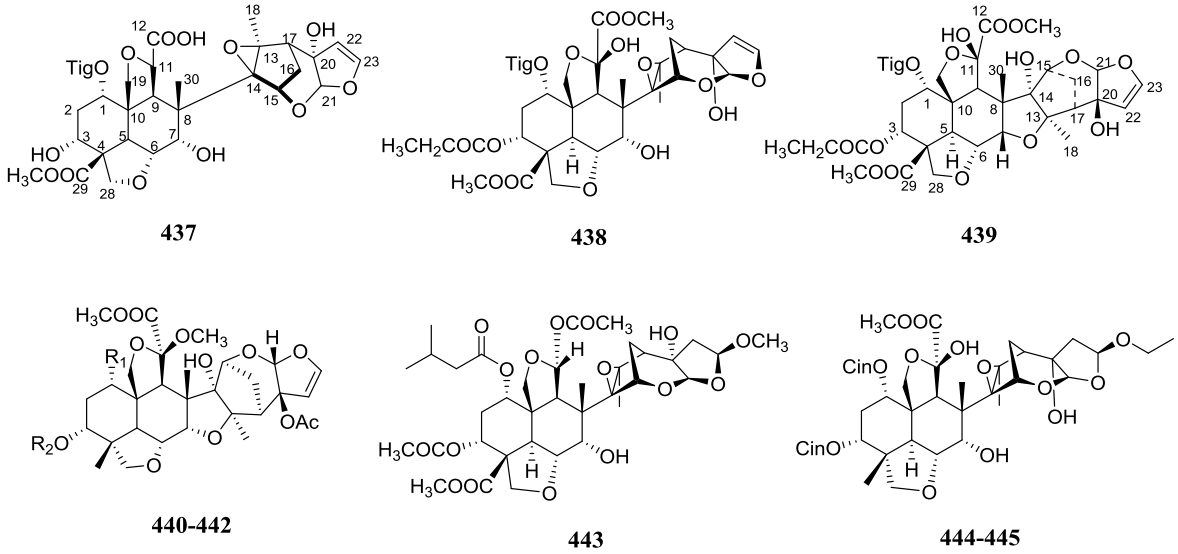


Figure 18. Structures of azadirachtin/meliacarpin class limonoids **437-445**.

2.3.1.3.2. Salannin

This class of limonoids are characterized by ether linkages between C6-C28 and C7-C13. Twenty eight Salannin class limonoids were isolated from *Melia azedarach*, *Melia Toosendan* and *Azadirachta indica* (Table 17/S17, Figure 19). Previously twenty one Salannin class limonoids were reported from Meliaceae family[12]. The tiglate group at C1 in salannin is displaced by methacrylate, cinnamoyl and benzoyl groups in compounds (**446**, **448**, **449**) respectively, whereas Toosendansin A (**447**) is tiglylated at C3. Compound (**449**) was isolated by two different research groups in 2013[188,119] from different plants but trivially named differently. Meliazedarine D (**450**), Meliazedarine E/Ohchinin benzoate (**451**), Meliazedarine F (**452**), Meliazedarine G (**453**), Meliazedarine H (**454**) and 1-(E)-3,4-dimethylpent-2-enal-11-methoxycarbonyl nimbidinol acetate (**455**) differs in substitution at C1, C3 with varying combination of cinnamoyl, benzoyl and tigloyl moieties compared to compound (**447**). Compound (**456**) is structurally similar to previously reported 2,3-dihydronimbolide[240] except at C3 additional α-methoxy group. Limonoids (**457-459**) are derivatives of compound (**456**) with presence of tiglate, benzyl and methacrylate moieties at C1 respectively. The furan ring in compound (**457**) is displaced by α,β-unsaturated γ-lactone ring in compound (**460**). The tiglate group at C1 and furan ring in salanin is replaced by isovalerate group and C23-OH substituted γ-lactone ring in Limonoid (**461**) respectively. Limonoids (**462-468**) are derivatives of compound (**461**) but differ in substitution at C1 and C23. The furan ring at C17 in 28-deoxonimbolide is replaced by α,β-unsaturated-21-hydroxy γ-lactone ring in limonoid (**469**). Nimbolide B (**470**) differs from compound (**469**) in additional keto carbonyl at C28. Compounds (**471**, **472**, **473**) are structural analogs of compounds (**469**, **460**, **467**) respectively differing in substitution at C17.

Table 17. Salannin class limonoid 446-473

No.	Limonoid	Substituent	Source
446	3-deacetyl-4'-demethylsalannin	R_1 = $COC(CH_2)CH_3$; R_2 = H	*Melia azedarach*[241]
447	Toosendansin A	R_1 = Tig; R_2 = Tig	*Melia Toosendan*[242]
448	1-O-decinnamoyl-1-O-Z-cinnamoylohchinin	R_1 = Z-Cin; R_2 = H	*Melia azedarach*[188]
449	1-O-decinnamoyl-1-Obenzoylohchinin/1-benzoyl-3-deacetyl-1- detigloyl salannin	R_1 = Bz; R_2 = H	*Melia azedarach*[188]/ *Azadirachta indica*[119]
450	Meliazedarine D	R_1 = Cin; R_2 = Tig	*Melia azedarach*[171]
451	Meliazedarine E/Ohchinin benzoate	R_1 = Cin; R_2 = Bz	*Melia azedarach*[171,174]
452	Meliazedarine F	R_1 = Bz; R_2 = Cin	*Melia azedarach*[171]
453	Meliazedarine G	R_1 = Bz; R_2 = Bz	*Melia azedarach*[171]
454	Meliazedarine H	R_1 = Tig; R_2 = Bz	*Melia azedarach*[171]
455	1-(E)-3,4-dimethylpent-2-enal-11-methoxycarb- onyl nimbidinol acetate	$COCHC(CH_3)CH(CH_3)_2$; R_2 = Ac	*Azadirachta indica*[156]
456	2,3-dihydro-3α-methoxynimbolide		*Azadirachta indica*[138]
457	3-deacetyl-28-oxosalannin	R = Tig	*Melia azedarach*[241]
458	1-O-decinnamoyl-1-O-benzoyl- 28-oxoohchinin	R = Bz	*Melia azedarach*[188]
459	3-O-deacetyl-40-demethyl- 28-oxosalannin	R = Met	*Melia azedarach*[188]
460	3-deacetyl-28-oxosalannolactone		*Melia azedarach*[243]
461	1-isovaleroyl- 1-detigloylsalanninolide	R_1 = $COCH_2CH(CH_3)_2$; R_2 = Ac; R_3 = OH	*Azadirachta indica*[138]
462	17-defurano-17-(5x-2,5-dihydro-5-hydroxy-2- oxofuran-3-yl)-2',3'-dehydrosalannol	R_1 = $COCHCH(CH_3)_2$; R_2 = H; R_3 = OH	*Azadirachta indica*[244]
463	Ohchininolide	R_1 = Cin; R_2 = R_3 = H	*Melia azedarach*[188]
464	1-O-decinnamoyl-1-O-benzoylohchininolide	R_1 = Bz; R_2 = R_3 = H	*Melia azedarach*[188]
465	23-methoxyohchininolide A	R_1 = Cin; R_2 = H; R_3 = OCH_3	*Melia azedarach*[188]
466	23-methoxyohchininolide B	R_1 = Bz; R_2 = H; R_3 = OCH_3	*Melia azedarach*[188]
467	23-hydroxyohchininolide	R_1 = Cin; R_2 = H; R_3 = OH	*Melia azedarach*[188]
468	1-O-decinnamoyl- 1-O-benzoyl-23-hydroxyohchininolide	R_1 = Bz; R_2 = H; R_3 = OH	*Melia azedarach*[188]
469	17-defurano-17-(2x-2,5-dihydro-2- hydroxy-5-oxofuran-3-yl)-28-deoxonimbolide		*Azadirachta indica*[244]
470	Nimbolide B		*Azadirachta indica*[245]
471	17- defurano-17-(2,5-dihydro-2-oxofuran-3-yl)-28-deoxonimbolide		*Azadirachta indica*[244]
472	3-deacetyl-28-oxoisosalanninolide		*Melia azedarach*[243]
473	21-hydroxyisoohchininolide		*Melia azedarach*[188]

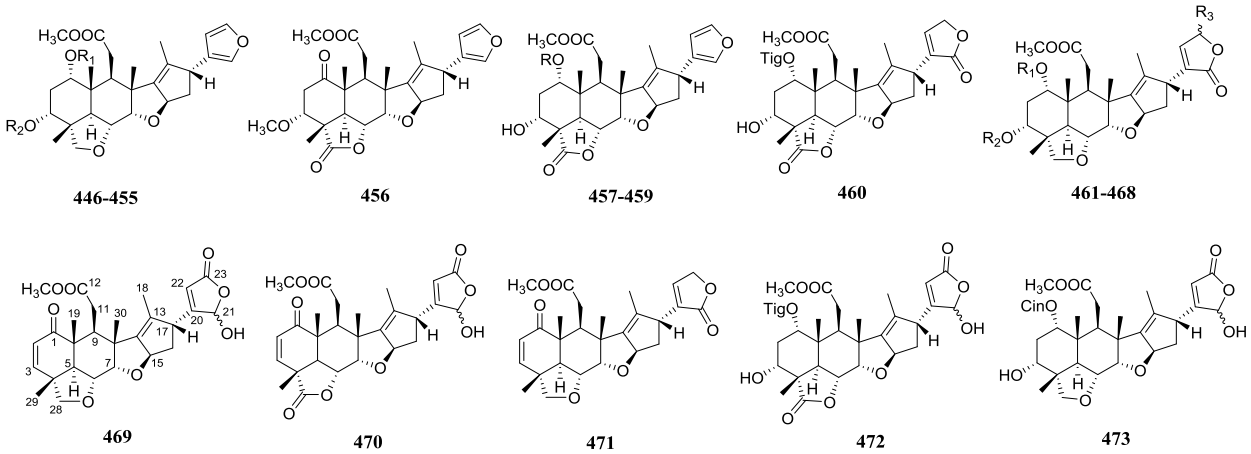


Figure 19. Structures of salannin class limonoids **446-473**.

2.3.1.3.3. Nimbolinin

This class of limonoids contain five and seven membered ring with ether linkage.Another notable feature of this class is the presence of unusual 17β furan ring in majority of the compounds reported instead of 17α furan ring. Thirty four compounds were isolated belonging to this class from *Melia toosendan, Munronia henryi, Melia azedarach* and *Azadirachta indica* (Table 18/S18, Figure 20). Prior to this thirty eight Nimbolinin class limonoids were reported from Meliaceae family[12]. Compound (**474**) is detigloylated derivative of previously reported 1α-tigloyloxy-3α-acetoxyl-7α-hydroxyl-12α-ethoxyl nimbolinin[246] and compound (**475**) is its epimer. Compounds (**474-490**) possess the same skeleton but differ among themselves in substituents at C1, C3 and C12. The cinnamoyl group in nimbolinin C is displaced by methacryl moiety in the compound (**476**). Compound (**477**) is decinnamoyl derivative of compound (**476**). The ethoxy group in previously isolated ethoxynimbolinin C[195] is displaced by methoxy group in compound (**478**). The tiglate group at C1 in compound (**478**) is shifted to C7 in compound (**479**). Compounds (**480**, **481**) are tigloyl and benzoyl analogs of compound (**479**) respectively. Meliatoosenin L (**482**) is 3-deacetyl, 7-tigloyl derivative of previously isolated 12-O-methylvolkensin[247]. Compounds (**483-486**) differ among themselves in tigloylation and acetylation at C1 and C3. Compounds (**487-490**) are derived from previously reported ethoxynimbolinin. The methoxy group at C12 is α-oriented in previously isolated 12-O-methylvolkensin but it is β-oriented in Munronin K (**491**). The tigloyl group in compound (**491**) is replaced by cinnamoyl moiety in 1-benzoylnimbolinin C (**492**). Compounds (**493** and **494**) are benzoyl and 3-deacetylbenzoyl derivatives of previously reported Nimbolinin C respectively[248]. Compound (**494**) exists in tautomeric form as 12α/12β. The cinnamoyl group in nimbolinin C is absent in Compound (**495**). The methoxy group in compound (**495**) is replaced by the methacryl group in compound (**496**). Toosendansin B and C (**497** and **498**) are C7 benzoyl and tigloyl derivatives of 12-O-methylvolkensin respectively. Meliatoosenin T (**499**) is C1 acetyl, C7 methacrylate analog of previously reported 15-O-deacetyl-15-O-methylnimbolidin A[249]. Meliatoosenin U (**500**) is C1 deacetyl analog of (**499**). The 15β-O bond in 12-O-methylvolkensin is α-oriented in Munronin L (**501**). Azadirachta R (**502**) is C3 acetylated form of previously reported azecin 2[250] except the furan ring shift from C26 to C27. The acetyl group at C1 and C7 in 17-epi-12-dehydroxyheudebolin is tigloylated and hydroxylated respectively, in Munronin M (**503**) along with altered C26 configuration. The furan ring at C17 in previously reported 1-deacetylnimbolinin B[251] is replaced by 21-hydroxybutenolide moiety in Meliazedalide A (**504**). Meliazedarine A (**505**) is C15 epimer of previously reported 15-O-deacetyl-15-O-methylnimbolidin B[249]. Meliazedarine B (**506**) is C15 epimer of previously reported 15-O-deacetyl-15-O-methylnimbolidin A[249]. Meliazedarine C (**507**) is the C7 methacrylate analog of previously reported 15-O-deacetyl-15-O-methylnimbolidin B[249].

Table 18. Nimbolinin class limonoid 474-507

No.	Limonoid	Substituent	Source
474	1*α*, 7*α*-dihydroxyl-3*α*-acetoxyl-12*α*-ethoxylnimbolinin	R_1 = H; R_2 = Ac; R_3 = H; R_4 = α-OCH_2CH_3	*Melia toosendan*[252]
475	1*α*-tigloyloxy-3*α*-acetoxyl-7*α*-hydroxyl-12*β*-ethoxylnimbolinin	R_1 = Tig; R_2 = Ac; R_3 = H; R_4 = β-OCH_2CH_3	*Melia toosendan*[252]
476	1-decinnamoyl-1-(20-methylacryloyl)nimbolinin C	R_1 = $COC(CH_2)CH_3$; R_2 = Ac; R_3 = H; R_4 = α-OCH_3	*Melia toosendan*[175]

477	1-decinnamoylnimbolinin C	R_1 = H; R_2 = Ac; R_3 = H; R_4 = α-OCH_3	*Melia toosendan*[175]
478	3-deacetyl-12-O-Methylvolkensin	R_1 = Tig; R_2 = R_3 = H; R_4 = α-OCH_3	*Melia toosendan*[175]
479	1α,3α-dihydroxyl-7α-tigloyloxy-12α -ethoxylnimbolinin	R_1 = R_2 = H; R_3 = Tig; R_4 = α-OCH_2CH_3	*Melia toosendan*[168]
480	7α-ditigloyloxy-3α-acetoxyl-12α- ethoxylnimbolinin	R_1 = Tig; R_2 = Ac; R_3 = Tig; R_4 = α-OCH_2CH_3	*Melia toosendan*[168]
481	1α-benzoyloxy-3α-acetoxyl- 7α-hydroxyl-12β-ethoxylnimbolinin	R_1 = Bz; R_2 = Ac; R_3 = H; R_4 = β-OCH_2CH_3	*Melia toosendan*[168]
482	Meliatoosenin L	R_1 = Tig; R_2 =H; R_3 = Tig; R_4 = α-OCH_3	*Melia toosendan*[176]
483	Meliatoosenin M	R_1 = H; R_2 = Ac; R_3 = Tig; R_4 = α-OCH_3	*Melia toosendan*[176]
484	Meliatoosenin N	R_1 = R_2 = Ac; R_3 = Tig; R_4 = β-OCH_3	*Melia toosendan*[176]
485	Meliatoosenin O	R_1 = Tig; R_2 = Ac; R_3 = H; R_4 = α-OCH_2CH_3	*Melia toosendan*[176]
486	Meliatoosenin S	R_1 = Tig; R_2 = R_3 = H; R_4 = α-OCH_3	*Melia toosendan*[176]
487	12-ethoxynimbolinin G	R_1 = Cin; R_2 = Ac; R_3 = H; R_4 = β-$COCH_2CH_3$	*Melia toosendan*[253]
488	12-ethoxynimbolinin H	R_1 = H; R_2 = Ac; R_3 = Tig; R_4 = β-$COCH_2CH_3$	*Melia toosendan*[253]
489	12-ethoxynimbolinin E	R_1 = Bz; R_2 = R_3 = H; R_4 = α-OCH_2CH_3	*Melia toosendan*[254]
490	12-ethoxynimbolinin F	R_1 = Tig; R_2 = R_3 = H; R_4 = β-OCH_2CH_3	*Melia toosendan*[254]
491	Munronin K	R_1 = Tig; R_2 = Ac; R_3 = H; R_4 = β-OCH_3	*Munronia henryi*[169]
492	1-benzoylnimbolinin C	R_1 = Cin; R_2 = Ac; R_3 = H; R_4 = α-OCH_3	*Melia azedarach*[190]
493	1-O-benzoyl-3-O-deactylnimbolinin C	R_1 = Bz; R_2 = R_3 = H; R_4 = α-OCH_3	*Melia azedarach*[192]
494	12 α-1-O-tigloyl-1-O-deacetyl-nimbolinin B	R_1 = Tig; R_2 = Ac; R_3 = Tig; R_4 = α-OH/β-OH	*Melia toosendan*[255]
495	3α-acetoxy-1 α,7 α -dihydroxy-12 α -methoxynimbolinin	R_1 = H; R_2 = Ac; R_3 = H; R_4 = α-OCH_3	*Melia azedarach*[256]
496	3 α -acetoxy-1 α,12 α -dihydroxy-7 α -(2-methylprop-2-enoyl) nimbolinin	R_1 = H; R_2 = Ac; R_3 =$COC(CH_2)CH_3$; R_4 = α-OH	*Melia azedarach*[256]
497	Toosendansin B	R = Bz	*Melia toosendan*[242]
498	Toosendansin C	R = Tig	*Melia toosendan*[242]
499	Meliatoosenin T	R = Ac	*Melia toosendan*[173]
500	Meliatoosenin U	R = H	*Melia toosendan*[173]
501	Munronin L		*Munronia henryi*[169]
502	Azadirachta R		*Azadirachta indica*[257]
503	Munronin M		*Munronia henryi*[169]
504	Meliazedalide A		*Melia azedarach*[191]
505	Meliazedarine A	R_1 = Tig; R_2 = α-OCH_3	*Melia azedarach*[171]
506	Meliazedarine B	R_1 = Bz; R_2 = α-OCH_3	*Melia azedarach*[171]
507	Meliazedarine C	R_1 = Met; R_2 = β-OCH_3	*Melia azedarach*[171]

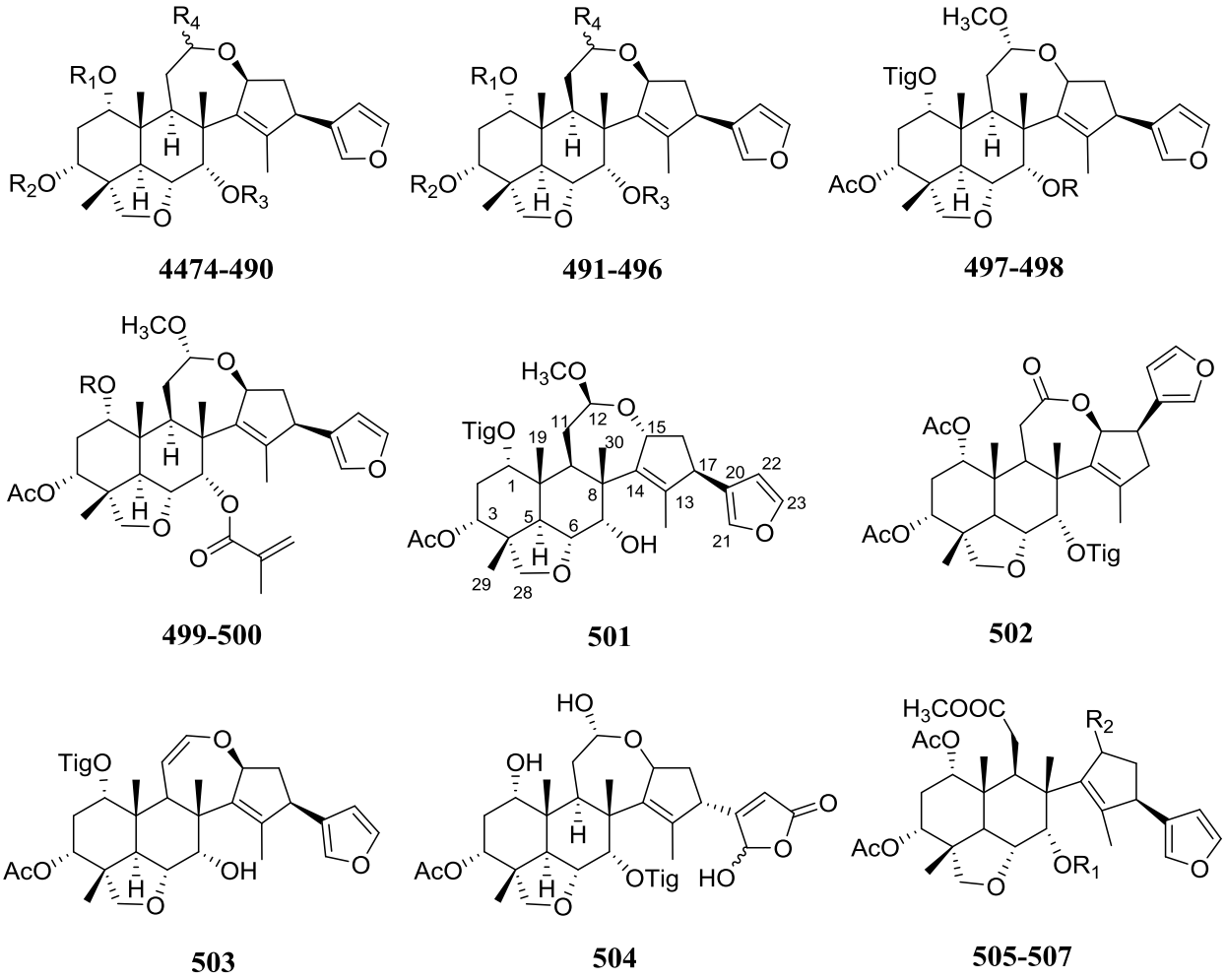


Figure 20. Structures of nimbolinin class limonoids **474-507**.

2.3.1.3.4. Nimbin

This class of limonoids consists of ether linkage at C ring. Six Limonoids belonging to this class were isolated from *Melia azedarach, Melia toosendan* and *Azadirachta indica* (Table 19/S19, Figure 21). Previously fourteen Nimbin class limonoids were reported from Meliaceae family[12].1-detigloylohchinolal (**508**) is C1 detigloylated form of previously reported Ohchinolal/salannal[258]. The tigloyl group at C1 in Ohchinolal is replaced by methacrylate in Mesendanin E (**509**). Mesendanin F (**510**) is acetylated at C1, C3 and is derived from 1-detigloylohchinolal. Toosendansin G (**511**) is C1, C3 ditigloyl, C6 acetyl analog of compound (**508**). The furan ring in 6-deacetylnimbin is replaced by β,γ-epoxy-γ-lactone ring in compound (**512**) and 3,4-dihydroxy-2,5-dimethoxytetrahydrofuran ring in compound (**513**).

Table 19. Nimbin class limonoid 508-513

No.	Limonoid	Substituent	Source
508	1-detigloylohchinolal	$R_1 = R_2 = H$; $R_3 = Ac$	*Melia azedarach*[241]
509	Mesendanin E	$R_1 = COC(CH_3)CH_2$; $R_2 = H$; $R_3 = Ac$	*Melia toosendan*[163]
510	Mesendanin F	$R_1 = R_2 = R_3 = Ac$	*Melia toosendan*[163]
511	Toosendansin G	$R_1 = R_2 = Tig$; $R_3 = H$	*Melia toosendan*[205]
512	deacetyl-20,21-epoxy-20,22-dihydro- 21-deoxyisonimbinolide		*Azadirachta indica*[138]
513	deacetyl-20,21,22,23-tetrahydro-20,22-dihydroxy-21,23-dimethoxynimbin		*Azadirachta indica*[138]

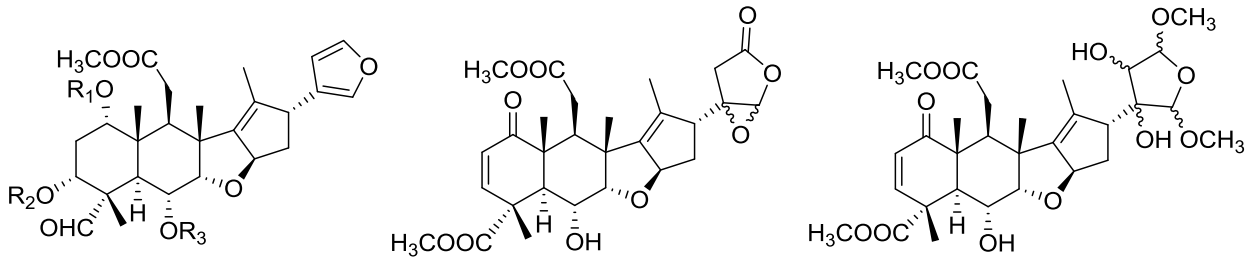


Figure 21. Structures of nimbin class limonoids **508-513**.

2.3.1.3.5 Nimbolidin

A total of nine compounds were isolated from *Melia toosendan* and *Walsura chrysogyne* (Table 20/S20, Figure 22). Eleven Nimbolidin class were reported previously from Meliaceae family[12]. Meliatoosenin P (**514**) is a deacetylated form of previously reported 1-O-tigloyl-1-O-debenzoylohchinal[259]. Meliatoosenin Q (**515**) is derived from compound (**514**) but differs in substitution at C3 and C11. The ester group at C11 in ohchinolal is replaced by the aldehyde group in Meliatoosenin R (**516**). Walsogyne C and E (**518** and **520**) are 2',3'-dihydro derivatives of Walsogyne B and D (**517** and **519**) respectively. Walsogyne F and G (**521** and **522**) are diastereomers and differ from walsogyne A at C17 substitution.

Table 20. Nimbolidin class limonoid 514-522

No.	Limonoid	Substituent	Source
514	Meliatoosenin P	R_1 = H; R_2 = CHO	*Melia toosendan*[176]
515	Meliatoosenin Q	R_1 = Ac; R_2 = $CH(OCH_3)_2$	*Melia toosendan*[176]
516	Meliatoosenin R		*Melia toosendan*[176]
517	Walsogyne B	$\Delta^{2,'3'}$	*Walsura chrysogyne*[260]
518	Walsogyne C		*Walsura chrysogyne*[260]
519	Walsogyne D	$\Delta^{2,'3'}$	*Walsura chrysogyne*[260]
520	Walsogyne E		*Walsura chrysogyne*[260]
521	Walsogyne F	R = β-OH	*Walsura chrysogyne*[260]
522	Walsogyne G	R = α-OH	*Walsura chrysogyne*[260]

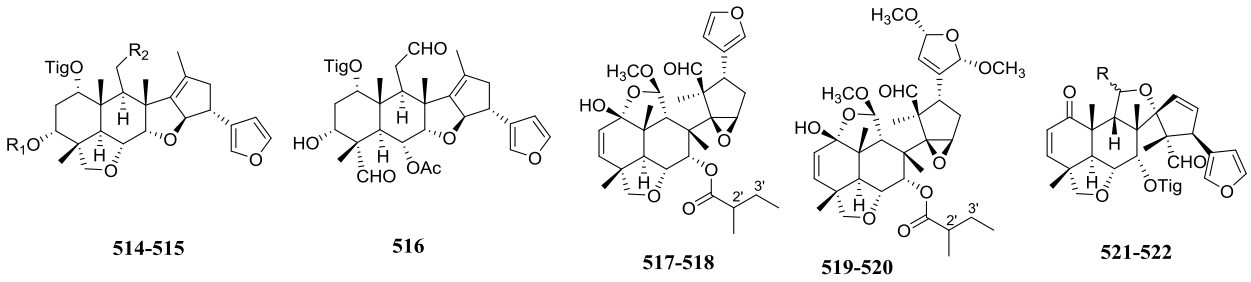


Figure 22. Structures of nimbolidin class limonoids **514-522**.

2.3.1.4. Ring D-seco

2.3.1.4.1. Gedunin

Baeyer Villiger oxidation at the D ring in the Azadiradione skeleton forms a δ-lactone D ring leading to a signature characteristic of the Gedunin class. A total of twenty one compounds belonging to Gedunin class were isolated from *Carapa guianensis*, *Entandrophragma angolense*, *Trichilia monadelpha*, *Khaya senegalensis*, *Azadirachta indica* and *Toona sinensis* (Table 21/S21, Figure 23). Previously thirty nine Gedunin class limonoids were reported from Meliaceae family[12]. Carapansin C (**523**) differs at C17 furan ring substitution when compared to nimolicinol. Andirolide A (**524**) is C6 acetyl derivative of Carapansin C (**523**). Andirolide H (**525**) is C7 deacetyl, C6 acetoxyl derivative of Gedunin. Compounds (**526**-**529**, **533**-**535**) are derived from 7-oxogedunin. Khasenegasin W (**530**) and Entangolensin N (**531**) are derived from previously reported khivorin[261]. Compound (**532**) is a dehydro form of compound (**526**). The furan ring in 1-deacetylkhivorin is replaced to 21-hydroxybutenolide in Khasenegasin

X (**536**). Compounds (**537-543**) possess gedunin skeleton but differ at C17 with varied substitutions of tetrahedron furan moiety. Toonasinemine K and L (**542** and **543**) differ in orientation of the methoxy group at C23.

Table 21. Gedunin class limonoid 523-543

No.	Limonoid	Substituent	Source
523	Carapansin C	R = H	*Carapa guianensis*[262]
524	Andirolide A	R = OAc	*Carapa guianensis*[263]
525	Andirolide H		*Carapa guianensis*[264]
526	5-hydroxy-7-deacetoxy-7-oxogedunin		*Entandrophragma angolense*[265]
527	Carapanolide J	R_1 = OH; R_2 = H	*Carapa guianensis*[266]
528	Monadelphin B	R_1 = H; R_2 = OAc	*Trichilia monadelpha*[267]
529	Entangolensin L	R_1 = OAc; R_2 = H	*Entandrophragma angolense*[141]
530	Khasenegasin W	R_1 = OH; R_2 = OAc; R_3 = H	*Khaya senegalensis*[268]
531	Entangolensin N	R_1 = R_2 = H; R_3 = OAc	*Entandrophragma angolense*[141]
532	5,6-dehydro-7-deacetoxy-7-oxogedunin		*Entandrophragma angolense*[265]
533	Andirolide I		*Carapa guianensis*[264]
534	Monadelphin A		*Trichilia monadelpha*[267]
535	Entangolensin M		*Entandrophragma angolense*[141]
536	Khasenegasin X		*Khaya senegalensis*[268]
537	Azadiraindin G		*Azadirachta indica*[146]
538	Andirolide J	R_1 = OAc; R_2 = R_3 = H	*Carapa guianensis*[264]
539	Toonasinemine H	R_1 = R_2 = H; R_3 = OH	*Toona sinensis*[269]
540	Toonasinemine I	R_1 = H; R_2 = OAc; R_3 = OH	*Toona sinensis*[269]
541	Toonasinemine J		*Toona sinensis*[269]
542	Toonasinemine K	R = α-OCH_3	*Toona sinensis*[269]
543	Toonasinemine L	R = β-OCH_3	*Toona sinensis*[269]

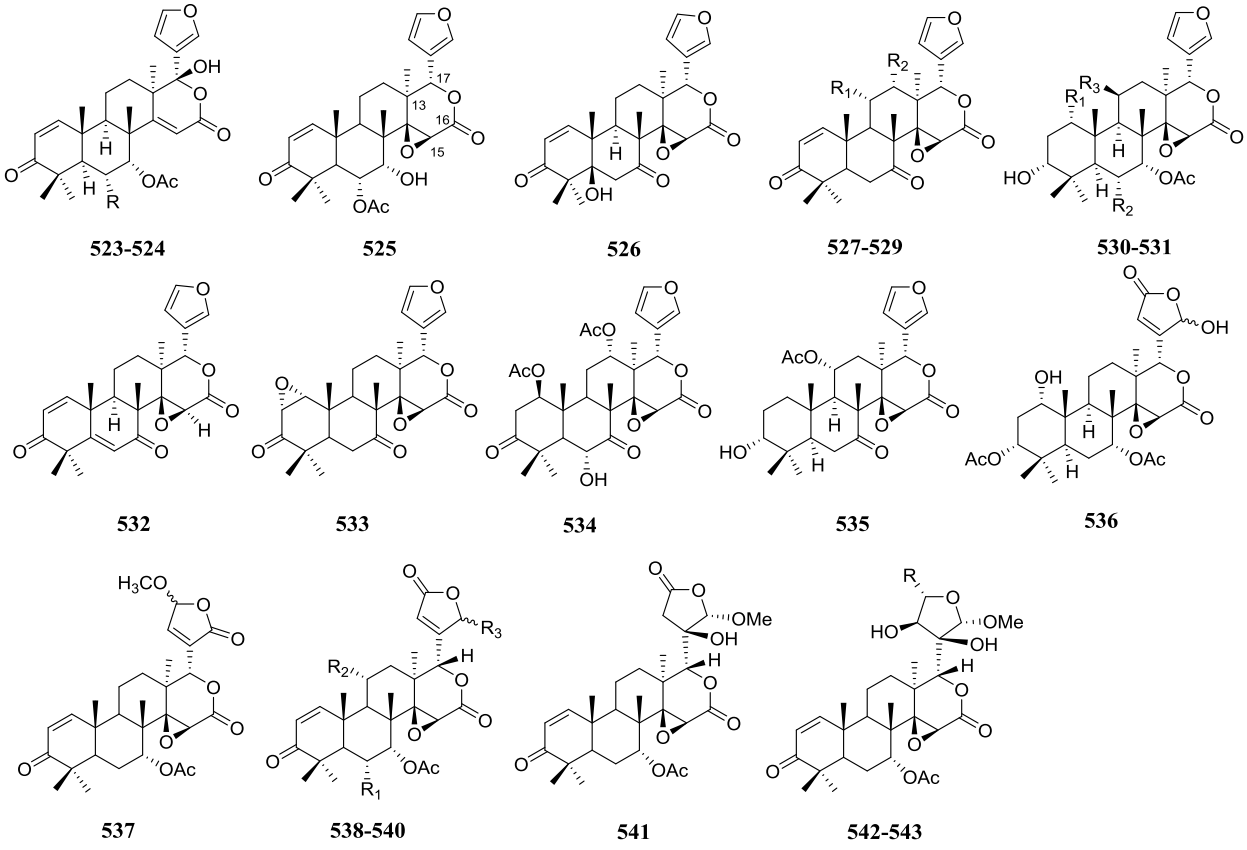


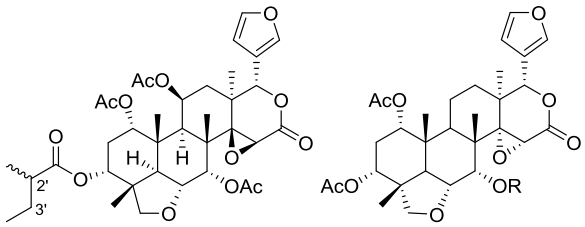
Figure 23. Structures of gedunin class limonoids **523-543**.

2.3.1.4.2. Other ring D-seco

Five compounds isolated from *Walsura cochinchinensis* and *Cipadessa baccifera* were grouped in this class (Table 22/S22, Figure 24). Only three other ring D-seco class limonoids were reported from the Meliaceae family[12]. Cochinchinoid E (**544**) is structurally similar to previously isolated piscidofuran[44] except in the deacetylation at C3, C7 and acetylation at C11. Cochinchinoid F and G (**545** and **546**) are analogs with varying orientation of methyl group at C3. The tigloyl group at C1 in previously isolated piscidofuran[44] is replaced by acetoxy group in Cipadesin J (**547**). Cipadesin K (**548**) differs from compound (**547**) in an additional 2-methylbutyryloxy group at C7 which was confirmed by HMBC correlation.

Table 22. Other class limonoid 544-548

No.	Limonoid	Substituent	Source
544	Cochinchinoid E	$\Delta^{2,3'}$	*Walsura cochinchinensis*[76]
545	Cochinchinoid F	β-2'	*Walsura cochinchinensis*[76]
546	Cochinchinoid G	α-2'	*Walsura cochinchinensis*[76]
547	Cipadesin J	R = H	*Cipadessa baccifera*[203]
548	Cipadesin K	R = $COCH(CH_3)CH_2CH_3$	*Cipadessa baccifera*[203]



544-546 **547-548**

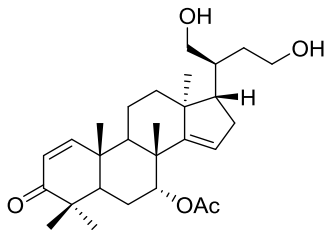
Figure 24. Structures of Other ring (D-seco) class limonoids **544-548**.

2.3.1.5. Ring E-seco

Compared with previously reported Azadirone[131] in Thaigranatin T (**549**) there is oxidative cleavage of the furan ring (Table 23/S23, Figure 25).

Table 23. Ring E-seco 549

No.	Limonoid	Substituent	Source
549	Thaigranatin T		*Xylocarpus granatum*[153]



549

Figure 25. Structures of **ring E-seco** class limonoids **549**.

2.3.2. Demolition of two rings

2.3.2.1. Rings A,B-seco

2.3.2.1.1. Prieurianin

Cleavage in the B ring of the evodulone class with formation of an exocyclic $\Delta^{8,30}$ olefinic double bond is noted characteristic of the prieurianin class. Seventy one compounds were isolated from *Munronia henryi, Munronia unifoliolata, Munronia delavayi, Aphanamixis polystachya, Cipadessa cinerascens, Dysoxylum mollissimum,*

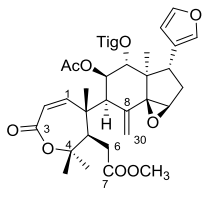
Dysoxylum hainanense, Trichilia welwitschii, Aphanamixis grandifolia, Munronia henryi and *Aphanamixis sinensis* (Table 24/S24, Figure 26). Previously thirty six Prieurianin class limonoids were reported from Meliaceae family[12]. The acetyl group in previously reported Nymania-3[270] is absent in Munronin P (**550**) which contained additional tigloyloxy moiety at C12 as confirmed by HREIMS and NMR data. The epoxide ring at C14/15 in Nymania-3 is converted to $\Delta^{14,15}$ double bond in Munronin Q (**551**). Munronoid B (**552**) is C11 deacetoxyl derivative of compound (**551**). Based on NMR data, the C14/15 oxirane ring in nymania-4 is absent in Munronin B (**553**). Munronoid A (**554**) is C11 deacetoxyl derivative of compound (**553**). Compounds (**555-561**) are structurally similar except in substitution at C17. The acetyl group at C12 in (**555**) is replaced by tigloyl group in Mulavanin A and B (**557** and **561**). The carbonyl group at C21 in compound Munronin C (**556**) is absent in Munronin E (**558**). Munronoid O (**560**) is a 21-dehydroxyl derivative of Munronin F (**559**). Mulavanin D (**562**) differs from previously reported 14,15β-epoxyprieurianin[271] in loss of substituent at C1 and acetyl group substitution at C2. Aphanamolide B (**563**) is a deacetylated analog of prieurianin. Aphanaonoid I (**564**) is C1 acetyl analog of previously reported Prieurianin[272]. Aphanaonoid J (**565**) is C12 3-methylbutanoyloxy analog of (**564**). The ether bridge between C1 and C11 in Aphapolynin B (**566**) is absent in the compound (**563**). Aphanaonoid H (**567**) is C29 acetyl analog of compound (**566**). Ciparasin P (**568**) is structurally similar to compound (**562**) except in the methoxy group at C30, double bond shift from $\Delta^{8,30}$ to $\Delta^{8,14}$ and open epoxide ring with hydroxylation at C15. The acetoxy group in dysoxylumin B is replaced by $\Delta^{1,2}$ double bond in Dysomollide A (**569**). Aphanamixoid K-M (**570-572**) and Aphanamixoid B (**573**) are structural congeners differing in substitution at C12. From the NMR spectroscopic data, Aphapolynin C (**574**) and rohituka-7 reported earlier[273] differ only in substitution at C15. The formyl group at C11 in compound (**574**) is replaced by hydroxyl group in Aphapolynin D (**575**). Aphapolynin E (**576**) differ from Aphapolynin D (**575**) in ether linkage between C1 and C11, shift in hydroxyl group from C14 to C16, shift in double bond from $\Delta^{8,30}$ to $\Delta^{8,14}$ and absence of double bond at $\Delta^{1,2}$. Dysohainanin D (**577**) differs from previously reported Dysoxylumolide A[274] in substitution at C12 and C16. Dregeanin DM4 (**578**) is an analog of compound (**577**). The isovalerate group at C12 and acetyl group at C15 in previously reported rohituka-13[273] is replaced by hydroxyl and keto carbonyl groups respectively in Aphanagranin C (**579**). Dysoxylumasin B (**580**) is analog of previously reported dysoxylumolide A[274] but has 2-methylbutanoxyl at C16 and γ-hydroxybutenolide at C17. Aphapolynin A (**581**) differs from Aphanamolide D (**582**) in substitution at C12. Aphagranols A and B (**583** and **584**) are regioisomers. The C1/11 ether linkage and lactone A ring in Aphanagranin C is cleaved in Munronin A (**585**) along with reduced keto carbonyl group. The C1/11 ether linkage in previously isolated Dysoxylumic acid C[274] is shifted to C11/14 in Dysoxylumasin A (**586**) along with an opened epoxide ring. Aphanamolide B, A (**587, 588**) and Aphanagranin B (**589**) share a similar skeleton but vary in substitution at C12. Aphanamolide C (**590**) differs from compound (**588**) in additional ether linkage between C1 and C11. The lactone A ring in compound (**579**) is cleaved in Aphanagranin D (**591**). Compound (**592**) was isolated by two different research groups from two different plants in the year 2011 and 2013 but trivially named as Dysohainanin A and Dysoxylumasin C. It is structurally similar to previously reported Dysoxylumic acid C[274] but vary in substitution at C16. Dysoxylumasin D (**594**) is a structural analog of compound (**592**). Aphanamixoid N-P (**594-596**) are structural analogs but differ in substitution at C12. The C1/11 ether linkage in Dysohainanin A (**592**) is cleaved in Dysohainanin B (**597**) followed by acetylation and formylation at C1 and C11 respectively, along with presence of methyl ester moiety at C3. Dysohainanin C (**598**) is C3 ethyl ester analog of compound (**597**). Dysoxylumasin E and F (**599** and **600**) have a non substituted acid group at C3 when compared to compound (**598**). The epoxide ring in Aphapolynin F (**601**) is cleaved in Aphapolynin G (**602**) along with hydroxylation and carbonylation at C14 and C15 respectively. Zaphaprinin P-Q (**603-604**) contains C3 acid and methyl ester moiety respectively when compared with compound (**602**). Zaphaprinin U-Y (**605-609**) differs in substitution at C3, C12 when compared with compound (**602**). The C1/11 ether bridge of compound (**602**) is cleaved in Aphapolynin H and I (**610** and **611**) along with hydroxylation and formylation at C11 respectively. Aphanaonoid F (**612**) is C1 deacetyl, C3 methyl ester C11 acetyl analog of compound (**610**). Aphanaonoid G (**613**) is C12 3-methylbutanoyloxy analog of compound (**612**). In Aphanaonoid A (**614**) there is formation of ether linkage between C1 and C29 compared with previously reported Zaphaprinin A[275]. In Zaphaprinin A (**615**) there is formation of ether linkage between C3, C11 when compared with Rohituka 2[276]. Aphanaonoid B (**616**) is C6 ethyl ester C11 deformy and C1, C29 ether linkage analog of compound (**563**). Aphanaonoid E (**617**) is C1, C4 substituted epimer of compound (**602**). Zaphaprinin R-T (**618-620**) are derived from compound (**602**) with varying substitution at C3, C15.

Table 24. Prieurianin class limonoid 550-620

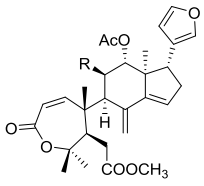
No.	Limonoid	Substituent	Source
550	Munronin P		*Munronia henryi*[277]

551	Munronin Q	R = OAc	*Munronia henryi*[277]
552	Munronoid B	R = H	*Munronia unifoliolata*[151]
553	Munronin B	R = OAc	*Munronia henryi*[169]
554	Munronoid A	R = H	*Munronia unifoliolata*[151]
555	Munronin C	R_1 = Ac; R_2 = H	*Munronia henryi*[169]
556	Munronin D	R_1 = Ac; R_2 = CH_3	*Munronia henryi*[169]
557	Mulavanin A	R_1 = Tig; R_2 = H	*Munronia delavayi*[215]
558	Munronin E		*Munronia henryi*[169]
559	Munronin F	R_1 = Ac; R_2 = OH	*Munronia henryi*[169]
560	Munronoid O	R_1 = Ac; R_2 = H	*Munronia unifoliolata*[200]
561	Mulavanin B	R_1 = Tig; R_2 = OH	*Munronia delavayi*[215]
562	Mulavanin D		*Munronia delavayi*[215]
563	Aphanamolide B	R_1 = β-OAc; R_2 = H; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[278]
564	Aphanaonoid I	R_1 = α-OH; R_2 = Ac; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis sinensis*[279]
565	Aphanaonoid J	R_1 = α-OH; R_2 = Ac; R_3 = $COCH_2CH(CH_3)_2$	*Aphanamixis sinensis*[279]
566	Aphapolynin B	R = H	*Aphanamixis polystachya*[280]
567	Aphanaonoid H	R = Ac	*Aphanamixis polystachya*[279]
568	Ciparasin P		*Cipadessa cinerascens*[281]
569	Dysomollide A		*Dysoxylum mollissimum*[144]
570	Aphanamixoid K	R = Tig	*Aphanamixis polystachya*[282]
571	Aphanamixoid L	R = $COCH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[282]
572	Aphanamixoid M	R = Bz	*Aphanamixis polystachya*[282]
573	Aphanamixoid B	R = Ac	*Aphanamixis polystachya*[283]
574	Aphapolynin C	R = CHO	*Aphanamixis polystachya*[284]
575	Aphapolynin D	R = H	*Aphanamixis polystachya*[284]
576	Aphapolynin E		*Aphanamixis polystachya*[284]
577	Dysohainanin D	R_1 = $COCH(OH)CH(CH_3)_2$; R_2 = $COCH(CH3)CH_2CH_3$	*Dysoxylum hainanense*[63]
578	Dregeanin DM4	R_1 = $COCH(OH)CH(CH_3)CH_2CH_3$; R_2 = H	*Trichilia welwitschii*[285]
579	Aphanagranin C		*Aphanamixis grandifolia*[218]
580	Dysoxylumasin B		*Dysoxylum mollissimum*[286]
581	Aphapolynin A	R_1 = β-CH_3; R_2 = CH_2CH_3	*Aphanamixis polystachya*[280]
582	Aphanamolide D	R_1 = R_2 = CH_3	*Aphanamixis grandifolia*[287]
583	Aphagranols A	R = β-H	*Aphanamixis grandifolia*[288]
584	Aphagranols B	R = α-H	*Aphanamixis grandifolia*[288]
585	Munronin A		*Munronia henryi*[169]
586	Dysoxylumasin A		*Dysoxylum mollissimum*[286]
587	Aphanamolide B	R_1 = H; R_2 = CH_3; R_3 = H	*Aphanamixis polystachya*[284]
588	Aphanamolide A	R_1 = β-OH; R_2 = α-CH_3; R_3 = CH_3	*Aphanamixis polystachya*[278]
589	Aphanagranin B	R_1 = OH; R_2 = CH_3; R_3 = H	*Aphanamixis grandifolia*[218]
590	Aphanamolide C		*Aphanamixis grandifolia*[287]
591	Aphanagranin D		*Aphanamixis grandifolia*[218]
592	Dysohainanin A/ Dysoxylumasin C	R = $COCH(CH_3)CH_2CH_3$	*Dysoxylum hainanense*[63]/ *Dysoxylum mollissimum*[286]
593	Dysoxylumasin D	R = $COCH(OAc)CH(CH_3)_2$	*Dysoxylum mollissimum*[286]
594	Aphanamixoid N	R = Tig	*Aphanamixis polystachya*[282]
595	Aphanamixoid O	R = $COCH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[282]
596	Aphanamixoid P	R = Bz	*Aphanamixis polystachya*[282]
597	Dysohainanin B	R_1 = CH_3; R_2 = $COCH(CH_3)CH_2CH_3$	*Dysoxylum hainanense*[63]
598	Dysohainanin C	R_1 = CH_2CH_3; R_2 = $COCH(CH_3)CH_2CH_3$	*Dysoxylum hainanense*[63]
599	Dysoxylumasin E	R_1 = H; R_2 = $COCH(OAc)CH(CH_3)_2$	*Dysoxylum mollissimum*[286]
600	Dysoxylumasin F	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$	*Dysoxylum mollissimum*[286]
601	Aphapolynin F		*Aphanamixis polystachya*[284]
602	Aphapolynin G	R_1 = OCH_2CH_3; R_2 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[284]
603	Zaphaprinin P	R_1 = OH; R_2 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
604	Zaphaprinin Q	R_1 = OCH_3; R_2 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
605	Zaphaprinin U	R_1 = OH; R_2 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
606	Zaphaprinin V	R_1 = OCH_3; R_2 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
607	Zaphaprinin W	R_1 = OCH_2CH_3; R_2 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
608	Zaphaprinin X	R_1 = OH; R_2 = $COCH_2CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
609	Zaphaprinin Y	R_1 = OCH_3; R_2 = $COCH_2CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
610	Aphapolynin H	R_1 = α-OAc; R_2 = CH_2CH_3; R_3 = H; R_4 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[284]
611	Aphapolynin I	R_1 = α-OAc; R_2 = CH_2CH_3; R_3 = CHO; R_4 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[284]
612	Aphanaonoid F	R_1 = β-OH; R_2 = CH_3; R_3 = Ac; R_4 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[279]
613	Aphanaonoid G	R_1 = α-OH; R_2 = CH_3; R_3 = Ac; R_4 = $COCH_2CH(CH_3)_2$	*Aphanamixis polystachya*[279]
614	Aphanaonoid A		*Aphanamixis polystachya*[279]
615	Zaphaprinin A		*Aphanamixis grandifolia*[275]
616	Aphanaonoid B		*Aphanamixis polystachya*[279]
617	Aphanaonoid E		*Aphanamixis polystachya*[279]

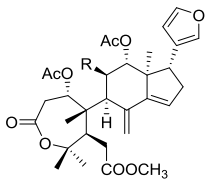
618	Zaphaprinin R	$R_1 = OCH_3$; R_2 = Ac	*Aphanamixis grandifolia*[275]
619	Zaphaprinin S	$R_1 = OCH_2CH_3$; R_2 = Ac	*Aphanamixis grandifolia*[275]
620	Zaphaprinin T	$R_1 = OCH_2CH_3$; R_2 = H	*Aphanamixis grandifolia*[275]



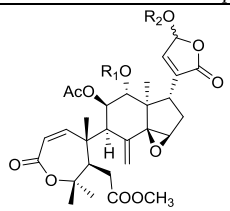
550



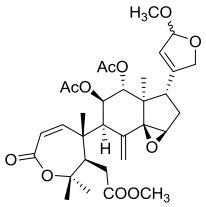
551-552



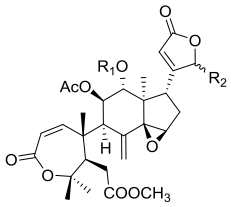
553-554



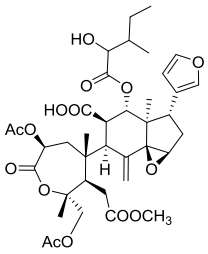
555-557



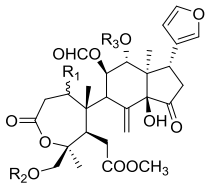
558



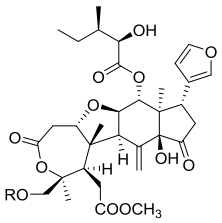
559-561



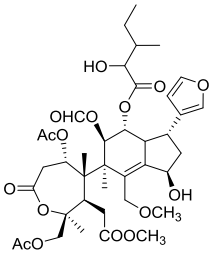
562



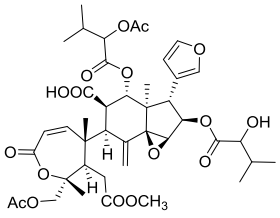
563-565



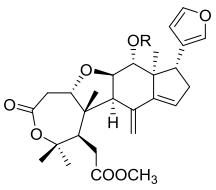
566-567



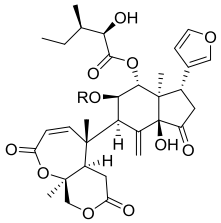
568



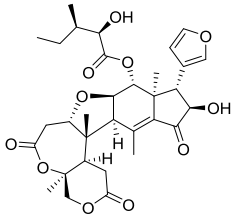
569



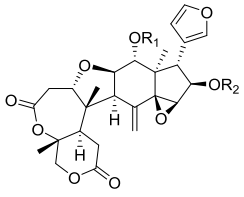
570-573



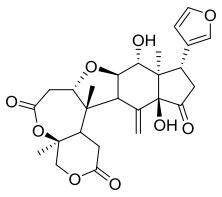
574-595



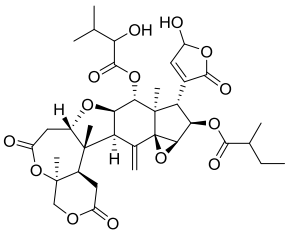
576



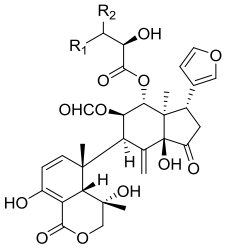
577-578



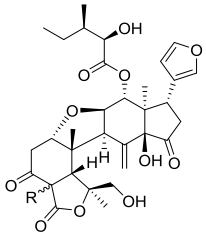
579



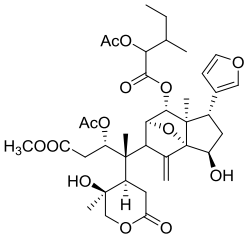
580



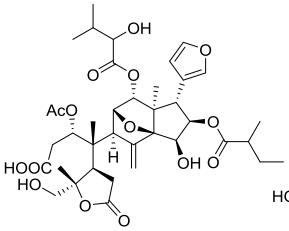
581-582



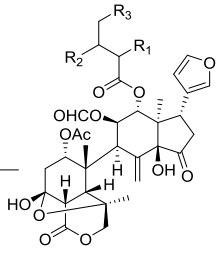
583-584



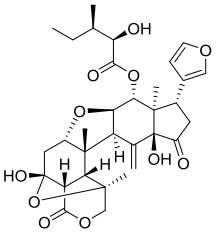
585



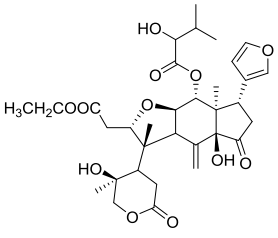
586



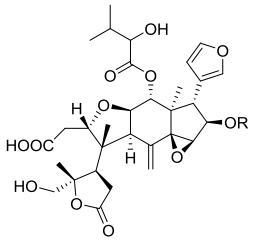
587-589



590



591



592-593

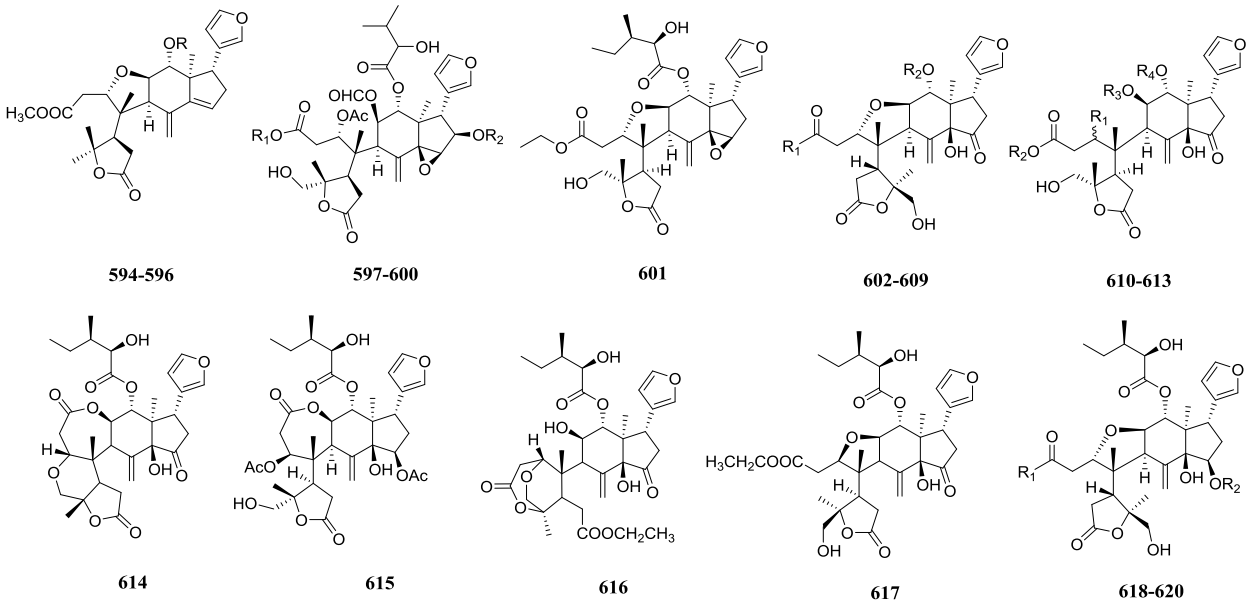


Figure 26. Structures of prieurianin class limonoids **550-620**.

2.3.2.1.2. Aphanamixoid

This class is characterized by the presence of seven membered lactone rings and intact C and D rings. Nine Limonoids belonging to Aphanamixoid class were isolated from *Aphanamixis polystachya* (Table 25/S25, Figure 27). Aphanamixoid C-E (**621-623**) are C11 acetoxyl analogs of Aphanamixoid A (**624**). And compounds (**622**, **623**) differ from each other in substitution at C12 containing tigloyloxy and 2-methylbutanoate groups respectively. The presence of additional $\Delta^{2,30}$ olefinic double bond in Aphanamixoid F and G (**625** and **626**) corresponds to compounds (**621** and **622**) respectively. The orientation of $\Delta^{2,30}$ olefinic bond in compound (**625**) is changed from *E* to *Z* in Aphanamixoid H (**627**). Aphanamixoid I and J (**628** and **629**) are structurally similar to compounds (**625** and **626**) respectively except at C14/15 epoxidation.

Table 25. Aphanamixoid class limonoid 621-629

No.	Limonoid	Substituent	Source
621	Aphanamixoid C	R_1 = OAc; R_2 = Ac	*Aphanamixis polystachya*[282]
622	Aphanamixoid D	R_1 = OAc; R_2 = Tig	*Aphanamixis polystachya*[282]
623	Aphanamixoid E	R_1 = OAc; R_2 = $COCH(CH_3)CH_2CH_3$	*Aphanamixis polystachya*[282]
624	Aphanamixoid A	R_1 = H; R_2 = Ac	*Aphanamixis polystachya*[283]
625	Aphanamixoid F	R = Ac	*Aphanamixis polystachya*[282]
626	Aphanamixoid G	R = Tig	*Aphanamixis polystachya*[282]
627	Aphanamixoid H		*Aphanamixis polystachya*[282]
628	Aphanamixoid I	R = Ac	*Aphanamixis polystachya*[282]
629	Aphanamixoid J	R = Tig	*Aphanamixis polystachya*[282]

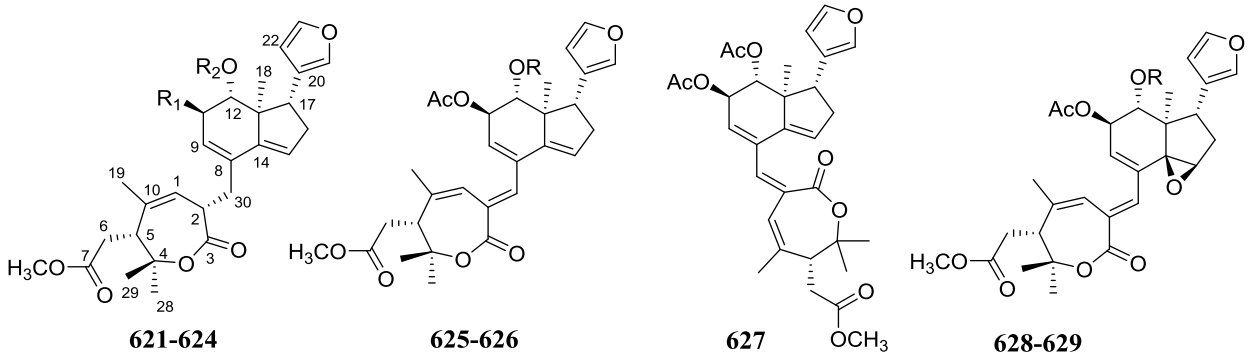


Figure 27. Structures of aphanamixoid class limonoids **621-629**.

2.3.2.1.3. Other rings A,B-seco

Twenty five Limonoids belonging to this class were isolated from *Toona sinensis, Trichilia connaroides, Toona ciliata, Aphanamixis polystachya* and *Aphanamixis grandifolia* (Table 26/S26, Figure 28). A total of thirty one limonoids belonginging to this class were reported previously from Meliaceae family[12]. Trichiconlide A (**630**) consists of an unprecedented 5/6/5/6/5 carbon ring skeleton and is a hybrid between basic limonoid and rearranged phragmalin class limonoid. Toonayunnanin E and I (**631** and **632**) are C6 acetoxyl and hydroxyl analogs of previously reported Toonaciliatin I respectively[223]. In Aphanaonoid C (**633**) there is formation of C1, C14 ether linkage with cleavage of C3, C11 ether linkage when compared with compound (**614**). C3 ester moiety in compound (**633**) is replaced by acid moiety in Aphanaonoid D (**634**). Zaphaprinin B (**635**) is C17 epimer of previously reported Rohituka 12[289]. Zaphaprinin C (**636**) is C3 methoxy analogs of previously reported Rohituka 1[276] with differing substitution at C11, C12 with presence of carbonyl group at C15 and formation of ether linkage between C1, C14. Zaphaprinin D (**637**) is the C3 ethoxy analog of compound (**636**). Zaphaprinin E-O (**638-648**) differs at C3, C11, and C12 substitution when compared with compound (**636**). Toonaolide B (**649**) when compared with compound (**367**) there is cleavage of the B ring with formation of C1, C8 ether linkage. Furan ring in previously reported Surenolactone[290], Toonaciliatin I[223] and Toonaciliatin H[223] is replaced by C21 hydroxy butenolide moiety in Toonaolide H (**650**), Toonaolide T (**651**) and Toonaolide V (**653**) respectively. Toonaolide U (**652**) is the C6 acetoxyl analog of compound (**651**). C8, C14 epoxide ring in compound (**653**) is replaced by $\Delta^{8,14}$ double bond in Toonaolide W (**654**).

Table 26. Other rings A,B-seco class limonoid 630-654

No.	Limonoid	Substituent	Source
630	Trichiconlide A		*Trichilia connaroides*[291]
631	Toonayunnanin E	R = Ac	*Toona ciliata*[136]
632	Toonasinenine I	R = H	*Toona sinensis*[214]
633	Aphanaonoid C	R = CH_3	*Aphanamixis polystachya*[279]
634	Aphanaonoid D	R = H	*Aphanamixis polystachya*[279]
635	Zaphaprinin B		*Aphanamixis grandifolia*[275]
636	Zaphaprinin C	R = OCH_3	*Aphanamixis grandifolia*[275]
637	Zaphaprinin D	R = OCH_2CH_3	*Aphanamixis grandifolia*[275]
638	Zaphaprinin E	R_1 = β-H; R_2 = OH; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
639	Zaphaprinin F	R_1 = β-H; R_2 = OCH_2CH_3; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
640	Zaphaprinin G	R_1 = α-H; R_2 = OH; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
641	Zaphaprinin H	R_1 = α-H; R_2 = OCH_3; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
642	Zaphaprinin I	R_1 = α-H; R_2 = OCH_2CH_3; R_3 = $COCH(OH)CH(CH_3)CH_2CH_3$	*Aphanamixis grandifolia*[275]
643	Zaphaprinin J	R_1 = β-H; R_2 = OH; R_3 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
644	Zaphaprinin K	R_1 = β-H; R_2 = OCH_2CH_3; R_3 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
645	Zaphaprinin L	R_1 = α-H; R_2 = OH; R_3 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
646	Zaphaprinin M	R_1 = α-H; R_2 = OCH_3; R_3 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
647	Zaphaprinin N	R_1 = α-H; R_2 = OCH_2CH_3; R_3 = $COCH(OH)CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
648	Zaphaprinin O	R_1 = α-H; R_2 = OH; R_3 = $COCH_2CH(CH_3)_2$	*Aphanamixis grandifolia*[275]
649	Toonaolide B		*Toona ciliata*[219]
650	Toonaolide H		*Toona ciliata*[219]
651	Toonaolide T	R = H	*Toona ciliata*[219]
652	Toonaolide U	R = OAc	*Toona ciliata*[219]
653	Toonaolide V		*Toona ciliata*[219]
654	Toonaolide W		*Toona ciliata*[219]

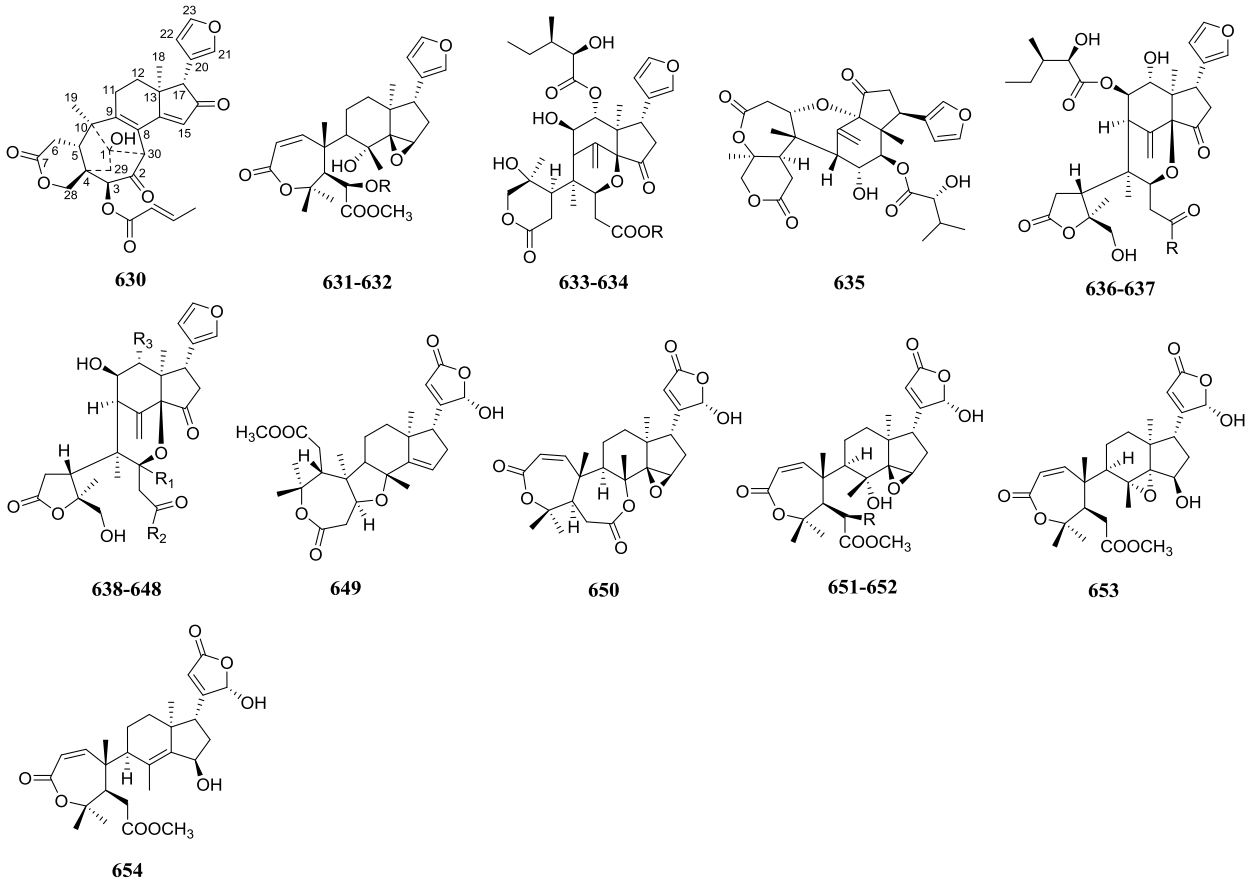


Figure 28. Structures of other rings A,B-seco class limonoids **630-654**.

2.3.2.2. Rings A,D-seco

2.3.2.2.1. Obacunol

Sixteen Limonoids were isolated from *Dysoxylum mollissimum*, *Clausena emarginata* and *Toona sinensis* (Table 27/S27, Figure 29). A total of thirty one Obacunol class limonoids were reported previously from Meliaceae family[12]. The $\Delta^{1,2}$ double bond in previously reported Dysoxylin[292] is reduced in Dysomollide B (**655**) along with presence of acetoxyl group at C1. Dysomollide C (**656**) differs from compound (**655**) in an additional 2-hydroxy-3-methylbutyryl group at C7. The acetoxy group at C11 in previously reported odoralide[293] is shifted to C6 in Dysomollide D (**657**). The hydroxyl group at C6 in previously reported methyl isoobacunoate diosphenol[294] is shifted to C11 in Clauemargine A (**658**) along with reduction of $\Delta^{5,6}$ double bond. Clauemargine B (**659**) is a C2 diastereomer of compound (**658**). The furan ring at C17 in compound (**658**) is replaced by γ-hydroxy butenolide moiety in Clauemargine C (**660**). Clauemargine D (**661**) differs from compound (**660**) at hydroxyl substitution in the lactone ring. The acetoxyl group at C7 in 11β-hydroxyceorin G is replaced by the keto carbonyl group in Clauemargine E (**662**). The furan moiety at C17 in compound (**662**) is replaced by γ-hydroxybutenolide moiety in structural analogs Clauemargine F and G (**663** and **664**). The A ring in compound (**662**) is cleaved in Clauemargine H-J (**665-667**). The methoxy carbonyl group at C3 in Clauemargine H and I (**665** and **666**) is replaced by ethoxy carbonyl group in Clauemargine J (**667**). The furan ring at C17 and acid group at C3 in compound (**665**) is replaced by γ-hydroxy butenolide and ester moiety in Clauemargine K (**668**) respectively. Clauemargine L (**669**) is derived from compound (**665**) in which a lactone ring is formed between C3 and C11 with loss of acetoxyl group from C1 and methoxy group from C3. The carbonyl group at C7 and hydroxyl group at C11 in compound (**662**) is replaced by acetoxyl group in Ttoonin A (**670**).

Table 27. Obacunol class limonoid 655-670

No.	Limonoid	Substituent	Source

655	Dysomollide B	R = H	*Dysoxylum mollissimum*[144]
656	Dysomollide C	R = COCH(OH)CH$(CH_3)_2$	*Dysoxylum mollissimum*[144]
657	Dysomollide D		*Dysoxylum mollissimum*[144]
658	Clauemargine A	R = β-H	*Clausena emarginata*[295]
659	Clauemargine B	R = α-H	*Clausena emarginata*[295]
660	Clauemargine C		*Clausena emarginata*[295]
661	Clauemargine D		*Clausena emarginata*[295]
662	Clauemargine E		*Clausena emarginata*[295]
663	Clauemargine F		*Clausena emarginata*[295]
664	Clauemargine G		*Clausena emarginata*[295]
665	Clauemargine H	R_1 = OCH_3; R_2 = OAc	*Clausena emarginata*[295]
666	Clauemargine I	R_1 = OCH_3; R_2 = OH	*Clausena emarginata*[295]
667	Clauemargine J	R_1 = OCH_2CH_3; R_2 = OAc	*Clausena emarginata*[295]
668	Clauemargine K		*Clausena emarginata*[295]
669	Clauemargine L		*Clausena emarginata*[295]
670	Ttoonin A		*Toona sinensis*[216]

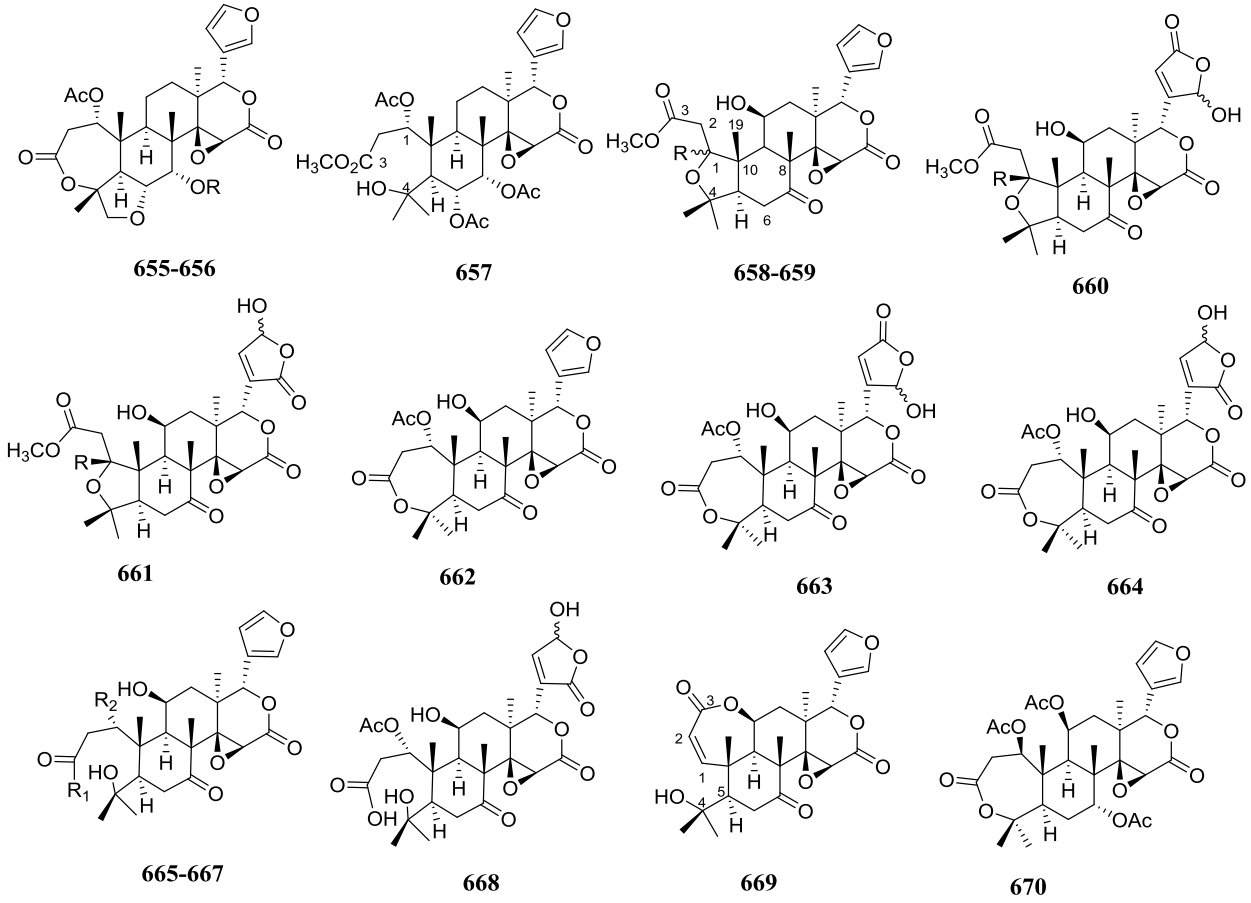


Figure 29. Structures of obacunol class limonoids **655-670**.

2.3.2.2.2. Chukrasone

This class of limonoids contains five membered, rearranged A ring with a carbonyl group at C6. Five Limonoids belonging to this class were isolated from *Chukrasia tabularis* and *Carapa guianensis* (Table 28/S28, Figure 30). Based on 1D and 2D NMR spectroscopic data, Chukrasone A (**671**) contains gedunin type skeleton with change at A ring, which is five membered. The hydroxyl group at C30 in compound (**671**) is absent in Guianofruit C (**672**) which also has an additional $\Delta^{14,15}$ olefinic double bond. The 2-methylpropanoyl group at C3 in compound (**672**) is replaced by the tigloyl group in Guianofruit D (**673**) which also has an additional acetoxyl group at C30. Guianofruit B (**674**) is C30 deacetyl analog of compound (**673**). The tigloyl moiety at C3 in compound (**674**) is

replaced by 3-methyl butanoate group in Guianofruit A (**675**) which also have additional $\Delta^{8,30}$ double bond formed by dehydroxylation.

Table 28. Chukrasone class limonoid 671-675

No.	Limonoid	Substituent	Source
671	Chukrasone A		*Chukrasia tabularis*[296]
672	Guianofruit C	R_1 = $COCH(CH_3)_2$; R_2 = H	*Carapa guianensis*[297]
673	Guianofruit D	R_1 = Tig; R_2 = OAc	*Carapa guianensis*[297]
674	Guianofruit B	R_1 = Tig; R_2 = H	*Carapa guianensis*[298]
675	Guianofruit A		*Carapa guianensis*[298]

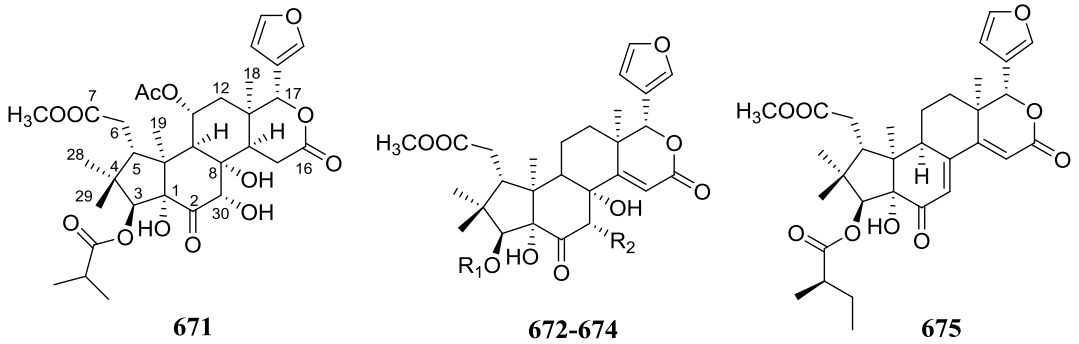


Figure 30. Structures of chukrasone class limonoids **671-675**.

2.3.2.2.3. Other rings A,D-seco

Trangmolin E (**676**) was isolated from *Xylocarpus moluccensis* in which there is oxidative cleavage of C2-C3 bond followed by rearrangement at A ring (Table 29/S29, Figure 31).

Table 29. Other rings A,D-seco class limonoid 676

No.	Limonoid	Substituent	Source
676	Trangmolin E		*Xylocarpus moluccensis*[299]

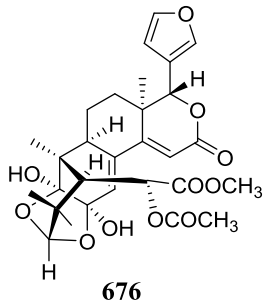


Figure 31. Structures of other rings A,D-seco class limonoid **676**.

2.3.2.3. Rings B,D-seco

2.3.2.3.1. Andirobin

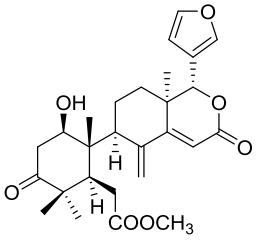
This class of Limonoids are characterized by a Gedunin skeleton with cleaved B ring and exocyclic double bond at $\Delta^{7,8}$ and/or presence of C1-O-C14 ether linkage. Forty two Limonoids belonging to this class were isolated from *Khaya senegalensis, Carapa guianensis, Cipadessa baccifera, Cipadessa cinerascens, Sandoricum koetjape, Xylocarpus moluccensis* and *Entandrophragma angolense* (Table 30/S30, Figure 32). Thirty nine Andirobin class limonoids were reported previously from the Meliaceae family[12]. Khasenegasin Y (**677**) is C1 epimer of previously reported swietmanin J[300]. Khasenegasin Z (**678**) differs from compound (**677**) in presence of hydroxyl group at C14 with reduced $\Delta^{14,15}$ double bond. Khayandirobilide A (**679**) varies from previously reported Domesticulide A[301] in

presence of γ-methoxy butenolide and hydroxyl moieties at C17 and C1 respectively with reduced $\Delta^{1,2}$ double bond. The furan ring at C17 in Andirobin isolated earlier[302] is replaced by γ-ethoxy butenolide in Andirolide S (**680**). The carbonyl at C3 in Methyl angolensate isolated previously[303] is replaced by the tigloyl group in Cipaferen N (**681**). Cipaferen E-G (**682-684**) are derived from compound (**681**) and differ in substitution at C2 and C3. The hydroxyl group at C3 in compound (**683**) is replaced by acetoxyl group in Sanjecumin A (**685**) along with additional acetoxyl and hydroxyl group at C12 and C15 respectively. The 2-methyl butanoate group at C2 in compound (**685**) is replaced by 2-methylpropanoate group in Sanjecumin B (**686**). Cipaferen I and J (**687** and **688**) are C17 γ-hydroxy butenolide analogs of compound (**684**). Xylomolin N (**689**) is a 21-dehydroxy analog of previously reported Moluccensin O[304]. Previously in the year 2010 6-deacetoxydomesticulide D (**690**) was reported as moluccensin O[304] but in 2011 it was renamed as 6-deacetoxydomesticulide D. 6-deacetoxydomesticulide D 21-methylether (**691**) is C21-methoxy analog of Moluccensin O. Andirolide W (**692**) is C23 ethoxy analog of previously reported Moluccensin N[304]. Khaysenelide K (**693**) is C6 deacetyl analog of previously reported Domesticulide C[301]. Cipaferen H (**694**) is C2 tigloyloxy analog of Moluccensin N. The furan ring at C17 in methyl angolensate is replaced by substituted tetrahydrofuran ring in Entangosin (**695**). The hydroxyl group at C11 in Cineracipadesin B is converted to keto carbonyl group in Cipadesin P (**696**) and is missing in Cipadesin Q (**697**) along with elimination of C2 acetoxyl group. Cibacciferin A (**698**) is C2 isobutyryloxy, C9 hydroxy analog of compound (**683**). 11α-Acetoxycibacciferin A (**699**) is C11 acetoxy analog of compound (**698**). Cibacciferin B (**700**) is C2 2-methylbutyryl with shift of hydroxyl group from C9 to C11 analog of compound (**698**). 2′-Epi-cibacciferin B (**701**) is C2' epimer of compound (**700**). Cibacciferin C (**702**), 2′-Epi-cibacciferin C (**703**) differs from compound (**700**), compound (**701**) with shift of hydroxyl group from C11 to C9. 11α-Acetoxycibacciferin C (**704**) is C11 acetoxy analog of (**702**). Cibacciferin D (**705**) is C2, C3 acetoxy C3 hydroxy analog of compound (**698**). Entangolensin C and D (**706** and **707**) are C1 and C11 epimers but differ from Cineracipadesin C at C3 (carbonyl) and C11 (hydroxyl) substitution. The acetoxy group at C11 in Cineracipadesin D is absent in Cineracipadesin G (**708**) which also has γ-methoxy butenolide at C17. The acetoxyl group at C3 in compound (**708**) is replaced by carbonyl group in Entangolensin E-F (**709-710**) along with shuffled carbonyl and methoxy groups from C21 to C23. Entangolensin I and J (**711** and **712**) are C21 epimers of compound (**710**) having hydroxyl group at C20 with reduced $\Delta^{20,22}$ double bond. Entangolensin G (**713**) is C21 methoxy analog of (**709**) and Entangolensin H (**714**) is C20 22-dihydroxy analog of (**713**). Koetjapin A-C (**715-717**) differ from each other in substitution at C9 and C11. Koetjapin D (**718**) is C3 epimer of previously isolated Cipatrijugin A[305]. Koetjapin A-D (**715-718**) has an unusual 17β furan ring instead of the canonical 17α furan ring.

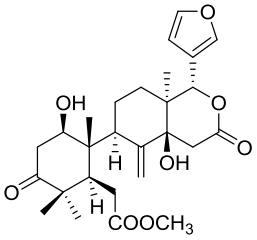
Table 30. Andirobin class limonoid 677-718

No.	Limonoid	Substituent	Source
677	Khasenegasin Y		*Khaya senegalensis*[268]
678	Khasenegasin Z		*Khaya senegalensis*[268]
679	Khayandirobilide A		*Khaya senegalensis*[306]
680	Andirolide S		*Carapa guianensis*[149]
681	Cipaferen N	R_1 = H; R_2 = Tig	*Cipadessa baccifera*[307]
682	Cipaferen E	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$	*Cipadessa baccifera*[308]
683	Cipaferen F	R_1 = $OCOCH(CH_3)CH_2CH_3$; R_2 = H	*Cipadessa baccifera*[308]
684	Cipaferen G	R_1 = H; R_2 = Ac	*Cipadessa baccifera*[308]
685	Sanjecumin A	R = $COCH(CH_3)CH_2CH_3$	*Sandoricum koetjape*[309]
686	Sanjecumin B	R = $COCH(CH_3)_2$	*Sandoricum koetjape*[309]
687	Cipaferen I		*Cipadessa baccifera*[308]
688	Cipaferen J		*Cipadessa baccifera*[308]
689	Xylomolin N	R = H	*Xylocarpus moluccensis*[143]
690	6-deacetoxydomesticulide D	R = OH	*Entandrophragma angolense*[265]
691	6-deacetoxydomesticulide D-21-methylether	R = OCH_3	*Entandrophragma angolense*[265]
692	Andirolide W	R_1 = H; R_2 = OCH_2CH_3	*Carapa guianensis*[310]
693	Khaysenelide K	R_1 = OH; R_2 = β-OH	*Khaya senegalensis*[311]
694	Cipaferen H		*Cipadessa baccifera*[308]
695	Entangosin		*Entandrophragma angolense*[265]
696	Cipadesin P		*Cipadessa baccifera*[203]
697	Cipadesin Q	R_1 = H; R_2 = β-OAc; R_3 = R_4 = R_5 = H	*Cipadessa baccifera*[203]
698	Cibacciferin A	R_1 = $OCOCH(CH_3)_2$; R_2 = α-OH; R_3 = R_4 = H; R_5 = OH	*Cipadessa baccifera*[312]
699	11α-Acetoxycibacciferin A	R_1 = $OCOCH(CH_3)_2$; R_2 = α-OH; R_3 = R_4 = H; R_5 = OAc	*Cipadessa baccifera*[312]
700	Cibacciferin B	R_1 = $OCOCH(\beta\text{-}CH_3)CH_2CH_3$; R_2 = α-OH; R_3 = R_4 = H; R_5 = OH	*Cipadessa baccifera*[312]
701	2′-Epi-cibacciferin B	R_1 = $OCOCH(\alpha\text{-}CH_3)CH_2CH_3$; R_2 = α-OH; R_3 = R_4 = H; R_5 = OH	*Cipadessa baccifera*[312]

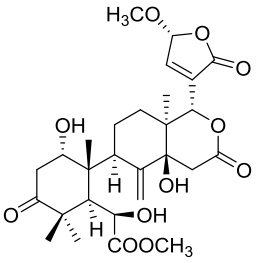
702	Cibacciferin C	R_1 = OCOCH(β-CH_3)CH_2CH_3; R_2 = α-OH; R_3 = R_4 = H; R_5 = OH	*Cipadessa baccifera*[312]
703	2′-Epi-cibacciferin C	R_1 = OCOCH(α-CH_3)CH_2CH_3; R_2 = α-OH; R_3 = R_4 = H; R_5 = OH	*Cipadessa baccifera*[312]
704	11α-Acetoxycibacciferin C	R_1 = OCOCH(β-CH_3)CH_2CH_3; R_2 = α-OH; R_3 = R_4 = H; R_5 = OAc	*Cipadessa baccifera*[312]
705	Cibacciferin D	R_1 = OAc; R_2 = β-OAc; R_3 = OH; R_4 = R_5 = H	*Cipadessa baccifera*[312]
706	Entangolensin C	R_1 = α-H; R_2 = α-OH	*Entandrophragma angolense*[141]
707	Entangolensin D	R_1 = β-H; R_2 = β-OH	*Entandrophragma angolense*[141]
708	Cineracipadesin G		*Cipadessa cinerascens*[313]
709	Entangolensin E		*Entandrophragma angolense*[141]
710	Entangolensin F		*Entandrophragma angolense*[141]
711	Entangolensin I	R = β-OCH_3	*Entandrophragma angolense*[141]
712	Entangolensin J	R = α-OCH_3	*Entandrophragma angolense*[141]
713	Entangolensin G		*Entandrophragma angolense*[141]
714	Entangolensin H		*Entandrophragma angolense*[141]
715	Koetjapin A	R_1 = H; R_2 = OH	*Sandoricum koetjape*[314]
716	Koetjapin B	R_1 = OH; R_2 = H	*Sandoricum koetjape*[314]
717	Koetjapin C	R_1 = R_2 = OH	*Sandoricum koetjape*[314]
718	Koetjapin D		*Sandoricum koetjape*[314]



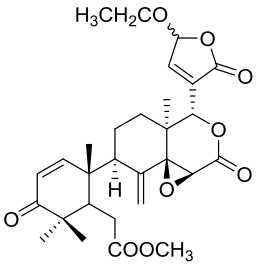
677



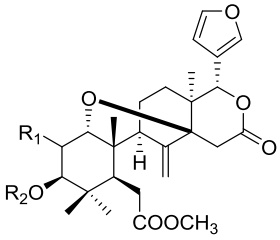
678



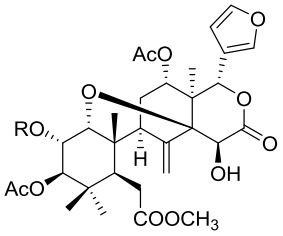
679



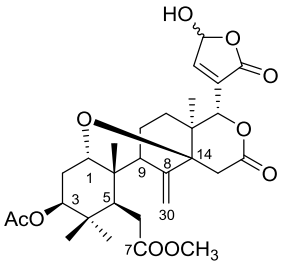
680



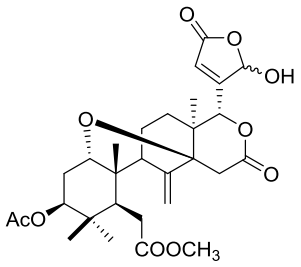
681-684



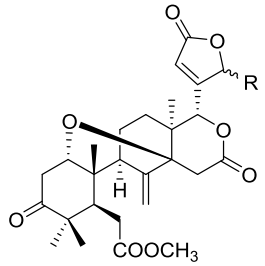
685-686



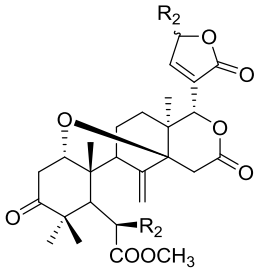
687



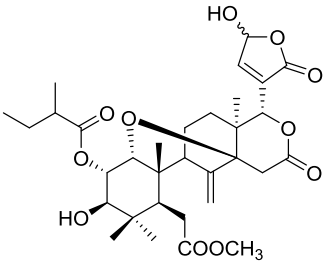
688



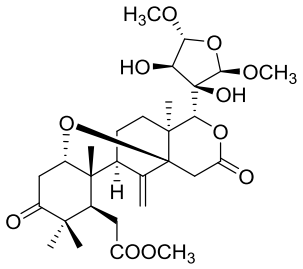
689-691



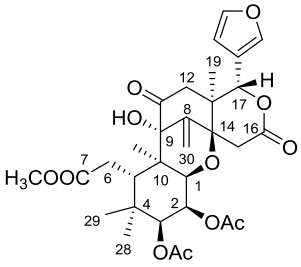
692-693



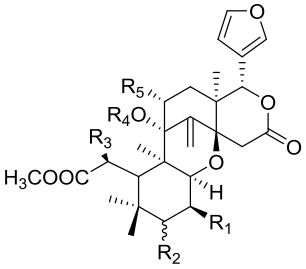
694



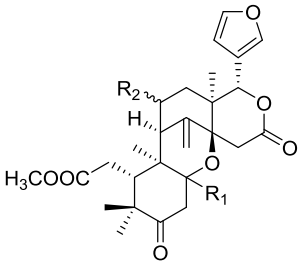
695



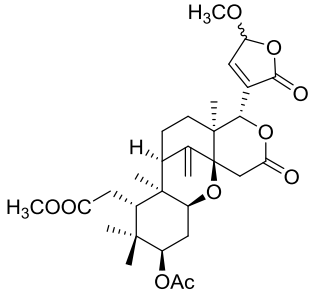
696



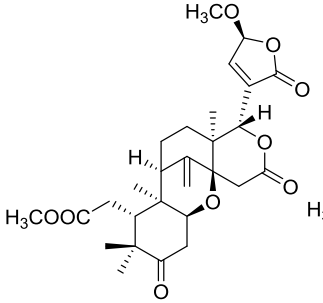
697-705



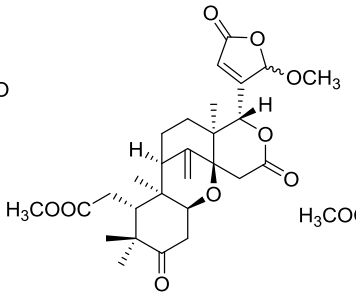
706-707



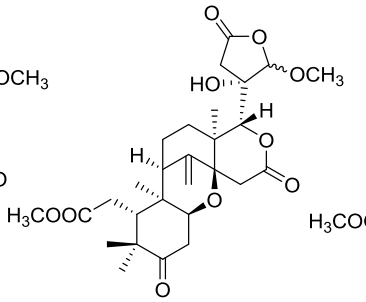
708



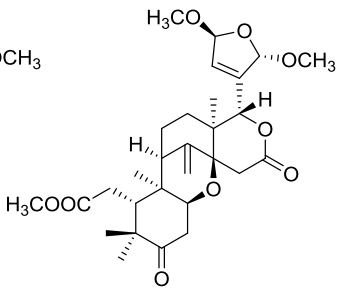
709



710



711-712



713

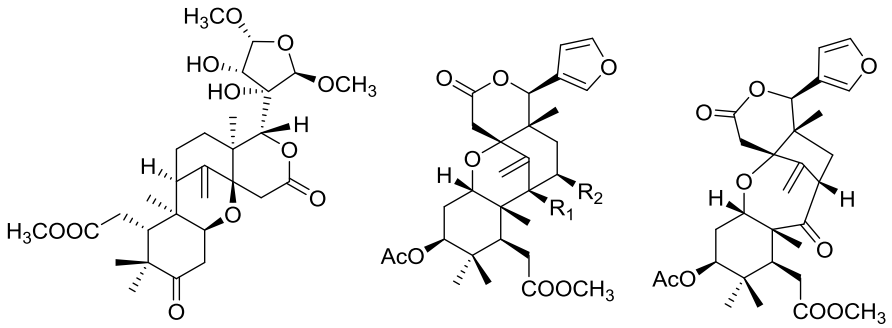


Figure 32. Structures of andirobin class limonoids **677-718**.

2.3.2.3.2. Other Rings B,D-seco

Eleven Limonoids belonging to this class of rings B,D-seco were isolated from *Swietenia macrophylla*, *Xylocarpus moluccensis*, *Entandrophragma angolense*, *Trichilia connaroides* and *Cipadessa baccifera* (Table 31/S31, Figure 33). Previously only six limonoids belonging to this class were reported from Meliaceae family[12]. Swietemacrolide D (**719**) is C8 hydroxy analog of previously reported domesticulide A[301]. Thaimoluccensin A (**720**) is a dehydroxy analog of compound (**719**). The hydroxyl group at C8, C14 in compound (**720**) is replaced by $\Delta^{8,14}$ double bond in Entangolensin B (**721**) with hydroxylation at C15. In Trichiconlide B (**722**) there is rearrangement of A/B ring moiety and the absolute configuration was determined by single crystal X-ray diffraction. The $\Delta^{1,2}$ double bond in previously reported Secomahoganin[315] is reduced in Thaixylomolin A (**723**) with additional ether linkage between C1 and C6 followed by deacetylation at C6. Trangmolin A-C (**724-726**) are structural analogs and differ among themselves in substitution at C3 and C6. The structure of Trangmolin D (**727**) was assigned by NMR spectroscopy. Cipaferoid C (**729**) is the C12 hydroxy analog of Cipaferoid B (**728**).

Table 31. Other Rings B,D-seco class limonoid 719-729

No.	Limonoid	Substituent	Source
719	Swietemacrolide D	R = OH	*Swietenia macrophylla*[316]
720	Thaimoluccensin A	R = H	*Xylocarpus moluccensis*[317]
721	Entangolensin B		*Entandrophragma angolense*[141]
722	Trichiconlide B		*Trichilia connaroides*[291]
723	Thaixylomolin A		*Xylocarpus moluccensis*[318]
724	Trangmolin A	$R_1 = R_2 = OAc$	*Xylocarpus moluccensis*[299]
725	Trangmolin B	$R_1 = OH$; $R_2 = OAc$	*Xylocarpus moluccensis*[299]
726	Trangmolin C	$R_1 = OAc$; $R_2 = H$	*Xylocarpus moluccensis*[299]
727	Trangmolin D		*Xylocarpus moluccensis*[299]
728	Cipaferoid B	R = H	*Cipadessa baccifera*[319]
729	Cipaferoid C	R = OH	*Cipadessa baccifera*[319]

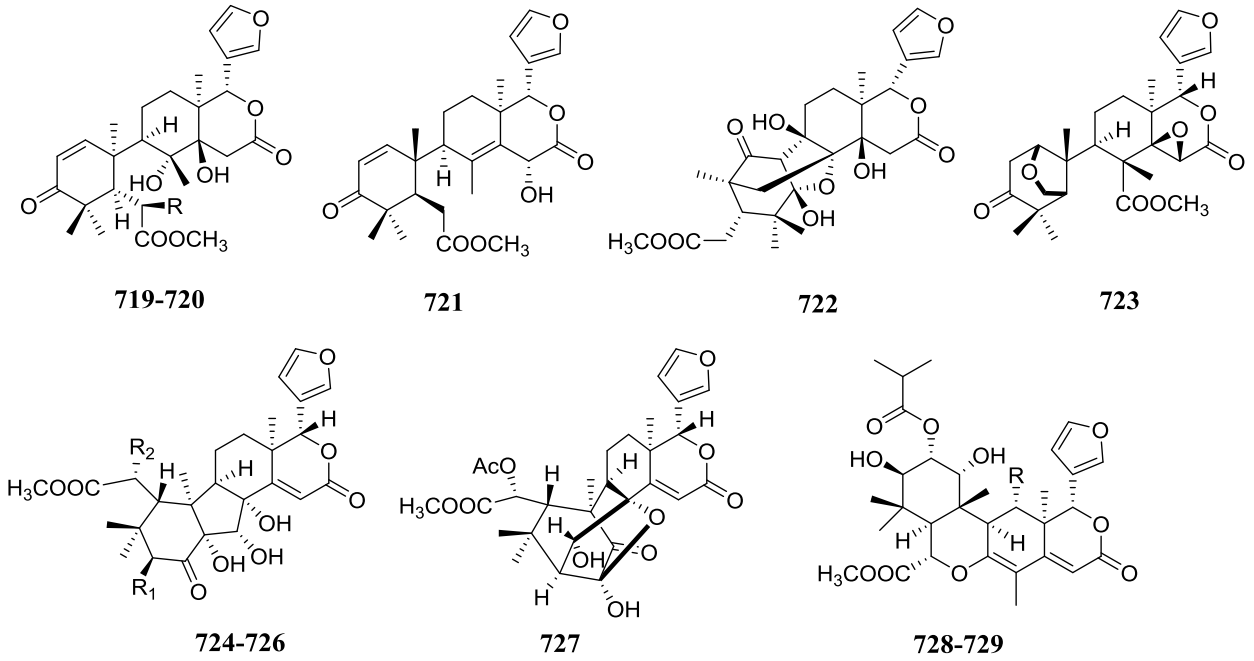


Figure 33. Structures of other rings (B,D-seco) class limonoids **719-729**.

2.3.2.4. Rings B,C-seco

Toonasecone A (**730**) is C9, C11 seco limonoid isolated from *Toona ciliata* and is derived from previously isolated Toonacilin[320] (Table 32/S32, Figure 34). It is deacetylated at C11, C12 and 2-methyl propanoate group is added at C11.

Table 32. Rings B,C-seco class limonoid 730

No.	Limonoid	Substituent	Source
730	Toonasecone A		*Toona ciliata*[321]

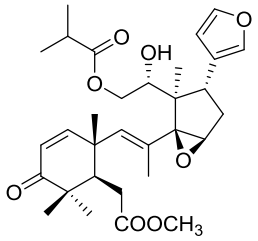


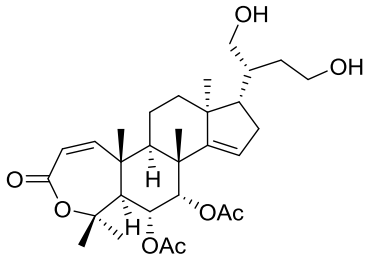
Figure 34. Structures of rings (B,C-seco) class limonoid **730**.

2.3.2.5. Rings A,E seco

Toonaolide S (**731**) is ring E cleaved analog of compound (**357**) (Table 33/S33, Figure 35).

Table 33. Rings A,E-seco class limonoid 731

No.	Limonoid	Substituent	Source
731	Toonaolide S		*Toona ciliata*[219]



731

Figure 35. Structures of rings (A,E-seco) class limonoid **731**.

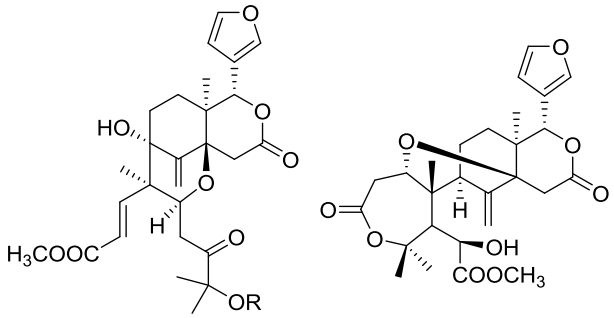
2.3.3. Demolition of three rings

2.3.3.1. Rings A,B,D-seco

Three such Limonoids were isolated from *Trichilia connaroides* and *Khaya senegalensis* (Table 34/S34, Figure 36). Prior to this only six limonoids belonging to this class were reported from Meliaceae family[12]. Trichiconin C (**733**) is C4 deacetyl derivative of Trichiconin B (**732**). Khayseneganin D (**734**) is a C6 hydroxy analog of previously isolated methyl ivorensate[322].

Table 34. Rings A,B,D-seco class limonoid 732-734

No.	Limonoid	Substituent	Source
732	Trichiconin B	R = Ac	*Trichilia connaroides*[323]
733	Trichiconin C	R = H	*Trichilia connaroides*[323]
734	Khayseneganin D		*Khaya senegalensis*[324]



732-733 **734**

Figure 36. Structures of rings (A,B,D-seco) class limonoids **732-734**.

2.4. Rearranged limonoids

2.4.1. 2,30-linkage

2.4.1.1. Mexicanolide

It consists of C2/30 linkage and C6, C7 are present outside the ring. About 255 limonoids were isolated belonging to this class from *Carapa guianensis, Xylocarpus moluccensis, Swietenia macrophylla, Khaya senegalensis, Chukrasia tabularis, Swietenia mahogani, Cipadessa baccifera, Trichilia sinensis, Cipadessa cinerascens, Heynea trijuga, Xylocarpus granatum, Trichilia connaroides, Guarea kunthiana, Khaya ivorensis, Xylocarpus rumphii, Chisocheton erythrocarpus, Aphanamixis polystachya* and *Chisocheton erythrocarpus* (Table 35/S35, Figure 37). Previously 199 Mexicanolide class limonoids were reported from Meliaceae family[12]. Limonoids (**735-758**) have $\Delta^{14,15}$ olefinic double bond and differ among themselves in substitution at C2, C3, C6 and C8. The olefinic double bond is shifted from $\Delta^{14,15}$ to $\Delta^{8,14}$ in compounds (**759-775**) and they differ among themselves in substitution at C2, C3, C6 and C30. In addition to this there is also change in substitution at C15 in compounds (**776-790**). Trichinenlide W (**791**) and Granatumin U (**792**) contain $\Delta^{8,30}$ double bond with acetylation at C29 and vary in substitution at C2 and C3. Limonoids (**793-818**) are structurally similar to compound (**791**) except in the deacetylation at C29, but compounds (**793-799**) differ in substitution at C2, C3, C6, C11, C14 whereas

compounds (**800-818**) differ in substitution at C2, C3 and C6. In Khasenegasin Q (**819**) and Cipadessain K (**820**) there is olefinic double bond at $\Delta^{8,9}$ but differ at C3-O with acetylation in compound (**819**) and tigloylation in compound (**820**). Limonoids (**821-823**) contain additional double bond at $\Delta^{14,15}$ with respect to compound (**819**) but differ in substitution at C2, C3, C6 and C15. The double bond at $\Delta^{8,9}$ in compound (**821**) is shifted to $\Delta^{8,30}$ in limonoids (**824-835**) along with varying substituents at C2, C3 and C6. The $\Delta^{8,30}$ double bond in compounds (**791**, **831**) is replaced by the epoxide group in Trichinenlide V (**836**) and Limonoids (**837-844**) respectively. Compounds (**845-854**) are $\Delta^{14,15}$ double bond reduced structural analogs of Khasenegasin O (**838**) but differ in substitution at C2, C3 and C6. Trichinenlide I-K (**855-857**) are structural analogs of previously reported Quivisianolide A[325] but differ in substitution at C3 and C6. Compounds (**858-862**) are structural analogs of previously reported quivisianolide B[326] with varying substituents at C3 and C6. Xylorumphiin L (**863**) differs from previously reported Xyloccensin H[327] in substitution at C3 and C30. Xylomexicanin I (**864**) contains bridged B and C rings. 6-O-Acetyl-2α-hydroxymexicanolide (**865**) is C6 acetoxyl analog of previously reported 2α-hydroxymexicanolide[328]. Structure of Trichiconin A (**866**) was determined by single crystal X-ray diffraction. At A ring, in Godavarin C (**867**) and Triconoid C (**868**) additional six and five membered rings are formed respectively, in contrast to previously reported grantumin A[329]. $\Delta^{14,15}$ double bond in compound (**867**) is absent in compounds (**869-872**). Thaigranatin K (**873**) is C30 hydroxy $\Delta^{8,9}$ analog of compound (**871**). The ether bridge is formed between C8 and C3 in Mexicanolide K (**874**). Mexicanolide J (**875**) and Xylorumphiin D (**876**) are $\Delta^{9,11}$ dehydro analogs of compound (**874**) differing in hydroxyl group substitution, whereas in compounds (**877, 878**) $\Delta^{9,11}$ double bond is shifted to $\Delta^{14,15}$ with dehydroxylation at C2 and C30. Furan ring in compound (**876**) is replaced by 21 hydroxy butenolide in Hainanxylogranin A (**879**). Hainanxylogranin B (**880**) is C6 acetoxyl analog of compound (**879**). Hainanxylogranin C (**881**) is the C6 hydroxy analog of compound (**879**). Hainanxylogranin D (**882**) is a C30 hydroxy analog of compound (**879**). The furan ring at C17 in compounds (**868, 853**) is replaced by γ-methoxy butenolide in Trichiliasinenoid E (**883**) and Cipadessain G, H (**884, 885**) respectively. Cipaferen M and D (**886** and **887**) are structurally similar to compound (**804**) except in substitution at C17. 3-O-detigloyl-3-O-isobutyryl-21-deoxo-23-oxofebrifugin A (**888**) is C3 isobutyryloxy analog of compound (**887**). 3-O-detigloyl-3-O-isobutyrylgranatumin E (**889**) and 3-O-detigloyl-3-O-isobutyryl-21-O-methylgranatumin E (**890**) are C21 hydroxy and methoxy analogs of compound (**888**) respectively. 3-O-detigloyl-3-O-propanoylgranatumin E (**891**) is C3 propanoyl analog of compound (**889**). 21-O-methylgranatumin E (**892**) is C3 tigloyl analog of compound (**890**). Compounds (**893-915**) are C17 γ-substituted butenolide analogs in which compounds (**893**, **894**) are analogs of Swietenolide (**766**); compounds (**895-897**) are analogs of 6-O-Acetyl-2α-hydroxymexicanolide (**865**); 8-hydro-14,15-en-cabralin (**898**) is analog of compound (**755**); compounds (**901, 903**) are analogs of khayasin T (**769**); Cipadessain F (**905**) is analog of compound (**853**) and compounds (**909-913**) are analogs of Swieteliacate C (**802**). 3-O-detigloyl-3-O-isobutyrylfebrifugin A (**914**) is C3 isobutyryloxy analog of previously reported Febrifugin A[329]. 3-O-detigloyl-3-O-isobutyryl-23-O-methylfebrifugin A (**915**) is C23 methoxy analog of compound (**914**). In compounds (**927-937**), C1/8 ether linkage is formed with respect to Carapanosin E (**735**) and compounds (**916-926**) are $\Delta^{14,15}$ double bond reduced analogs of Xylomolin F (**927**). Hainanxylogranin E (**938**) is C3 tigloyl, C23 hydroxy butenolide, C30 acetyl analog of compound (**928**). Hainanxylogranin H (**939**) is C21 methoxy butenolide analog of compound (**938**). Hainanxylogranin I (**940**) is C21 hydroxy butenolide analog of compound (**938**). Limonoids (**941-954**) are structural analogs of previously isolated xyloccensin L[330] but differ in substitution at C3 and C29. Krishnagranatin E and F (**951** and **952**) are epimers. In Granatumin R and S (**955** and **957**) epoxide group is absent at C8/30. Limonoids (**958-987**) are structurally similar to compound (**955**) but in compounds (**958, 959**) double bonds are present at $\Delta^{8,9}$ and $\Delta^{14,15}$; in compounds (**960-963**) double bonds are present at $\Delta^{8,30}$ and $\Delta^{14,15}$; in compounds (**964-972**) double bond is present at $\Delta^{8,14}$; in compound (**975**) double bond is present at $\Delta^{8,9}$ and in compounds (**976-987**) double bond is present at $\Delta^{8,30}$. Carapanin B (**988**) is ring D cleaved analog of mexicanolide skeleton with presence of C16 C30 δ lactone ring for the first time in mexicanolide class of compound. Thaigranatin F (**989**) is C30 epimer of compound (**975**).

Table 35. Mexicanolide class limonoid 735-989

No.	Limonoid	Substituent	Source
735	Carapanosin E	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = α-OH; R_5 = $OCOCH(CH_3)CH_2CH_3$	*Carapa guianensis*[331]
736	Carapanosin F	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = α-OH; R_5 = $OCOCH(CH_3)CH_2CH_3$	*Carapa guianensis*[331]
737	Xylomolin D	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OH; R_4 = α-OH; R_5 = H	*Xylocarpus moluccensis*[143]
738	Swieteliacate E	R_1 = R_2 = H; R_3 = β-OH; R_4 = α-OH; R_5 = H	*Swietenia macrophylla*[116]
739	Khasenegasin P	R_1 = OH; R_2 = Ac; R_3 = H; R_4 = α-OH; R_5	*Khaya senegalensis*[268]

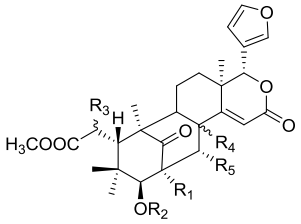
		= H	
740	Carapanolide T	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = α-OH; R_5 = H	*Carapa guianensis*[332]
741	Carapanolide U	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = α-OH; R_5 = H	*Carapa guianensis*[332]
742	Andirolide X	R_1 = OH; R_2 = Ac; R_3 = H; R_4 = α-OH; R_5 = $OCOCH(CH_3)_2$	*Carapa guianensis*[310]
743	Carapanolide C	R_1 = OAc; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = α-OH; R_5 = H	*Carapa guianensis*[333]
744	Carapanolide D	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = α-OH; R_5 = OAc	*Carapa guianensis*[333]
745	Carapanolide E	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = α -OH; R_5 = H	*Carapa guianensis*[333]
746	Andirolide T	R_1 = OH; R_2 = Ac; R_3 = H; R_4 = α-OH; R_5 = $OCOCH(CH_3)CH_2CH_3$	*Carapa guianensis*[149]
747	Andirolide B	R_1 = OAc; R_2 = Ac; R_3 = H; R_4 = β-OH; R_5 = H	*Carapa guianensis*[263]
748	Andirolide C	R_1 = OAc; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = β-OH; R_5 = H	*Carapa guianensis*[263]
749	Andirolide D	R_1 = OAc; R_2 = Tig; R_3 = H; R_4 = β-OH; R_5 = H	*Carapa guianensis*[263]
750	Andirolide L	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = α-OH; R_5 = $OCOCH(CH_3)_2$	*Carapa guianensis*[264]
751	Andirolide M	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = α-OH R_5 = $OCOCH(CH_3)_2$	*Carapa guianensis*[264]
752	Carapanolide R	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = α-OH; R_5 = OAc	*Carapa guianensis*[334]
753	Carapanolide S	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = α-OH; R_5 = OAc	*Carapa guianensis*[334]
754	Andirolide Q	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = α-OH; R_5 = H	*Chukrasia tabularis*[335]
755	Godavarin I	R_1 = H; R_2 = Ac; R_3 = H; R_4 = β-OH; R_5 = H	*Xylocarpus moluccensis*[336]
756	Thaixylomolin W	R_1 = OH; R_2 = Ac; R_3 = OH; R_4 = α-OH; R_5 = H	*Xylocarpus moluccensis*[337]
757	Thaixylomolin X	R_1 = OH; R_2 = Ac; R_3 = OAc; R_4 = α-OH; R_5 = H	*Xylocarpus moluccensis*[337]
758	Thaixylomolin Y	R_1 = OH; R_2 = H; R_3 = OAc; R_4 = α-OH; R_5 = H	*Xylocarpus moluccensis*[337]
759	Xylomolin A1	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = OAc; R_4 = H	*Xylocarpus moluccensis*[143]
760	Xylomolin A2	R_1 = OH; R_2 = $COCH_2CH_3$; R_3 = OH; R_4 = H	*Xylocarpus moluccensis*[143]
761	Xylomolin A3	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = R_4 = OH	*Xylocarpus moluccensis*[143]
762	Xylomolin A5	R_1 = OH; R_2 = Ac; R_3 = OAc; R_4 = OH	*Xylocarpus moluccensis*[143]
763	Xylomolin A6	R_1 = OAc; R_2 = Ac; R_3 = OH; R_4 = H	*Xylocarpus moluccensis*[143]
764	Xylomolin A7	R_1 = OAc; R_2 = Ac; R_3 = R_4 = H	*Xylocarpus moluccensis*[143]
765	3-*O*-propionylproceranolide	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = R_4 = H	*Swietenia macrophylla*[338]
766	Swietenolide	R_1 = R_2 = H; R_3 = β-OH; R_4 = H	*Swietenia mahogani*[339]
767	3-O-acetylswietenolide	R_1 = H; R_2 = Ac; R_3 = β-OH; R_4 = H	*Swietenia mahogani*[339]
768	3, 6-*OO*-diacetylswietenolide	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = H	*Swietenia mahogani*[339]
769	khayasin T	R_1 = H; R_2 = Tig; R_3 = R_4 = H	*Swietenia mahogani*[339]
770	3-*O*-tigloylswietenolide	R_1 = H; R_2 = Tig; R_3 = β-OH; R_4 = H	*Swietenia mahogani*[339]
771	Moluccensin R	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = α-OH; R_4 = H	*Xylocarpus moluccensis*[340]
772	Moluccensin S	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = α-OH; R_4 = H	*Xylocarpus moluccensis*[340]
773	Cipadesin N	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = R_4 = H	*Cipadessa baccifera*[203]
774	Thaigranatin M	R_1 = R_2 = H; R_3 = OAc; R_4 = H	*Xylocarpus granatum*[153]
775	Thaixylomolin U	R_1 = OH; R_2 = H; R_3 = α-OAc; R_4 = H	*Xylocarpus moluccensis*[337]
776	Xylomolin A4	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OAc; R_4 = H; R_5 = OH	*Xylocarpus moluccensis*[143]
777	Trichinenlide U	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = Ac; R_5 = $OCOCH(CH_3)CH_2CH_3$	*Trichilia sinensis*[341]
778	Trichinenlide L	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = Ac; R_5 = OAc	*Trichilia sinensis*[342]
779	Trichinenlide M	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = H; R_5 = OAc	*Trichilia sinensis*[342]

780	Trichinenlide N	R_1 = OH; R_2 = Tig; R_3 = R_4 = H; R_5 = OAc	*Trichilia sinensis*[342]
781	Trichinenlide O	R_1 = OH; R_2 = $COCHCHCH_3$; R_3 = OAc; R_4 = Ac; R_5 = OAc	*Trichilia sinensis*[342]
782	Trichinenlide P	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OAc; R_4 = Ac; R_5 = OAc	*Trichilia sinensis*[342]
783	Trichinenlide Q	R_1 = OH; R_2 = Tig; R_3 = R_4 = H; R_5 = $OCOCH(CH_3)_2$	*Trichilia sinensis*[342]
784	Trichinenlide R	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = Tig; R_5 = OAc	*Trichilia sinensis*[342]
785	Trichinenlide S	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = Tig; R_5 = OAc	*Trichilia sinensis*[342]
786	Cipadessain I	R_1 = H; R_2 = Tig; R_3 = R_4 = R_5 = H	*Cipadessa cinerascens*[343]
787	Heytrijunolide A	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = H; R_5 = OH	*Heynea trijuga*[344]
788	Heytrijunolide B	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = Ac; R_5 = OH	*Heynea trijuga*[344]
789	Heytrijunolide C	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = Ac; R_5 = OAc	*Heynea trijuga*[344]
790	Godavarin J	R_1 = H; R_2 = Ac; R_3 = R_4 = R_5 = H	*Xylocarpus moluccensis*[336]
791	Trichinenlide W	R_1 = OH; R_2 = Tig	*Trichilia sinensis*[341]
792	Granatumin U	R_1 = H; R_2 = Ac	*Xylocarpus granatum*[345]
793	Xylomolin E	R_1 = OH; R_2 = Ac; R_3 = OAc; R_4 = H; R_5 = OH	*Xylocarpus moluccensis*[143]
794	Khasenegasin S	R_1 = H; R_2 = Ac; R_3 = H; R_4 = OH; R_5 = H	*Khaya senegalensis*[268]
795	Cipadessain A	R_1 = H; R_2 = Tig; R_3 = H; R_4 = OH; R_5 = H	*Cipadessa cinerascens*[343]
796	Cipadessain B	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = H; R_5 = OH	*Cipadessa cinerascens*[343]
797	Hainanxylogranin J	R_1 = OAc; R_2 = Ac; R_3 = OH; R_4 = R_5 = H	*Xylocarpus granatum*[152]
798	Hainanxylogranin K	R_1 = OAc; R_2 = Ac; R_3 = H; R_4 = R_5 = H	*Xylocarpus granatum*[152]
799	Hainanxylogranin L	R_1 = H; R_2 = Bz; R_3 = H; R_4 = R_5 = H	*Xylocarpus granatum*[152]
800	Swietemacrolide A	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OAc	*Swietenia macrophylla*[316]
801	Swietemacrolide B	R_1 = H; R_2 = $COC(CH_3)CH_2$; R_3 = OAc	*Swietenia macrophylla*[316]
802	Swieteliacate C	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = H	*Swietenia macrophylla*[116]
803	6-*O*-acetylswietenin B	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = OAc	*Swietenia macrophylla*[338]
804	Febrifugin	R_1 = H; R_2 = Tig; R_3 = H	*Swietenia mahogani*[339]
805	Swietenine	R_1 = H; R_2 = Tig; R_3 = β-OH	*Swietenia mahogani*[339]
806	Swietenine acetate	R_1 = H; R_2 = Tig; R_3 = β-$OCOCH_3$	*Swietenia mahogani*[339]
807	Khasenegasin R	R_1 = R_2 = H; R_3 = β-OAc	*Khaya senegalensis*[268]
808	3-de(2-methylbutanoyl)-3-propanoylcipadesin	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = H	*Cipadessa cinerascens*[346]
809	2-hydroxy-6-deacetoxyswietenine	R_1 = OH; R_2 = Tig; R_3 = H	*Swietenia mahogani*[347]
810	Granatumin H	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H	*Xylocarpus granatum*[348]
811	Granatumin I	R_1 = H; R_2 = $COC(CH_3)CH_2$; R_3 = H	*Xylocarpus granatum*[348]
812	Trichiconnarone A	R_1 = OH; R_2 = $COCHCHCH_3$; R_3 = H	*Trichilia connaroides*[349]
813	Trichiconnarone B	R_1 = OH; R_2 = $COC(CH_3)CH_2$; R_3 = H	*Trichilia connaroides*[349]
814	Humilinolide E	R_1 = OH; R_2 = Tig; R_3 = $OCOCH_3$	*Guarea kunthiana*[350]
815	methyl 2-hydroxy-3b-tigloyloxy-1-oxomeliac-8(30)-enate	R_1 = OH; R_2 = Tig; R_3 = H	*Guarea kunthiana*[350]
816	Swietenine acetate	R_1 = H; R_2 = Tig; R_3 = $OCOCH_3$	*Guarea kunthiana*[350]
817	Thaixylogranin E	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OAc	*Xylocarpus granatum*[351]
818	Thaixylogranin F	R_1 = H; R_2 = $COC(CH_3)CH_2$; R_3 = OAc	*Xylocarpus granatum*[351]
819	Khasenegasin Q	R = Ac	*Khaya senegalensis*[268]
820	Cipadessain K	R = Tig	*Cipadessa cinerascens*[343]
821	Xylomolin B1	R_1 = OH; R_2 = Ac; R_3 = H	*Xylocarpus moluccensis*[143]
822	Xylomolin B2	R_1 = R_2 = R_3 = H	*Xylocarpus moluccensis*[143]
823	Heytrijunolide E	R_1 = OH; R_2 = H; R_3 = OH	*Heynea trijuga*[344]
824	Xylomolin C1	R_1 = OH; R_2 = Ac; R_3 = OH	*Xylocarpus moluccensis*[143]
825	Xylomolin C2	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H	*Xylocarpus moluccensis*[143]
826	6-O-Acetyl-6-dehydroxymoluccensin T	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = OAc	*Xylocarpus moluccensis*[352]
827	Swielimonoid A	R_1 = H; R_2 = Tig; R_3 = OH	*Swietenia macrophylla*[353]
828	3-*O*- methylbutyrylseneganolide A	R_1 = H; R_2 = $COCH_2CH(CH_3)_2$; R_3 = H	*Khaya ivorensis*[354]
829	Moluccensin T	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = OH	*Xylocarpus moluccensis*[340]
830	Moluccensin U	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OH	*Xylocarpus moluccensis*[340]
831	Thaixylogranin G	R_1 = H; R_2 = Ac; R_3 = OH	*Xylocarpus granatum*[351]
832	Thaixylogranin H	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OH	*Xylocarpus granatum*[351]
833	Thaigranatin J	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OAc	*Xylocarpus granatum*[153]
834	Trichanolide F	R_1 = OH; R_2 = Tig; R_3 = β-OH	*Trichilia connaroides*[355]

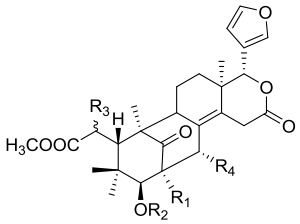
835	Hainanxylogranin M	R_1 = OAc; R_2 = Ac; R_3 = H	*Xylocarpus granatum*[152]
836	Trichinenlide V		*Trichilia sinensis*[341]
837	Sundarbanxylogranin B	R_1 = H; R_2 = Ac; R_3 = H	*Xylocarpus granatum*[356]
838	Khasenegasin O	R_1 = R_2 = R_3 = H	*Khaya senegalensis*[268]
839	14,15-didehydroruageanin A	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H	*Khaya ivorensis*[354]
840	Thaixylogranin A	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OH	*Xylocarpus granatum*[351]
841	Thaixylogranin B	R_1 = H; R_2 = Ac; R_3 = OAc	*Xylocarpus granatum*[351]
842	Thaigranatin L	R_1 = H; R_2 = Ac; R_3 = β-OH	*Xylocarpus granatum*[153]
843	Hainanxylogranin P	R_1 = H; R_2 = $COCH(\alpha\text{-}CH_3)CH_2CH_3$; R_3 = H	*Xylocarpus granatum*[152]
844	Trichanolide G	R_1 = OH; R_2 = Tig; R_3 = β-OH	*Trichilia connaroides*[355]
845	Mexicanolide I	R_1 = OH; R_2 = R_3 = H	*Heynea trijuga*[357]
846	6-deoxyswietemahonin A	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = H	*Swietenia macrophylla*[338]
847	swietemahonin E	R_1 = H; R_2 = Tig; R_3 = β-OH	*Swietenia mahogani*[339]
848	Swietemacrophin	R_1 = OAc; R_2 = Tig; R_3 = H	*Swietenia macrophylla*[358]
849	Swielimonoid B	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OH	*Swietenia macrophylla*[353]
850	Trichinenlide H	R_1 = OH; R_2 = $COCHCHCH_3$; R_3 = OH	*Trichilia sinensis*[342]
851	Trichanolide	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H	*Trichilia connaroides*[359]
852	Heytrijunolide D	R_1 = OH; R_2 = $COCHCHCH_3$; R_3 = H	*Heynea trijuga*[344]
853	14-hydroxy-14,15-dihydrogranatumin C	R_1 = H; R_2 = Tig; R_3 = H	*Xylocarpus granatum*[154]
854	Thaixylogranin C	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = H	*Xylocarpus granatum*[351]
855	Trichinenlide I	R_1 = Tig; R_2 = H	*Trichilia sinensis*[342]
856	Trichinenlide J	R_1 = COCHCHCH3; R_2 = H	*Trichilia sinensis*[342]
857	Trichinenlide K	R_1 = Tig; R_2 = OH	*Trichilia sinensis*[342]
858	Trichinenlide B	R_1 = $COCHCHCH_3$; R_2 = H	*Trichilia sinensis*[342]
859	Trichinenlide C	R_1 = $COCHCHCH_3$; R_2 = OH	*Trichilia sinensis*[342]
860	Trichinenlide D	R_1 = Tig; R_2 = H	*Trichilia sinensis*[342]
861	Trichinenlide E	R_1 = Tig; R_2 = OH	*Trichilia sinensis*[342]
862	Cipadesin O	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = H	*Cipadessa baccifera*[203]
863	Xylorumphiin L		*Xylocarpus rumphii*[360]
864	Xylomexicanin I		*Xylocarpus granatum*[361]
865	6-O-Acetyl-2α-hydroxymexicanolide		*Xylocarpus moluccensis*[352]
866	Trichiconin A		*Trichilia connaroides*[323]
867	Godavarin C		*Xylocarpus moluccensis*[336]
868	Triconoid C		*Trichilia connaroides*[362]
869	Trichinenlide X	R_1 = OH; R_2 = Tig	*Trichilia sinensis*[341]
870	Moluccensin V	R_1 = H; R_2 = Ac	*Xylocarpus moluccensis*[340]
871	Godavarin A	R_1 = H; R_2 = Tig	*Xylocarpus moluccensis*[336]
872	Godavarin B	R_1 = H; R_2 = $COCH(CH_3)_2$	*Xylocarpus moluccensis*[336]
873	Thaigranatin K		*Xylocarpus granatum*[153]
874	Mexicanolide K		*Heynea trijuga*[357]
875	Mexicanolide J	R_1 = H; R_2 = OH	*Heynea trijuga*[357]
876	Xylorumphiin D	R_1 = OH; R_2 = H	*Xylocarpus rumphii*[363]
877	Andirolide N	R = OH	*Carapa guianensis*[264]
878	14-deoxy-Δ14,15-xyloccensin K	R = H	*Chisocheton erythrocarpus*[364]
879	Hainanxylogranin A	R_1 = R_2 = H	*Xylocarpus granatum*[152]
880	Hainanxylogranin B	R_1 = α-OAc; R_2 = H	*Xylocarpus granatum*[152]
881	Hainanxylogranin C	R_1 = OH; R_2 = H	*Xylocarpus granatum*[152]
882	Hainanxylogranin D	R_1 = H; R_2 = OH	*Xylocarpus granatum*[152]
883	Trichiliasinenoid E		*Trichilia sinensis*[365]
884	Cipadessain G	R = S-Methylbut	*Cipadessa cinerascens*[343]
885	Cipadessain H	R = Tig	*Cipadessa cinerascens*[343]
886	Cipaferen M	R1 = $COCH(CH_3)CH_2CH_3$; R_2 = OH	*Cipadessa baccifera*[308]
887	Cipadessain D/21-deoxo-23-oxofebrifugin A	R1 = Tig; R_2 = H	*Cipadessa cinerascens*[343]/ *Cipadessa baccifera*[366]
888	3-O-detigloyl-3-O-isobutyryl-21-deoxo-23-oxofebrifugin A	R_1 = $COCH(CH_3)_2$; R_2 = H	*Cipadessa baccifera*[366]
889	3-O-detigloyl-3-O-isobutyrylgranatumin E	R_1 = $COCH(CH_3)_2$; R_2 = α-OH	*Cipadessa baccifera*[366]
890	3-O-detigloyl-3-O-isobutyryl-21-O-methylgranatumin E	R_1 = $COCH(CH_3)_2$; R_2 = $\alpha\text{-}OCH_3$	*Cipadessa baccifera*[366]
891	3-O-detigloyl-3-O-propanoylgranatumin E	R_1 = $COCH_2CH_3$; R_2 = H	*Cipadessa baccifera*[366]
892	21-O-methylgranatumin E	R_1 = Tig; R_2 = $\alpha\text{-}CH_3$	*Cipadessa baccifera*[366]
893	Swieteliacate D	R_1 = H; R_2 = β-OH	*Swietenia macrophylla*[116]
894	Cipadessain J	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = H	*Cipadessa cinerascens*[343]
895	Khaysenelide A	R = H	*Khaya senegalensis*[367]
896	Khaysenelide B	R = CH_3	*Khaya senegalensis*[367]
897	3-deacetyl-8-hydro-cabralin-14,15-en-3-one		*Aphanamixis polystachya*[368]
898	8-hydro-14,15-en-cabralin	R_1 = Ac; R_2 = H	*Aphanamixis polystachya*[368]

899	Hainanxylogranin N	R_1 = Tig; R_2 = α-OH	*Xylocarpus granatum*[152]
900	Hainanxylogranin O	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = α-OH	*Xylocarpus granatum*[152]
901	Cipaferen K	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = R_4 = R_5 = H	*Cipadessa baccifera*[308]
902	Cipaferen L	R_1 = H; R_2 = Tig; R_3 = R_4 = R_5 = H	*Cipadessa baccifera*[308]
903	Trichinenlide T	R_1 = OH; R_2 = Tig; R_3 = R_4 = R_5 = OAc	*Trichilia sinensis*[342]
904	Thaixylomolin V	R_1 = OH; R_2 = Ac; R_3 = OAc; R_4 = R_5 = H	*Xylocarpus moluccensis*[337]
905	Cipadessain F	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = CH_3	*Cipadessa cinerascens*[343]
906	21-oxo-23-hydroxylruageanin A	R_1 = $COCH(CH_3)_2$; R_2 = H	*Cipadessa baccifera*[366]
907	3-O-detigloyl-3-O-(2′R-methylbutanoyl)-21-oxo-23-hydroxylruageanin A	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = H	*Cipadessa baccifera*[366]
908	3-O-deisobutyryl-3-O-tigloyl-14,15-dedihydro-21-oxo-23-hydroxylruageanin A		*Cipadessa baccifera*[366]
909	Khasenegasin T	R_1 = R_2 = R_3 = R_4 = OH	*Khaya senegalensis*[268]
910	Khasenegasin U	R_1 = H; R_2 = β-OAc; R_3 = R_4 = OH	*Khaya senegalensis*[268]
911	Khasenegasin V	R_1 = R_2 = H; R_3 = OAc; R_4 = OH	*Khaya senegalensis*[268]
912	Cipadessain C	R_1 = Tig; R_2 = R_3 = R_4 = OH	*Cipadessa cinerascens*[343]
913	Cipadessain E	R_1 = $COCH_2CH_3$; R_2 = R_3 = R_4 = OH	*Cipadessa cinerascens*[343]
914	3-O-detigloyl-3-O-isobutyrylfebrifugin A	R_1 = $COCH(CH_3)_2$; R_2 = R_3 = H; R_4 = α-OH	*Cipadessa baccifera*[366]
915	3-O-detigloyl-3-O-isobutyryl-23-O-methylfebrifugin A	R_1 = $COCH(CH_3)_2$; R_2 = R_3 = H; R_4 = α-OCH_3	*Cipadessa baccifera*[366]
916	Andirolide U/ Ivorenoid G	R_1 = OAc; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = H	*Carapa guianensis*[149]/ *Chukrasia tabularis*[335]
917	Xylorumphiin A	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = $OCOCH(CH_3)_2$	*Xylocarpus rumphii*[363]
918	Xylorumphiin B	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$, 2'S; R_3 = H; R_4 = $OCOCH(CH_3)_2$	*Xylocarpus rumphii*[363]
919	Xylorumphiin E	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = $OCOCH(CH_3)_2$	*Xylocarpus rumphii*[369]
920	Xylorumphiin F	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = $OCOCH(CH_3)CH_2CH_3$ 2'S	*Xylocarpus rumphii*[369]
921	2-hydroxy xylorumphiin F	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = $OCOCH(CH_3)CH_2CH_3$, 2'S	*Xylocarpus rumphii*[369]
922	Xylorumphiin G	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$, 2'S; R_3 = H; R_4 = $OCOCH(CH_3)CH_2CH_3$, 2'S	*Xylocarpus rumphii*[369]
923	Xylorumphiin H	R_1 = OH; R_2 = Ac; R_3 = H; R_4 = $OCOCH(CH_3)_2$	*Xylocarpus rumphii*[369]
924	Carapanin C	R_1 = OAc; R_2 = Tig; R_3 = R_4 = H	*Carapa guianensis*[370]
925	Chukorthoester G	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OH; R_4 = H	*Chukrasia tabularis*[371]
926	Chukorthoester H	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = OH; R_4 = H	*Chukrasia tabularis*[371]
927	Xylomolin F	R_1 = OH; R_2 = Ac; R_3 = OH; R_4 = $COCH(CH_3)_2$	*Xylocarpus moluccensis*[143]
928	Xylorumphiin K	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = $COCH(CH_3)CH_2CH_3$	*Xylocarpus rumphii*[360]
929	Carapanolide F	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = $COCH(CH_3)CH_2CH_3$	*Carapa guianensis*[333]
930	Carapanolide G	R_1 = OH; R_2 = Tig; R_3 = H; R_4 = $COCH(CH_3)_2$	*Carapa guianensis*[333]
931	Xylogranin A	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = $COCH(CH_3)_2$	*Xylocarpus granatum*[372]
932	Xylomexicanin D	R_1 = H; R_2 = Ac; R_3 = H; R_4 = $COCH(CH_3)_2$	*Xylocarpus granatum*[373]
933	Xylorumphiin C	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = $COCH(CH_3)_2$	*Xylocarpus rumphii*[363]
934	Xylorumphiin I	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = $COCH(CH_3)CH_2CH_3$	*Xylocarpus rumphii*[369]
935	Thaixylomolin T	R_1 = OH; R_2 = Ac; R_3 = OH; R_4 = $COCH(CH_3)CH_2CH_3$	*Xylocarpus moluccensis*[337]
936	Hainanxylogranin F	R_1 = H; R_2 = Tig; R_3 = α-OH; R_4 = Ac	*Xylocarpus granatum*[152]
937	Hainanxylogranin G	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OH; R_4 = AC	*Xylocarpus granatum*[152]
938	Hainanxylogranin E	R = OH	*Xylocarpus granatum*[152]
939	Hainanxylogranin H	R = α-OCH_3	*Xylocarpus granatum*[152]
940	Hainanxylogranin I		*Xylocarpus granatum*[152]
941	Sundarbanxylogranin E	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = H	*Xylocarpus granatum*[356]
942	Xylomexicanin J	R_1 = Ac; R_2 = H	*Xylocarpus granatum*[361]
943	Granatumin P	R_1 = Ac; R_2 = H	*Xylocarpus granatum*[345]

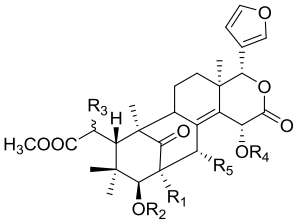
944	Granatumin Q	R_1 = $COC(CH_3)CH_2$; R_2 = H	*Xylocarpus granatum*[345]
945	Hainangranatumin F	R_1 = $COCH_2CH_3$; R_2 = H	*Xylocarpus granatum*[374]
946	Godavarin F	R_1 = $COCH(CH_3)_2$; R_2 = H	*Xylocarpus moluccensis*[336]
947	Hainanxylogranin U	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = α-OH	*Xylocarpus granatum*[152]
948	Sundarbanxylogranin C	R_1 = Tig; R_2 = α-OCH_3	*Xylocarpus granatum*[356]
949	Sundarbanxylogranin D	R_1 = $COCH(CH_3)_2$; R_2 = β-OCH_3	*Xylocarpus granatum*[356]
950	Moluccensin W	R_1 = Tig; R_2 = β-OCH_3	*Xylocarpus moluccensis*[340]
951	Krishnagranatin E	R_1 = R_2 = α-OH	*Xylocarpus granatum*[375]
952	Krishnagranatin F	R_1 = R_2 = β-OH	*Xylocarpus granatum*[375]
953	Godavarin G	R_1 = $COCH(CH_3)_2$; R_2 = α-OCH_3	*Xylocarpus moluccensis*[336]
954	Thaixylogranin D	R_1 = Tig; R_2 = β-OCH_2CH_3	*Xylocarpus granatum*[351]
955	Granatumin R	R = Tig	*Xylocarpus granatum*[345]
956	Granatumin S	R = $COCH(CH_3)_2$	*Xylocarpus granatum*[345]
957	Thaigranatin I	R = Ac	*Xylocarpus granatum*[153]
958	GranatuminT	R = Ac	*Xylocarpus granatum*[345]
959	Godavarin K	R = Tig	*Xylocarpus moluccensis*[130]
960	Krishnagranatin B	R_1 = Tig; R_2 = H	*Xylocarpus granatum*[375]
961	Krishnagranatin C	R_1 = $COCH(CH_3)_2$; R_2 = H	*Xylocarpus granatum*[375]
962	Krishnagranatin D	R_1 = Ac; R_2 = OH	*Xylocarpus granatum*[375]
963	Erythrocarpine F	R_1 = Bz; R_2 = H	*Chisocheton erythrocarpus*[364]
964	Swietemacrolide C	R_1 = H; R_2 = α-OH; R_3 = H	*Swietenia macrophylla*[316]
965	Granatumin N	R_1 = Ac; R_2 = R_3 = H	*Xylocarpus granatum*[345]
966	Granatumin O	R_1 = $COC(CH_3)CH_2$; R_2 = R_3 = H	*Xylocarpus granatum*[345]
967	Thaigranatin C	R_1 = Tig; R_2 = R_3 = H	*Xylocarpus granatum*[376]
968	Thaigranatin D	R_1 = Tig; R_2 = OH; R_3 = H	*Xylocarpus granatum*[376]
969	Erythrocarpine G	R_1 = Bz; R_2 = R_3 = H	*Chisocheton erythrocarpus*[364]
970	Erythrocarpine H	R_1 = Cin; R_2 = R_3 = H	*Chisocheton erythrocarpus*[364]
971	Godavarin D	R_1 = Tig; R_2 = R_3 =H	*Xylocarpus moluccensis*[336]
972	Godavarin E	R_1 = $COCH(CH_3)_2$; R_2 = R_3 = H	*Xylocarpus moluccensis*[336]
973	Thaigranatin H	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = OH; R_3 = H	*Xylocarpus granatum*[153]
974	Thaigranatin G	R_1 = Tig; R_2 = H; R_3 = OH	*Xylocarpus granatum*[153]
975	Thaigranatin E		*Xylocarpus granatum*[376]
976	Granatumin L	R_1 = H; R_2 = Tig; R_3 = R_4 = H	*Xylocarpus granatum*[345]
977	Granatumin M	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = R_4 = H	*Xylocarpus granatum*[345]
978	Granatumin V	R_1 = H; R_2 = Ac; R_3 = R_4 = H	*Xylocarpus granatum*[377]
979	Granatumin W	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = H	*Xylocarpus granatum*[377]
980	Granatumin X	R_1 = H; R_2 = $COC(CH_3)CH_2$; R_3 = R_4 = H	*Xylocarpus granatum*[377]
981	Granatumin Y	R_1 = H; R_2 = Tig; R_3 = H; R_4 = OH	*Xylocarpus granatum*[377]
982	Thaimoluccensin B	R_1 = OH; R_2 = Ac; R_3 = R_4 = H	*Xylocarpus moluccensis*[317]
983	Krishnagranatin A	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H; R_4 = OH	*Xylocarpus granatum*[375]
984	Thaigranatin A	R_1 = H; R_2 = Tig; R_3 = β-OH; R_4 = H	*Xylocarpus granatum*[376]
985	Thaigranatin B	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = R_4 = H	*Xylocarpus granatum*[376]
986	Xylomexicanin G	R_1 = H; R_2 = Ac; R_3 = R_4 = H	*Xylocarpus granatum*[378]
987	Xylomexicanin H	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = R_4 = H	*Xylocarpus granatum*[378]
988	Carapanin B		*Carapa guianensis*[370]
989	Thaigranatin F		*Xylocarpus granatum*[153]



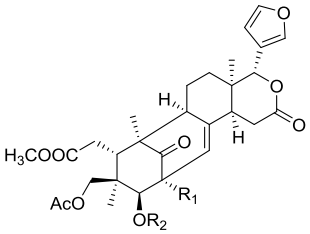
735-758



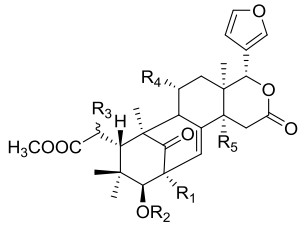
759-775



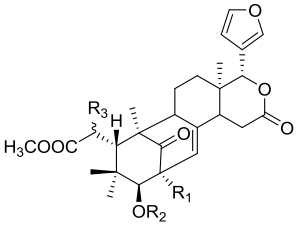
776-790



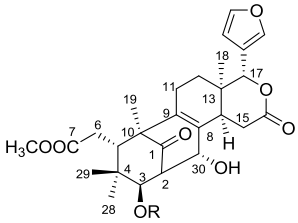
791-792



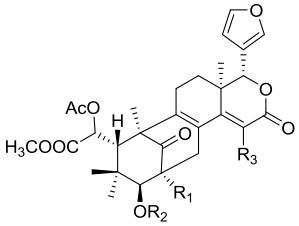
793-799



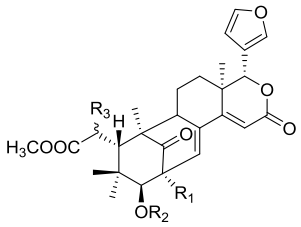
800-818



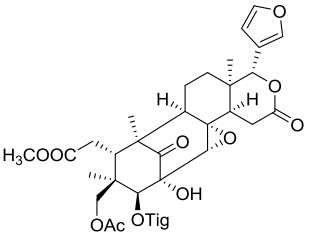
819-820



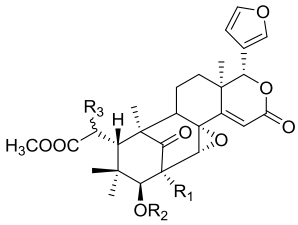
821-823



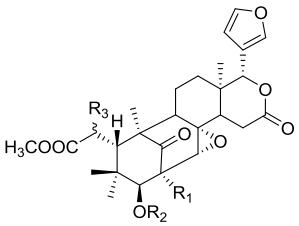
824-835



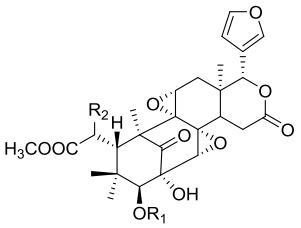
836



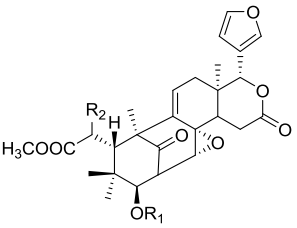
837-844



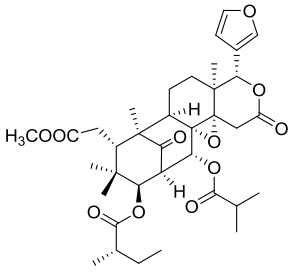
845-854



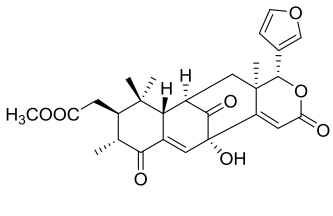
855-857



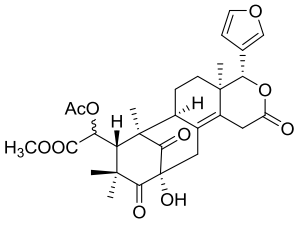
858-862



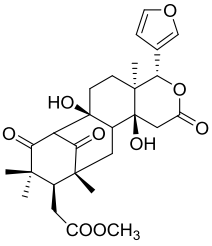
863



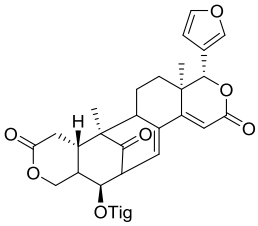
864



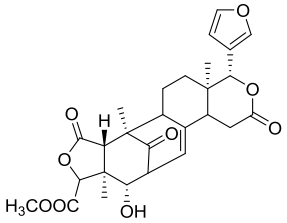
865



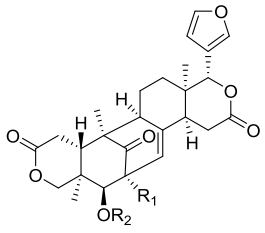
866



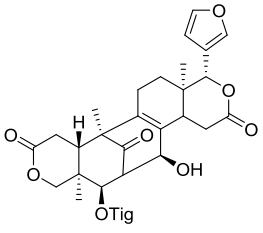
867



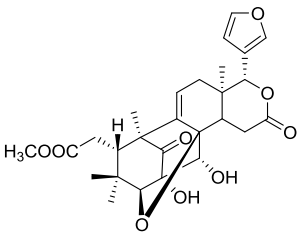
868



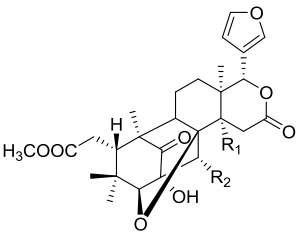
869-872



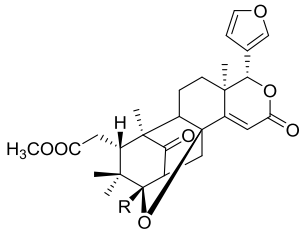
873



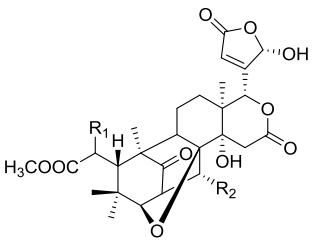
874



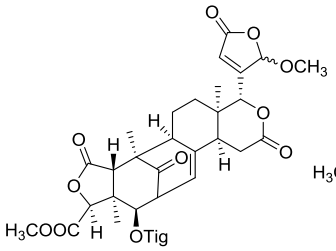
875-876



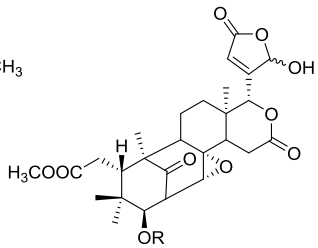
877-878



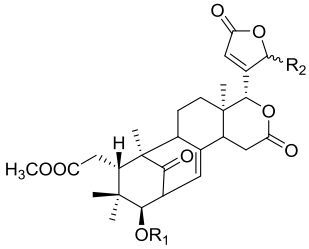
879-882



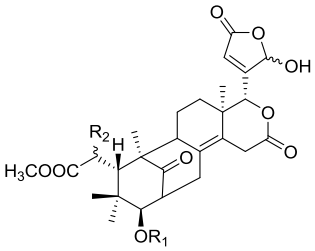
883



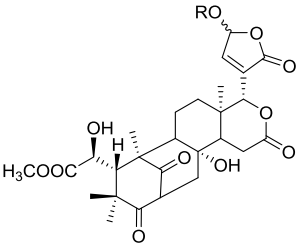
884-885



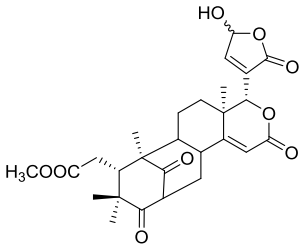
886-892



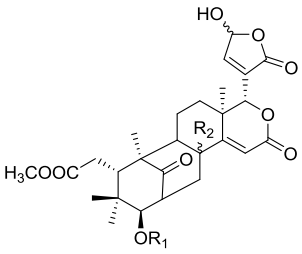
893-894



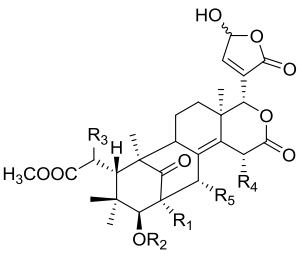
895-896



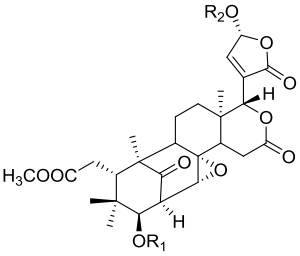
897



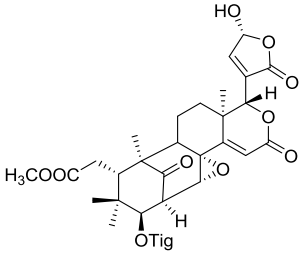
898-900



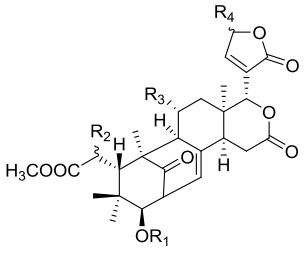
901-904



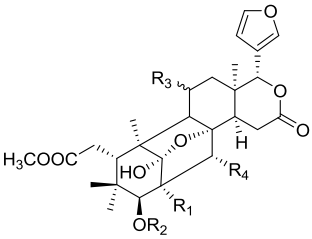
905-907



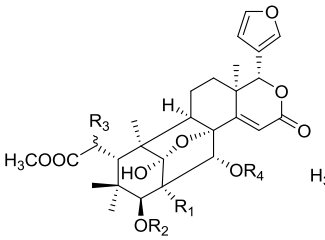
908



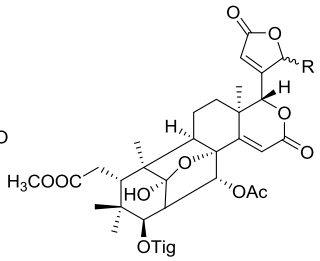
909-915



916-926



927-937



938-939

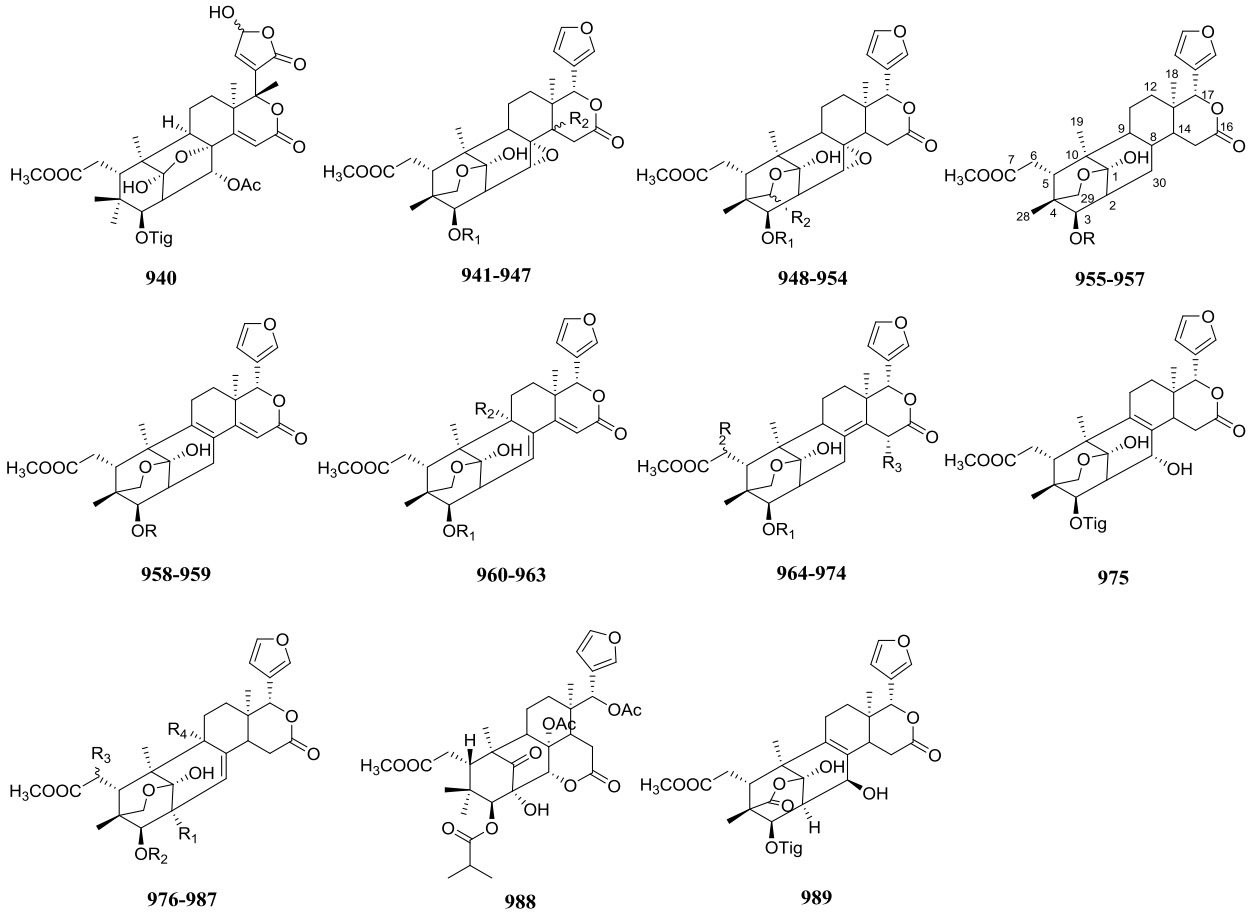


Figure 37. Structures of mexicanolide class limonoids **735-989**.

2.4.1.2. 9,10-seco-Mexicanolide

This class is characterized by cleavage of C9-C10 bonds. Eighteen compounds were assigned in this class which were isolated from *Xylocarpus granatum, Xylocarpus moluccensis*, *Entandrophragma angolense* and *Carapa guianensis* (Table 36/S36, Figure 38). A total of twenty one limonoids belonging to this class were reported previously from Meliaceae family[12]. Xylomexicanin C (**990**) is structurally similar to previously reported Xylomexicanin A[379]. Hainangranatumin A and B (**991** and **992**) are C2' epimers but differ from compound (**990**) at C30-O by presence of methacrylate group whereas Hainangranatumin C (**993**) has propyl group at C30-O. The $\Delta^{14,15}$ double bond in compound (**993**) is reduced in Hainangranatumin D (**994**) containing acetoxylated C30. The structure of Hainangranatumin I (**995**) differs from compound (**993**) by flipping at C8 and C9. Hainangranatumin J (**996**) and 30-O-tigloylhainangranatumin J (**997**) are C30-O isopropyl and tigloyl analogs of compound (**995**) respectively. Xylomexicanin F (**998**) is C18 β-CH_3, C19 α-CH_3 and C8 β-OH, C30 detigloyl epimer of compound (**997**). In Thaixylomolin Q (**999**), C2/C30/C8 bridge is formed between A and C rings. The keto carbonyl group at C1 in compound (**999**) is replaced by $\Delta^{1,2}$ double bond in Entangolensin A (**1000**) which also have additional hydroxyl group at C10 followed by dehydroxylation and deacetoxylation at C2 and C6 respectively. The furan ring in compound (**994**) is replaced by γ-hydroxy butenolide group in Hainangranatumin E (**1001**) and 30-O-acetylhainangranatumin E (**1002**). Carapanolide A and B (**1003** and **1004**) have ether linkage between C2 and C9. 9-epixylograntinA (**1005**) is C9 epimer of previously reported Xylogranatin A[380]. The $\Delta^{1,10}$ and $\Delta^{14,15}$ double bonds in compound (**1005**) are reduced in Xylogranatumin A (**1006**) with ether bridge formation between C1 and C8. 9-O-methyl xylogranatin R (**1007**) is C9 methyl ester analog of previously reported xylogranatin R[381].

Table 36. 9,10-seco-Mexicanolide class limonoid 990-1007

No.	Limonoid	Substituent	Source
990	Xylomexicanin C	R = $COCH(CH_3)_2$	*Xylocarpus granatum*[373]
991	Hainangranatumin A	R = $COCH(CH_3)CH_2CH_3$; 2'R	*Xylocarpus granatum*[374]
992	Hainangranatumin B	R = $COCH(CH_3)CH_2CH_3$; 2'S	*Xylocarpus granatum*[374]
993	Hainangranatumin C	R = $COCH_2CH_3$	*Xylocarpus granatum*[374]
994	Hainangranatumin D		*Xylocarpus granatum*[374]
995	Hainangranatumin I	R = $COCH_2CH_3$	*Xylocarpus granatum*[374]
996	Hainangranatumin J	R = $COCH(CH_3)_2$	*Xylocarpus granatum*[374]
997	30-O-tigloylhainangranatumin J	R = Tig	*Xylocarpus granatum*[154]
998	Xylomexicanin F		*Xylocarpus granatum*[378]
999	Thaixylomolin Q		*Xylocarpus moluccensis*[382]
1000	Entangolensin A		*Entandrophragma angolense*[141]
1001	Hainangranatumin E	R = $COCH(CH_3)CH_2CH_3$; 2'S	*Xylocarpus granatum*[374]
1002	30-O-acetylhainangranatumin E	R = Ac	*Xylocarpus granatum*[154]
1003	Carapanolide A	R = $COCH(CH_3)_2$	*Carapa guianensis*[383]
1004	Carapanolide B	R = Tig	*Carapa guianensis*[383]
1005	9-epixylogranatinA		*Xylocarpus granatum*[154]
1006	Xylogranatumin A		*Xylocarpus granatum*[154]
1007	9-O-methyl xylogranatin R		*Xylocarpus granatum*[154]

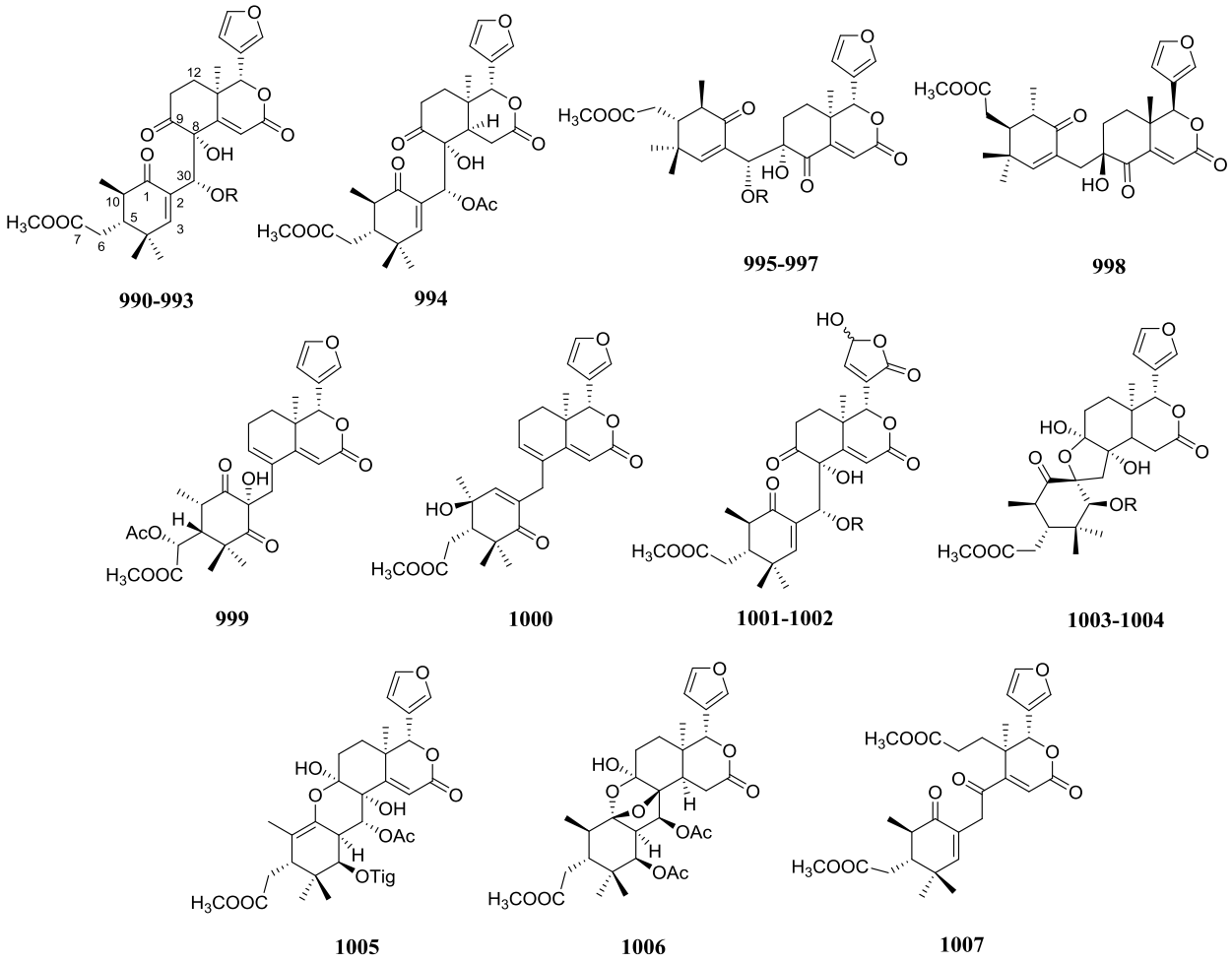


Figure 38. Structures of 9,10-seco mexicanolide class limonoids **990-1007**.

2.4.1.3. Phragmalin

2.4.1.3.1. Phragmalin orthoester

2.4.1.3.1.1. (1-8-9) Phragmalin orthoester

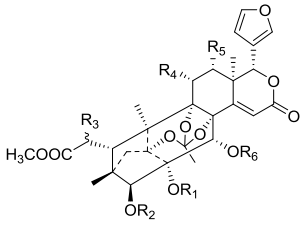
This class of Limonoid is characterized by presence of ortho-acetate groups at C1, C8 and C9. A total of 118 compounds belonging to this class were isolated from *Carapa guianensis, Swietenia macrophylla, Chukrasia tabularis, Soymida febrifuga, Xylocarpus rumphii, Xylocarpus granatum, Entandrophragma candollei, Neobeguea mahafalensis* and *Entandrophragma utile* (Table 37/S37, Figure 39). Sixty five Meliaceae limonoids belonging to this class were reported earlier[12]. Compounds (**1008-1019**) are structurally similar to previously reported Febrinin A[384] but differ in substitution at A and C rings. The $\Delta^{14,15}$ double bond in compound (**1019**) is replaced by exocyclic double bond at C15 in Chukrasine F (**1020**) and Velutinasin A (**1021**). Chubularisin J (**1022**) has cyclopropyl ring at C13-C14 and Chubularisin K (**1023**) is deacetyl derivative of compound (**1022**). Chukorthoester F (**1024**) is C12 deacetyl analog of compound (**1023**). The $\Delta^{14,15}$ double bond in compound (**1019**) is reduced in compounds (**1025-1030**) with substituent variation at C2, C3, C12, C15, C30 in compounds (**1025**, **1028**) and at C30 in compounds (**1029**, **1030**). Compounds (**1031-1047**) are structural analogs of compound (**1008**) with reduced $\Delta^{14,15}$ double bond. Five and six membered lactone rings are formed between C5-C10 in Chukbularisin B (**1048**) and Swietenitin R-S (**1049**, **1050**) respectively. Limonoids (**1051-1060**) differ from compound (**1049**) at C2, C3, and C30 substitution but limonoids (**1056-1060**) have additional substitution at C12 and $\Delta^{14,15}$ double bond. The lactone moiety at D ring in compound (**1048**) is cleaved in Carapanosin D (**1061**). Dormir F (**1062**) contains a cleaved D ring with an ether bridge formed between C11 and C19 which is shifted to C11/12 in Dormir G (**1063**). The five membered lactone ring in compound (**1061**) is six membered in Andirolide O and P (**1064** and **1065**). The epoxide ring at C11/12 in compound (**1063**) is replaced by acetoxyl group at C11 in compounds (**1066**, **1067**). At C3, the 2-methyl butenolide group in Dodoguin (**1066**) is replaced by isopropyl group in Dormir A (**1067**). Encandollen C (**1068**) is C2, C3 di-acetyl, C11 deacetoxyl, C30 propionate analog of compound (**1066**). Encandollen D (**1069**) is C3 propionate, C30 acetyl analog of compound (**1068**). Encandollen E (**1070**) is C3 isopropionate analog of compound (**1068**). Dormir B and C (**1071** and **1072**) are analogs of compounds (**1066** and **1067**) respectively with an additional six membered lactone ring formed between C6 and C19. Libiguin B (**1073**) exists in keto-enol form with a lactone ring formed between C16 and C30. The isopropyl group at C15 in compound (**1073**) is replaced by methyl group in Chukvelutilide I-P (**1074-1081**) with substituent variation in C2, C11 and C19. Dormir E (**1082**) and Libiguin A (**1083**) are structural analogs of compounds (**1066**, **1067**) respectively, and have six membered lactone ring formed between B and C ring junctions with deacetoxylation at C11. The keto carbonyl at C17 in Dormir E (**1082**) is replaced by acetoxyl group in Limonoids (**1084-1088**). In comparison to compound (**1074**), Limonoids (**1089-1094**) exist in enol form with six membered lactone ring formed at A ring. Compounds (**1095-1117**) are structurally similar to compound (**1073**) with substituent variation at A and C rings. Guianolide B (**1119**) is deacetyl form of Guianolide A (**1118**) which is structurally similar to Guianofruit E (**1120**) except at C30 substitution. Chubularisin B (**1121**) differs from compound (**1012**) at C31 substitution. Chukfuransin B (**1123**) is the C12 acetoxyl form of Chukfuransin A (**1122**). The structures of Chukfuransin C and D (**1124** and **1125**) were determined by X-ray crystallographic studies.

Table 37. [1-8-9] Phragmalin orthoester class limonoid 1008-1125

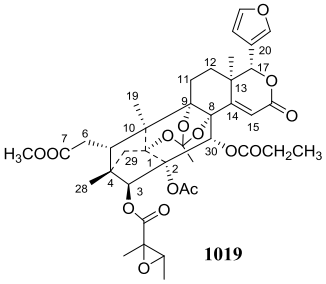
No.	Limonoid	Substituent	Source
1008	Carapanosin A	R_1 = H; R_2 = Ac; R_3 = β-OH; R_4 = H; R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[262]
1009	Carapanosin B	R_1 = H; R_2 = Ac; R_3 = β-OAc; R_4 = H; R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[262]
1010	Carapanolide W	R_1 = H; R_2 = Ac; R_3 = R_4 = H; R_5 = OH; R_6 = $COCH_2CH_3$	*Carapa guianensis*[332]
1011	Carapanolide I	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = R_5 = H; R_6= Ac	*Carapa guianensis*[333]
1012	Swietenitin Q	R_1 = Ac; R_2 = Tig; R_3 = R_4 = H; R_5 = OH; R_6 = H	*Swietenia macrophylla*[385]
1013	Carapanolide Y	R_1 = H; R_2 = Ac; R_3 = H; R_4 = OH; R_5 = $OCOCH(CH_3)_2$; R_6 = $COCH(CH_3)_2$	*Chukrasia tabularis*[386]
1014	Guianofruit F	R_1 = R_2 = Ac; R_3 = R_4 = H; R_5 = OH; R_6 = $COCH_2CH_3$	*Carapa guianensis*[297]
1015	Guianofruit G	R_1 = R_2 = Ac; R_3 = R_4 = H; R_5 = OH; R_6 = $COCH(CH_3)_2$	*Carapa guianensis*[297]
1016	Entanutilin E	R_1 = R_2 = R_3 = H; R_4 = OH; R_5 = OAc; R_6 = $COCH(CH_3)_2$	*Entandrophragma utile*[387]
1017	Chukorthoester C	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = H; R_5 = OAc; R_6 = $COCH(CH_3)_2$	*Chukrasia tabularis*[371]
1018	Chukorthoester D	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = H; R_5 = OAc; R_6 = $COCH_2CH_3$	*Chukrasia tabularis*[371]
1019	Soymidin D		*Soymida febrifuga*[388]
1020	Chukrasine F	R_1 = H; R_2 = CH_3	*Chukrasia tabularis*[389]
1021	Velutinasin A	R_1 = OAc; R_2 = H	*Chukrasia tabularis*[390]
1022	Chubularisin J	R_1 = R_2 = Ac	*Chukrasia tabularis*[391]
1023	Chubularisin K	R_1 = H; R_2 = Ac	*Chukrasia tabularis*[391]
1024	Chukorthoester F	R_1 = H; R_2 = H	*Chukrasia tabularis*[371]
1025	Xylorumphiin J	R_1 = R_2 = Ac; R_3 = H; R_4 = β-OH; R_5 = Ac	*Xylocarpus rumphii*[369]
1026	Soymidin A	R_1 = H; R_2 = Tig; R_3 = H; R_4 = β-$OCOCH_2CH_3$; R_5 = H	*Soymida febrifuga*[392]
1027	Chukorthoester A	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OAc; R_4 = α-$OCOCH(CH_3)_2$; R_5 = $COCH(CH_3)_2$	*Chukrasia tabularis*[371]

1028	Chukorthoester B	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OAc; R_4 = α-$OCOCH(CH_3)_2$; R_5 = $COCH_2CH_3$	*Chukrasia tabularis*[371]
1029	Swietenitin N	R = $COCH_2CH_3$	*Swietenia macrophylla*[385]
1030	Swietenitin O	R = Ac	*Swietenia macrophylla*[385]
1031	Carapanolide X	R_1 = H; R_2 = Ac; R_3 = β-OH; R_4 = R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[332]
1032	Velutinasin E	R_1 = H; R_2 = Ac; R_3 = OH; R_4 = OH; R_5 = OAc; R_6 = $COCH_2CH_3$	*Chukrasia tabularis*[390]
1033	Swietenitin P	R_1 = Ac; R_2 = Tig; R_3 = OH; R_4 = R_5 = H; R_6 = $COCH_2CH_3$	*Swietenia macrophylla*[385]
1034	Chuktabularoid J	R_1 = H; R_2 = Ac; R_3 = R_4 = OH; R_5 = OAc; R_6 = H	*Chukrasia tabularis*[393]
1035	Carapanolide M	R_1 = H; R_2 = Ac; R_3 = R_4 = OH; R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[334]
1036	Carapanolide N	R_1 = H; R_2 = Ac; R_3 = β-OAc; R_4 = R_5 = OAc; R_6 = $COCH(CH_3)_2$	*Carapa guianensis*[334]
1037	Carapanolide O	R_1 = H; R_2 = Ac; R_3 = β-OAc; R_4 = OH; R_5 = OAc; R_6 = $COCH(CH_3)_2$	*Carapa guianensis*[334]
1038	Carapanolide P	R_1 = H; R_2 = Ac; R_3 = β-OAc; R_4 = OH; R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[334]
1039	Carapanolide Q	R_1 = H; R_2 = Ac; R_3 = β-OAc; R_4 = H; R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[334]
1040	Guianofruit H	R_1 = H; R_2 = Ac; R_3 = R_4 = OH; R_5 = OAc; R_6 = $COCH(CH_3)_2$	*Carapa guianensis*[297]
1041	Guianofruit I	R_1 = H; R_2 = Ac; R_3 = β-OAc; R_4 = R_5 = OAc; R_6 = $COCH_2CH_3$	*Carapa guianensis*[297]
1042	Hainangranatumin H	R_1 = Ac; R_2 = H; R_3 = β-OAc; R_4 = H; R_5 = OAc; R_6 = Ac	*Xylocarpus granatum*[374]
1043	Velutabularin M	R_1 = R_2 = Ac; R_3 = α-OAc; R_4 = H; R_5 = OAc; R_6 = Ac	*Chukrasia tabularis*[394]
1044	Entanutilin D	R_1 = H; R_2 = H; R_3 = H; R_4 = R_5 = OAc; R_6 = $COCH(CH_3)_2$	*Entandrophragma utile*[387]
1045	Chukorthoester E	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = R_5 = H; R_6 = Ac	*Chukrasia tabularis*[371]
1046	Hainanxylogranin S	R_1 = H; R_2 = Tig; R_3 = R_4 = R_5 = H; R_6 = Ac	*Xylocarpus granatum*[152]
1047	Hainanxylogranin T	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = R_4 = R_5 = H; R_6 = Ac	*Xylocarpus granatum*[152]
1048	Chukbularisin B		*Chukrasia tabularis*[395]
1049	Swietenitin R	R = H	*Swietenia macrophylla*[385]
1050	Swietenitin S	R = Ac	*Swietenia macrophylla*[385]
1051	Carapanolide L	R_1 = H; R_2 = Ac; R_3 = $COCH_2CH_3$	*Carapa guianensis*[266]
1052	Andirolide V	R_1 = H; R_2 = Ac; R_3 = $COCH(CH_3)_2$	*Carapa guianensis*[149]
1053	Swietenitin T	R_1 = H; R_2 = Tig; R_3 = $COCH_2CH_3$	*Swietenia macrophylla*[385]
1054	Swietenitin U	R_1 = H; R_2 = Tig; R_3 = Ac	*Swietenia macrophylla*[385]
1055	Andirolide E	R_1 = R_2 = Ac; R_3 = $COCH_2CH_3$	*Carapa guianensis*[263]
1056	Encandollen B	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = $COCH(CH_3)_2$	*Entandrophragma candollei*[396]
1057	Dormir D	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = H; R_4 = $COCH(CH_3)_2$	*Neobeguea mahafalensis*[397]
1058	Carapanolide V/Andirolide F	R_1 = R_2 = Ac; R_3 = H; R_4 = $COCH_2CH_3$	*Carapa guianensis*[263,332]
1059	Swietenitin V	R_1 = H; R_2 = Tig; R_3 = H; R_4 = Ac	*Swietenia macrophylla*[385]
1060	Tabulvelutin A	R_1 = R_2 = H; R_3 = OBz; R_4 = $COCH(CH_3)_2$	*Chukrasia tabularis*[398]
1061	Carapanosin D		*Carapa guianensis*[331]
1062	Dormir F		*Neobeguea mahafalensis*[397]
1063	Dormir G		*Neobeguea mahafalensis*[397]
1064	Andirolide O	R = Ac	*Carapa guianensis*[264]
1065	Andirolide P	R = H	*Carapa guianensis*[264]
1066	Dodoguin	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OAc; R_4 = $COCH(CH_3)_2$	*Neobeguea mahafalensis*[397]
1067	Dormir A	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = OAc; R_4 = $COCH(CH_3)_2$	*Neobeguea mahafalensis*[397]
1068	Encandollen C	R_1 = R_2 = Ac; R_3 = H; R_4 = $COCH_2CH_3$	*Entandrophragma candollei*[399]
1069	Encandollen D	R_1 = Ac; R_2 = $COCH_2CH_3$; R_3 = H; R_4 =Ac	*Entandrophragma candollei*[399]
1070	Encandollen E	R_1 = R_2 = Ac; R_3 = H; R_4 = $COCH(CH_3)_2$	*Entandrophragma candollei*[399]
1071	Dormir B	R = $COCH(CH_3)CH_2CH_3$	*Neobeguea mahafalensis*[397]
1072	Dormir C	R = $COCH(CH_3)_2$	*Neobeguea mahafalensis*[397]
1073	Libiguin B		*Neobeguea mahafalensis*[400]
1074	Chukvelutilide I	R_1 = Ac; R_2 = H; R_3 = OAc	*Chukrasia tabularis*[401]
1075	Chukvelutilide J	R_1 = R_2 = H; R_3 = OAc	*Chukrasia tabularis*[401]
1076	Chukvelutilide K	R_1 = R_2 = Ac; R_3 = OAc	*Chukrasia tabularis*[401]
1077	Chukvelutilide L	R_1 = H; R_2 = Ac; R_3 = OAc	*Chukrasia tabularis*[401]
1078	Chukvelutilide M	R_1 = Ac; R_2 = R_3 = H	*Chukrasia tabularis*[401]
1079	Chukvelutilide N	R_1 = R_2 = R_3 = H	*Chukrasia tabularis*[401]
1080	Chukvelutilide O	R_1 = R_2 = Ac; R_3 = H	*Chukrasia tabularis*[401]
1081	Chukvelutilide P	R_1 = H; R_2 = Ac; R_3 = H	*Chukrasia tabularis*[401]
1082	Dormir E	R = $COCH(CH_3)CH_2CH_3$	*Neobeguea mahafalensis*[397]
1083	Libiguin A	R = $COCH(CH_3)_2$	*Neobeguea mahafalensis*[400]
1084	Tabulalin C	R_1 = R_2 = R_3 = R_4 = H; R_5 = OAc	*Chukrasia tabularis*[402]
1085	Tabulalin N	R_1 = R_2 = Ac; R_3 = H; R_4 = OAc; R_5 = H	*Chukrasia tabularis*[386]
1086	Chuktabularoid G	R_1 = H; R_2 = Ac; R_3 = R_4 = OAc; R_5 = H	*Chukrasia tabularis*[393]
1087	Chuktabularoid H	R_1 = H; R_2 = Ac; R_3 = R_4 = OAc; R_5 = H	*Chukrasia tabularis*[393]
1088	Chuktabularoid I	R_1 = R_2 = Ac; R_3 = R_4 = R_5 = H	*Chukrasia tabularis*[393]
1089	Velutinasin D	R_1 = H; R_2 = R_3 = $COCH(CH_3)_2$; R_4 = Ac	*Chukrasia tabularis*[390]
1090	Velutinasin J	R_1 = Ac; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = Ac	*Chukrasia tabularis*[386]
1091	Chukvelutilide Z	R_1 = R_2 = H; R_3 = R_4 = Ac	*Chukrasia tabularis*[335]

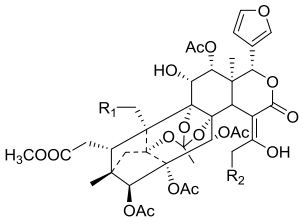
1092	Chubularisin N	R_1 = Ac; R_2 = R_3 = R_4 = $COCH(CH_3)_2$	*Chukrasia tabularis*[391]
1093	Chubularisin L	R = H	*Chukrasia tabularis*[391]
1094	Chubularisin M	R = Ac	*Chukrasia tabularis*[391]
1095	Encandollen A	R_1 = H; R_2 = Ac; R_3 = H; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = H	*Entandrophragma candollei*[396]
1096	Chukvelutilide U	R_1 = R_2 = Ac; R_3 = H; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = OAc	*Chukrasia tabularis*[401]
1097	Chukvelutilide V	R_1 = H; R_2 = Ac; R_3 = H; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = OAc	*Chukrasia tabularis*[401]
1098	Chukvelutilide W	R_1 = R_2 = Ac; R_3 = OAc; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = H	*Chukrasia tabularis*[401]
1099	Chukvelutilide X	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = H	*Chukrasia tabularis*[401]
1100	Chukvelutilide I	R_1 = R_2 = Ac; R_3 = H; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = OAc	*Chukrasia tabularis*[403]
1101	Chukvelutilide J	R_1 = R_2 = Ac; R_3 = H; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = H	*Chukrasia tabularis*[403]
1102	Chukvelutilide K	R_1 = R_2 = Ac; R_3 = R_4 = OAc; R_5 = OH; R_6 = Ac; R_7 = H	*Chukrasia tabularis*[403]
1103	Chukvelutilide L	R_1 = H; R_2 = Ac; R_3 = H; R_4 = OH; R_5 = OAc; R_6 = Ac; R_7 = OAc	*Chukrasia tabularis*[403]
1104	Chukvelutilide G	R_1 = H; R_2 = Ac; R_3 = H; R_4 = R_5 = $OCOCH(CH_3)_2$; R_6 = $COCH(CH_3)_2$; R_7 = H	*Chukrasia tabularis*[389]
1105	Velutinalide A	R_1 = R_2 = R_3 = R_4 = R_5 = H; R_6 = $COCH(CH_3)_2$; R_7 = H	*Chukrasia tabularis*[404]
1106	Velutinalide B	R_1 = R_2 = R_3 = R_4 = R_5 = H; R_6 = $COCH_2CH_3$; R_7 = H	*Chukrasia tabularis*[404]
1107	Chuktabularoid A	R_1 = R_2 = Ac; R_3 = OH; R_4 = R_5 = OAc; R_6 = Ac; R_7 = H	*Chukrasia tabularis*[393]
1108	Chukvelutilide Q	R_1 = R_2 = Ac; R_3 = H; R_4 = Ac; R_5 = OAc	*Chukrasia tabularis*[401]
1109	Chukvelutilide R	R_1 = H; R_2 = Ac; R_3 = H; R_4 = Ac; R_5 = OAc	*Chukrasia tabularis*[401]
1110	Chukvelutilide S	R_1 = R_2 = Ac; R_3 = H; R_4 = Ac; R_5 = H	*Chukrasia tabularis*[401]
1111	Chukvelutilide T	R_1 = H; R_2 = Ac; R_3 = H; R_4 = Ac; R_5 = H	*Chukrasia tabularis*[401]
1112	Chukvelutilide M	R_1 = H; R_2 = Ac; R_3 = H; R_4 = $COCH(CH_3)_2$; R_5 = OAc	*Chukrasia tabularis*[403]
1113	Velutinasin B	R_1 = R_2 = Ac; R_3 = H; R_4 = Ac; R_5 = OAc	*Chukrasia tabularis*[390]
1114	Velutinasin C	R_1 = H; R_2 = Ac; R_3 = H; R_4 = Ac; R_5 = OAc	*Chukrasia tabularis*[390]
1115	Chukvelutilide H	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = Ac; R_5 = OAc	*Chukrasia tabularis*[405]
1116	Chukvelutilide A1	R_1 = H; R_2 = R_3 = Ac; R_4 = $COCH_2CH_3$; R_5 = OAc	*Chukrasia tabularis*[386]
1117	Chukvelutilide Y	R_1 = R_2 = Ac; R_3 = H; R_4 = $COCH_2CH3$; R_5 = OAc	*Chukrasia tabularis*[335]
1118	Guianolide A	R_1 = Ac; R_2 = $COCH_2CH_3$	*Carapa guianensis*[406]
1119	Guianolide B	R_1 = H; R_2 = $COCH_2CH_3$	*Carapa guianensis*[406]
1120	Guianofruit E	R_1 = Ac; R_2 = $COCH(CH_3)_2$	*Carapa guianensis*[297]
1121	Chubularisin B		*Chukrasia tabularis*[391]
1122	Chukfuransin A	R = H	*Chukrasia tabularis*[407]
1123	Chukfuransin B	R = OAc	*Chukrasia tabularis*[407]
1124	Chukfuransin C		*Chukrasia tabularis*[407]
1125	Chukfuransin D		*Chukrasia tabularis*[407]



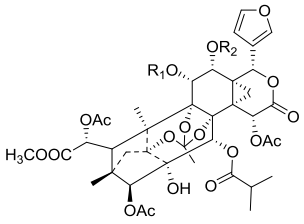
1008-1018



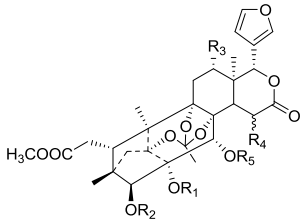
1019



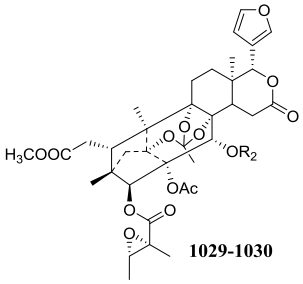
1020-1021



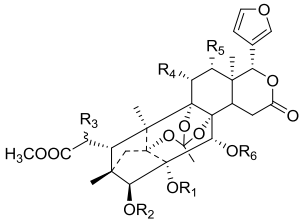
1022-1024



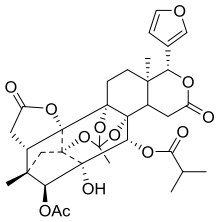
1025-1028



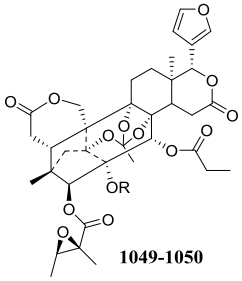
1029-1030



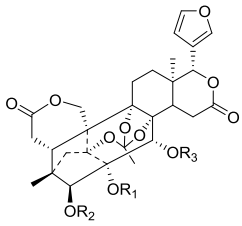
1031-1047



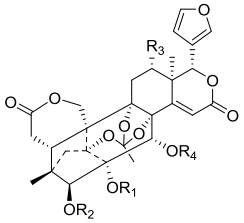
1048



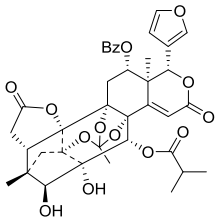
1049-1050



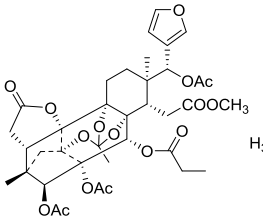
1051-1055



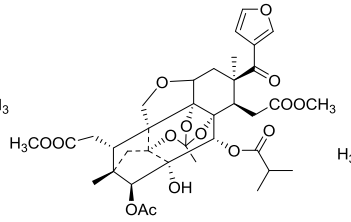
1056-1059



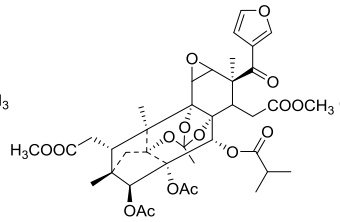
1060



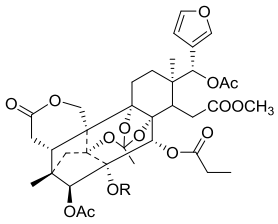
1061



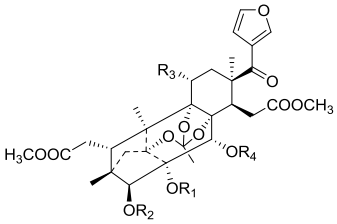
1062



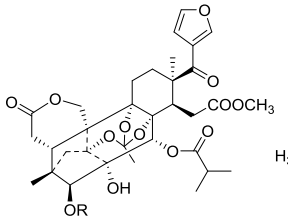
1063



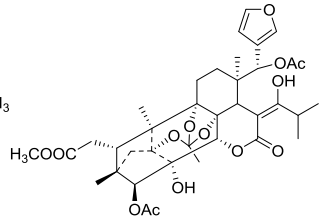
1064-1065



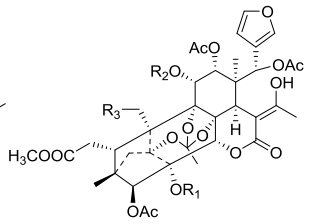
1066-1070



1071-1072



1073



1074-1081

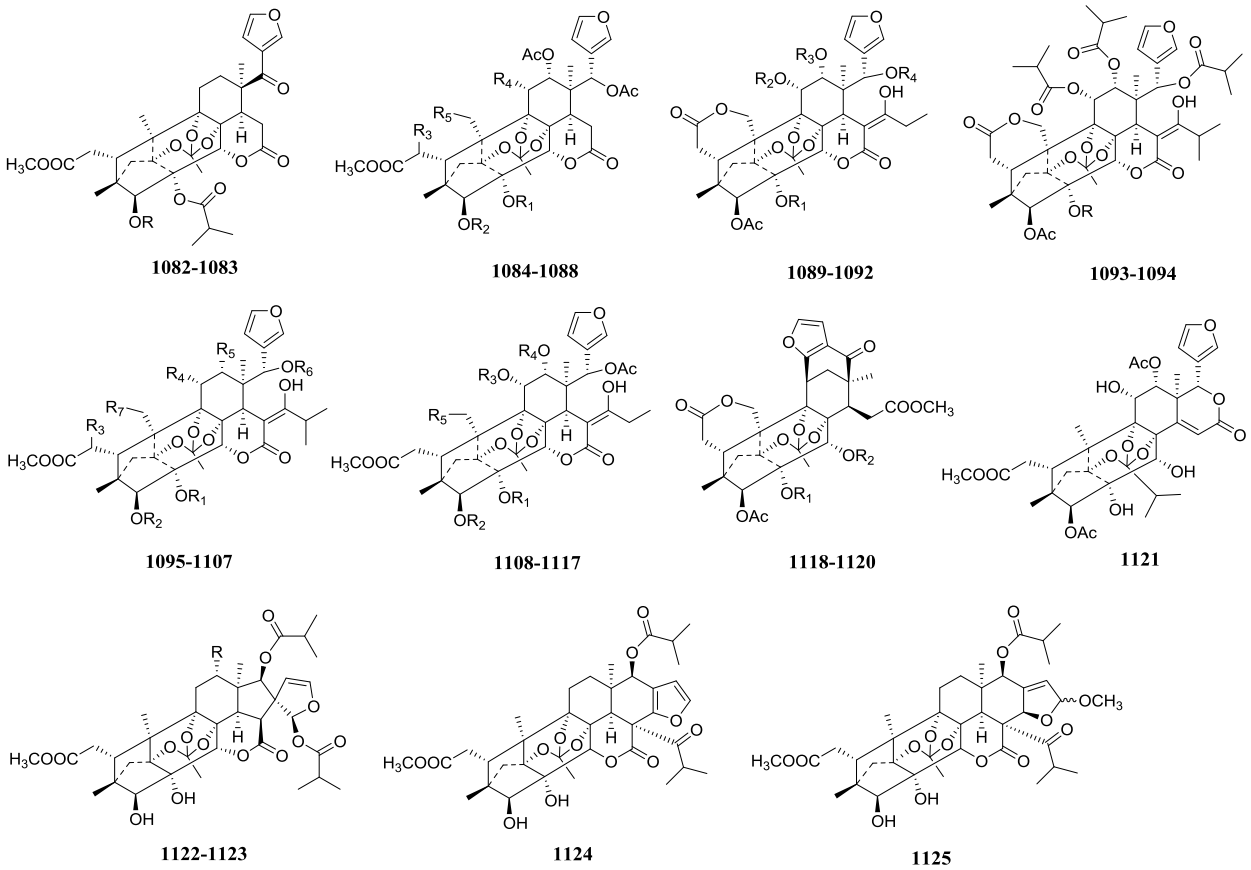


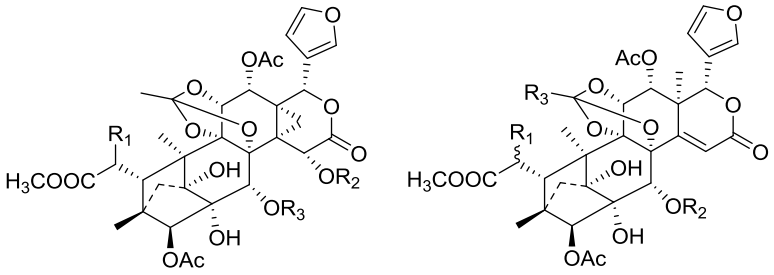
Figure 39. Structures of (1-8-9) phragmalin orthoester class limonoids **1008-1125**.

2.4.1.3.1.2. (8-9-11) Phragmalin orthoester

This class of limonoid is characterized by presence of ortho-acetate groups at C8, C9 and C11. A total of nine compounds were isolated belonging to this class from *Chukrasia tabularis* (Table 38/S38, Figure 40). Previously six Meliaceae limonoids of this class were reported[12]. Compounds (**1126-1131**) share similar skeletal structure with previously reported tabularisin E[408] but vary in substituents at C2, C3, C6 C12, C15 and C30. The cyclopropyl group at C13-C14 in compound (**1126**) is replaced by $\Delta^{14,15}$ double bond in compounds (**1132-1134**).

Table 38. [8-9-11] Phragmalin orthoester class limonoid 1126-1134

No.	Limonoid	Substituent	Source
1126	Tabularisin T	R_1 = H; R_2 = Ac; R_3 = $COCH_2CH_3$	*Chukrasia tabularis*[409]
1127	Chukbularisin C	R_1 = H; R_2 = R_3 = $COCH(CH_3)_2$	*Chukrasia tabularis*[395]
1128	Chubularisin H	R_1 = OAc; R_2 = R_3 = $COCH(CH_3)_2$	*Chukrasia tabularis*[391]
1129	Chubularisin I	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = $COCH_2CH_3$	*Chukrasia tabularis*[391]
1130	Chuklarisin B	R_1 = OAc; R_2 = $COCH(CH_3)_2$; R3 = $COCH_2CH_3$	*Chukrasia tabularis*[410]
1131	Velutabularin K	R_1 = H; R_2 = Ac; R3 = $COCH_2CH_3$	*Chukrasia tabularis*[394]
1132	Chuktabularoid E	R_1 = α-OH; R_2 = $COCH(CH_3)_2$; R_3 = CH_3	*Chukrasia tabularis*[393]
1133	Chuktabularoid F	R_1 = α-OH; R_2 = H; R_3 = $CH(CH_3)_2$	*Chukrasia tabularis*[393]
1134	Velutabularin L	R_1 = OAc; R_2 = $COCH(CH_3)_2$; R_3 = CH_3	*Chukrasia tabularis*[394]



1126-1131 **1132-1134**

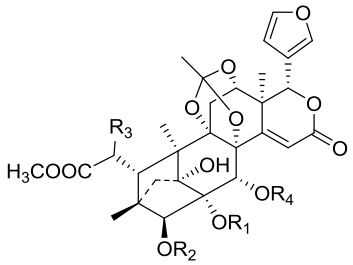
Figure 40. Structures of (8-9-11) phragmalin orthoester class limonoids **1126-1134**.

2.4.1.3.1.3. (8-9-12) Phragmalin orthoester

This class of limonoid is characterized by ortho-acetate groups at C8, C9 and C12. Three Limonoids were isolated from *Xylocarpus moluccensis* and *Chukrasia tabularis* belonging to this class (Table 39/S39, Figure 41). The 8,9,30-orthoacetate group in compound (**1132**) is replaced by 8,9,12-orthoacetate group in limonoids (**1135-1137**).

Table 39. [8-9-12] Phragmalin orthoester class limonoid 1135-1137

No.	Limonoid	Substituent	Source
1135	Thaixylomolin O	$R_1 = R_2 = Ac$; $R_3 = H$; $R_4 = Ac$	*Xylocarpus moluccensis*[382]
1136	Thaixylomolin P	$R_1 = H$; $R_2 = Ac$; $R_3 = H$; $R_4 = Ac$	*Xylocarpus moluccensis*[382]
1137	Chubularisin A	$R_1 = R_2 = H$; $R_3 = OAc$; $R_4 = COCH(CH_3)_2$	*Chukrasia tabularis*[391]



1135-1137

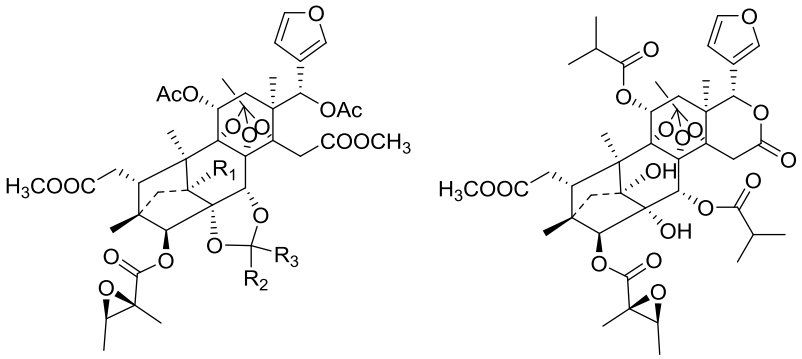
Figure 41. Structures of (8-9-12) phragmalin orthoester class limonoids **1135-1137**.

2.4.1.3.1.4. (8-9-14) Phragmalin orthoester

This class of Limonoids is characterized by the presence of ortho-acetate group is situated at C8, C9 and C14. Five compounds were isolated from *Swietenia macrophylla* and *Entandrophragma utile* belonging to this class (Table 40/S40, Figure 42). A total of fourteen Meliaceae limonoids were reported earlier[12]. Compounds (**1138-1141**) are C11 acetoxyl forms of previously reported Swietenitin J[411] and have 8,9,14-orthoacetate group differing at A ring substitution. Entanutilin O (**1142**) is C11 isobutyrate analog of previously reported Entandrophragmin[412].

Table 40. [8-9-14] Phragmalin orthoester class limonoid 1138-1142

No.	Limonoid	Substituent	Source
1138	Swielimonoid C	$R_1 = OAc$; $R_2 = \alpha\text{-}CH_2CH_3$; $R_3 = \beta\text{-}OCH_3$	*Swietenia macrophylla*[353]
1139	Swielimonoid D	$R_1 = OAc$; $R_2 = \beta\text{-}CH_2CH_3$; $R_3 = \alpha\text{-}OCH_3$	*Swietenia macrophylla*[353]
1140	Swielimonoid E	$R_1 = OH$; $R_2 = \beta\text{-}CH_2CH_3$; $R_3 = \alpha\text{-}OCH_3$	*Swietenia macrophylla*[353]
1141	Swielimonoid F	$R_1 = OAc$; $R_2 = \beta\text{-}CH_3$; $R_3 = \alpha\text{-}OCH_3$	*Swietenia macrophylla*[353]
1142	Entanutilin O		*Entandrophragma utile*[115]



1138-1141 **1142**

Figure 42. Structures of (8-9-14) phragmalin orthoester class limonoids **1138-1142**.

2.4.1.3.1.5. (8-9-30) Phragmalin orthoester

Ortho-acetate group situated at C8, C9 and C30 is the signature trait to identify this class of Limonoids. Forty nine Limonoids belonging to this class were isolated from *Xylocarpus moluccensis*, *Carapa guianensis*, *Chukrasia tabularis*, *Xylocarpus granatum*, *Swietenia mahogany*, *Swietenia macrophylla*, *Soymida febrifuga* and *Entandrophragma utile* (Table 41/S41, Figure 43). Previously thirty two Meliaceae limonoids of this class were reported[12]. The 8,9,11-orthoacetate group in compound (**1132**) is replaced by 8,9,30-orthoacetate group in compounds (**1143-1176**) and also differ in substitution at A and C rings. Compounds (**1177-1187**) have cyclopropyl group at C13-C14. Moluccensin Z1 and Z2 (**1188** and **1190**) are C17 γ-methoxy butenolide analog of Moluccensin Y (**1154**). Hainanxylogranin R (**1189**) is C6, C12 diacetoxyl, C23 demethyl analog of compound (**1188**). Limonoid (**1191**) is structurally similar to 8,9,30-ortho-tigloylate-swietemacrophine (**1162**) but differ at C31 by presence of methyl group and 20,21,22,23-diepoxy furan ring at C17.

Table 41. [8,9,30] Phragmalin orthoester class limonoid 1143-1191

No.	Limonoid	Substituents	Source
1143	Xylomolin L1	R_1 = OAc; R_2 = Ac; R_3 = OH; R_4 = R_5 = H; R_6 = CH_3	*Xylocarpus moluccensis*[143]
1144	Xylomolin L2	R_1 = OH; R_2 = Tig; R_3 = R_4 = H; R_5 = OH; R_6 = CH_3	*Xylocarpus moluccensis*[143]
1145	12-Deacetylxyloccensin U	R_1 = OH; R_2 = Ac; R_3 = R_4 = H; R_5 = OH; R_6 = CH_3	*Xylocarpus moluccensis*[352]
1146	2-O-Acetyl-2-dehydroxy-12-deacetylxyloccensin U	R_1 = OAc; R_2 = Ac; R_3 = R_4 = H; R_5 = OH; R_6 = CH_3	*Xylocarpus moluccensis*[352]
1147	Andirolide Y	R_1 = $OCOCH_2CH_3$; R_2 = Ac; R_3 = OAc; R_4 = H; R_5 = OAc; R_6 = CH_3	*Carapa guianensis*[310]
1148	Chukvelutilide N	R_1 = $OCOCH(CH_3)_2$; R_2 = Ac; R_3 = R_4 = H; R_5 = OH; R_6 = CH_3	*Chukrasia tabularis*[403]
1149	Carapanolide H	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = R_5 = H; R_6 = CH_3	*Carapa guianensis*[333]
1150	Xylogranin B	R_1 = OH; R_2 = Bz; R_3 = R_4 = R_5 = H; R_6 = CH_3	*Xylocarpus granatum*[372]
1151	Swietephragmin H	R_1 = OAc; R_2 = Tig; R_3 = R_4 = R_5 = H; R_6 = CH_3	*Swietenia mahogani*[347]
1152	Swietephragmin I	R_1 = OAc; R_2 = Tig; R_3 = R_4 = R_5 = H; R_6 = CH_2CH_3	*Swietenia mahogani*[347]
1153	11-hydroxyswietephragmin B	R_1 = OAc; R_2 = Tig; R_3 = H; R_4 = OH; R_5 = H; R_6 = $CH(CH_3)CH_2CH_3$	*Swietenia mahogani*[347]
1154	Moluccensin Y	R_1 = OAc; R_2 = Ac; R_3 = R_4 = R_5 = H; R_6 = CH_3	*Xylocarpus moluccensis*[340]
1155	Krishnagranatin I	R_1 = OH; R_2 = H; R_3 = α-OAc; R_4 = H; R_5 = α-OAc; R_6 = CH_3	*Xylocarpus granatum*[375]
1156	2-dehydroxylswietephragmin C	R_1 = H; R_2 = Tig; R_3 = R_4 = R_5 = H; R_6 = $CH(CH_3)CH_2CH_3$	*Swietenia macrophylla*[413]
1157	Chuktabularoid D	R_1 = OH; R_2 = Ac; R_3 = α-OH; R_4 = α-OH; R_5 = α-OAc; R_6 = $CH(CH_3)_2$	*Chukrasia tabularis*[393]
1158	Andirolide G	R_1 = $OCOCH_2CH_3$; R_2 = Ac; R_3 = R_4 = H; R_5 = α-OH; R_6 = CH_3	*Carapa guianensis*[263]
1159	Granaxylocartin A	R_1 = H; R_2 = Ac; R_3 = OH; R_4 = H; R_5 = OH	*Xylocarpus granatum*[414]
1160	12α-acetoxyswietephragmin I	R_1 = OAc; R_2 = Tig; R_3 = R_4 = H; R_5 = OAC; R_6 = CH_3	*Swietenia macrophylla*[415]
1161	3β-O-detigloyl-3β-O-benzoyl-12α-acetoxyswietephragmin I	R_1 = OAc; R_2 = Bz; R_3 = R_4 = H; R_5 = OAc; R_6 = CH_3	*Swietenia macrophylla*[415]
1162	8,9,30-ortho-tigloylate-swietemacrophine	R_1 = OH; R_2 = Tig; R_3 = R_4 = H; R_5 = OAc; R_6 = (*E*)-CH_3C=$CHCH_3$	*Swietenia macrophylla*[415]
1163	2-deacetyl-6-acetoxyl-swietephragmin I	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = R_5 = H; R_6 = CH_3	*Swietenia macrophylla*[415]

1164	2-deacetyl-12α-acetoxyswietephragmin I	R_1 = OH; R_2 = Tig; R_3 = R_4 = H; R_5 = OAc; R_6 = CH_3	*Swietenia macrophylla*[415]
1165	3β-O-detigloyl-3β-O-benzoyl-6-O-acetylswietephragmin D	R_1 = OH; R_2 = Bz; R_3 = OAc; R_4 = R_5 = H; R_6 = $CH(CH_3)_2$	*Swietenia macrophylla*[415]
1166	6-acetoxyl-12α-deacetoxyl-8,9,30-ortho-tigloylate-swietemacrophine	R_1 = OH; R_2 = Tig; R_3 = OAc; R_4 = R_5 = H; R_6 = (*E*)-CH_3C=$CHCH_3$	*Swietenia macrophylla*[415]
1167	Entanutilin F	R_1 = OH; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = H; R_5 = OAc; R_6 = CH_3	*Entandrophragma utile*[387]
1168	Entanutilin G	R_1 = $OCOCH(CH_3)_2$; R_2 = R_3 = R_4 = H; R_5 = OAc; R_6 = CH_3	*Entandrophragma utile*[387]
1169	Entanutilin H	R_1 = $OCOCH(CH_3)_2$; R_2 = R_3 = H; R_4 = R_5 = OAc; R_6 = CH_3	*Entandrophragma utile*[387]
1170	Entanutilin I	R_1 = OH; R_2 = H; R_3 = H; R_4 = R_5 = OAc; R_6 = $CH(CH_3)_2$	*Entandrophragma utile*[387]
1171	Thaixylomolin Z	R_1 = OH; R_2 = Ac; R_3 = α-OH; R_4 = H; R_5 = OH; R_6 = CH_3	*Xylocarpus moluccensis*[337]
1172	2-*O*-acetylthaixylomolin Z	R_1 = OAc; R_2 = Ac; R_3 = α-OH; R_4 = H; R_5 = OH; R_6 = CH_3	*Xylocarpus moluccensis*[337]
1173	Hainanxylogranin Q	R_1 = OH; R_2 = Ac; R_3 = R_4 = R_5 = H; R_6 = CH_3	*Xylocarpus granatum*[152]
1174	Entanutilin K		*Entandrophragma utile*[387]
1175	2, 11-O, O-diacetyl epoxy febrinin, (2-acetyl soymidin B)	R = Ac	*Soymida febrifuga*[388]
1176	Velutabularin L	R = H	*Soymida febrifuga*[392]
1177	Tabularisin S	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = H; R_5 = Ac; R6 = $CH(CH_3)_2$	*Chukrasia tabularis*[409]
1178	Chukbularisin D	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = R_5 = Ac; R_6 = $CH(CH_3)_2$	*Chukrasia tabularis*[395]
1179	Chukbularisin E	R_1 = $COCH(CH_3)_2$; R_2 = Ac; R_3 = OAc; R_4 = R_5 = Ac; R_6 = CH_3	*Chukrasia tabularis*[395]
1180	Chukvelutilide O	R_1 = $COCH(CH_3)_2$; R_2 = Ac; R_3 = OH; R_4 = H; R_5 = Ac; R_6 = CH_3	*Chukrasia tabularis*[403]
1181	Tabularin R	R_1 = R_2 = H; R_3 = OAc; R_4 = R_5 = Ac; R_6 = CH_3	*Chukrasia tabularis*[405]
1182	Chubularisin C	R_1 = R_2 = R_3 = H; R_4 = Ac; R_5 = $COCH(CH_3)_2$; R_6 = CH_2CH_3	*Chukrasia tabularis*[391]
1183	Chubularisin D	R_1 = COCH2CH3; R_2 = Ac; R_3 = R_4 = H; R_5 = $COCH(CH_3)_2$; R_6 = CH_3	*Chukrasia tabularis*[391]
1184	Chubularisin E	R_1 = $COCH(CH_3)_2$; R_2 = Ac; R_3 = R_4 = H; R_5 = $COCH(CH_3)_2$; R_6 = CH_3	*Chukrasia tabularis*[391]
1185	Chubularisin F	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = R_5 = H; R_6 = $CH(CH_3)_2$	*Chukrasia tabularis*[391]
1186	Chubularisin G	R_1 = H; R_2 = Ac; R_3 = OAc; R_4 = R_5 = Ac; R_6 = $CH(CH_3)_2$	*Chukrasia tabularis*[391]
1187	Chuklarisin A	R_1 = $COCH(CH_3)_2$; R_2 = Ac; R_3 = OAc; R_4 = Ac; R_5 = $COCH(CH_3)_2$; R_6 = CH_3	*Chukrasia tabularis*[410]
1188	Moluccensin Z1		*Chukrasia tabularis*[386]
1189	Hainanxylogranin R		*Xylocarpus granatum*[152]
1190	Moluccensin Z2		*Chukrasia tabularis*[386]
1191	12α-acetoxyl-20β,21β-22α,23α-diepoxyswietephragmin C		*Swietenia macrophylla*[415]

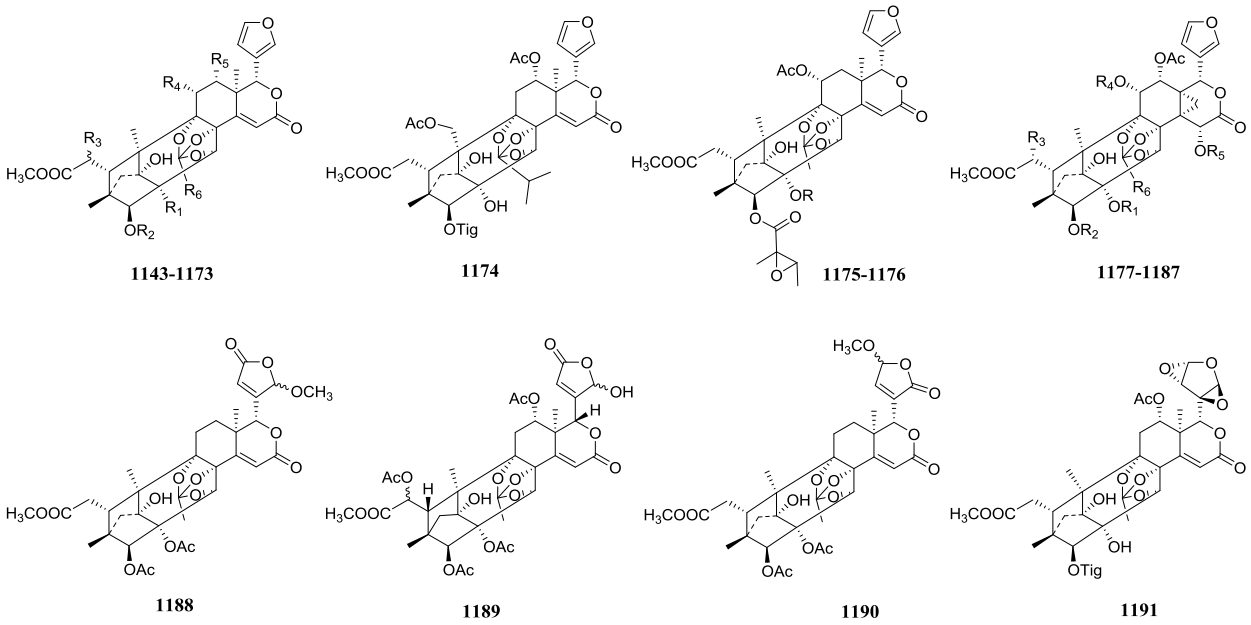


Figure 43. Structures of (8,9,30) phragmalin orthoester class limonoids **1143-1191**.

2.4.1.3.2. Polyoxyphragmalin

A total of seventy five polyoxyphragmalins were isolated from *Carapa guianensis*, *Heynea trijuga*, *Trichilia connaroides*, *Trichilia sinensis*, *Soymida febrifuga*, *Khaya senegalensis*, *Swietenia macrophylla*, *Xylocarpus moluccensis*, *Xylocarpus granatum*, *Aphanamixis polystachya* and *Chukrasia tabularis* (Table 42/S42, Figure 44). Thirty four Polyoxyphragmalin class limonoids were reported from Meliaceae family[12]. Limonoids (**1192-1216**) contain $\Delta^{8,14}$ double bond and differ from each other in substituents at C1, C2, C3, C6, C15 and C30. The olefinic $\Delta^{8,14}$ double bond in Carapanolide K (**1192**) is shifted to $\Delta^{8,30}$ in Soymidin E (**1217**). Thaigranatin N (**1218**) is C2 dehydroxy, C3 acetyl analog of compound (**1217**). Thaigranatin O (**1219**) is C2 dehydroxy analog of compound (**1217**). Thaigranatin P (**1220**) is C2 dehydroxy, C3 acetyl analog of compound (**1217**) with shift in double bond from $\Delta^{8,30}$ to $\Delta^{8,14}$. Khayseneganin B (**1221**) is structurally similar to previously reported Khayanolide C[416] except the interchanged substituents at C2 and C3. Khayseneganin C (**1222**) is a C1 acetyl analog of compound (**1221**). The only difference between compound (**1192**) and Swietenitin W and X (**1223** and **1224**) is the epoxide group at C8/9, and substituted exocyclic double bond at C15. Compounds (**1225-1227**) have additional keto carbonyl group at C30 and differ at C1 and C2 substitutions when compared to compound (**1192**). Swietenine J (**1228**) is structurally similar to previously reported Tabulalin[417] except the variation in substituents at A and B rings. Godavarin H (**1229**) is C2, C6, C12, C30 acetoxyl form of compound (**1228**). The hydroxyl group at C8 in compound (**1221**) is replaced by an additional conjugated double bond at $\Delta^{8,9}$ in Khayseneganin A (**1230**). Compounds (**1231-1234**) are analogs of previously reported Moluccensin H[418] containing additional hydroxyl group at C15 with loss of carbonyl group at C30 and varying substituents at A ring. Compounds (**1235-1238**) differ from compound (**1225**) at C1, C3 and C6 substitution. The $\Delta^{8,9}$ olefinic double bond and acetoxyl group at C2 in compound (**1232**) is shifted to $\Delta^{8,30}$ and C3 respectively in Granatumin K (**1239**). Granatumin J (**1240**) is C12 α-acetoxyl form of previously reported Xylocarpin A[419]. Krishnagranatin G (**1241**) is C1 deacetyl analog of compound (**1240**) whereas Krishnagranatin H (**1242**) is C12 deacetoxyl analog of compound (**1241**). 6-O-acetyl xylocarpin D (**1243**) is C2 epimer of compound (**1240**). Compound (**1244**) differ from compound (**1242**) at C17 where there is 20,22-dihydroxy-21,23-dimethoxy tetrahydrofuran moiety and epoxide group at C8/14 with C3, C6 deacetylation. The furan ring at C17 in compound (**1217**) is replaced by γ-substituted butenolide ring in compounds (**1245** and **1246**) along with C2/14 ether bridge formation. Khayseneganin I (**1247**) differs from compound (**1246**) at C3, C6 containing hydroxyl group and furan ring at C17. Khayseneganin I (**1247**) was isolated in 2014[420] from *Swietenia mahogani* and named as 2-methoxy khayseneganin E. Khayseneganin E-H (**1248-1251**) differ from compound (**1247**) at A ring substitution. Velutabularin A-F (**1252-1257**) have six membered lactone ring between C15-C30, D ring lactone is cleaved to form five membered ring with C15/17ether linkage, cyclopropyl ring is present at C13-C14 and they vary among themselves only in substitution at C6, C11 and C12. The D ring ether linkage in compound (**1252**) is cleaved in Velutabularin G-J (**1258-1261**) and differs in substitution at C2, C6, C11, C12 and

C17. The five and six membered lactone rings are present at C and A rings respectively in Tabulalin D (**1262**). The lactone ring attached to A ring in compound (**1262**) is cleaved in Tabulalin E (**1263**). The cyclopropyl ring at C13-14 in compound (**1258**) is absent in compounds (**1264-1266**) and also differ in substitution at C6, C11 and C12.

Table 42. Polyoxyphragmalin class limonoid 1192-1266

No.	Limonoid	Substituent	Source
1192	Carapanolide K	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = Ac; R_6 = $COCH(CH_3)CH_2CH_3$	*Carapa guianensis*[266]
1193	Heytrijumalin A	$R_1 = R_2 = H$; R_3 = Tig; R_4 = OAc; R_5 = $COC(OH)(CH_3)_2$; $R_6 = COCH(CH_3)_2$	*Heynea trijuga*[421]
1194	Heytrijumalin B	$R_1 = R_2$ = Ac; R_3 = Tig; $R_4 = H$; R_5 = $COC(OH)(CH_3)_2$; R_6 = Ac	*Heynea trijuga*[421]
1195	Heytrijumalin C	$R_1 = R_2$ = Ac; R_3 = Tig; R_4 = OAc; R_5 = $COC(OH)(CH_3)_2$; R_6 = Ac	*Heynea trijuga*[421]
1196	Heytrijumalin D	$R_1 = R_2 = H$; R_3 = Tig; R_4 = OAc; $R_5 = R_6$ = Ac	*Heynea trijuga*[421]
1197	Heytrijumalin E	R_1 = Ac; $R_2 = H$; R_3 = Tig; R_4 = OAc; $R_5 = R_6$ = Ac	*Heynea trijuga*[421]
1198	Heytrijumalin F	$R_1 = R_2$ = Ac; R_3 = Tig; R_4 = OAc; $R_5 = R_6$ = Ac	*Heynea trijuga*[421]
1199	Heytrijumalin G	$R_1 = R_2$ = Ac; $R_3 = COC(CH_3)CH_2$; R_4 = OAc; $R_5 = R_6$ = Ac	*Heynea trijuga*[421]
1200	Trichagmalin C	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = R_5 = H$; R_6 = $COCH(CH_3)_2$	*Trichilia connaroides*[359]
1201	15-Acetyltrichagmalin C	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = Ac; R_6 = $COCH(CH_3)_2$	*Trichilia connaroides*[359]
1202	1,2-Diacetyltrichagmalin C	$R_1 = R_2$ = Ac; R_3 = Tig; $R_4 = R_5 = H$; R_6 = $COCH(CH_3)_2$	*Trichilia connaroides*[359]
1203	Trichagmalin D	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; $R_5 = R_6$ = Ac	*Trichilia connaroides*[359]
1204	Trichagmalin E	$R_1 = R_2$ = Ac; R_3 = Tig; $R_4 = R_5 = H$; R_6 = Ac	*Trichilia connaroides*[359]
1205	15-Acetyltrichagmalin E	$R_1 = R_2$ = Ac; R_3 = Tig; $R_4 = H$; $R_5 = R_6$ = Ac	*Trichilia connaroides*[359]
1206	Trichagmalin F	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; $R_5 = COC(OH)(CH_3)_2$; $R_6 = H$	*Trichilia connaroides*[359]
1207	30-Acetyltrichagmalin F	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = $COC(OH)(CH_3)_2$; R_6 = Ac	*Trichilia connaroides*[359]
1208	1,30-Diacetyltrichagmalin F	R_1 = Ac; $R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = $COC(OH)(CH_3)_2$; R_6 = Ac	*Trichilia connaroides*[359]
1209	Trisinenmalin A	R_1 = Ac; $R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = $COCH(CH_3)_2$; R_6 = Ac	*Trichilia sinensis*[422]
1210	Trisinenmalin B	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = $COCH(CH_3)CH_2CH_3$; $R_6 = H$	*Trichilia sinensis*[422]
1211	Trisinenmalin C	$R_1 = R_2 = H$; R_3 = Tig; $R_4 = H$; R_5 = $COCH(CH_3)CH_2CH_3$; R_6 = Ac	*Trichilia sinensis*[422]
1212	Trisinenmalin E	$R_1 = R_2$ = Ac; $R_3 = COCH(CH_3)_2$; $R_4 = H$; R_5 = $COCH(CH_3)_2$; R_6 = Ac	*Trichilia sinensis*[422]
1213	Trisinenmalin F	$R_1 = H$; R_2 = Ac; $R_3 = COCH(CH_3)_2$; $R_4 = H$; R_5 = $COCH(CH_3)2$; R_6 = Ac	*Trichilia sinensis*[422]
1214	Trisinenmalin G	$R_1 = R_2 = H$; $R_3 = COCH(CH_3)CH_2CH_3$; $R_4 = H$; R_5 = $COCH(CH_3)_2$; R_6 = Ac	*Trichilia sinensis*[422]
1215	Trisinenmalin H	R_1 = Ac; $R_2 = H$; $R_3 = COCH(CH_3)_2$; $R_4 = H$; R_5 = $COCH(CH_3)_2$; R_6 = Ac	*Trichilia sinensis*[422]
1216	Trisinenmalin I	$R_1 = R_2 = H$; $R_3 = COCH(CH_3)_2$; $R_4 = H$; R_5 = $COCH(CH_3)_2$; R_6 = Ac	*Trichilia sinensis*[422]
1217	Soymidin E	R_1 = OH; R_2 = Tig	*Soymida febrifuga*[388]
1218	Thaigranatin N	$R_1 = H$; R_2 = Ac	*Xylocarpus granatum*[153]
1219	Thaigranatin O	$R_1 = H$; R_2 = Tig	*Xylocarpus granatum*[153]
1220	Thaigranatin P		*Xylocarpus granatum*[153]
1221	Khayseneganin B	R = OH	*Khaya senegalensis*[324]
1222	Khayseneganin C	R = OAc	*Khaya senegalensis*[324]
1223	Swietenitin W	R= H	*Swietenia macrophylla*[385]
1224	Swietenitin X	$R = CH_3$	*Swietenia macrophylla*[385]
1225	Thaixylomolin D	R_1 = Tig; $R_2 = H$	*Xylocarpus moluccensis*[423]
1226	Thaixylomolin E	$R_1 = H$; $R_2 = COCH(CH_3)_2$	*Xylocarpus moluccensis*[423]
1227	Thaimoluccensin C	$R_1 = COCH(CH_3)_2$; $R_2 = H$	*Xylocarpus moluccensis*[317]
1228	Swietenine J	$R_1 = R_2 = R_3 = R_4 = R_5 = H$	*Swietenia macrophylla*[424]
1229	Godavarin H	R_1 = Ac; R_2 = OAc; R_3 = OH; $R_4 = R_5$ = OAc	*Xylocarpus moluccensis*[336]
1230	Khayseneganin A		*Khaya senegalensis*[324]
1231	Heytrijumalin H	$R_1 = H$; R_2 = Tig; R_3 = OAc	*Heynea trijuga*[421]
1232	Heytrijumalin I	$R_1 = H$; R_2 = Tig; $R_3 = H$	*Heynea trijuga*[421]
1233	Trichagmalin A	R_1 = Ac; R_2 = Tig; $R_3 = H$	*Trichilia connaroides*[359]

1234	Trichagmalin B	R_1 = Ac; R_2 = $COC(CH_3)CH_2$; R_3 = H	*Trichilia connaroides*[359]
1235	Xylomolin K1	R_1 = H; R_2 = $COCH(CH_3)CH_2CH_3$; R_3 = OH	*Xylocarpus moluccensis*[143]
1236	Xylomolin K2	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H	*Xylocarpus moluccensis*[143]
1237	Moluccensin X	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = H	*Xylocarpus moluccensis*[340]
1238	Thaixylomolin F	R_1 = $COCH(CH_3)_2$; R_2 = Ac; R_3 = H	*Xylocarpus moluccensis*[423]
1239	Granatumin K		*Xylocarpus granatum*[348]
1240	Granatumin J	R_1 = Ac; R_2 = α-OAc	*Xylocarpus granatum*[348]
1241	Krishnagranatin G	R_1 = H; R_2 = β-OAc	*Xylocarpus granatum*[375]
1242	Krishnagranatin H	R_1 = R_2 = H	*Xylocarpus granatum*[375]
1243	6-O-acetyl xylocarpin D	R_1 = Ac; R_2 = α-OAc	*Xylocarpus granatum*[154]
1244	20,22-dihydroxy-21,23-dimethoxytetrahydrofuran khayanolide A		*Aphanamixis polystachya*[368]
1245	1-deacetyl-3-dehydroxy- 3-oxokhaysenelide E	R_1 = H; R_2 = CH_3	*Aphanamixis polystachya*[368]
1246	Meliaphanamixin A	R_1 = OCH_3; R_2 = H	*Aphanamixis polystachya*[368]
1247	Khayseneganin I	R_1 = CH_3; R_2 = OH	*Khaya senegalensis*[425]
1248	Khayseneganin E	R_1 = H; R_2 = OH	*Khaya senegalensis*[324]
1249	Khayseneganin F	R_1 = CH_3; R_2 = H	*Khaya senegalensis*[324]
1250	Khayseneganin G	R = H	*Khaya senegalensis*[324]
1251	Khayseneganin H	R = Ac	*Khaya senegalensis*[324]
1252	Velutabularin A	R_1 = H; R_2 = $COCH_2CH_3$; R_3 = Ac	*Chukrasia tabularis*[426]
1253	Velutabularin B	R_1 = H; R_2 = $COCH(CH_3)_2$; R_3 = Ac	*Chukrasia tabularis*[426]
1254	Velutabularin C	R_1 = OAc; R_2 = Ac; R_3 = $COCH(CH_3)_2$	*Chukrasia tabularis*[426]
1255	Velutabularin D	R_1 = OAc; R_2 = H; R_3 = $COCH(CH_3)_2$	*Chukrasia tabularis*[426]
1256	Velutabularin E	R_1 = OAc; R_2 = $COCH(CH_3)_2$; R_3 = Ac	*Chukrasia tabularis*[426]
1257	Velutabularin F	R_1 = OAc; R_2 = R_3 = Ac	*Chukrasia tabularis*[426]
1258	Velutabularin G	R_1 = H; R_2 = OAc; R_3 = Ac; R_4 = $COCH(CH_3)_2$	*Chukrasia tabularis*[426]
1259	Velutabularin H	R_1 = H; R_2 = OAc; R_3 = $COCH(CH_3)_2$; R_4 = Ac	*Chukrasia tabularis*[426]
1260	Velutabularin I	R_1 = $COCH(CH_3)_2$; R_2 = OAc; R_3 = R_4 = Ac	*Chukrasia tabularis*[426]
1261	Velutabularin J	R_1 = R_2 = H; R_3 = Ac; R_4 = $COCH(CH_3)_2$	*Chukrasia tabularis*[426]
1262	Tabulalin D		*Chukrasia tabularis*[402]
1263	Tabulalin E		*Chukrasia tabularis*[402]
1264	Tabulalin J	R_1 = H; R_2 = R_3 = Ac	*Chukrasia tabularis*[427]
1265	Tabulalin A	R_1 = R_2 = R_3 = H	*Chukrasia tabularis*[402]
1266	Tabulalin B	R_1 = OAc; R_2 = R_3 = H	*Chukrasia tabularis*[402]

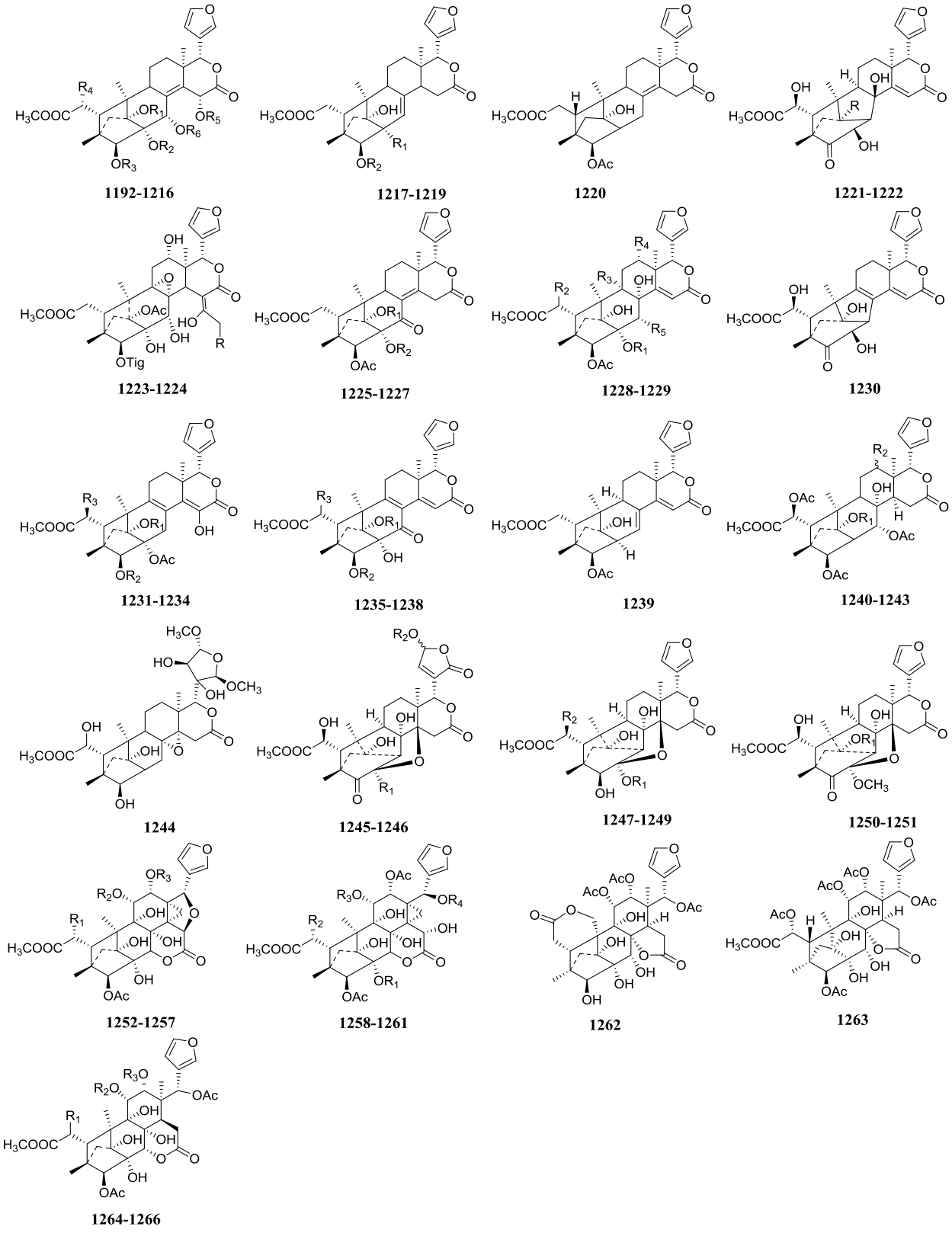


Figure 44. Structures of Polyoxyphragmalin class limonoids **1192-1266**.

2.4.1.3.3. Seco Phragmalin

2.4.1.3.3.1. 1,2-seco Phragmalin

Twenty six 1,2-seco Limonoids were isolated from *Trichilia connaroides, Chisocheton ceramicus, Trichilia sinensis, Xylocarpus granatum, Xylocarpus moluccensis* and *Chisocheton erythrocarpus*(Table 43/S43, Figure 45). Previously nineteen Meliaceae limonoids of this class were reported[12]. The structure of Trichiliton G (**1267**) was determined by 1D and 2D NMR studies. Trichiliton H (**1268**) differs from compound (**1267**) at C17 substitution. In Chisomicine B (**1269**) there is epoxide ring at C8/30 and the structure was confirmed by X-ray crystallography. Triconoid D (**1270**) contains five membered lactone ring at C4-C5 relative to compound (**1267**) and furan ring at C17. The epoxide group in previously reported Granaxylocarpin C[419] is replaced by $\Delta^{8,30}$ double bond in Chisomicine C (**1271**). The $\Delta^{8,14}$ double bond and γ-hydroxy butenolide ring at C17 in compound (**1268**) is replaced by $\Delta^{8,9}$, $\Delta^{14,15}$ double bond and furan ring in Trichiliton I (**1272**) respectively. Trichisinton A (**1273**) is structurally similar to previously reported Trichiliton A[428] except in keto carbonyl group at C2 and substituent variation at C3, C15 and C30. Trichisinton B-D (**1274-1276**) differs from compound (**1273**) at C3 and C15 substitution. Relative configuration of Trichisinton C (**1277**) was determined with respect to Khayseneganin A reported earlier[429,416]. Trichiconlide E (**1278**) is structurally similar to previously reported Trichiliton A[428] except in substitution at C3 and additional δ-lactone ring at C7 and C28. Trichiconlide F (**1279**) is C15 dehydroxy derivative of compound (**1278**). The δ-lactone ring at C28 in compound (**1279**) is cleaved in Sundarbanxylogranin A (**1280**) which also have isobutyryloxy group at C3. Andhraxylocarpin C (**1281**) and Chisomicine A (**1282**) are C3 acetyl and tigloyl derivatives of compound (**1282**) respectively. Chisomicine A (**1282**) was first isolated from *Chisocheton ceramicus* in the year 2011, and it was again isolated in the year 2012 from *Xylocarpus granatum* by a different research group who named it as Andhraxylocarpin D. The $\Delta^{2,30}$, $\Delta^{8,14}$ olefinic double bonds in compound (**1281**) are shifted to $\Delta^{8,30}$, $\Delta^{14,15}$ in Xylomolin J1 (**1283**) which is carbonylated at C2. At C3, Xylomolin J2 (**1284**) and Trangmolin F (**1285**) are 2-methylbutyryloxy and isobutyryloxy analogs of compound (**1283**) respectively. The C1 carbonyl and C3 acetate groups in compound (**1283**) is reduced and tigloylated in Andhraxylocarpin A (**1286**) along with C2-O-C1 ether bridge formation. Andhraxylocarpin B (**1287**) and Malayanine A (**1288**) are C3-O acetyl and benzoyl analogs of compound (**1286**) respectively. The carbonyl at C2 in compound (**1283**) is reduced in Trichiconlide C and D (**1289** and **1290**) with C1-O-C2 ether bridge formation and additional δ-lactone ring at C7, C28 with varying substituents at C3. Thaigranatin Q (**1291**) is $\Delta^{2,30}$, $\Delta^{8,14}$ double bond reduced, C2 hydroxy analog of compound (**1282**). Thaigranatin R (**1292**) is C15 hydroxy analog of compound (**1282**).

Table 43. 1,2-seco Phragmalin class limonoid 1267-1292

No.	Limonoid	Substituent	Source
1267	Trichiliton G		*Trichilia connaroides*[430]
1268	Trichiliton H		*Trichilia connaroides*[430]
1269	Chisomicine B		*Chisocheton ceramicus*[431]
1270	Triconoid D		*Trichilia connaroides*[362]
1271	Chisomicine C		*Chisocheton ceramicus*[431]
1272	Trichiliton I		*Trichilia connaroides*[432]
1273	Trichisinton A	R_1 = $COCH(CH_3)_2$; R_2 = $COCH(CH_3)_2$	*Trichilia sinensis*[422]
1274	Trichisinton B	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = $COCH(CH_3)CH_2CH_3$	*Trichilia sinensis*[422]
1275	Trichisinton C	R_1 = Tig; R_2 = $COCH(CH_3)_2$	*Trichilia sinensis*[422]
1276	Trichisinton D	R_1 = Tig; R_2 = $COCH(CH_3)CH_2CH_3$	*Trichilia sinensis*[422]
1277	Trichiconlide C		*Trichilia connaroides*[291]
1278	Trichiconlide E	R = OH	*Trichilia connaroides*[433]
1279	Trichiconlide F	R = H	*Trichilia connaroides*[433]
1280	Sundarbanxylogranin A	R = $COCH(CH_3)_2$	*Xylocarpus granatum*[356]
1281	Andhraxylocarpin C	R = Ac	*Xylocarpus moluccensis*[434]
1282	Andhraxylocarpin D/ Chisomicine A	R = Tig	*Xylocarpus granatum*[434]/ *Chisocheton ceramicus*[431]
1283	Xylomolin J1	R = Ac	*Xylocarpus moluccensis*[143]
1284	Xylomolin J2	R = $COCH(CH_3)CH_2CH_3$	*Xylocarpus moluccensis*[143]
1285	Trangmolin F	R = $COCH(CH_3)_2$	*Xylocarpus moluccensis*[299]
1286	Andhraxylocarpin A	R = Tig	*Xylocarpus moluccensis*[434]/ *Xylocarpus granatum*[434]
1287	Andhraxylocarpin B	R = Ac	*Xylocarpus granatum*[434]
1288	Malayanine A	R = Bz	*Chisocheton erythrocarpus*[435]
1289	Trichiconlide C	R = Tig	*Trichilia connaroides*[433]
1290	Trichiconlide D	R = $COCHCHCH_3$	*Trichilia connaroides*[433]
1291	Thaigranatin Q		*Xylocarpus granatum*[153]
1292	Thaigranatin R		*Xylocarpus granatum*[153]

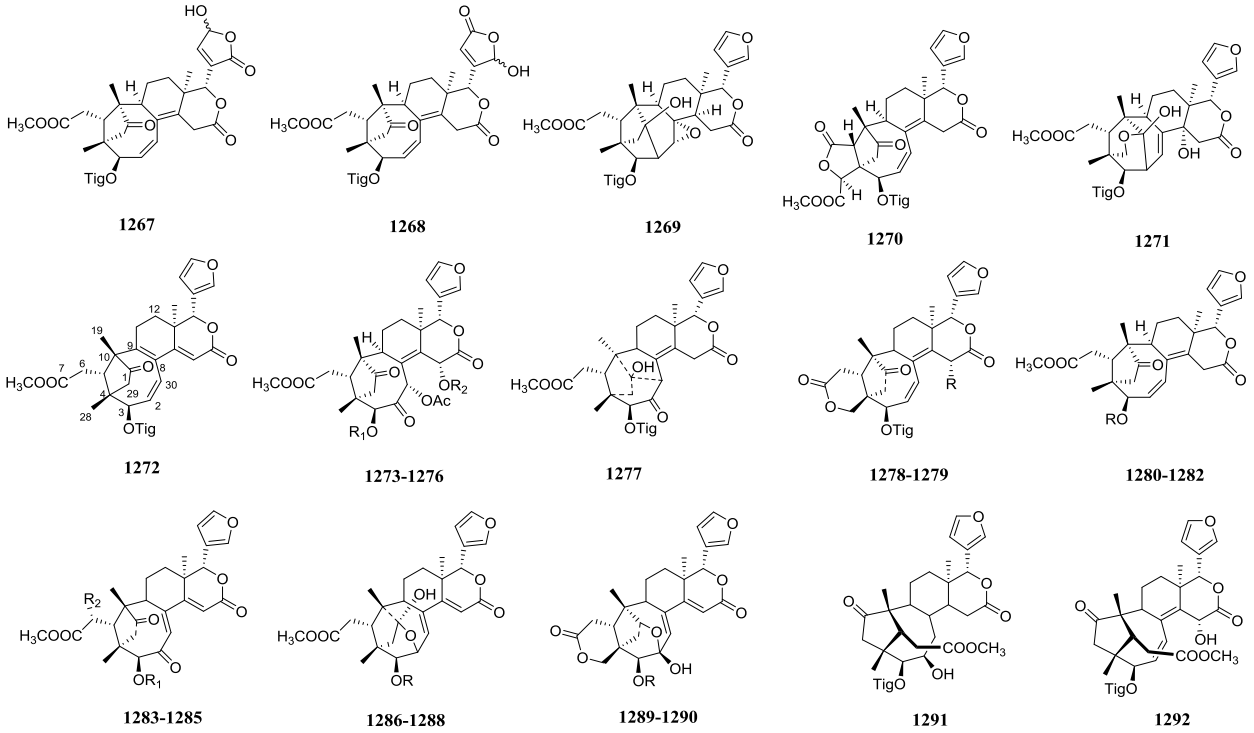


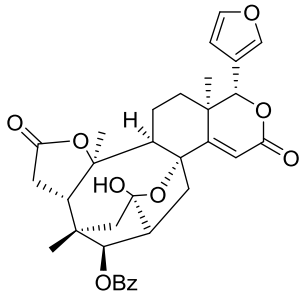
Figure 45. Structures of (1,2-seco) phragmalin class limonoids 1267-1292.

2.4.1.3.3.2. 1,10-seco Phragmalin

Malayanine B (**1293**) isolated from *Chisocheton erythrocarpus* is structurally similar to compound (**1288**) except in the γ-lactone ring between C7-C10, C1/8 ether linkage instead of C1/2, presence of C1-C2 bond with cleavage of C1-C10 bond and has benzoyl group at C3-O (Table 44/S44, Figure 46).

Table 44. 1,10-seco Phragmalin class limonoid 1293

No.	Limonoid	Substituent	Source
1293	Malayanine B		*Chisocheton erythrocarpus*[435]



1293

Figure 46. Structure of (1,10-seco) phragmalin class limonoid **1293**.

2.4.1.3.4. 16-Nor Phragmalin

All 27 limonoids (**1294-1320**) belonging to this class were isolated from *Chukrasia tabularis* (Table 45/S45, Figure 47). Previously twenty five Meliaceae limonoids of this class were reported[12]. The furan ring at C17 in previously reported Chuktabularin B[436] is replaced by γ-hydroxy butenolide moiety in Chukbularisin A (**1294**). Compounds (**1295-1297**) are structurally similar to previously reported Chuktabularin A[436] but differ in substitution

at A and C rings. The δ-lactone ring in previously reported Chuktabularin D[436] is replaced by γ-lactone ring in Chukrasone B (**1298**) and also varies in substituents at C17, C31, A and C rings. Compounds (**1299-1308**) are structurally similar to previously reported Chuktabularin A[436] except in the substituents at C2, C3, C11, C12 and C31. Compounds (**1309-1313**) are structurally similar to previously reported Chuktabrin A reported earlier[436] with varying substituents at C6, C11, C12, C19 and C31. Similar skeletal features were observed in limonoids (**1314-1316**) with formation of δ-lactone ring at C7/19. Cleavage at C31 in Chuktabrin G (**1315**) leads to the formation of Chuktabrin J (**1317**). The carbonate at OH-9 in Chuktabrin E and J (**1312** and **1317**) is shifted to OH-1 in Chuktabrin F (**1318**) and OH-30 in Chuktabrin I (**1319**) respectively. The δ-lactone ring in compound (**1319**) is cleaved in Chukvelutin D (**1320**).

Table 45. 16-Nor Phragmalin class limonoid 1294-1320

No.	Limonoid	Substituent	Source
1294	Chukbularisin A		*Chukrasia tabularis*[395]
1295	Velutinasin G	R_1 = Ac; R_2 = H; R_3 = Ac; R_4 = H; R_5 = CH_2CH_3	*Chukrasia tabularis*[390]
1296	Velutinasin H	R_1 = R_2 = H; R_3 = R_4 = Ac; R_5 = CH_3	*Chukrasia tabularis*[390]
1297	Chukvelutin E	R_1 = R_2 = Ac; R_3 = R_4 = H; R_5 = iPr	*Chukrasia tabularis*[437]
1298	Chukrasone B		*Chukrasia tabularis*[296]
1299	Chuktabularin U	R_1 = R_2 = Ac; R_3 = R_4 = H; R_5 = CH_3	*Chukrasia tabularis*[395]
1300	Chuktabularin V	R_1 = R_2 = R_3 = Ac; R_4 = $COCH(CH_3)_2$; R_5 = CH_3	*Chukrasia tabularis*[395]
1301	Chuktabularin W	R_1 = Ac; R_2 = $COCH(CH_3)_2$; R_3 = R_4 = Ac; R_5 = CH_2CH_3	*Chukrasia tabularis*[395]
1302	Chuktabularin X	R_1 = R_2 = R_3 = R_4 = H; R_5 = CH_2CH_3	*Chukrasia tabularis*[395]
1303	Chuktabularoid C	R_1 = H; R_2 = R_3 = R_4 = Ac; R_5 = CH_3	*Chukrasia tabularis*[393]
1304	Chukvelutin F	R_1 = R_2 = Ac; R_3 = R_4 = H; R_5 = iPr	*Chukrasia tabularis*[437]
1305	Chubularisin O	R_1 = R_2 = R_3 = Ac; R_4 = $COCH(CH_3)_2$; R_5 = CH_3	*Chukrasia tabularis*[391]
1306	Chubularisin P	R_1 = H; R_2 = R_3 = Ac; R_4 = $COCH_2CH_3$; R_5 = CH_2CH_3	*Chukrasia tabularis*[391]
1307	Chubularisin Q	R_1 = Ac; R_2 = H; R_3 = Ac; R_4 = $COCH(CH_3)_2$; R_5 = CH_2CH_3	*Chukrasia tabularis*[391]
1308	Chubularisin R	R_1 = H; R_2 = R_3 = R_4 = Ac; R_5 = iPr	*Chukrasia tabularis*[391]
1309	Velutinasin F	R_1 = H; R_2 = R_3 = OAc; R_4 = H; R_5 = CH_3	*Chukrasia tabularis*[390]
1310	Chuktabrin C	R_1 = R_2 = R_3 = OAc; R_4 = H; R_5 = CH_2CH_3	*Chukrasia tabularis*[395]
1311	Chuktabrin D	R_1 = H; R_2 = R_3 = OH; R_4 = H; R_5 = CH_2CH_3	*Chukrasia tabularis*[395]
1312	Chuktabrin E	R_1 = H; R_2 = R_3 = R_4 = OAc; R_5 = CH_2CH_3	*Chukrasia tabularis*[395]
1313	Chuktabularoid B	R_1 = R_2 = R_3 = OAc; R_4 = H; R_5 = iPr	*Chukrasia tabularis*[393]
1314	Chuktabrin K	R_1 = R_2 = H	*Chukrasia tabularis*[427]
1315	Chuktabrin G	R_1 = R_2 = Ac	*Chukrasia tabularis*[395]
1316	Chuktabrin H	R_1 = H; R_2 = Ac	*Chukrasia tabularis*[395]
1317	Chuktabrin J		*Chukrasia tabularis*[395]
1318	Chuktabrin F		*Chukrasia tabularis*[395]
1319	Chuktabrin I		*Chukrasia tabularis*[395]
1320	Chukvelutin D		*Chukrasia tabularis*[437]

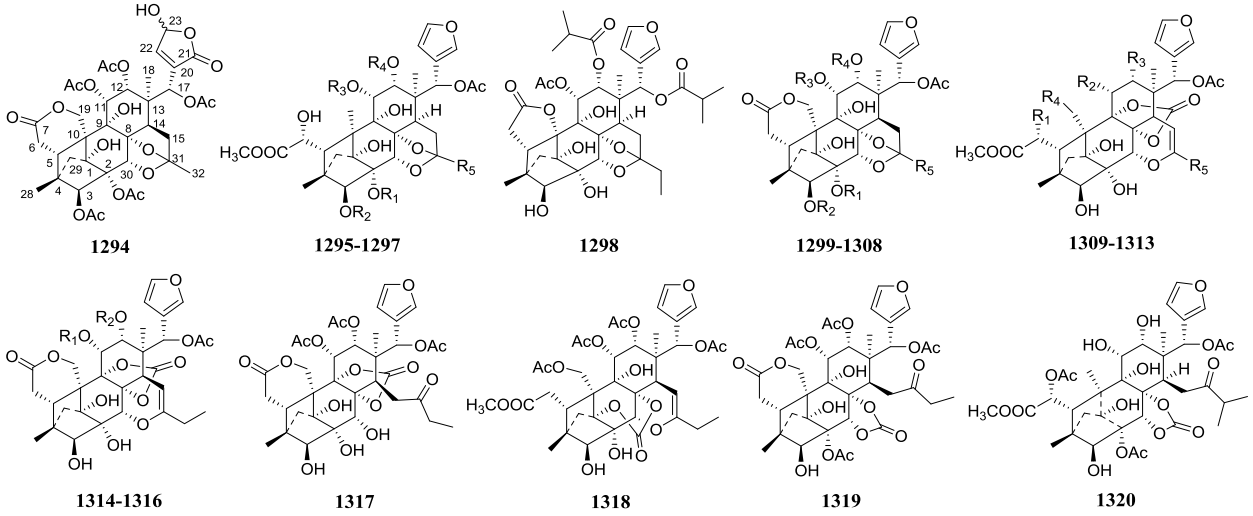


Figure 47. Structures of 16-Nor phragmalin class limonoids **1294-1320**.

2.4.2. 1,30-linkage along with 2,30-linkage

2.4.2.1. Khayanolide

These are rearranged phragmalin class limonoids. Twenty four Limonoids were isolated from *Xylocarpus moluccensis* and *Khaya senegalensis* (Table 46/S46, Figure 48). The epoxide group at C30 in previously reported Khayanolide A[429] is replaced by $\Delta^{8,14}$ olefinic double bond in Xylomolin G1 (**1321**) which also has an additional ethoxide group at C30. Compounds (**1322-1329**) are analogs of compound (**1321**) with differing substituent groups at C3, C6 and C30. The $\Delta^{8,14}$ double bond in compound (**1321**) is shifted to $\Delta^{14,15}$ in Xylomolin H (**1330**) which also has C1-O isobutyryl moiety, hydroxyl group at C8 and C30. Compounds (**1331-1333**) contain additional conjugated double bond at $\Delta^{8,9}$ relative to compound (**1330**) and differ in substitution at C3 and C30. Xylomolin I (**1334**) and Thaixylomolin H (**1335**) are structural analogs of Thaixylomolin M (**1331**) except the substituents at C6 and interchanged substituents between C2 and C3. Thaixylomolin G (**1336**) is a C11 keto carbonyl analog of compound (**1335**). The $\Delta^{8,9}$, $\Delta^{14,15}$ double bond in compound (**1335**) is replaced by $\Delta^{8,14}$ double bond in Thaixylomolin I (**1337**). Thaixylomolin J (**1338**) is C30 ethoxide analog of compound (**1337**). Krishnolide A (**1339**) is a structural analog of previously isolated Khayanolide A[429] but differs in substitution at C3, C6 and C30. The C17 furan ring in previously reported khayanolide B[429] is replaced by γ-substituted butenolide moiety in Khaysenelide C-F (**1340-1343**) and also varying substituents at C1 and C3. Thaixylomolin S (**1344**) is C6 hydroxy, C30 2-methylbutyryloxy, $\Delta^{14,15}$ analog of previously reported 3-acetyl khayalactone[438].

Table 46. Khayanolide class limonoid 1321-1344

No.	Limonoid	Substituent	Source
1321	Xylomolin G1	R_1 = Ac; R_2 = OH; R_3 = OCH_2CH_3	*Xylocarpus moluccensis*[143]
1322	Xylomolin G2	R_1 = $COCH(CH_3)_2$; R_2 = OH; R_3 = OCH_2CH_3	*Xylocarpus moluccensis*[143]
1323	Xylomolin G3	R_1 = Ac; R_2 = OH; R_3 = H;	*Xylocarpus moluccensis*[143]
1324	Xylomolin G4	R_1 = $COCH(CH_3)_2$; R_2 = R_3 = H	*Xylocarpus moluccensis*[143]
1325	Xylomolin G5	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = R_3 = H	*Xylocarpus moluccensis*[143]
1326	Thaixylomolin K	R_1 = Ac; R_2 = R_3 = H	*Xylocarpus moluccensis*[352]
1327	Thaixylomolin L	R_1 = Ac; R_2 = H; R_3 = OCH_2CH_3	*Xylocarpus moluccensis*[352]
1328	Krishnolide C	R_1 = $COCH(\alpha\text{-}CH_3)CH_2CH_3$; R_2 = H; R_3 = $OCOCH(CH_3)_2$	*Xylocarpus moluccensis*[439]
1329	Krishnolide D	R_1 = $COCH(CH_3)_2$; R_2 = H; R_3 = $OCOCH(CH_3)_2$	*Xylocarpus moluccensis*[439]
1330	Xylomolin H		*Xylocarpus moluccensis*[143]
1331	Thaixylomolin M	R_1 = Ac; R_2 = H	*Xylocarpus moluccensis*[352]
1332	Thaixylomolin N	R_1 = Ac; R_2 = OTig	*Xylocarpus moluccensis*[352]
1333	Krishnolide B	R_1 = $COCH(\alpha\text{-}CH_3)CH_2CH_3$; R_2 = $OCOCH(CH_3)_2$	*Xylocarpus moluccensis*[439]
1334	Xylomolin I	R_1 = $COCH(CH_3)CH_2CH_3$; R_2 = OH	*Xylocarpus moluccensis*[143]
1335	Thaixylomolin H	R_1 = Ac; R_2 = H	*Xylocarpus moluccensis*[352]
1336	Thaixylomolin G		*Xylocarpus moluccensis*[352]
1337	Thaixylomolin I	R = OH	*Xylocarpus moluccensis*[352]
1338	Thaixylomolin J	R = OCH_2CH_3	*Xylocarpus moluccensis*[352]
1339	Krishnolide A		*Xylocarpus moluccensis*[439]
1340	Khaysenelide C		*Khaya senegalensis*[367]
1341	Khaysenelide D		*Khaya senegalensis*[367]
1342	Khaysenelide E	R = CH_3	*Khaya senegalensis*[367]
1343	Khaysenelide F	R = H	*Khaya senegalensis*[367]
1344	Thaixylomolin S		*Xylocarpus moluccensis*[337]

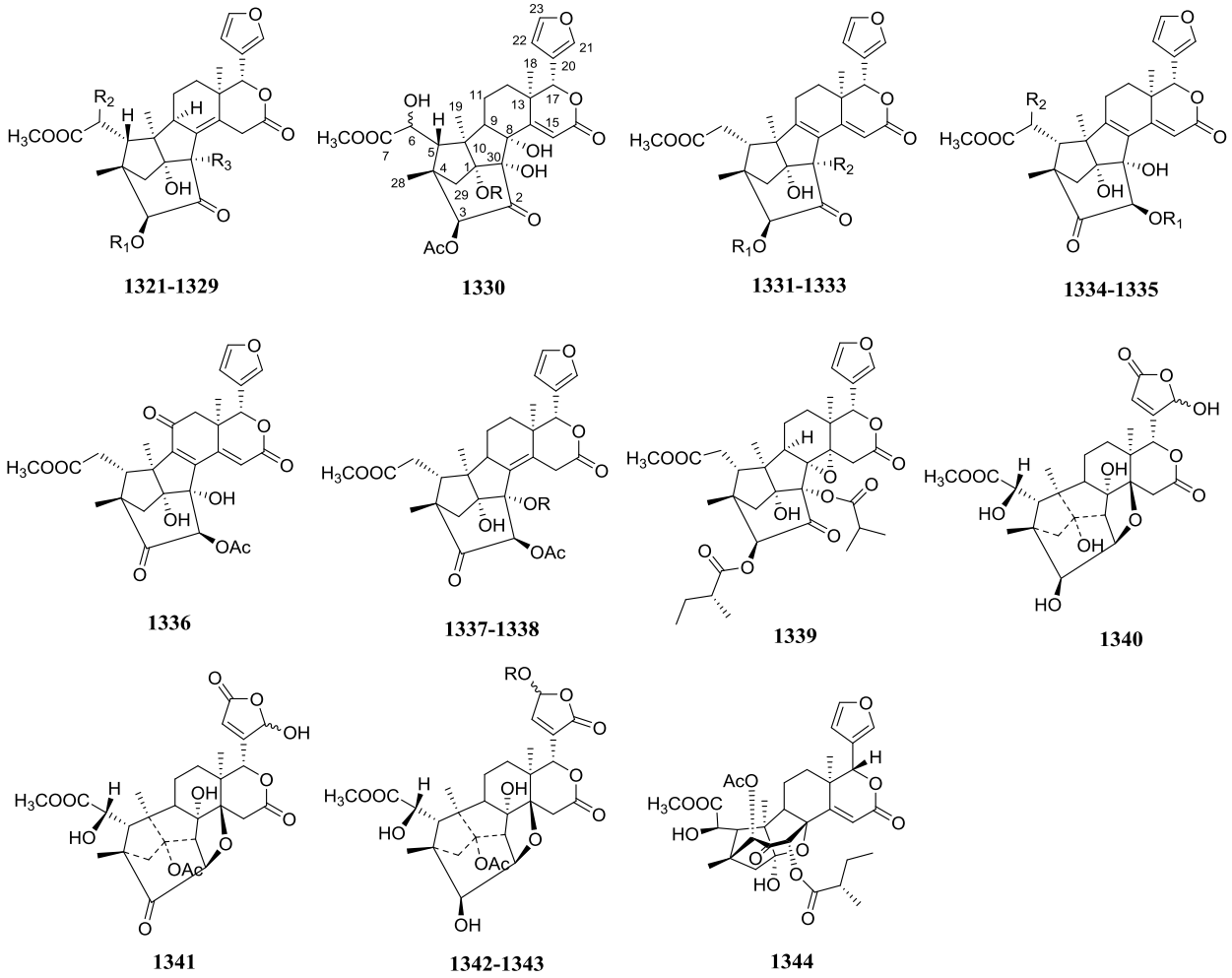


Figure 48. Structures of khayanolide class limonoids **1321-1344**.

2.4.3. 8,11-linkage

2.4.3.1. Trijugin

The presence of C8-C11 linkage and ether linkage in the form of an eight membered ring is the signature mark of this class. Twenty three Limonoids were isolated from *Heynea trijuga, Cipadessa baccifera, Cipadessa cinerascens* and *Trichilia connaroides* (Table 47/S47, Figure 49). Previously Trijugin class limonoids were reported from the Meliaceae family[12]. The $\Delta^{8,30}$ olefinic double bond in previously reported Trijugin H[440] is replaced by epoxide moiety in Trichisin A (**1345**). The $\Delta^{2,6}$ ether bridge and hydroxyl group at C2 in compound (**1345**) is absent in Trichisin D (**1346**). In comparison to compound (**1346**), there is an additional hydroxyl group at C9 with formation of ether linkage at C9-O-C6 in Trichisin E (**1347**). The C2-O-C6 ether bridge and C2 hydroxyl group in Trijugin H are absent in Cipatrijugin E (**1348**). Cipatrijugin G (**1349**) is a C11 hydroxyl analog of compound (**1348**). Compounds (**1350-1355**) are structural analogs of compound (**1348**) with variation at C2, C3 and C11 substitution. Limonoids (**1356-1359**) are 12-deacetyl analogs of previously reported Trijugin A[441] except in the substituents at C6 and C11. Trichisin B and C (**1360** and **1361**) are D ring cleaved analogs of compounds (**1357** and **1349**) respectively. Ciparasin E-G (**1362-1364**) and Cipatrijugin G (**1365**) are C17 γ-hydroxy butenolide analogs of compound (**1350**) with varying substituents at C2 and C12. Trichiliton B (**1366**) is structurally similar to previously reported Trichilin A[442] except in the cleaved ether bridges at C6/9 and C1/14. Cipaferoid A (**1367**) is structurally similar to previously reported methyl angolensate[443] except in the additional seven membered lactone ring between C7 and C11.

Table 47. Trijugin class limonoid 1345-1367

No.	Limonoid	Substituent	Source
1345	Trichisin A		*Heynea trijuga*[357]
1346	Trichisin D		*Heynea trijuga*[357]
1347	Trichisin E		*Heynea trijuga*[357]
1348	Cipatrijugin E	R = H	*Cipadessa baccifera*[444]
1349	Cipatrijugin G	R = OH	*Cipadessa cinerascens*[445]
1350	Ciparasin A	R_1 = OAc; R_2 = Ac; R_3 = OH	*Cipadessa cinerascens*[281]
1351	Ciparasin B	R_1 = OH; R_2 = Ac; R_3 = OH	*Cipadessa cinerascens*[281]
1352	Ciparasin C	R_1 = OH; R_2 = Ac; R_3 = OAc	*Cipadessa cinerascens*[281]
1353	Ciparasin D	R_1 = R_2 = R_3 = H	*Cipadessa cinerascens*[281]
1354	Cipatrijugin F	R_1 = OAc; R_2 = Ac; R_3 = H	*Cipadessa baccifera*[444]
1355	Cipatrijugin H	R_1 = H; R_2 = Ac; R_3 = OH	*Cipadessa cinerascens*[445]
1356	Trichisin F	R_1 = β-H; R_2 = OH	*Heynea trijuga*[357]
1357	Trichisin G	R_1 = α-H; R_2 = OH	*Heynea trijuga*[357]
1358	Trichisin H	R_1 = α-H; R_2 = H	*Heynea trijuga*[357]
1359	12-deacetoxyltrijugin A	R_1 = β-H; R_2 = H	*Trichilia connaroides*[432]
1360	Trichisin B		*Heynea trijuga*[357]
1361	Trichisin C		*Heynea trijuga*[357]
1362	Ciparasin E	R_1 = R_2 = H; R_3 = β-OH	*Cipadessa cinerascens*[281]
1363	Ciparasin F	R_1 = R_2 = OAc; R_3 = β-OH	*Cipadessa cinerascens*[281]
1364	Ciparasin G	R_1 = H; R_2 = OAc; R_3 = β-OH	*Cipadessa cinerascens*[281]
1365	Cipatrijugin G	R_1 = OAc; R_2 = H; R_3 = OH	*Cipadessa cinerascens*[446]
1366	Trichiliton B		*Trichilia connaroides*[447]
1367	Cipaferoid A		*Cipadessa baccifera*[319]

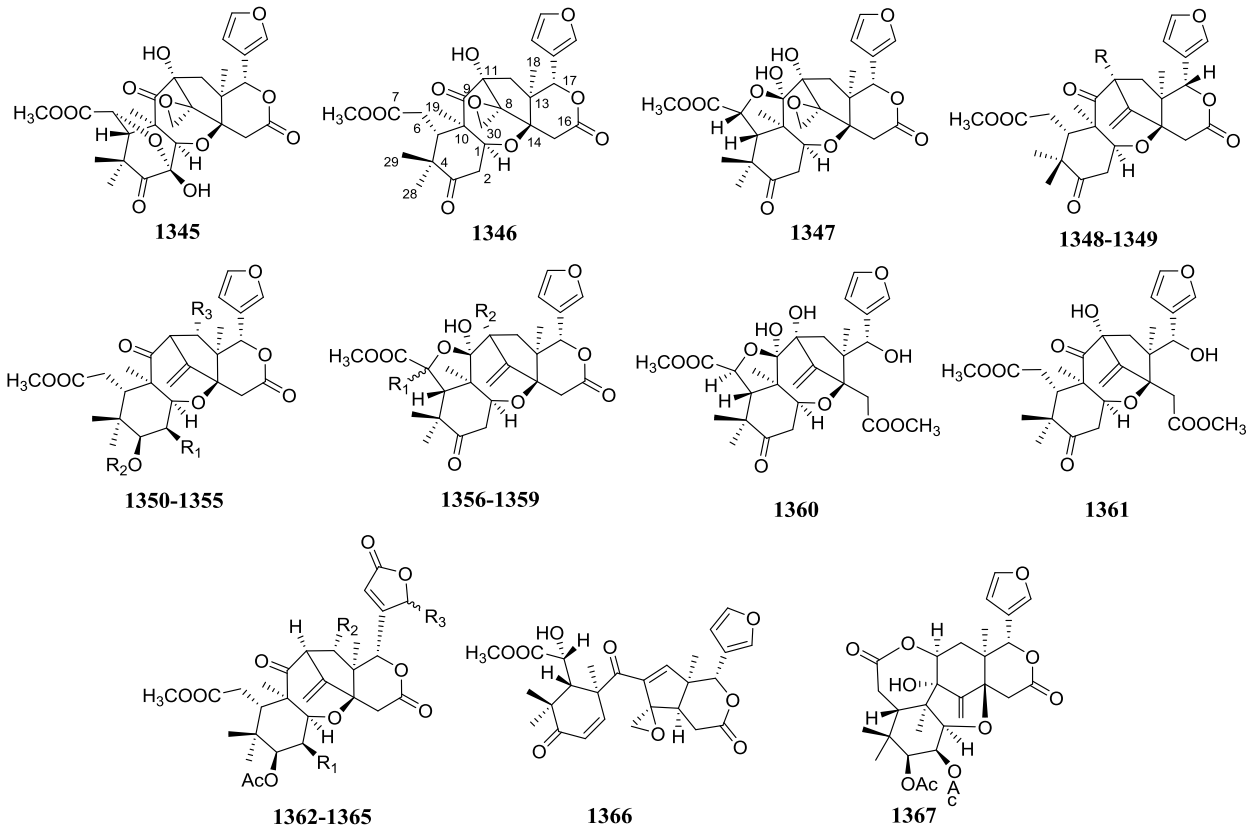


Figure 49. Structures of trijugin class limonoids **1345-1367**.

2.4.4. 10,11-linkage

2.4.4.1. Cipadesin

This class of Limonoids is characterized by linkage between C10 and C11. Twenty three Limonoids belonging to this class were isolated from *Cipadessa cinerascens* and *Cipadessa baccifera* (Table 48/S48, Figure 50). Earlier ten Cipadesin class limonoids were reported from Meliaceae family[12]. The structure of Ciparasin H (**1368**) is structurally similar to previously reported Cipadesin A[448] except in the rearrangement at B ring. Ciparasin I-L (**1369-1372**) are structurally similar to compound (**1368**) but differ in substitution at C2 and C8. Ciparasin K and L (**1371** and **1372**) are C8 epimers. Cibacciferin E (**1373**) is C2 deacetoxyl, C6 hydroxy analog of previously reported Cipadesin A[449]. 2β-Acetoxycibacciferin E (**1374**) is C6 hydroxy analog of previously reported Cipadesin A[449]. 6-Dehydroxycibacciferin F (**1375**) is C2 isobutyrate, C3 deacetyl analog of previously reported Cipadesin G[450]. Cibacciferin F (**1376**) and 12-Deacetoxycibacciferin E (**1377**) are C6 hydroxy analogs of compound (**1375**) and previously reported Cipadesin G[450] respectively. 2β-Acetoxy-12-deacetoxycibacciferin E (**1378**) is C2 acetoxyl analog of compound (**1377**). Ciparasin M (**1379**) is C2 deacetyl analog of previously reported Cipadesin C[450]. Ciparasin N and O (**1380** and **1381**) are C3 deacetyl and C12 dehydroxyl analogs of compounds (**1379** and **1380**) respectively. Cibacciferin G (**1382**) is C3 deacetyl analog of previously reported Cipadesin C[450]. Cibacciferin H (**1383**) and 12-Dehydroxycibacciferin H (**1384**) are C2 hydroxy analog of previously reported Cipadesin E[313] and Cipadonoid C[305] respectively. Cibacciferin I (**1385**) is C6 hydroxy analog of previously reported Cipadonoid D[305]. Cipaferen O and C (**1386** and **1387**) differ in substitutions at C2 and C6. The C2-O tiglate and γ-hydroxy butenolide groups in compound (**1386**) are replaced by 2-methylbutanoate and furan moiety in Cipaferen A (**1388**) respectively. Cipaferen B (**1389**) is a C6 hydroxy analog of compound (**1388**). Cipaferen D (**1390**) differs at C17 substitution from compound (**1387**).

Table 48. Cipadesin class limonoid 1368-1390

No.	Limonoid	Substituent	Source
1368	Ciparasin H	R_1 = OAc; R_2 = α-H	*Cipadessa cinerascens*[281]
1369	Ciparasin I	R_1 = H; R_2 = α-H	*Cipadessa cinerascens*[281]
1370	Ciparasin J	R_1 = OH; R_2 = α-H	*Cipadessa cinerascens*[281]
1371	Ciparasin K	R_1 = OAc; R_2 = β-OH	*Cipadessa cinerascens*[281]
1372	Ciparasin L	R_1 = OAc; R_2 = α-OH	*Cipadessa cinerascens*[281]
1373	Cibacciferin E	R_1 = H; R_2 = β-OAc; R_3 = OH; R_4 = OAc	*Cipadessa baccifera*[312]
1374	2β-Acetoxycibacciferin E	R_1 = OAc; R_2 = β-OAc; R_3 = OH; R_4 = OAc	*Cipadessa baccifera*[312]
1375	6-Dehydroxycibacciferin F	R_1 = $OCOCH(CH_3)_2$; R_2 = α-OH; R_3 = R_4 = H	*Cipadessa baccifera*[312]
1376	Cibacciferin F	R_1 = $OCOCH(CH_3)_2$; R_2 = α-OH; R_3 = OH; R_4 = H	*Cipadessa baccifera*[312]
1377	12-Deacetoxycibacciferin E	R_1 = H; R_2 = β-OAc; R_3 = OH; R_4 = H	*Cipadessa baccifera*[312]
1378	2β-Acetoxy-12-deacetoxycibacciferin E	R_1 = OAc; R_2 = β-OAc; R_3 = OH; R_4 = H	*Cipadessa baccifera*[312]
1379	Ciparasin M	R_1 = OH; R_2 = β-OAc; R_3 = H; R_4 = OH	*Cipadessa cinerascens*[281]
1380	Ciparasin N	R_1 = OH; R_2 = β-OH; R_3 = H; R_4 = OH	*Cipadessa cinerascens*[281]
1381	Ciparasin O	R_1 = OH; R_2 = β-OH; R_3 = H; R_4 = H	*Cipadessa cinerascens*[281]
1382	Cibacciferin G	R_1 = OAc; R_2 = α-OH; R_3 = H; R_4 = OH	*Cipadessa baccifera*[312]
1383	Cibacciferin H	R_1 = OH; R_2 = α-OAc; R_3 = H; R_4 = OH	*Cipadessa baccifera*[312]
1384	12-Dehydroxycibacciferin H	R_1 = OH; R_2 = α-OAc; R_3 = R_4 = H	*Cipadessa baccifera*[312]
1385	Cibacciferin I	R_1 = H; R_2 = β-OAc; R_3 = β-OH; R_4 = OAc	*Cipadessa baccifera*[312]
1386	Cipaferen O	R_1 = H; R_2 = Tig	*Cipadessa baccifera*[307]
1387	Cipaferen C	R_1 = OH; R_2 = $COCH(CH_3)CH_2CH_3$	*Cipadessa baccifera*[451]
1388	Cipaferen A	R = H	*Cipadessa baccifera*[451]
1389	Cipaferen B	R = OH	*Cipadessa baccifera*[451]
1390	Cipaferen D		*Cipadessa baccifera*[451]

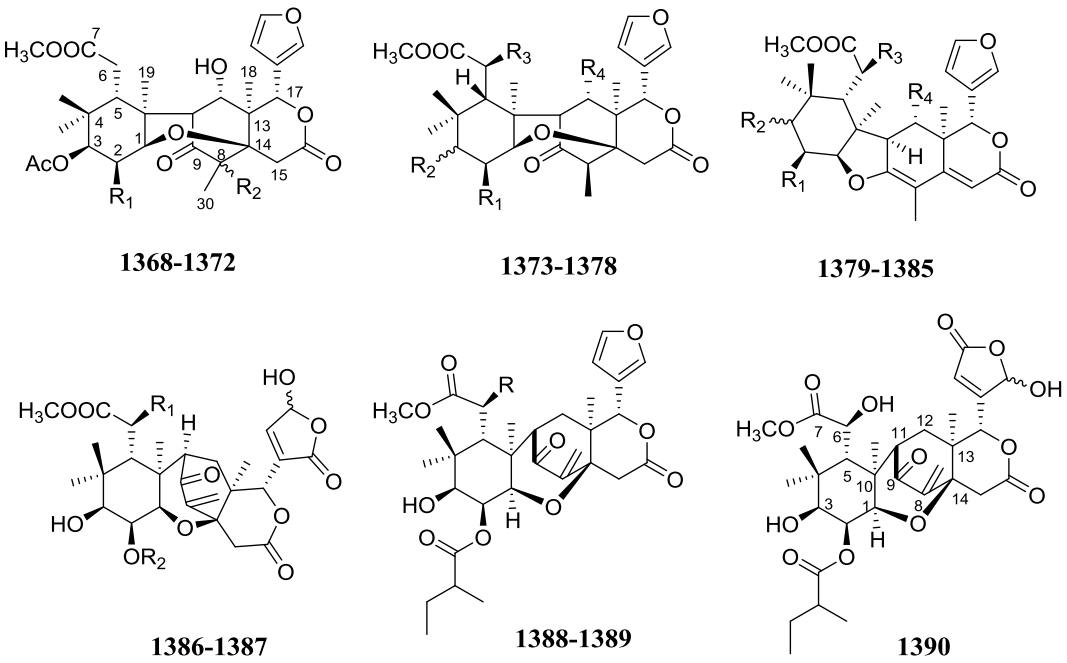


Figure 50. Structures of cipadesin class limonoids **1368-1390**.

2.4.5. Other linkage

Nineteen Limonoids belonging to this class were isolated from *Carapa guianensis, Trichilia connaroides, Cipadessa cinerascens, Xylocarpus granatum, Entandrophragma utile, Khaya senegalensis, Swietenia mahogani* and *Toona ciliata* (Table 49/S49, Figure 51). A total of twenty six Meliaceae limonoids of this class were reported from[12]. Guianolactone A (**1391**) contains a 5,6,6,6,6 ring system. Guianolactone B (**1392**) possesses a 6,6,5,6,6 ring system and exhibits keto-enol tautomeism. Spirotrichilin A (**1393**) has a 1,7-dioxadispiro [2.3.0.4]-hendecane system in B/C rings. The C2-methylformate group in compound (**1393**) is absent in Spirotrichilin B (**1394**). Cipacinoid A (**1395**) has a cleaved D ring and Cipacinoid B (**1396**) is a C2 hydroxy analog of compound (**1395**). Cipacinoid C and D (**1397** and **1398**) are C17 epimers. Andhraxylocarpin E (**1399**) is structurally similar to previously reported Xylogranatin A[380] except in the additional five membered ring formed by C28 and C30 linkage. Entanutilin L (**1400**) is C3 carbonyl analog of previously reported Delevoyin C[452]. Entanutilin M (**1401**) is C6 isobutyrate analog of compound (**1400**). Entanutilin A (**1402**) is C3-deacetyl analog of previously reported Delevoyin C[452]. Entanutilin N (**1403**) is C3 deacetyl, C7 isovaleryl analog of previously reported Delevoyin C[452]. Senegalension A (**1404**) is structurally similar to previously reported Khayanolide C[416] except in the additional five membered lactone ring. Senegalension B (**1405**) is C1 acetyl derivative of compound (**1404**). Senegalension C (**1406**) contains a spiro ring system. Swietemahalactone (**1407**) corresponds to Khayanolide C except in the rearranged A and B rings. When compared with previously reported Toonacilin[320] in Toonayunnanae B (**1408**) there is formation of C1, C14 ether linkage with opening of C14, C15 epoxide ring. Toonaolide A (**1409**) contains C21 hydroxy butenolide moiety and rearranged ring A having lactone moiety.

Table 49. Other linkage class limonoid 1391-1409

No.	Limonoid	Substituent	Source
1391	Guianolactone A		*Carapa guianensis*[453]
1392	Guianolactone B		*Carapa guianensis*[453]
1393	Spirotrichilin A		*Trichilia connaroides*[454]
1394	Spirotrichilin B		*Trichilia connaroides*[454]
1395	Cipacinoid A	R = H	*Cipadessa cinerascens*[455]
1396	Cipacinoid B	R = OH	*Cipadessa cinerascens*[455]
1397	Cipacinoid C	17S	*Cipadessa cinerascens*[455]
1398	Cipacinoid D	17R	*Cipadessa cinerascens*[455]
1399	Andhraxylocarpin E		*Xylocarpus granatum*[434]

1400	Entanutilin L	R = Ac	*Entandrophragma utile*[387]
1401	Entanutilin M	R = $COCH(CH_3)_2$	*Entandrophragma utile*[387]
1402	Entanutilin A	R = $COCH(CH_3)_2$	*Entandrophragma utile*[456]
1403	Entanutilin N	R = $COCH_2CH(CH_3)_2$	*Entandrophragma utile*[387]
1404	Senegalension A	R = H	*Khaya senegalensis*[457]
1405	Senegalension B	R = Ac	*Khaya senegalensis*[457]
1406	Senegalension C		*Khaya senegalensis*[457]
1407	Swietemahalactone		*Swietenia mahogani*[458]
1408	Toonayunnanae B		*Toona ciliata*[232]
1409	Toonaolide A		*Toona ciliata*[219]

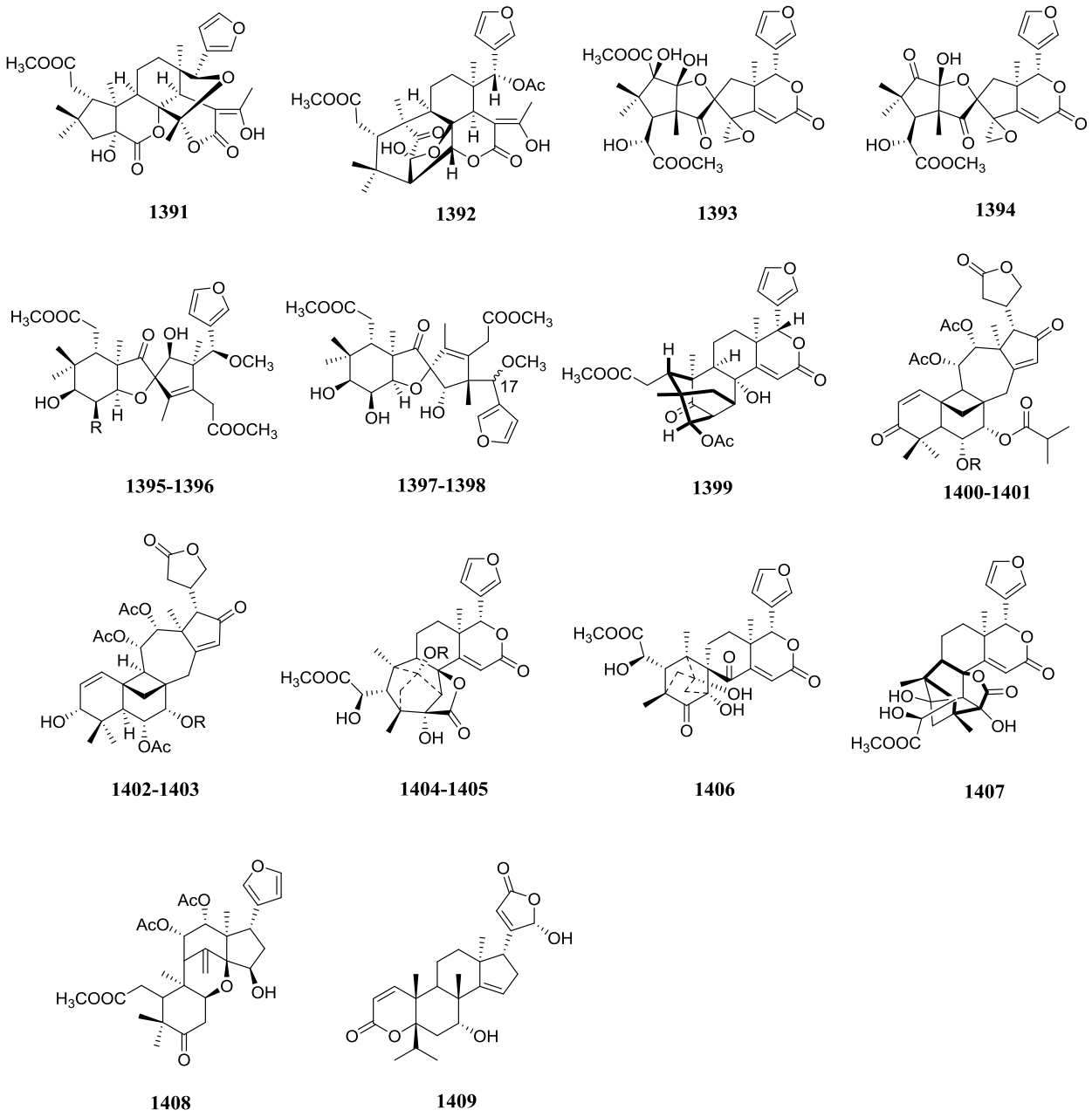


Figure 51. Structures of other linkage class limonoids **1391-1409**.

2.5. Limonoid derivatives

2.5.1. Pentanor triterpenoids

The major characteristic of this class is the absence of five carbons on the steroidal skeleton. Twenty eight Limonoids belonging to this class were isolated from *Swietenia macrophylla, Chisocheton ceramicus, Walsura robusta, Azadirachta indica, Chisocheton cumingianus, Toona ciliata, Xylocarpus moluccensis, Toona sinensis* and *Carapa guianensis* (Table 50/S50, Figure 52). Previously twenty seven Pentanor class limonoids were reported from Meliaceae family[12]. Swieteliacate A (**1410**) is structurally similar to Azadirone skeleton but differs at C17 substitution and lacks one carbon unit at C28 with presence of glucose moiety at C7. Swieteliacate B (**1411**) is a C4 hydroxy analog of compound (**1410**). Ceramicine L (**1412**) is structurally similar to previously reported Ceramicine A[459] except in the additional methyl group at C4 and deacetylation at C6. The C4-O-C29 linkage leads to the formation of the epoxide group at C4 in Ceramicine P (**1413**). In Ceramicine E (**1414**) there is shuffling of C6, C7 substituents and presence of additional epoxide at C2/3 with respect to compound (**1413**). Walsunoid A (**1415**) resembles previously reported 11β-hydroxycedrelone[460] but differs at C17 substitution. From NMR data, the structure of Azadiraindin B (**1416**) matches with previously reported Azadiradione[110] except at C17 substitution. The acetoxyl group at C12, C1-C10 bond and C1/14 ether linkage in previously reported Trijugin A[441] is absent in Chisotrijugin (**1417**) with C1/2 epoxide ring formation. The C28 methyl group in previously reported Toonacilianin G[227] is absent in Toonaciliatone A (**1418**). The $\Delta^{1,2}$ double bond and C3 keto carbonyl in compound (**1418**) is reduced in Toonaciliatone B (**1419**). In comparison to Nimbinene[461] olefinic double bond is formed at $\Delta^{4,29}$ in Morenolide (**1420**). Compounds (**1421** and **1422**) are structurally similar to Nimbandiol[462] except at C17 substitution. The methyl formate group at C8 in previously reported Thaixylomolin A[318] is absent in Thaixylomolin R (**1423**) with opening of C14/15 epoxide ring and $\Delta^{8,14}$ olefinic bond formation. The furan ring at C17 in previously reported Nimbandiol[462] is replaced by γ-hydroxy butenolide moiety in Nimbandiolactone-21 (**1424**) and substituted tetrahydrofuran ring moiety in Nimbandioloxyfuran (**1425**). Toonacilianin K (**1426**) is structurally similar to previously reported toonaciliatin F[223] except the hydroxylation at C1. Toonacilianin L (**1427**) is C3 epimer of compound (**1426**). Toonaciliatin O (**1428**) and Toonasinenine D (**1429**) are C12 acetyl analog and C12 dehydroxyl derivative of compound (**1427**) respectively. The hydroxyl at C3 in previously reported Toonaciliatin F[223] is carbonylated in Toonaciliatin N (**1430**) along with C12 acetylation. Ciliatonoid C (**1431**) is C2 dehydroxy analog of compound (**1429**). Ciliatasecone R (**1432**) is the C1 dimethyl analog of previously reported Toonaciliatin J[463]. Toonaciliatone C (**1433**) differs from compound (**1431**) in the additional keto carbonyl group at C12. The C12 hydroxyl group in previously reported Toonaciliatin F[223] is converted to carbonyl group in Toonaciliatone D (**1434**). Carapanin A (**1435**) when compared with previously reported Swiemahogin A[464] C16 is absent. Ciliatasecone N (**1436**) is C12 dehydroxy analog of compound (**1418**). Toonayunnanae I (**1437**) is $\Delta^{1,2}$ double bond reduced analog of compound (**1418**).

Table 50. Pentanor triterpenoids class limonoid 1410-1437

No.	Limonoid	Substituent	Source
1410	Swieteliacate A	R_1 = H; $R_{2=}$ Glucose	*Swietenia macrophylla*[116]
1411	Swieteliacate B	R_1 = OH; $R_{2=}$ Glucose	*Swietenia macrophylla*[116]
1412	Ceramicine L		*Chisocheton ceramicus*[204]
1413	Ceramicine P		*Chisocheton ceramicus*[201]
1414	Ceramicine E		*Chisocheton ceramicus*[199]
1415	Walsunoid A		*Walsura robusta*[159]
1416	Azadiraindin B		*Azadirachta indica*[465]
1417	Chisotrijugin		*Chisocheton cumingianus*[466]
1418	Toonaciliatone A		*Toona ciliata*[229]
1419	Toonaciliatone B		*Toona ciliata*[229]
1420	Morenolide		*Azadirachta indica*[467]
1421	17-desfuran-17-(22-hydroxybut-20(21)-ene-21,23-γ-lactone) nimbandiol		*Azadirachta indica*[145]
1422	17-desfuran-17-(21-hydroxy-20(22)-ene-21,23-γ-lactone) nimbandiol		*Azadirachta indica*[145]
1423	Thaixylomolin R		*Xylocarpus moluccensis*[382]
1424	Nimbandiolactone-21		*Azadirachta indica*[468]
1425	Nimbandioloxyfuran		*Azadirachta indica*[468]
1426	Toonacilianin K	R_1 = β-OH; R_2 = OH	*Toona ciliata*[227]
1427	Toonacilianin L	R_1 = α-OH; R_2 = OH	*Toona ciliata*[227]
1428	Toonaciliatin O	R_1 = α-OH; R_2 = OAc	*Toona ciliata*[228]
1429	Toonasinenine D	R_1 = α-OH; R_2 = H	*Toona sinensis*[214]
1430	Toonaciliatin N		*Toona ciliata*[228]
1431	Ciliatonoid C	R_1 = R_2 = H	*Toona ciliata*[230]
1432	Ciliatasecone R	R_1 = CH_3; R_2 = OH	*Toona ciliata*[139]
1433	Toonaciliatone C		*Toona ciliata*[229]
1434	Toonaciliatone D		*Toona ciliata*[229]
1435	Carapanin A		*Carapa guianensis*[370]
1436	Ciliatasecone N		*Toona ciliata*[139]
1437	Toonayunnanae I		*Toona ciliata*[155]

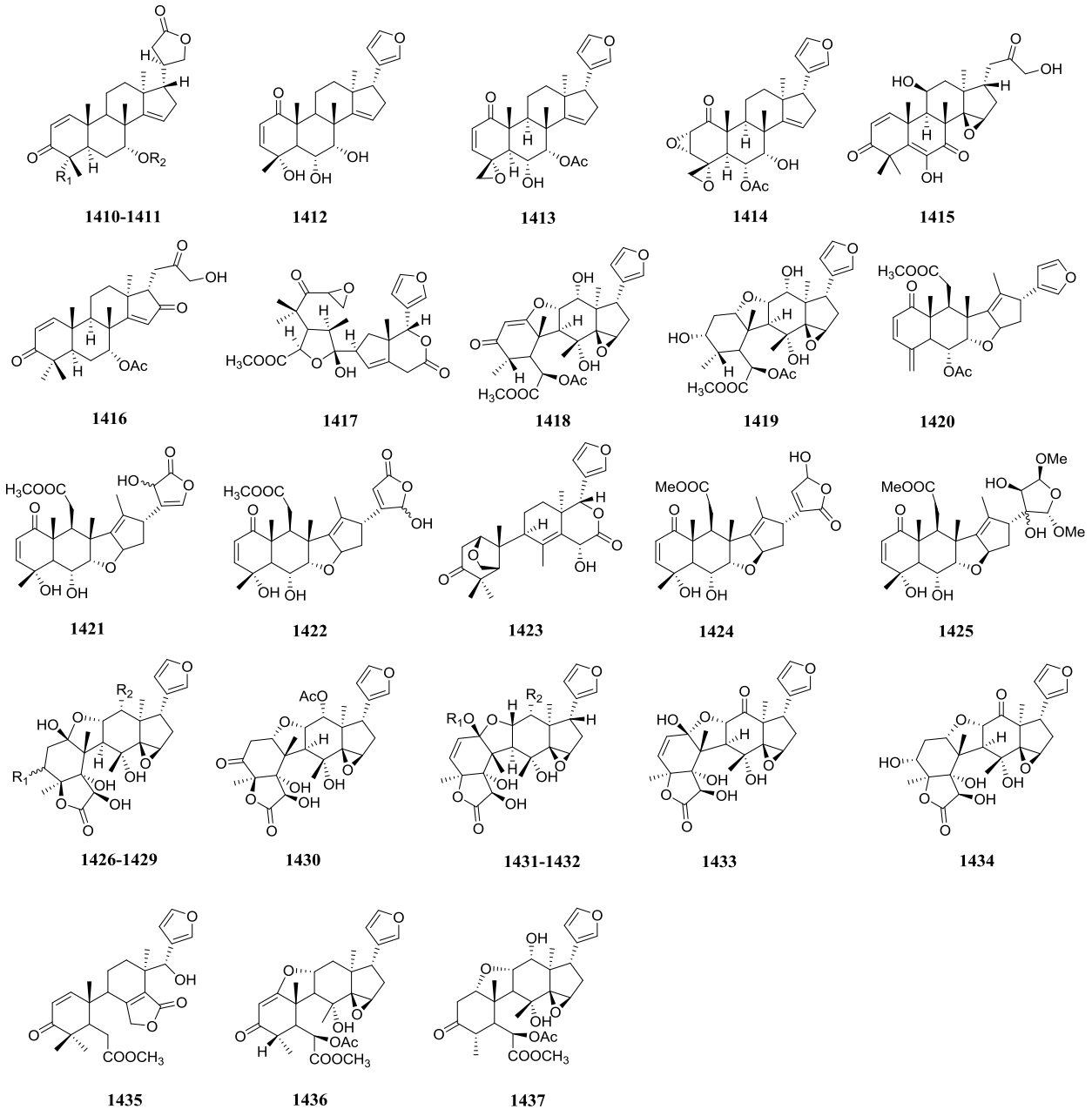


Figure 52. Structures of pentanor triterpenoids class limonoids **1410-1437**.

2.5.2. Hexanor triterpenoids

Seven limonoids belonging to this class were isolated from *Munronia henryi*, *Azadirachta indica*, *Chisocheton ceramicus*, *Carapa guianensis Aphanamixis polystachya* and *Cipadessa baccifera* (Table 51/S51, Figure 53). Earlier four limonoids of this class were reported from Meliaceae family[12]. The furan ring in previously reported Nymania-3[270] is replaced by ethynyl group in Munronin O (**1438**). The furan ring in previously reported Epoxyazadiradione[131] is absent in Azadiraindin A (**1439**) which also contains additional five membered ring at C16 and C17. Ceramicine K (**1440**) is C6-deacetyl, C4-acetyl derivative of previously reported Ceramicine A[459]. The furan ring moiety at C17 in previously reported Methyl angolensate[443] is replaced by acetyl group in Andirolide K

(**1441**). The C28 methyl group in compound (**1412**) is absent in Ceramicine M (**1442**) which also has C7-O-C4 ether bridge. Aphananoid A (**1443**) when compared with compound (**347**) there is ring B contraction with absence of C7. Cipaferen R (**1444**) differs from compound (**887**) at C17 substitution where butenolide moiety is replaced by acetyl group.

Table 51. Hexanor triterpenoids class limonoid 1438-1444

No.	Limonoid	Substituent	Source
1438	Munronin O		*Munronia henryi*[277]
1439	Azadiraindin A		*Azadirachta indica*[465]
1440	Ceramicine K		*Chisocheton ceramicus*[204]
1441	Andirolide K		*Carapa guianensis*[264]
1442	Ceramicine M		*Chisocheton ceramicus*[201]
1443	Aphananoid A		*Aphanamixis polystachya*[469]
1444	Cipaferen R		*Cipadessa baccifera*[366]

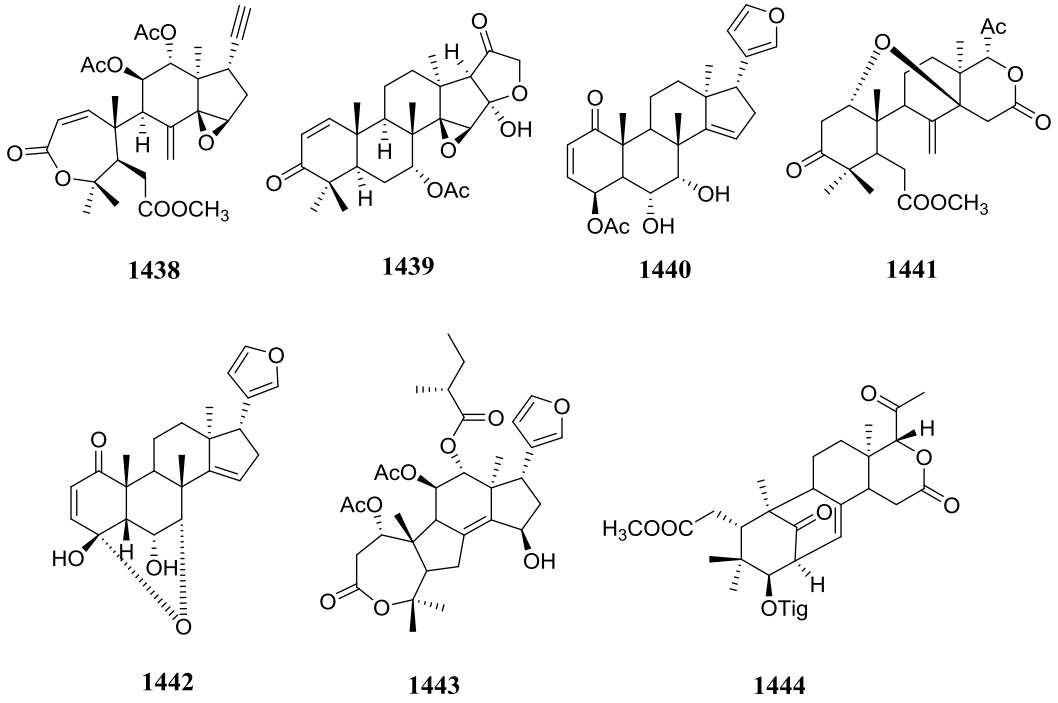


Figure 53. Structures of hexanor triterpenoids class limonoids **1438-1444**.

2.5.3. Heptanor triterpenoids

Five compounds belonging to this class were isolated from *Munronia henryi*, *Munronia delavayi*, *Toona ciliata* and *Entandrophragma utile* (Table 52/S52, Figure 54). Prior to this eight Meliaceae limonoids of this class were reported[12]. The tiglate group at C12 and furan moiety at C17 in compound (**550**) are replaced by acetate and carboxylic acid groups respectively in Munronin G (**1445**). The acetate group at C12 in compound (**1445**) is replaced by tiglate group in Mulavanin C (**1446**). Oxidative cleavage of C17 furan ring in Cedrelone gives Toonapubesic acid B (**1447**) and further reduction of $\Delta^{5,6}$ olefinic double bond and C7 carbonyl followed by C6, C7 acetylation of hydroxyl group gives Toonapubesic acid A (**1448**). Entanutilin R (**1449**) is C3 isobutyrate analog of previously reported Entilin D[470].

Table 52. Heptanor triterpenoid 1445-1449

No.	Limonoid	Substituent	Source
1445	Munronin G	R = Ac	*Munronia henryi*[169]
1446	Mulavanin C	R = Tig	*Munronia delavayi*[215]
1447	Toonapubesic acid B		*Toona ciliata*[61]
1448	Toonapubesic acid A		*Toona ciliata*[61]

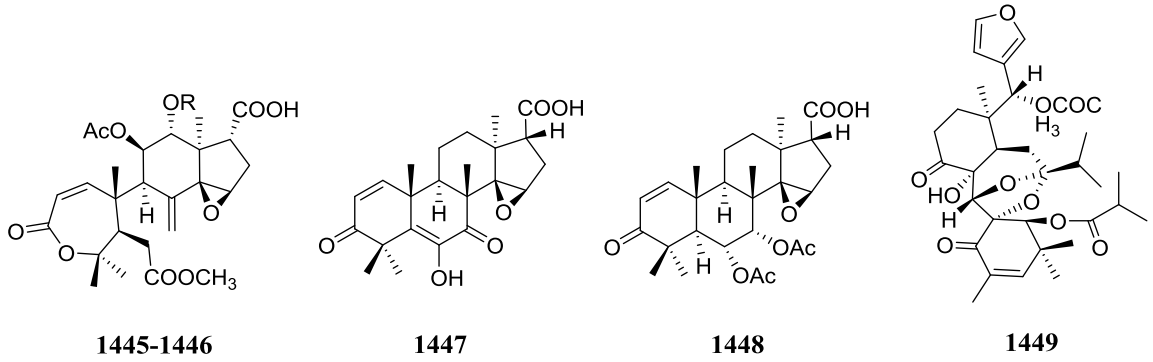


Figure 54. Structures of heptanor triterpenoids **1445-1449**.

2.5.4. Octanor triterpenoids

A total of six Limonoids belonging to this class were isolated from *Azadirachta indica, Carapa guianensis* and *Melia azedarach* (Table 53/S53, Figure 55). Three Meliaceae limonoids of this class were reported earlier[12]. Azadiraindin C and D (**1450** and **1451**) are C17 hydroxy epimers of previously reported desfuranoazadiradione[471]. Andirolide R (**1452**) is C6 acetoxyl analog of previously reported desfuranoazadiradione[471]. The furan ring at C17 in compound (**458**) is replaced by keto carbonyl group in 3-deacetyl-17- defurano-17,28-dioxosalannin (**1453**). 17-defurano-17-oxoohchinin (**1454**) differs from compound (**1453**) at C1 substitution. 17-defurano-17-oxosalannin (**1455**) is C3 acetyl analog of compound (**1453**).

Table 53. Octanor triterpenoids class limonoid 1450-1455

No.	Limonoid	Substituent	Source
1450	Azadiraindin C	R_1 = H; R_2 = α-OH	*Azadirachta indica*[465]
1451	Azadiraindin D	R_1 = H; R_2 = β-OH	*Azadirachta indica*[465]
1452	Andirolide R	R_1 = OAc; R_2 = H	*Carapa guianensis*[149]
1453	3-deacetyl-17- defurano-17,28-dioxosalannin		*Melia azedarach*[243]
1454	17-defurano-17-oxoohchinin	R_1 = Cin; R_2 = H	*Melia azedarach*[188]
1455	17-defurano-17-oxosalannin	R_1 = Tig; R_2 = Ac	*Azadirachta indica*[472]

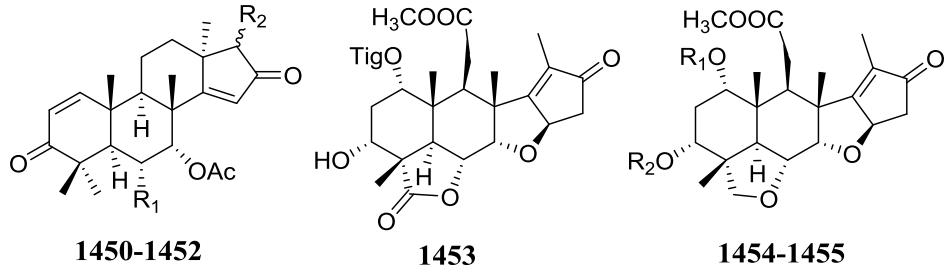


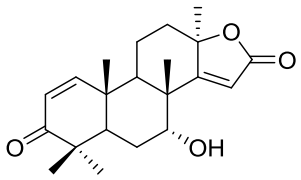
Figure 55. Structures of octanor triterpenoids class limonoids **1450-1455**.

2.5.5. Enneanor triterpenoids

Azadiralactone (**1456**) isolated from *Azadirachta indica* is deacetyl analog of previously reported 7α-acetoxy-4,4,8-trimethyl-5α-(13αMe)-17-oxa-androsta-1,14-dien-3,16-dione (13α-nimolactone)[471] (Table 54/S54, Figure 56).

Table 54. Enneanor triterpenoids class limonoid 1456

No.	Limonoid	Substituent	Source
1456	Azadiralactone		*Azadirachta indica*[119]



1456

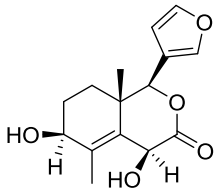
Figure 56. Structures of enneanor triterpenoids class limonoid **1456**.

2.5.6. Degraded derivatives

Isodictamdiol A (**1457**) isolated from *Dictamnus angustifolius* is C7 epimer of previously reported Isodictamdiol[473] (Table 55/S55, Figure 57). Previously eighteen Meliaceae limonoids of this class were reported[12].

Table 55. Degraded derivatives class limonoid 1457

No.	Limonoid	Substituent	Source
1457	Isodictamdiol A		*Dictamnus angustifolius*[474]



1457

Figure 57. Structures of degraded derivatives class limonoid **1457**.

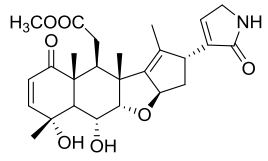
2.5.7. N-containing derivatives

As the name indicates, this class of Limonoids contain nitrogen in their structure. Forty three Limonoids belonging to this class were isolated from *Azadirachta indica, Amoora tsangii, Aphanamixis grandifolia, Xylocarpus moluccensis, Xylocarpus granatum, Trichilia sinensis, Entandrophragma utile, Trichilia connaroides, Entandrophragma angolense* and *Toona ciliata* (Table 56/S56, Figure 58). Previously ten Meliaceae limonoids of this class were reported[12]. Nimbandiolactam-21 (**1458**) differs from previously reported Nimbandiol[462] at C17 substitution containing α,β-unsaturated γ-lactam moiety. The hydroxyl group at C4 in Nimbolide is replaced by carboxylic acid group in Nimbic acid B (**1459**) along with a cleaved C ring and γ-hydroxyl group is present at C17. The C3 acetyl group in previously reported Salannolactam-21[475] is replaced by keto carbonyl group in Azadiramide A (**1460**) which also has $\Delta^{1,2}$ olefinic double bond with detigloylation. The C17 furan ring in compound (**550**) is replaced by N-substituted lactam ring in Amooramide A-C (**1461-1463**) which also differ at C12 substitution. The acetyl group at C11 in compound (**1461**) is replaced by formyl group in Amooramide G (**1466**). Amooramide F (**1467**) differs from compound (**1464**) at lactam ring N-substitution. The carbonyl group at C21 in compound (**1461**) is shifted to C23 in Amooramide H-J (**1468-1470**) along with variation at C12 substitution. Amooramide K and L (**1471** and **1472**) are N-methyl substituted analogs of compounds (**1468** and **1469**) respectively. Aphanalide M (**1473**) differs from compound (**337**) at C12 substitution. Thaixylomolin B (**1474**) shows structural similarities with phragmalins but has substituted pyridine ring at C7-C15. The methyl group at C2 in compound (**1474**) is replaced by isopropyl group in Thaixylomolin C (**1475**). Xylomexicanin E (**1476**) has azaspiro skeleton between B and C rings along with an unusual 17β furan ring. Trichinenlide A (**1477**) is structurally similar to previously reported Swietenine F[326] except at C3 substituted benzoyl moiety which contain nitrogen. The hydroxyl group at C6 in compound (**1477**) is shifted to C2 in Trichinenlide F (**1478**) which also has epoxide group at C8 and C30. Trichinenlide G (**1479**) is C6 acetoxyl analog of compound (**1478**). The acetyl group at C3 in previously reported Utilin C[476] is replaced by nicotinoyl group in Entanutilin B (**1480**). The C3 hydroxyl group in compound (**868**) is replaced by nicotinoyl group in Triconoid A (**1481**). The hydroxylation at C14 in compound (**1481**) yields Triconoid B (**1482**). The olefinic double bond at $\Delta^{8,30}$ in compound (**1481**) is shifted to $\Delta^{8,14}$ in Trichiliasinenoid D (**1483**). The

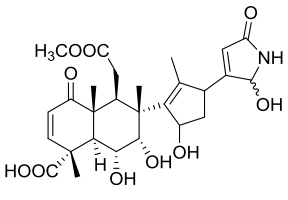
ethoxy group at C3 in Hainangranatumin G (**1484**) is the only structural difference from previously reported xylogranatin F[381]. The furan ring at C17 in previously reported methyl angolensate[477] is replaced by 21-methoxy lactam ring in Entangolensin K (**1485**). The furan ring at C17 in Azadirone and Epoxyazadiradione is replaced by lactam ring in Toonasinemine B and A (**1486** and **1487**) respectively. The C17 furan ring in gedunin is replaced by maleimide moiety in compound (**1488**). Compounds (**1488** and **1491**) were isolated from *Toona sinensis* and reported by two different research groups in 2016 but trively named differently as Toonasin A/Toonasinemine D and Toonasin C/Toonasinemine F respectively. Toonasin B (**1489**) and Toonasinemine E (**1490**) are C6 and C11 acetoxyl analogs of compound (**1488**) respectively. The carbonyl group at C23 and C21 in compound (**1488**) is reduced in compound (**1491**) and Toonasinemine G (**1492**) respectively. The furan ring at C17 in gedunin is replaced by lactam moiety in Toonasinemine C (**1493**). Entanutilin C (**1494**) is C3 N-containing benzoyl, C6 deacetoxyl, C11 deacetyl analog of compound (**1036**). Entanutilin J (**1495**) is C3 N-containing benzoyl analog of compound (**1170**). Entanutilin P (**1496**) is C3 N-containing benzoyl, C12 acetoxy analog of compound (**1052**). Entanutilin Q (**1497**) is C3 N-containing benzoyl, C6 hydroxy analog of compound (**1132**). 21-hydroxybutenolide moiety in compound (**650**), compound (**370**) and compound (**651**) is replaced by maleimide moiety in Toonaolide I (**1498**), Toonaolide R (**1499**) and Toonaolide X (**1500**) respectively.

Table 56. N-containing derivatives class limonoid 1458-1500

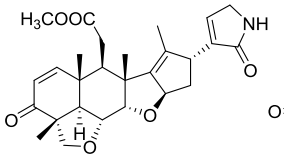
No.	Limonoid	Substituent	Source
1458	Nimbandiolactam-21		*Azadirachta indica*[478]
1459	Nimbic acid B		*Azadirachta indica*[245]
1460	Azadiramide A		*Azadirachta indica*[479]
1461	Amooramide A	R_1= OAc; R_2 = OBz; R_3 = H	*Amoora tsangii*[480]
1462	Amooramide B	R_1= OAc; R_2 = OBz; R_3 = CH_3	*Amoora tsangii*[480]
1463	Amooramide C	R_1= OAc; R_2 = OBz; R_3 = CH_2CH_2OH	*Amoora tsangii*[480]
1464	Amooramide D	R_1= OAc; R_2 = $OCOCH(CH_3)CH_2CH_3$; R_3 = H	*Amoora tsangii*[480]
1465	Amooramide E	R_1= OAc; R_2 = $OCOCH(CH_3)_2$; R_3 = H	*Amoora tsangii*[480]
1466	Amooramide G	R_1= OCHO; R_2 = OBz; R_3 = H	*Amoora tsangii*[480]
1467	Amooramide F		*Amoora tsangii*[480]
1468	Amooramide H	R_1= OBz; R_2 = H	*Amoora tsangii*[480]
1469	Amooramide I	R_1= OCOCH(CH3)CH2CH3; R_2 = H	*Amoora tsangii*[480]
1470	Amooramide J	R_1= $OCOCH(CH_3)_2$; R_2 = H	*Amoora tsangii*[480]
1471	Amooramide K	R_1= OBz; R_2 = CH_3	*Amoora tsangii*[480]
1472	Amooramide L	R_1= $OCOCH(CH_3)CH_2CH_3$; R_2 = CH_3	*Amoora tsangii*[480]
1473	Aphanalide M		*Aphanamixis grandifolia*[124]
1474	Thaixylomolin B	R = CH_3	*Xylocarpus moluccensis*[318]
1475	Thaixylomolin C	R = iPr	*Xylocarpus moluccensis*[318]
1476	Xylomexicanin E		*Xylocarpus granatum*[378]
1477	Trichinenlide A		*Trichilia sinensis*[342]
1478	Trichinenlide F	R = H	*Trichilia sinensis*[342]
1479	Trichinenlide G	R = OAc	*Trichilia sinensis*[342]
1480	Entanutilin B		*Entandrophragma utile*[456]
1481	Triconoid A	R = H	*Trichilia connaroides*[362]
1482	Triconoid B	R = OH	*Trichilia connaroides*[362]
1483	Trichiliasinenoid D		*Trichilia sinensis*[365]
1484	Hainangranatumin G		*Xylocarpus granatum*[374]
1485	Entangolensin K		*Entandrophragma angolense*[141]
1486	Toonasinemine B		*Toona sinensis*[269]
1487	Toonasinemine A		*Toona sinensis*[269]
1488	Toonasin A/Toonasinemine D	R_1 = R_2 = H	*Toona sinensis*[481,269]
1489	Toonasin B	R_1 = OAc; R_2 = H	*Toona sinensis*[481]
1490	Toonasinemine E	R_1 = H; R_2 = OAc	*Toona sinensis*[269]
1491	Toonasin C/Toonasinemine F		*Toona sinensis*[481,269]
1492	Toonasinemine G		*Toona sinensis*[269]
1493	Toonasinemine C		*Toona sinensis*[269]
1494	Entanutilin C		*Entandrophragma utile*[387]
1495	Entanutilin J		*Entandrophragma utile*[387]
1496	Entanutilin P		*Entandrophragma utile*[115]
1497	Entanutilin Q		*Entandrophragma utile*[115]
1498	Toonaolide I		*Toona ciliata*[219]
1499	Toonaolide R		*Toona ciliata*[219]
1500	Toonaolide X		*Toona ciliata*[219]



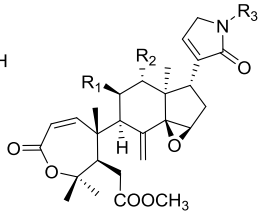
1458



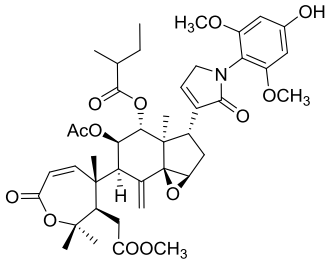
1459



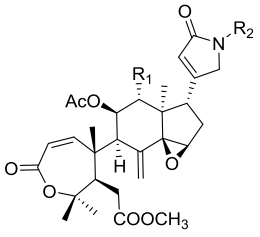
1460



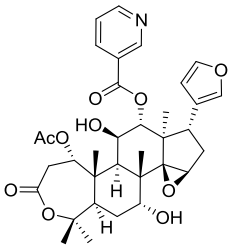
1461-1466



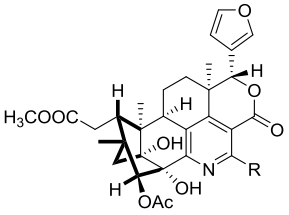
1467



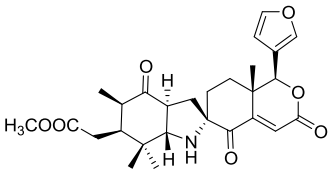
1468-1472



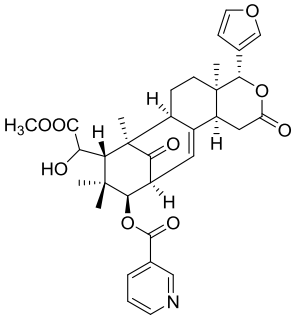
1473



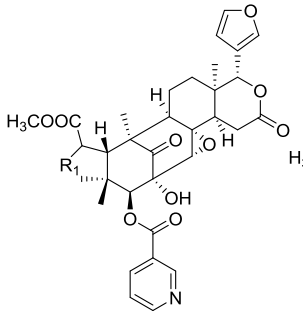
1474-1475



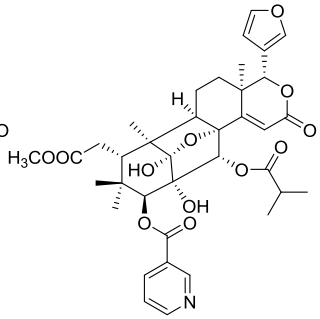
1476



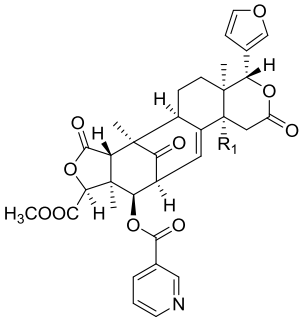
1477



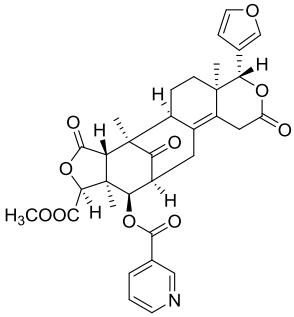
1478-1479



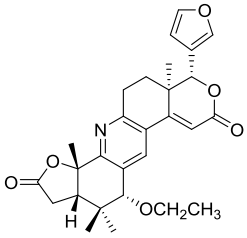
1480



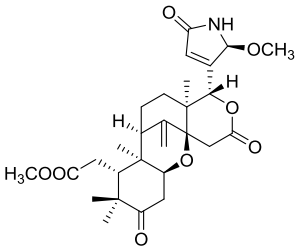
1481-1482



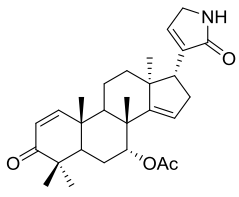
1483



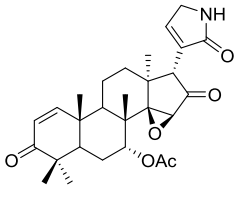
1484



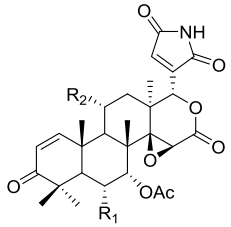
1485



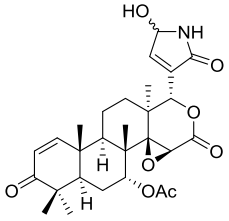
1486



1487



1488-1490



1491

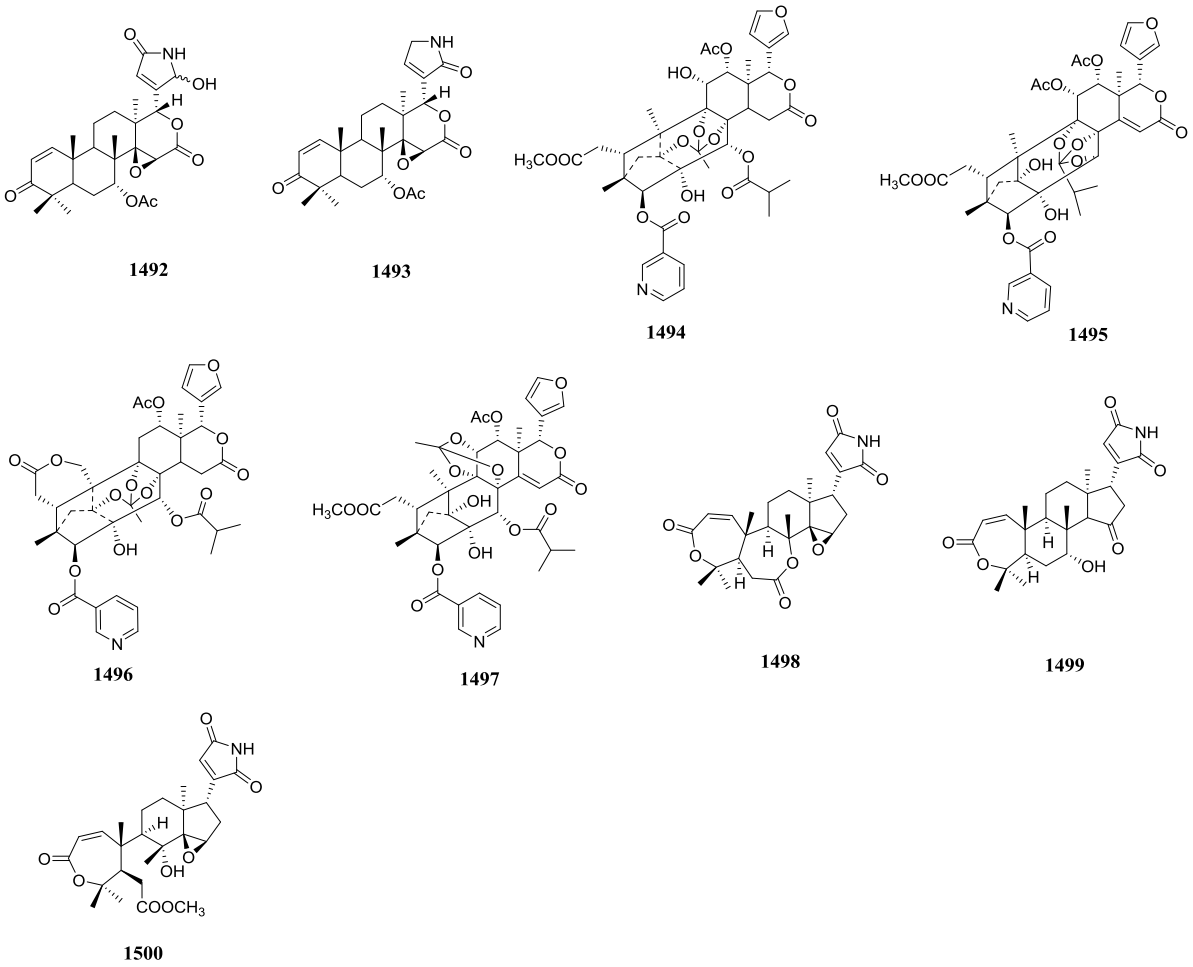


Figure 58. Structures of (N-containing) derivatives class limonoids **1458-1500**.

2.5.8. Other derivatives

Walsucochinoid A and B (**1501** and **1502**) were isolated from *Walsura cochinchinensis* (Table 57/S57, Figure 59). Compound (**1501**) has a vilasinin skeleton with rearranged C/D rings and contains five membered C ring fused with six membered aromatic D ring. The C3-isobutyryloxyl and C16-methoxy groups in compound (**1501**) are replaced by tiglyloxyl and hydroxyl groups respectively in compound (**1502**).

Table 57. Other derivatives class limonoid 1501-1502

No.	Limonoid	Substituent	Source
1501	Walsucochinoid A	R_1 = $COCH(CH_3)_2$; R_2 = CH_3	*Walsura cochinchinensis*[482]
1502	Walsucochinoid B	R_1 = Tig; R_2 = H	*Walsura cochinchinensis*[482]

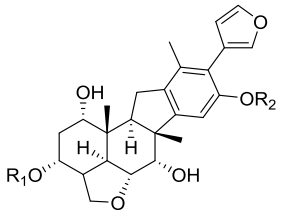


Figure 59. Structures of other derivatives class limonoids **1501-1502**.

3. Biological activities of Meliaceae Limonoids

Numerous biological activities of novel limonoids are described in this section such as antineoplastic, anti-inflammatory, anti microbial, anti malarial, anti viral, mealanogeneis/11β-HSD1 inhibitory activity, insecticidal/antifeedant activity etc. But the biological activity profiling of previously known limonoids are not included. A total of 1368 novel limonoids were screened for various bioactivities among which anti-neoplastic topped the list (39.69 %) followed by others (Figure 60).

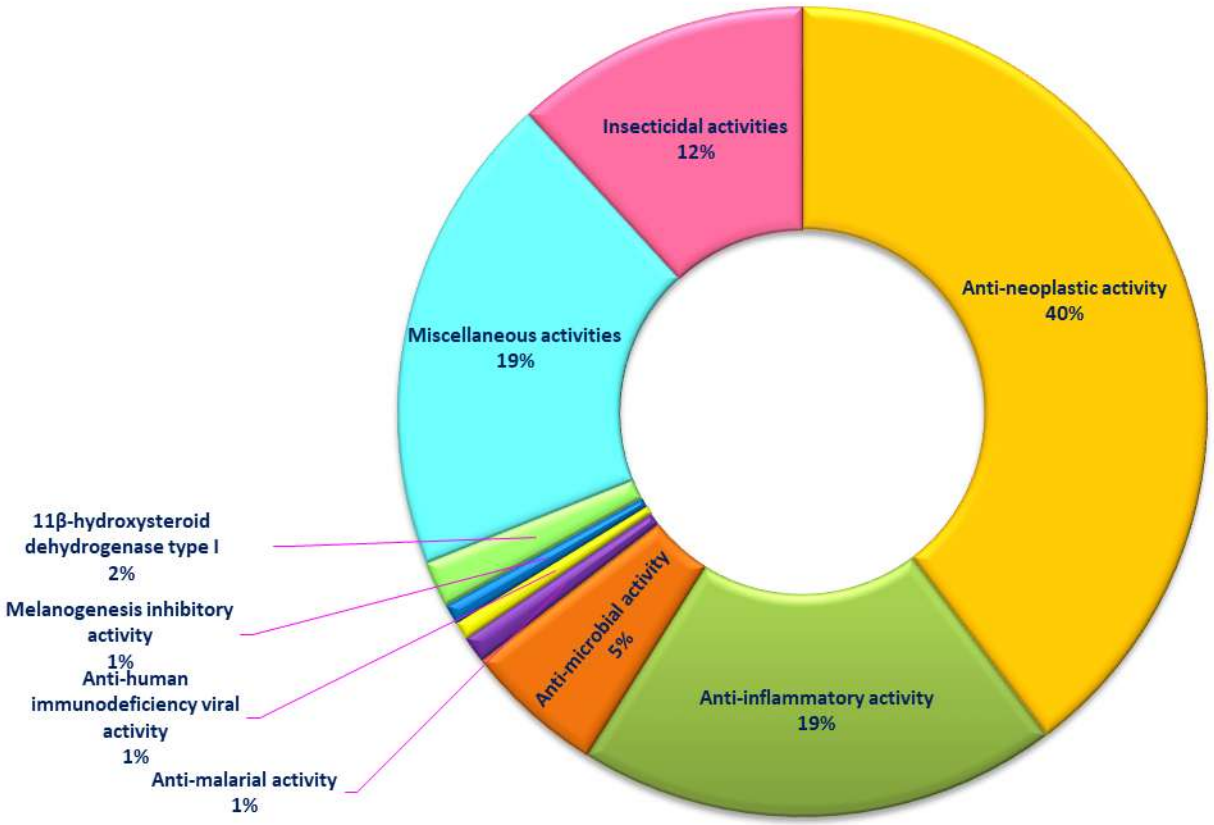


Figure 60. Distribution of novel limonoids screened for various bioactivities

3.1 Antineoplastic activity

The meliaceae limonoids have shown promising antineoplastic activities against various types of cancers. In vitro these new Limonoids have shown prominent antineoplastic activity. About 36.15 % of novel limonoids isolated from different meliaceae plants were screened for anitneoplastic activity. Among them only 42.90 % of them exhibited cytotoxic effects against 49 different types of cancer cell line and the rest were inactive (Table 58, 59). The most abundant cytotoxic effects were exhibited by Mexicanolide class limonoids (12.87 %), followed by

Protolimonoid (10.30 %), Salannin (9.01 %), Azadirone (5.57 %), Andirobin (5.15 %), Apoprotolimonoid (4.72 %), Polyoxyphragmalin (4.72 %), Cedrelone (4.29 %), Ring-B seco (4.29 %) and other classes (Figure 61). However Phragmalin orthoester (1-8-9) class constituted the most inactive limonoids (11.29 %) for antineoplastic activity followed by Mexicanolide (10.96 %), Ring-B seco (10.0 %), Prieurianin (7.74 %), Apoprotolimonoid (4.83 %), Obacunol (4.83 %), 1,2-seco Phragmalin (3.87 %), Azadirone (3.22 %), Andirobin (3.22 %), Polyoxyphragmalin (3.22 %), Pentanor triterpenoids (3.22 %) and other classes (Figure 61). The novel limonoids were mainly screened for human breast carcinoma MCF-7 cells (13.67 %), lung adenocarcinoma A549 cells (12.90 %), acute promyelocytic leukemia HL-60 (12.48 %), hepatocellular carcinoma SMMC-7721 (7.35 %), Hepatoblastoma HepG2 (5.80 %), colon adenocarcinoma SW480 (5.54 %) and followed by other cell lines (Figure 62). The most potent novel limonoids which exhibited cytotoxic effects (<2 μM) are discussed. The most potent cytotoxic effects against human cancer cells HCT116, SW480 with IC_{50} value of 0.05 and 0.26 μM respectively, was exhibited by Xylogranin B (**1150**). The limonoid Trichostemonate (**123**) showed significant cytotoxicity against HeLa cells (human endocervical adenocarcinoma) with IC_{50} value of 0.93 μg/mL. Another most potent limonoid 1α-hydroxy-1,2-dihydrodeacetylhirtin (**205**) exhibited cytotoxicity against human cancer cell lines SMMC-7721, A549, MCF-7 and SW480 with IC_{50} value of 1.0, 1.1, 1.0, 1.6 μM respectively. Also Munronin A (**585**) display strong cytotoxicity against human cancer cell lines HL-60, A549, MCF-7 and SW480 with IC_{50} value of 0.44, 1.6, 1.5, 0.86 μM respectively. Monadelphin A (**534**) exhibited cytotoxic effect against mouse leukemia cell line L5178Y with IC_{50} value of 0.62 μg/mL.

Table 58: Cytotoxic Activity of Meliaceous Limonoids against Cancer Cell Lines

Limonoid	Cells	Activity
Toonamicrocarpavarin (**2**)	HL-60	At 40 μM, showed weak cytotoxicity with inhibition ratio of 25-36 %[52]
	SMMC-7721	At 40 μM, showed weak cytotoxicity with inhibition ratio of 25-36 %[52]
	A549	At 40 μM, showed weak cytotoxicity with inhibition ratio of 25-36 %[52]
	MCF-7	At 40 μM, showed weak cytotoxicity with inhibition ratio of 25-36 %[52]
	SW480	At 40 μM, showed weak cytotoxicity with inhibition ratio of 25-36 %[52]
Toonaciliatavarin D (**55**)	MCF-7	IC_{50} = >50 μM[72]
	MCF-7/ADM	IC_{50} = >50 μM[72]
	KB	IC_{50} = 39.5 μM[72]
	KB/VCR	IC_{50} = >50 μM[72]
	SMMC-7721	IC_{50} = 31.4 μM[72]
	K562	IC_{50} = 43.1 μM[72]
Dysohainanin F (**7**)	HL-60	IC_{50} = >40 μM[55]
	SMMC-7721	IC_{50} = >40 μM[55]
	A549	IC_{50} = >40 μM[55]
	MCF-7	IC_{50} = >40 μM[55]
	SW480	IC_{50} = >40 μM[55]
Dysohainanin E/Mesendanin U (**115**)	HL-60	IC_{50} = >40 μM[55]
	SMMC-7721	IC_{50} = >40 μM[55]
	A549	IC_{50} = >40 μM[55]
	MCF-7	IC_{50} = >40 μM[55]
	SW480	IC_{50} = >40 μM[55]
Dysohainanin A (**592**)	HL-60	IC_{50} = >40 μM[55]
	SMMC-7721	IC_{50} = >40 μM[55]
	A549	IC_{50} = >40 μM[55]
	MCF-7	IC_{50} = >40 μM[55]
	SW480	IC_{50} = >40 μM[55]
Aphagranin B (**14**)	L6	IC_{50} = 57.4 μM[57]
3β-hydroxytirucalla-7,24-diene-6,23-dione (**18**)	A549	IC_{50} = 24.89 μM[58]
	BGC-823	IC_{50} = 24.01 μM[58]
	HCT-15	IC_{50} = 24.23 μM[58]
	HeLa	IC_{50} = 27.09 μM[58]
	HepG2	IC_{50} = 25.33 μM[58]
	MCF-7	IC_{50} = 25.99 μM[58]
	SGC-7901	IC_{50} = 27.31 μM[58]

	SK-MEL-2	IC_{50} = 27.75 μM[58]
3β-hydroxytirucalla-7,24-dien-23-one (**16**)	A549	IC_{50} = 18.64 μM[58]
	BGC-823	IC_{50} = 17.95 μM[58]
	HCT-15	IC_{50} = 18.41 μM[58]
	HeLa	IC_{50} = 20.68 μM[58]
	HepG2	IC_{50} = 19.77 μM[58]
	MCF-7	IC_{50} = 20.23 μM[58]
	SGC-7901	IC_{50} = 20.68 μM[58]
	SK-MEL-2	IC_{50} = 21.59μM[58]
3β,26-dihydroxytirucalla-7,24-diene-6,23-dione (**19**)	A549	IC_{50} = 26.54 μM[58]
	BGC-823	IC_{50} = 23.87 μM[58]
	HCT-15	IC_{50} = 25.51 μM[58]
	HeLa	IC_{50} = 27.78 μM[58]
	HepG2	IC_{50} = 25.72 μM[58]
	MCF-7	IC_{50} = 22.22 μM[58]
	SGC-7901	IC_{50} = 26.13 μM[58]
	SK-MEL-2	IC_{50} = 26.75 μM[58]
Methyl 6-oxomasticadienolate (**20**)	A549	IC_{50} = 25.41 μM[58]
	BGC-823	IC_{50} = 24.38 μM[58]
	HCT-15	IC_{50} = 27.27 μM[58]
	HeLa	IC_{50} = 28.10 μM[58]
	HepG2	IC_{50} = 24.59 μM[58]
	MCF-7	IC_{50} = 26.03 μM[58]
	SGC-7901	IC_{50} = 26.65 μM[58]
	SK-MEL-2	IC_{50} = 28.10 μM[58]
Dysoxylumstatin A (**53**)	A549	IC_{50} = 26.17 μM[58]
	BGC-823	IC_{50} = 27.87 μM[58]
	HCT-15	IC_{50} = 28.09 μM[58]
	HeLa	IC_{50} = 27.45 μM[58]
	HepG2	IC_{50} = 28.94 μM[58]
	MCF-7	IC_{50} = 25.53 μM[58]
	SGC-7901	IC_{50} = 28.09 μM[58]
	SK-MEL-2	IC_{50} = 28.30 μM[58]
Dysoxylumstatin B (**54**)	A549	IC_{50} = 28.88 μM[58]
	BGC-823	IC_{50} = 30.08 μM[58]
	HCT-15	IC_{50} = 30.48 μM[58]
	HeLa	IC_{50} = 29.68 μM[58]
	HepG2	IC_{50} = 30.88 μM[58]
	MCF-7	IC_{50} = 27.09 μM[58]
	SGC-7901	IC_{50} = 27.89 μM[58]
	SK-MEL-2	IC_{50} = 31.27 μM[58]
Dysoxylumstatin C (**182**)	A549	IC_{50} = 62.62 μM[58]
	BGC-823	IC_{50} = 65.29 μM[58]
	HCT-15	IC_{50} = 65.78 μM[58]
	HeLa	IC_{50} = 64.32 μM[58]
	HepG2	IC_{50} = 66.02 μM[58]
	MCF-7	IC_{50} = 62.38 μM[58]
	SGC-7901	IC_{50} = 64.56 μM[58]
	SK-MEL-2	IC_{50} = 68.45μM[58]
(21S,23R,24R)-21,23-epoxy-21,24-dihydroxy-25-methoxytirucall-7-en-3-one (**27**)	HepG2	IC_{50} = >100 μM[63]
	K562	IC_{50} = 93.0 μM[63]
	SGC-7901	IC_{50} = 47.6 μM[63]
	HL-60	IC_{50} = 21.3 μM[63]
(3S,21S,23R,24S)-21,23-epoxy-21,25-dimethoxytirucall-7-ene-3,24-diol (**28**)	HepG2	IC_{50} = > 100 μM[63]
	HL-60	IC_{50} = 44.9 μM[63]
(21S,23R,24R)-21,23-epoxy-24-hydroxy-21-methoxytirucalla-7,25-dien-3-one (**29**)	HepG2	IC_{50} = 48.3 μM[63]
	K562	IC_{50} = 42.1 μM[63]
	SGC-7901	IC_{50} = 49.4 μM[63]
	HL-60	IC_{50} = 10.8 μM[63]
(21S,23R,24R)-21,23-epoxy-21,24-dihydroxytirucalla-7,25-dien-3-one (**30**)	HepG2	IC_{50} = 38.5 μM[63]
	K562	IC_{50} = 34.3 μM[63]
	SGC-7901	IC_{50} = 38.5 μM[63]
	HL-60	IC_{50} = 81.7 μM[63]
(3R,5R, 9R,10R,13S,14S,17S)-17-{(2R,3S,5R)-5-[(2S)-3,3-dimethyloxiran-2-yl]-2,3,4,5-tetrahydro-	MCF-7	IC_{50} = >100 μM[64]
	HeLa	IC_{50} = 15.3 μM[64]

2,5-dimethoxyfuran- 3-yl}-4,4,10,13,14-pentamethyl-2,3,4,5,6,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta- [α]phenanthren-3-ol (**35**)		
(5R,9R,10R,13S,14S,17S)-17-{(2R,3S,5R)-5-[(2S)-3,3-dimethyloxiran-2-yl]-2,5-dimethoxytetrahydrofuran-3-yl}-1,2,4,5,6,9,10,11,12,13,14,15,16,17-tetradecahydro-4,4,10,13,14-pentamethyl- 3H-cyclopenta[α]phenanthren-3-one (**36**)	MCF-7	IC_{50} = 10.3 μM[64]
	HeLa	IC_{50} = 29.9 μM[64]
(13α,14β,17 α,23Z)-25-methoxy-21,23-epoxylanosta-7,20(22),23-triene- 3,21-dione (**50**)	MCF-7	IC_{50} = 53.3 μM[64]
	HeLa	IC_{50} = 21.4 μM[64]
(+)-21R*,23R*-epoxy-21α-methoxy-24S*,25-dihydroxyapotirucall- 7-en-3-one (**44**)	A549	IC_{50} = 20.2 μM[70]
	BGC-823	IC_{50} = 64.9 μM[70]
	HCT-15	IC_{50} = 22.1 μM[70]
	HeLa	IC_{50} = 68.6 μM[70]
	HepG2	IC_{50} = 7.5 μM[70]
	MCF-7	IC_{50} = 78.7 μM[70]
	SGC-7901	IC_{50} = 21.7 μM[70]
	SK-MEL-2	IC_{50} = 23.7 μM[70]
(+)-21R*,23R*-epoxy-21α- methoxy-25-hydroxyapotirucall-7-en-3,24-dione (**45**)	A549	IC_{50} = 20.6 μM[70]
	BGC-823	IC_{50} = 68.4 μM[70]
	HCT-15	IC_{50} = 21.6 μM[70]
	HeLa	IC_{50} = 77.6 μM[70]
	HepG2	IC_{50} = 8.4 μM[70]
	MCF-7	IC_{50} = 84.4 μM[70]
	SGC-7901	IC_{50} = 25.8 μM[70]
	SK-MEL-2	IC_{50} = 27.2 μM[70]
(+)- 21R*,23R*-epoxy-21α,25-dimethoxyapotirucall-7-en-3,24- dione (**46**)	A549	IC_{50} = 22.0 μM[70]
	BGC-823	IC_{50} = 63.2 μM[70]
	HCT-15	IC_{50} = 20.6 μM[70]
	HeLa	IC_{50} = 70.6 μM[70]
	HepG2	IC_{50} = 7.6 μM[70]
	MCF-7	IC_{50} = 81.1 μM[70]
	SGC-7901	IC_{50} = 23.2 μM[70]
	SK-MEL-2	IC_{50} = 23.3 μM[70]
(+)-21R*,23R*-epoxy-21α-methoxy-24S*,25-oxidoapotirucall-7-en-3-one (**47**)	A549	IC_{50} = 25.6 μM[70]
	BGC-823	IC_{50} = 63.4 μM[70]
	HCT-15	IC_{50} = 24.4 μM[70]
	HeLa	IC_{50} = 73.3 μM[70]
	HepG2	IC_{50} = 7.6 μM[70]
	MCF-7	IC_{50} = 83.9 μM[70]
	SGC-7901	IC_{50} = 24.0 μM[70]
	SK-MEL-2	IC_{50} = 25.4 μM[70]
24,25-epoxy-3β-hydroxy-20- oxo-7-tirucallene (**25**)	HL-60	IC_{50} = 18.0 μM[61]
	SMMC-7721	IC_{50} = >40 μM[61]
	A549	IC_{50} = >40 μM[61]
	MCF-7	IC_{50} = 34.6 μM[61]
	SW480	IC_{50} = >40 μM[61]
Mesendanin M (**43**)	HL-60	IC_{50} = 17.8 μM[69]
	SMMC-7721	IC_{50} = >40 μM[69]
	A549	IC_{50} = >40 μM[69]
	MCF-7	IC_{50} = >40 μM[69]
	SW480	IC_{50} = >40 μM[69]
Guareoic acid A (**57**)	Jurkat	EC_{50} = 39 μM[74]
	HeLa	EC_{50} = 55 μM[74]
	MCF-7	EC_{50} = 75 μM[74]
	PBMC	EC_{50} = >100 μM[74]
(20S)-3-oxo-tirucalla-25-nor-7-en-24-oic acid (**67**)	A549	IC_{50} = >40 μM[76]
	SGC-7901	IC_{50} = >40 μM[76]
(20S)-5α,8α-epidioxy-3-oxo-24-nor-6,9(11)-dien-23-oic acid (**68**)	A549	IC_{50} = 20.3 μM[76]
	SGC-7901	IC_{50} = >40 μM[76]
3α-Hydroxy-21α-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone (**70**)	MCF-7	IC_{50} = 42.2 μM[77]
	HeLa	IC_{50} = 37.6 μM[77]
	HepG2	IC_{50} = 31.4 μM[77]
	SGC-7901	IC_{50} = 26.1 μM[77]
	BGC-823	IC_{50} = 24.2 μM[77]
3α-Hydroxy-21β-methoxy-24,25,26,27-	MCF-7	IC_{50} = 67.1 μM[77]

tetranortirucall-7-ene- 23(21)-lactone (**71**)	HeLa	IC_{50} = 24.3 μM[77]
	HepG2	IC_{50} = 32.6 μM[77]
	SGC-7901	IC_{50} = 21.3 μM[77]
	BGC-823	IC_{50} = 12.8 μM[77]
3-Oxo-21α-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone (**72**)	MCF-7	IC_{50} = 166.5 μM[77]
	HeLa	IC_{50} =95.5 μM[77]
	HepG2	IC_{50} = 91.2 μM[77]
	SGC-7901	IC_{50} = 70.9 μM[77]
	BGC-823	IC_{50} = 154.4 μM[77]
3-Oxo-21β-methoxy-24,25,26,27-tetranortirucall-7-ene- 23(21)-lactone (**73**)	MCF-7	IC_{50} = 76.2 μM[77]
	HeLa	IC_{50} = 52.8 μM[77]
	HepG2	IC_{50} = 71.8 μM[77]
	SGC-7901	IC_{50} = 71.9 μM[77]
	BGC-823	IC_{50} = 41.7 μM[77]
3-Oxo-21α-ethoxy-24,25,26,27-tetranortirucall-7-ene-23(21)- lactone (**74**)	MCF-7	IC_{50} = 50.2 μM[77]
	HeLa	IC_{50} = 76.2 μM[77]
	HepG2	IC_{50} = 58.3 μM[77]
	SGC-7901	IC_{50} = 108 μM[77]
	BGC-823	IC_{50} = 126.6 μM[77]
7-deacetylbrujavanone E (**99**)	KB	IC_{50} = 12.92 μg/mL[100]
21,24,25- triacetyl-7-deacetyl-6-hydroxylbrujavanone E (**100**)	KB	IC_{50} = 17.06 μg/mL[100]
11,25-dideacetyltrichostemonate (**122**)	HeLa	IC_{50} = 12.99 μg/mL[100]
	KB	IC_{50} = 3.95 μg/mL[100]
Trichostemonate (**123**)	HeLa	IC_{50} = 0.93 μg/mL[109]
	KB	IC_{50} = 3.28 μg/mL[109]
Indicalilacol B (**42**)	KB	IC_{50} = 15.0 μM[67]
	KB-C2	IC_{50} = 16.1 μM[67]
	KB-C2 (+2.5 μM colchicine.)	IC_{50} = 7.29 μM[67]
	MCF-7	IC_{50} = 19.0 μM[67]
Piscidinone A (**126**)	HT-29	IC_{50} = 34.23 μg/mL[110]
	MCF-7	IC_{50} = 17.77 μg/mL[110]
	HeLa	IC_{50} = 25.17 μg/mL[110]
	A549	IC_{50} = 17.94 μg/mL[110]
	B-16	IC_{50} = 27.78 μg/mL[110]
	IEC-6	IC_{50} = 16.37 μg/mL[110]
	L6	IC_{50} = 21.22 μg/mL[110]
	PC-3	IC_{50} = 13.62 μg/mL[110]
Piscidinone B (**127**)	HT-29	IC_{50} = 50.63 μg/mL[110]
	MCF-7	IC_{50} = 24.62 μg/mL[110]
	HeLa	IC_{50} = 27.74 μg/mL[110]
	A549	IC_{50} =18.48 μg/mL[110]
	B-16	IC_{50} = 46.08 μg/mL[110]
	IEC-6	IC_{50} = 18.52 μg/mL[110]
	L6	IC_{50} = 13.52 μg/mL[110]
	PC-3	IC_{50} = 14.10 μg/mL[110]
Aphataiwanin C/Apowalsogyne B (**130**)	HL-60	IC_{50} = 26.9 μM[113]
	HepG2	IC_{50} = 68.0 μM[113]
	A549	IC_{50} = >50 μM[113]
	MCF-7	IC_{50} = 62.5 μM[113]
	HEp-2	ED_{50} = 37.78 μg/mL[112]
	HepG2	ED_{50} = 30.34 μg/mL[112]
	A549	ED_{50} = >40 μg/mL[112]
	MCF-7	ED_{50} = >40 μg/mL[112]
Aphataiwanin D/Apowalsogyne A (**131**)	HL-60	IC_{50} = 35.9 μM[113]
	HepG2	IC_{50} = 30.9 μM[113]
	A549	IC_{50} = 31.1 μM[113]
	MCF-7	IC_{50} = 32.2 μM[113]
	HEp-2	ED_{50} = 37.72 μg/mL[112]
	HepG2	ED_{50} = >40 μg/mL[112]
	A549	ED_{50} = >40 μg/mL[112]
	MCF-7	ED_{50} = >40 μg/mL[112]
Aphataiwanin A (**132**)	HEp-2	ED_{50} = 28.12 μg/mL[112]
	HepG2	ED_{50} = 16.02 μg/mL[112]

	A549	ED_{50} = 33.56 μg/mL[112]
	MCF-7	ED_{50} = >40 μg/mL[112]
Aphataiwanin B (**133**)	HEp-2	ED_{50} = 36.05 μg/mL[112]
	HepG2	ED_{50} = 24.86 μg/mL[112]
	A549	ED_{50} = >40 μg/mL[112]
	MCF-7	ED_{50} = >40 μg/mL[112]
Argentinin B (**135**)	P388	IC_{50} = 59.5 μM or 34.25 μg/mL[115]
Polystanin E (**136**)	BEL-7402	IC_{50} = 8.50 μM[116]
	SMMC-7721	IC_{50} = 7.84 μM[116]
Swieteliacate B (**1411**)	HL-60	IC_{50} = 30.59 μM[108]
	SW480	IC_{50} = 32.86 μM[108]
Lepidotrichilin A (**109**)	U937	IC_{50} = 48.0 μg/mL[103]
	MOLT4	IC_{50} = 42.7 μg/mL[103]
Lepidotrichilin B (**108**)	U937	IC_{50} = 48.0 μg/mL[103]
	MOLT4	IC_{50} = 42.7 μg/mL[103]
Xylogranatumine F (**89**)	A549	54.2 % inhibition at 10 μM[97]
Walsurin A (**138**)	MCF-7/DOX	IC_{50} = 0.52 μM[126] (Cytotoxicity of doxorubicin in presence of compound)
1 α -methoxy-11β-hydroxydihydrocedrelone (**198**)	MCF-7/DOX	IC_{50} = 2.23 μM[126] (Cytotoxicity of doxorubicin in presence of compound)
1 α -ethoxy-11 β –hydroxydihydrocedrelone (**199**)	MCF-7/DOX	IC_{50} = 1.86 μM[126] (Cytotoxicity of doxorubicin in presence of compound)
Walsuronoid F (**233**)	MCF-7/DOX	IC_{50} = 4.36 μM[126] (Cytotoxicity of doxorubicin in presence of compound)
Ciliatasecone F (**418**)	MCF-7/DOX	IC_{50} = 1.14 μM[131] (Cytotoxicity of doxorubicin in presence of compound)
Ciliatasecone K (**434**)	MCF-7/DOX	IC_{50} = 5.41 μM[131] (Cytotoxicity of doxorubicin in presence of compound)
Chukorthoester A (**1027**)	MCF-7/DOX	IC_{50} = 0.26 μM[363] (Cytotoxicity of doxorubicin in presence of compound)
Chukorthoester B (**1028**)	MCF-7/DOX	IC_{50} = 0.46 μM[363] (Cytotoxicity of doxorubicin in presence of compound)
Toonayunnanin B (**145**)	HL-60	IC_{50} = 18.47 μM[128]
	SMMC-7721	IC_{50} = 22.77 μM[128]
	A549	IC_{50} = 21.70 μM[128]
	MCF-7	IC_{50} = 20.17 μM[128]
	SW480	IC_{50} = 21.46 μM[128]
7-benzoyl-17-epinimbocinol (**147**)	HL-60	IC_{50} = 2.8 μM[130]
	A549	IC_{50} = 6.3 μM[130]
	AZ521	IC_{50} = 3.8 μM[130]
	SK-BR-3	IC_{50} = 8.7 μM[130]
3-acetyl-7-tigloylnimbidinin (**313**)	HL-60	IC_{50} = 12.3 μM[130]
	A549	IC_{50} = 20.9 μM[130]
	AZ521	IC_{50} = 21.8 μM[130]
	SK-BR-3	IC_{50} = 55.0 μM[130]
2,3-dihydro-3α-methoxynimbolide (**456**)	HL-60	IC_{50} = 5.0 μM[130]
	A549	IC_{50} = 12.8 μM[130]
	AZ521	IC_{50} = 2.6 μM[130]
	SK-BR-3	IC_{50} = 8.1 μM[130]
1-isovaleroyl- 1-detigloylsalanninolide (**461**)	HL-60	IC_{50} = 21.7 μM[130]
	A549	IC_{50} = >100 μM[130]
	AZ521	IC_{50} = >100 μM[130]
	SK-BR-3	IC_{50} = >100 μM[130]
deacetyl-20,21-epoxy-20,22-dihydro- 21-deoxyisonimbinolide (**512**)	HL-60	IC_{50} = 24.2 μM[130]
	A549	IC_{50} = >100 μM[130]
	AZ521	IC_{50} = >100 μM[130]
	SK-BR-3	IC_{50} = >100 μM[130]
deacetyl-20,21,22,23-tetrahydro-20,22-dihydroxy-21,23-dimethoxynimbin (**513**)	HL-60	IC_{50} = 58.6 μM[130]
	A549	IC_{50} = >100 μM[130]
	AZ521	IC_{50} = >100 μM[130]
	SK-BR-3	IC_{50} = >100 μM[130]
Dysobinol (**154**)	P388	IC_{50} = 49.7 μg/mL[132]
Entangolensin O (**155**)	HepG2	IC_{50} = 21.00 μM[133]
	MCF-7	IC_{50} = 36.93 μM[133]
Entangolensin L (**529**)	HepG2	IC_{50} = 20.39 μM[133]
	MCF-7	IC_{50} = 17.20 μM[133]

Entangolensin F (**710**)	HepG2	IC_{50} = 13.19 μM[133]
	MCF-7	IC_{50} = 14.06 μM[133]
Entangolensin K (**1485**)	HepG2	IC_{50} = >50 μM[133]
	MCF-7	IC_{50} = >50 μM[133]
Xylomolin C2 (**825**)	HCT-8	IC_{50} = 70.14 μM[135]
	HCT-8/T	IC_{50} = 64.14 μM[135]
	A2780	IC_{50} = 62.04 μM[135]
	A2780/T	IC_{50} = 82.17 μM[135]
	MDA-MB-231	IC_{50} = >100 μM[135]
Xylomolin J2 (**1284**)	HCT-8	IC_{50} = 68.84 μM[135]
	HCT-8/T	IC_{50} = >100 μM[135]
	A2780	IC_{50} = 64.18 μM[135]
	A2780/T	IC_{50} = 77.80 μM[135]
	MDA-MB-231	IC_{50} = 37.68 μM[135]
Xylomolin G2 (**1322**)	HCT-8	IC_{50} = >100 μM[135]
	HCT-8/T	IC_{50} = >100 μM[135]
	A2780	IC_{50} = >100 μM[135]
	A2780/T	IC_{50} = >100 μM[135]
	MDA-MB-231	IC_{50} = 94.51 μM[135]
24,25,26,27-tetranor-apotirucall-6α-hydroxy-7α-acetoxy-1,14-dien-3-one-21,24-anhydride (**169**)	HeLa	IC_{50} = 95 μM[137]
	PC-3	IC_{50} = >100 μM[137]
11β-hydroxyisowalsuranolide (**215**)	HL-60	IC_{50} = 3.1 μM[139]
	SMMC-7721	IC_{50} = 2.2 μM[139]
	A549	IC_{50} = 2.6 μM[139]
	MCF-7	IC_{50} = 3.9 μM[139]
	SW480	IC_{50} = 2.4 μM[139]
	BEAS-2B	IC_{50} = 9.4 μM[139]
Yunnanolide A (**230**)	HL-60	IC_{50} = 3.6 μM[139]
	SMMC-7721	IC_{50} = 2.4 μM[139]
	A549	IC_{50} = 3.7 μM[139]
	MCF-7	IC_{50} = 4.2 μM[139]
	SW480	IC_{50} = 3.5 μM[139]
	BEAS-2B	IC_{50} = 5.0 μM[139]
7-O-acetyl-7-O-debenzoyl-22-hydroxy-21-methoxylimocinin (**173**)	HL-60	IC_{50} = 10.9 μM[140]
	A549	IC_{50} = 25.4 μM[140]
	AZ521	IC_{50} = 23.2 μM[140]
	SK-BR-3	IC_{50} = 33.8 μM[140]
Andirolide Q (**174**)	P388	IC_{50} = >100 mM[141]
	HL-60	IC_{50} = 58.4 mM[141]
Andirolide S (**680**)	P388	IC_{50} = 1.4 mM[141]
	HL-60	IC_{50} = 1.3 mM[141]
Andirolide T (**746**)	P388	IC_{50} = 1.8 mM[141]
	HL-60	IC_{50} = 1.3 mM[141]
Andirolide U (**916**)	P388	IC_{50} = 19.8 mM[141]
	HL-60	IC_{50} = 12.9 mM[141]
Andirolide V (**1052**)	P388	IC_{50} = 33.5 mM[141]
	HL-60	IC_{50} = 22.0 mM[141]
Andirolide R (**1452**)	P388	IC_{50} = 15.4 mM[141]
	HL-60	IC_{50} = 13.5 mM[141]
1 α,11β-dihydroxy-1,2-dihydrocedrelone (**200**)	HL-60	IC_{50} = >40 μM[150]
	SMMC-7721	IC_{50} = 20.6 μM[150]
	A549	IC_{50} = 18.5 μM[150]
	MCF-7	IC_{50} =>40 μM[150]
	SW480	IC_{50} = >40 μM[150]
1,2-dihydrodeacetylhirtin (**204**)	HL-60	IC_{50} = 4.9 μM[150]
	SMMC-7721	IC_{50} = 3.1 μM[150]
	A549	IC_{50} = 2.9 μM[150]
	MCF-7	IC_{50} = 9.8 μM[150]
	SW480	IC_{50} = 9.0 μM[150]
1α-hydroxy-1,2-dihydrodeacetylhirtin (**205**)	HL-60	IC_{50} = 3.1 μM[150]
	SMMC-7721	IC_{50} = 1.0 μM[150]
	A549	IC_{50} = 1.1 μM[150]
	MCF-7	IC_{50} = 1.0 μM[150]
	SW480	IC_{50} = 1.6 μM[150]
1 α -hydroxy- 1,2-dihydrohirtin (**206**)	HL-60	IC_{50} = >40 μM[150]
	SMMC-7721	IC_{50} = 18.0 μM[150]

	A549	IC_{50} = 18.6 μM[150]
	MCF-7	IC_{50} = 39.6 μM[150]
	SW480	IC_{50} = 33.3 μM[150]
1 α -methoxy-1,2-dihydrodeacetylhirtin (**207**)	HL-60	IC_{50} = 5.3 μM[150]
	SMMC-7721	IC_{50} = 3.7 μM[150]
	A549	IC_{50} = 5.2 μM[150]
	MCF-7	IC_{50} = 10.2 μM[150]
	SW480	IC_{50} = 15.9 μM[150]
11β-hydroxy-12 α –propanoyloxycedrelone (**210**)	HL-60	IC_{50} = 14.8 μM[150]
	SMMC-7721	IC_{50} = 5.3 μM[150]
	A549	IC_{50} = 6.4 μM[150]
	MCF-7	IC_{50} = 15.4 μM[150]
	SW480	IC_{50} = 15.7 μM[150]
Munronin A (**585**)	HL-60	IC_{50} = 0.44 μM[161]
	SMMC-7721	IC_{50} = 2.3 μM[161]
	A549	IC_{50} = 1.6 μM[161]
	MCF-7	IC_{50} = 1.5 μM[161]
	SW480	IC_{50} = 0.86 μM[161]
	HL-60	It showed 58.8% inhibition at 10^{-5} mol/L[161]
12- dehydroneoazedarachin D (**265**)	HL-60	IC_{50} = 11.8 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 11.8 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
12-dehydro- 29-exo-neoazedarachin D (**266**)	HL-60	IC_{50} = 9.1 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 18.8 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
1-O-decinnamoyl-1-O-Z-cinnamoylohchinin (**448**)	HL-60	IC_{50} = 32.9 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = >100 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
1-O-decinnamoyl-1-Obenzoylohchinin (**449**)	HL-60	IC_{50} = 54.8 μM[180]
	A549	IC_{50} = 82.3 μM[180]
	AZ521	IC_{50} = 35.1 μM[180]
	SK-BR-3	IC_{50} = 14.9 μM[180]
1-O-decinnamoyl-1-O-benzoyl- 28-oxoohchinin (**458**)	HL-60	IC_{50} = 22.7 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 61.7 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
3-O-deacetyl-40-demethyl- 28-oxosalannin (**459**)	HL-60	IC_{50} = 2.8 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 3.2 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
Ohchininolide (**463**)	HL-60	IC_{50} = 31.7 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 82.9 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
1-O-decinnamoyl-1-O-benzoylohchininolide (**464**)	HL-60	IC_{50} = 14.1 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 34.7 μM[180]
	SK-BR-3	IC_{50} = 54.5 μM[180]
23-methoxyohchininolide A (**465**)	HL-60	IC_{50} = 4.9 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = >100 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
23-methoxyohchininolide B (**466**)	HL-60	IC_{50} = 15.2 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 30.0 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
23-hydroxyohchininolide (**467**)	HL-60	IC_{50} = 25.1 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = 78.5 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
1-O-decinnamoyl- 1-O-benzoyl-23-hydroxyohchininolide (**468**)	HL-60	IC_{50} = 12.6 μM[180]
	A549	IC_{50} = 90.1 μM[180]
	AZ521	IC_{50} = 55.7 μM[180]

	SK-BR-3	IC_{50} = 4.3 μM[180]
21-hydroxyisoohchininolide (**473**)	HL-60	IC_{50} = 22.7 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = >100 μM[180]
	SK-BR-3	IC_{50} = 91.5 μM[180]
17-defurano-17-oxoohchinin (**1454**)	HL-60	IC_{50} = 50.4 μM[180]
	A549	IC_{50} = >100 μM[180]
	AZ521	IC_{50} = >100 μM[180]
	SK-BR-3	IC_{50} = >100 μM[180]
12α-hydroxymeliatoxin B_2 (**270**)	K562	IC_{50} = 25.14 μM[181]
	SGC-7901	IC_{50} = 32.09 μM[181]
	BEL-7402	IC_{50} = 38.62 μM[181]
Trichisinlin F (**278**)	K562	IC_{50} = 27.38 μM[181]
	SGC-7901	IC_{50} = 34.81 μM[181]
	BEL-7402	IC_{50} = 20.58 μM[181]
Ceramicine I (**298**)	HL-60	IC_{50} = 42.2 μM[191]
	A549	IC_{50} = >50 μM[191]
	MCF-7	IC_{50} = 44.0 μM[191]
	HCT116	IC_{50} = >50 μM[191]
Ceramicine G (**331**)	HL-60	IC_{50} = 26.1 μM[191]
	A549	IC_{50} = 41.4 μM[191]
	MCF-7	IC_{50} = 27.3 μM[191]
	HCT116	IC_{50} = >50 μM[191]
Walsuronoid D (**303**)	HL-60	IC_{50} = 2.7 μM[194]
	SMMC-7721	IC_{50} = 3.1 μM[194]
	A549	IC_{50} = 4.1 μM[194]
	MCF-7	IC_{50} = 3.1 μM[194]
	SW480	IC_{50} = 2.8 μM[194]
Walsuronoid E (**312**)	HL-60	IC_{50} = 3.3 μM[194]
	SMMC-7721	IC_{50} = 4.1 μM[194]
	A549	IC_{50} = 4.4 μM[194]
	MCF-7	IC_{50} = 4.4 μM[194]
	SW480	IC_{50} = 4.5 μM[194]
Cipadesin K (**548**)	HL-60	IC_{50} = 20.39 μM[195]
	SMMC-7721	IC_{50} = 36.55 μM[195]
	A549	IC_{50} = >40 μM[195]
	MCF-7	IC_{50} = >40 μM[195]
	SW480	IC_{50} = >40 μM[195]
Cipadesin N (**773**)	HL-60	IC_{50} = 20.17 μM[195]
	SMMC-7721	IC_{50} = >40 μM[195]
	A549	IC_{50} = >40 μM[195]
	MCF-7	IC_{50} = >40 μM[195]
	SW480	IC_{50} = >40 μM[195]
Ceramicine J (**311**)	HL-60	At 50 μM 36 % inhibition[196]
Ceramicine L (**1412**)	HL-60	At 50 μM 25 % inhibition[196]
Ceramicine K (**1440**)	HL-60	At 50 μM 33 % inhibition[196]
Walsucochinone C (**329**)	MCF-7	IC_{50} = 16.4 μM[202]
Toonasinenine J (**334**)	A549	IC_{50} = > 50 μM[206]
	BGC-823	IC_{50} = 22.7 μM[206]
	CHG-5	IC_{50} = > 50 μM[206]
	HCT-15	IC_{50} = 49.7 μM[206]
	HeLa	IC_{50} = > 50 μM[206]
	HepG2	IC_{50} = 46.7 μM[206]
	MDA-MB-231	IC_{50} = > 50 μM[206]
	SGC-7901	IC_{50} = > 50 μM[206]
	SHG-44	IC_{50} = 31.4 μM[206]
Toonasinenine E (**383**)	A549	IC_{50} = 20.4 μM[206]
	BGC-823	IC_{50} = > 50 μM[206]
	CHG-5	IC_{50} = 19.9 μM[206]
	HCT-15	IC_{50} = 21.5 μM[206]
	HeLa	IC_{50} = 23.6 μM[206]
	HepG2	IC_{50} = 23.4 μM[206]
	MDA-MB-231	IC_{50} = 21.0 μM[206]
	SGC-7901	IC_{50} = 21.1 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine G (**388**)	A549	IC_{50} = 18.4 μM[206]

	BGC-823	IC_{50} = > 50 μM[206]
	CHG-5	IC_{50} = 19.5 μM[206]
	HCT-15	IC_{50} = 18.4 μM[206]
	HeLa	IC_{50} = 21.6 μM[206]
	HepG2	IC_{50} = 21.7 μM[206]
	MDA-MB-231	IC_{50} = 20.8 μM[206]
	SGC-7901	IC_{50} = 19.9 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine B (**397**)	A549	IC_{50} = 5.7 μM[206]
	BGC-823	IC_{50} = 33.7 μM[206]
	CHG-5	IC_{50} = 5.0 μM[206]
	HCT-15	IC_{50} = 5.7 μM[206]
	HeLa	IC_{50} = 6.2 μM[206]
	HepG2	IC_{50} = 5.5 μM[206]
	MDA-MB-231	IC_{50} = 6.0 μM[206]
	SGC-7901	IC_{50} = 6.0 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine A (**406**)	A549	IC_{50} = 13.3 μM[206]
	BGC-823	IC_{50} = > 50 μM[206]
	CHG-5	IC_{50} = 14.6 μM[206]
	HCT-15	IC_{50} = 14.7 μM[206]
	HeLa	IC_{50} = 14.0 μM[206]
	HepG2	IC_{50} = 13.9 μM[206]
	MDA-MB-231	IC_{50} = 14.2 μM[206]
	SGC-7901	IC_{50} = 13.1 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine C (**407**)	A549	IC_{50} = 9.7 μM[206]
	BGC-823	IC_{50} = > 50 μM[206]
	CHG-5	IC_{50} = 8.3 μM[206]
	HCT-15	IC_{50} = 10.1 μM[206]
	HeLa	IC_{50} = 8.1 μM[206]
	HepG2	IC_{50} = 9.1 μM[206]
	MDA-MB-231	IC_{50} = 9.4 μM[206]
	SGC-7901	IC_{50} = 9.4 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine F (**411**)	A549	IC_{50} = 23.3 μM[206]
	BGC-823	IC_{50} = > 50 μM[206]
	CHG-5	IC_{50} = 23.9 μM[206]
	HCT-15	IC_{50} = 24.6 μM[206]
	HeLa	IC_{50} = 24.7 μM[206]
	HepG2	IC_{50} = 24.0 μM[206]
	MDA-MB-231	IC_{50} = 22.4 μM[206]
	SGC-7901	IC_{50} = 24.2 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine H (**417**)	A549	IC_{50} = 34.8 μM[206]
	BGC-823	IC_{50} = > 50 μM[206]
	CHG-5	IC_{50} = 31.2 μM[206]
	HCT-15	IC_{50} = 33.2 μM[206]
	HeLa	IC_{50} = 31.4 μM[206]
	HepG2	IC_{50} = 31.6 μM[206]
	MDA-MB-231	IC_{50} = 33.2 μM[206]
	SGC-7901	IC_{50} = 33.6 μM[206]
	SHG-44	IC_{50} = > 50 μM[206]
Toonasinenine I (**632**)	A549	IC_{50} = 44.3 μM[206]
	BGC-823	IC_{50} = 18.6 μM[206]
	CHG-5	IC_{50} = > 50 μM[206]
	HCT-15	IC_{50} = > 50 μM[206]
	HeLa	IC_{50} = > 50 μM[206]
	HepG2	IC_{50} = 43.2 μM[206]
	MDA-MB-231	IC_{50} = > 50 μM[206]
	SGC-7901	IC_{50} = 39.1 μM[206]
	SHG-44	IC_{50} = 28.0 μM[206]
Toonasinenine D (**1429**)	A549	IC_{50} = 2.3 μM[206]
	BGC-823	IC_{50} = 27.9 μM[206]
	CHG-5	IC_{50} = 2.8 μM[206]
	HCT-15	IC_{50} = 2.6 μM[206]

	HeLa	IC_{50} = 2.9 μM[206]
	HepG2	IC_{50} = 3.0 μM[206]
	MDA-MB-231	IC_{50} = 2.7 μM[206]
	SGC-7901	IC_{50} = 2.1 μM[206]
	SHG-44	IC_{50} = 44.9 μM[206]
Toonacilianin F (**390**)	A549	IC_{50} = 5.75 μM[219]
	HL-60	IC_{50} = 0.91 μM[219]
Toonaciliatone C (**1433**)	HepG2	IC_{50} = 5.22 μM[221]
	MCF-7	IC_{50} = > 50 μM[221]
	HL-60	IC_{50} = 5.38 μM[221]
Ciliatonoid C (**1431**)	HL-60	IC_{50} = 1.19 μM[222]
	P388	IC_{50} = 2.50 μM[222]
3-deacetyl-4'-demethylsalannin (**446**)	HL-60	IC_{50} = 9.6 μM[233]
	A549	IC_{50} = > 100 μM[233]
	AZ521	IC_{50} = 47.5 μM[233]
	SK-BR-3	IC_{50} = > 100 μM[233]
3-deacetyl-28-oxosalannin (**457**)	HL-60	IC_{50} = 39.1 μM[233]
	A549	IC_{50} = > 100 μM[233]
	AZ521	IC_{50} = > 100 μM[233]
	SK-BR-3	IC_{50} = > 100 μM[233]
1-detigloylohchinolal (**508**)	HL-60	IC_{50} = 5.0 μM[233]
	A549	IC_{50} = 25.7 μM[233]
	AZ521	IC_{50} = 7.3 μM[233]
	SK-BR-3	IC_{50} = 76.5 μM[233]
17-defurano-17-(5x-2,5-dihydro-5-hydroxy-2-oxofuran-3-yl)-2',3'-dehydrosalannol (**462**)	HL-60	IC_{50} = 41.6 μM[236]
	A549	IC_{50} = >100 μM[236]
	AZ521	IC_{50} = >100 μM[236]
	SK-BR-3	IC_{50} = >100 μM[236]
17-defurano-17-(2x-2,5-dihydro-2- hydroxy-5-oxofuran-3-yl)-28-deoxonimbolide (**469**)	HL-60	IC_{50} = 2.1 μM[236]
	A549	IC_{50} = 37.8 μM[236]
	AZ521	IC_{50} = 9.9 μM[236]
	SK-BR-3	IC_{50} = 24.9 μM[236]
17- defurano-17-(2,5-dihydro-2-oxofuran-3-yl)-28-deoxonimbolide (**471**)	HL-60	IC_{50} = 18.5 μM[236]
	A549	IC_{50} = >100 μM[236]
	AZ521	IC_{50} = 72.2 μM[236]
	SK-BR-3	IC_{50} = 83.4 μM[236]
12-ethoxynimbolinin G (**487**)	SMMC-7721	IC_{50} = 27.6 μg/mL[245]
	MCF-7	IC_{50} = 31.6 μg/mL[245]
12-ethoxynimbolinin E (**489**)	HL-60	IC_{50} = 21.5 μM[246]
	SMMC-7721	IC_{50} = >40 μM[246]
	A549	IC_{50} = 26.4 μM[246]
	MCF-7	IC_{50} = 25.2 μM[246]
	SW480	IC_{50} = 31.8 μM[246]
Walsogyne B (**517**)	HL-60	IC_{50} = 27.7 μM[252]
	HepG2	IC_{50} = >50 μM[252]
	A549	IC_{50} = >50 μM[252]
	MCF-7	IC_{50} = >50 μM[252]
Walsogyne C (**518**)	HL-60	IC_{50} = 7.7 μM[252]
	HepG2	IC_{50} = 37.7 μM[252]
	A549	IC_{50} = 29.9 μM[252]
	MCF-7	IC_{50} = >50 μM[252]
Walsogyne D (**519**)	HL-60	IC_{50} = >50 μM[252]
	HepG2	IC_{50} = 21.7 μM[252]
	A549	IC_{50} = >50 μM[252]
	MCF-7	IC_{50} = 42.4 μM[252]
Walsogyne G (**522**)	HL-60	IC_{50} = 7.8 μM[252]
	HepG2	IC_{50} = 26.6 μM[252]
	A549	IC_{50} = >50 μM[252]
	MCF-7	IC_{50} = 18.2 μM[252]
Andirolide A (**524**)	P388	IC_{50} = 3.3 mM[255]
	HL-60	IC_{50} = 19.4 mM[255]
	L1210	IC_{50} = 16.7mM[255]
	KB	IC_{50} = 11.4 mM[255]
Andirolide D (**749**)	P388	IC_{50} = >100 mM[255]

	HL-60	IC_{50} = 79.9 mM[255]
	L1210	IC_{50} = >100 mM[255]
	KB	IC_{50} = >100 mM[255]
Andirolide F (**1058**)	P388	IC_{50} = 14.4 mM[255]
	HL-60	IC_{50} = 16.1 mM[255]
	L1210	IC_{50} = 27.0 mM[255]
	KB	IC_{50} = 29.3 mM[255]
Andirolide G (**1158**)	P388	IC_{50} = 50.6 mM[255]
	HL-60	IC_{50} = >100 mM[255]
	L1210	IC_{50} = >100 mM[255]
	KB	IC_{50} = 68.5 mM[255]
Andirolide H (**525**)	FM3A	EC_{50} = 7.7x10^{-6} mol/L[256]
Andirolide N (**877**)	FM3A	EC_{50} = 9.7x10^{-6} mol/L[256]
Monadelphin A (**534**)	L5178Y	IC_{50} = 0.62 μg/mL[259]
Toonasinemine H (**539**)	HepG2	IC_{50} = >50 μM[261]
	MCF-7	IC_{50} = >50 μM[261]
	U2OS	IC_{50} = 15.44 μM[261]
Toonasinemine A (**1487**)	HepG2	IC_{50} = 40.67 μM[261]
	MCF-7	IC_{50} = >50 μM[261]
	U2OS	IC_{50} = >50 μM[261]
Toonasinemine D / Toonasin A (**1488**)	HepG2	IC_{50} = 11.63 μM[261]
	MCF-7	IC_{50} = 36.77 μM[261]
	U2OS	IC_{50} = >50 μM[261]
Aphanamolide B (**563**)	A549	IC_{50} = 60.4 μM[270]
	HL-60	IC_{50} = 20.6 μM[270]
Aphanamolide A (**588**)	A549	IC_{50} = 88.1 μM[270]
	HL-60	IC_{50} = 191.0 μM[270]
Aphapolynin A (**581**)	BEL-7402	IC_{50} = 23.7 μM[272]
	SGC-7901	IC_{50} = >50 μM[272]
	BGC-823	IC_{50} = 25.6 μM[272]
	HepG2	IC_{50} = >50 μM[272]
	HeLa	IC_{50} = >50 μM[272]
	MCF-7	IC_{50} = >50 μM[272]
Aphanamolide D (**582**)	MCF-7	IC_{50} = >100 μM[279]
	A549	IC_{50} = 32.3 μM[279]
	SMMC-7721	IC_{50} = 16.5 μM[279]
	HL-60	IC_{50} = 10.2 μM[279]
Aphanamolide C (**590**)	MCF-7	IC_{50} = >100 μM[279]
	A549	IC_{50} = >100 μM[279]
	SMMC-7721	IC_{50} = >100 μM[279]
	HL-60	IC_{50} = 55.3 μM[279]
Cipaferen E (**682**)	A549	IC_{50} = 16.21 μg/mL[300]
	MCF-7	IC_{50} = 19.95 μg/mL[300]
	ME-180	IC_{50} = 15.30 μg/mL[300]
	HT-29	IC_{50} = 28.84 μg/mL[300]
	B-16	IC_{50} = 10.47 μg/mL[300]
	ACHN	IC_{50} =24.56 μg/mL[300]
Cipaferen F (**683**)	A549	IC_{50} = 18.62 μg/mL[300]
	MCF-7	IC_{50} = 15.84 μg/mL[300]
	ME-180	IC_{50} =20.43 μg/mL[300]
	HT-29	IC_{50} = 43.65 μg/mL[300]
	B-16	IC_{50} = 14.45 μg/mL[300]
	ACHN	IC_{50} = 30.79 μg/mL[300]
Cipaferen G (**684**)	A549	IC_{50} = 16.21 μg/mL[300]
	MCF-7	IC_{50} = 12.58 μg/mL[300]
	ME-180	IC_{50} = 13.03 μg/mL[300]
	HT-29	IC_{50} = 14.69 μg/mL[300]
	B-16	IC_{50} = 10.71 μg/mL[300]
	ACHN	IC_{50} = 16.11 μg/mL[300]
Cipaferen I (**687**)	A549	IC_{50} = 12.02 μg/mL[300]
	MCF-7	IC_{50} = 17.15 μg/mL[300]
	ME-180	IC_{50} = 18.19 μg/mL[300]
	HT-29	IC_{50} = 21.50 μg/mL[300]
	B-16	IC_{50} = 15.24 μg/mL[300]
	ACHN	IC_{50} = 14.58 μg/mL[300]

Cipaferen J (**688**)	A549	IC_{50} = 37.15 μg/mL[300]
	MCF-7	IC_{50} = 26.08 μg/mL[300]
	ME-180	IC_{50} = 39.81 μg/mL[300]
	HT-29	IC_{50} = 41.92 μg/mL[300]
	B-16	IC_{50} = 56.78 (>50) μg/mL[300]
	ACHN	IC_{50} = 28.38 μg/mL[300]
Cipaferen H (**694**)	A549	IC_{50} = 23.96 μg/mL[300]
	MCF-7	IC_{50} = 17.88 μg/mL[300]
	ME-180	IC_{50} = 16.59 μg/mL[300]
	HT-29	IC_{50} = 14.45 μg/mL[300]
	B-16	IC_{50} = 8.51 μg/mL[300]
	ACHN	IC_{50} = 14.03 μg/mL[300]
Cipaferen M (**886**)	A549	IC_{50} = 24.10 μg/mL[300]
	MCF-7	IC_{50} = 30.5 μg/mL[300]
	ME-180	IC_{50} = 39.81 μg/mL[300]
	HT-29	IC_{50} = 85.11 μg/mL[300]
	B-16	IC_{50} = 51.40 μg/mL[300]
	ACHN	IC_{50} = 21.37 μg/mL[300]
Cipaferen K (**901**)	A549	IC_{50} = 75.85 μg/mL[300]
	MCF-7	IC_{50} = 12.58 μg/mL[300]
	ME-180	IC_{50} = 15.71 μg/mL[300]
	HT-29	IC_{50} = 16.59 μg/mL[300]
	B-16	IC_{50} = 12.02 μg/mL[300]
	ACHN	IC_{50} = 60.25 μg/mL[300]
Cipaferen L (**902**)	A549	IC_{50} = 31.06 μg/mL[300]
	MCF-7	IC_{50} = 12.58 μg/mL[300]
	ME-180	IC_{50} = 14.18 μg/mL[300]
	HT-29	IC_{50} = 28.90 μg/mL[300]
	B-16	IC_{50} = 16.21 μg/mL[300]
	ACHN	IC_{50} = 25.11 μg/mL[300]
Koetjapin A (**715**)	P388	IC_{50} = 46.8 μg/mL[306]
Koetjapin B (**716**)	P388	IC_{50} = 52.0 μg/mL[306]
Koetjapin C (**717**)	P388	IC_{50} = 59.2 μg/mL[306]
Koetjapin D (**718**)	P388	IC_{50} = 16.8 μg/mL[306]
Carapanolide C (**743**)	P388	IC_{50} = 17.9 μM[325]
	HL-60	IC_{50} = 52.3 μM[325]
	L1210	IC_{50} = 13.3 μM[325]
Carapanolide D (**744**)	P388	IC_{50} = 27.1 μM[325]
	HL-60	IC_{50} = 11.0 μM[325]
	L1210	IC_{50} = >100 μM[325]
Carapanolide E (**745**)	P388	IC_{50} = 15.8 μM[325]
	HL-60	IC_{50} = 45.0 μM[325]
	L1210	IC_{50} = 18.1 μM[325]
Carapanolide F (**929**)	P388	IC_{50} = >100 μM[325]
	HL-60	IC_{50} = 63.7 μM[325]
	L1210	IC_{50} = 15.9 μM[325]
Carapanolide G (**930**)	P388	IC_{50} = 81.2 μM[325]
	HL-60	IC_{50} = 39.7 μM[325]
	L1210	IC_{50} = 14.2 μM[325]
Carapanolide I (**1011**)	P388	IC_{50} = 22.2 μM[325]
	HL-60	IC_{50} = 21.2 μM[325]
	L1210	IC_{50} = 16.9 μM[325]
Carapanolide H (**1149**)	P388	IC_{50} = 89.8 μM[325]
	HL-60	IC_{50} = 90.8 μM[325]
	L1210	IC_{50} = 24.3 μM[325]
Cipadessain F (**905**)	HepG2	IC_{50} = 8.67 μM[335]
Cipadessain C (**912**)	HepG2	IC_{50} = 5.23 μM[335]
Heytrijunolide C (**789**)	HL-60	IC_{50} = 21.88 μM[336]
	SMMC-7721	IC_{50} = 20.66 μM[336]
	A549	IC_{50} = 12.70 μM[336]
Thaixylogranin E (**817**)	HCT-8/T	IC_{50} = 36.4 μM[343]
	MDA-MB-231	IC_{50} = 57.9 μM[343]
Thaixylogranin F (**818**)	MDA-MB-231	IC_{50} = 44.6 μM[343]
Thaixylogranin G (**831**)	MDA-MB-231	IC_{50} = 40.6 μM[343]
Thaixylogranin H (**832**)	MDA-MB-231	IC_{50} = 38.5 μM[343]
Thaixylogranin A (**840**)	MDA-MB-231	IC_{50} = 49.4 μM[343]

Thaixylogranin B (**841**)	MDA-MB-231	IC_{50} = 58.3 μM[343]
Thaixylogranin C (**854**)	A375	IC_{50} = 47.1 μM[343]
	AGS	IC_{50} = 41.7 μM[343]
	MDA-MB-231	IC_{50} = 53.6 μM[343]
Thaixylogranin D (**954**)	A375	IC_{50} = 41.9 μM[343]
	AGS	IC_{50} = 35.0 μM[343]
	MDA-MB-231	IC_{50} = 61.1 μM[343]
Swielimonoid B (**849**)	Huh-7	CC_{50} = >200 μM[345]
3-*O*- methylbutyrylseneganolide A (**828**)	HL-60	IC_{50} = >40 μM[346]
	SMMC-7721	IC_{50} = >40 μM[346]
	A549	IC_{50} = 37.3 μM[346]
	MCF-7	IC_{50} = >40 μM[346]
	SW480	IC_{50} = >40 μM[346]
Trichagmalin D (**1203**)	HL-60	IC_{50} = 17.05 μM[351]
15-Acetyltrichagmalin E (**1205**)	HL-60	IC_{50} = 21.01 μM[351]
Xylogranin B (**1150**)	DLD-1	IC_{50} = 3.75 μM[364]
	HCT116	IC_{50} = 0.05 μM[364]
	SW480	IC_{50} = 0.26 μM[364]
	STF293(HEK)	IC_{50} = 5.58 μM[364]
Xylomexicanin C (**990**)	KT	IC_{50} = 4.60 μM[365]
Xylomexicanin F (**998**)	A549	IC_{50} = 18.83 μM[370]
	RERF	IC_{50} = 15.83 μM[370]
Thaixylomolin P (**1136**)	A2780	IC_{50} = 37.5 μM[374]
	A2780/T	IC_{50} = 37.5 μM[374]
Carapanolide A (**1003**)	L1210	IC_{50} = 8.7 μM[375]
Guianolide A (**1118**)	P388	IC_{50} = 33.7 μM[398]
Chukfuransin A (**1122**)	HL-60	IC_{50} = 13.81 μM[399]
	SMMC-7721	IC_{50} = 11.72 μM[399]
	A549	IC_{50} = 39.09 μM[399]
	MCF-7	IC_{50} = 16.54 μM[399]
	SW480	IC_{50} = 16.25 μM[399]
Heytrijumalin B (**1194**)	HL-60	IC_{50} = 23.08 μM[413]
	SMMC-7721	IC_{50} = 25.69 μM[413]
	A549	IC_{50} = 14.55 μM[413]
	MCF-7	IC_{50} = >40 μM[413]
	SW480	IC_{50} = >40 μM[413]
Trisinenmalin A (**1209**)	K562	IC_{50} = 15.75 μM[414]
	SGC-7901	IC_{50} = 15.54 μM[414]
	BEL-7402	IC_{50} = 10.63 μM[414]
Trisinenmalin B (**1210**)	K562	IC_{50} = >40 μM[414]
	SGC-7901	IC_{50} = >40 μM[414]
	BEL-7402	IC_{50} = 38.57 μM[414]
Trisinenmalin C (**1211**)	K562	IC_{50} = 24.81 μM[414]
	SGC-7901	IC_{50} = 14.56 μM[414]
	BEL-7402	IC_{50} = 11.87 μM[414]
Trisinenmalin E (**1212**)	K562	IC_{50} = >40 μM[414]
	SGC-7901	IC_{50} = 27.99 μM[414]
	BEL-7402	IC_{50} = 36.11 μM[414]
Trisinenmalin F (**1213**)	K562	IC_{50} = >40 μM[414]
	SGC-7901	IC_{50} = >40 μM[414]
	BEL-7402	IC_{50} = 37.30 μM[414]
Trisinenmalin G (**1214**)	K562	IC_{50} = 26.77 μM[414]
	SGC-7901	IC_{50} = 15.22 μM[414]
	BEL-7402	IC_{50} = 11.72 μM[414]
Trisinenmalin H (**1215**)	K562	IC_{50} = >40 μM[414]
	SGC-7901	IC_{50} = >40 μM[414]
	BEL-7402	IC_{50} = 27.14 μM[414]
Trisinenmalin I (**1216**)	K562	IC_{50} = 27.65 μM[414]
	SGC-7901	IC_{50} = 17.15 μM[414]
	BEL-7402	IC_{50} = 19.15 μM[414]
Cipatrijugin E (**1348**)	MCF-7	IC_{50} = 5.0 μM[436]
	SW480	IC_{50} = 6.6 μM[436]
	HL-60	IC_{50} = 4.5 μM[436]
	SMMC-7721	IC_{50} = 21.6 μM[436]
	A549	IC_{50} = >40 μM[436]
Cipatrijugin G (**1365**)	A549	IC_{50} = 9.78 μM[438]

Cipaferen C (**1387**)	KBS	IC_{50} = 51.5 μM[443]
	A549	IC_{50} = 47.4 μM[443]
	MCF-7	IC_{50} = 23.7 μM[443]
	IMR-32	IC_{50} = 64.1 μM[443]
	HeLa	IC_{50} = 44.7 μM[443]
Cipaferen A (**1388**)	KBS	IC_{50} = 31.2 μM[443]
	A549	IC_{50} = 24.9 μM[443]
	MCF-7	IC_{50} = 12.5 μM[443]
	IMR-32	IC_{50} = 19.0 μM[443]
	HeLa	IC_{50} = 25.9 μM[443]
Cipaferen B (**1389**)	KBS	IC_{50} = 71.2 μM[443]
	A549	IC_{50} = 50.5 μM[443]
	MCF-7	IC_{50} = 25.2 μM[443]
	IMR-32	IC_{50} = 39.0 μM[443]
	HeLa	IC_{50} = 51.0 μM[443]
Cipaferen D (**1390**)	KBS	IC_{50} = 46.7 μM[443]
	A549	IC_{50} = 38.9 μM[443]
	MCF-7	IC_{50} = 19.5 μM[443]
	IMR-32	IC_{50} = 67.1 μM[443]
	HeLa	IC_{50} = 40.5 μM[443]
Senegalension A (**1404**)	HL-60	IC_{50} = 40.0 μM[449]
	A549	IC_{50} = 39.7 μM[449]
	MCF-7	IC_{50} = 16.1 μM[449]
	SW480	IC_{50} = 19.0 μM[449]
Azadiramide A (**1460**)	MDA-MB-231	IC_{50} = 2.70 μmol/L[471]
Toonasin C/ Toonasinemine F (**1491**)	HL-60	IC_{50} = 18.61 μM[473]
	SMMC-7721	IC_{50} = 19.55 μM[473]
	A549	IC_{50} = 15.07 μM[473]
	MCF-7	IC_{50} = 17.79 μM[473]
	SW480	IC_{50} = 12.47 μM[473]
Meliazedarine G (**453**)	HCT116	IC_{50} = 0.3 μM[163]
Angustifolianin (**377**)	MCF-7	IC_{50} = 50.5 μg/mL[214]
1-(E)-3,4-dimethylpent-2-enal-11-methoxycarb- onyl nimbidinol acetate (**455**)	HL-60	IC_{50} = 25.1 μM[148]
	A549	IC_{50} = 27.7 μM[148]
	AZ521	IC_{50} = >100 μM[148]
	SK-BR-3	IC_{50} = >100 μM[148]
(5R,6R,7S,13S,17R)-6-hydroxy-7-(benzoyloxy)-21,23-epoxy- 4,4,8-trimethyl-24-norchola-1,14,20,22-tetraene-3-one (**186**)	HL-60	IC_{50} = 3.6 μM[148]
	A549	IC_{50} = 5.7 μM[148]
	AZ521	IC_{50} = 3.1 μM[148]
	SK-BR-3	IC_{50} = 8.9 μM[148]
3-O-detigloyl-3-O-isobutyrylfebrifugin A (**914**)	HL-60	IC_{50} = 22.64 μM[358]
	SMMC-7721	IC_{50} = >40 μM[358]
	A549	IC_{50} = >40 μM[358]
	MCF-7	IC_{50} = >40 μM[358]
	SW480	IC_{50} = 30.34 μM[358]
3-O-detigloyl-3-O-isobutyrylgranatumin E (**889**)	HL-60	IC_{50} = >40 μM[358]
	SMMC-7721	IC_{50} = >40 μM[358]
	A549	IC_{50} = >40 μM[358]
	MCF-7	IC_{50} = >40 μM[358]
	SW480	IC_{50} = >40 μM[358]
21-O-methylgranatumin E (**892**)	HL-60	IC_{50} = >40 μM[358]
	SMMC-7721	IC_{50} = >40 μM[358]
	A549	IC_{50} = >40 μM[358]
	MCF-7	IC_{50} = >40 μM[358]
	SW480	IC_{50} = >40 μM[358]
Pentandricine B (**187**)	MCF-7	IC_{50} = 212.02 μM[149]
Pentandricine C (**188**)	MCF-7	IC_{50} = 122.02 μM[149]
Pentandricine D (**189**)	MCF-7	IC_{50} = 313.92μM[149]
Toosendansin E (**444**)	U2OS	At 50 μM, showed cytotoxicity with inhibition rate of 42.8 %[197]
	MCF-7	MDR reversal fold change is 114 times[197]
Toosendansin H (**315**)	U2OS	At 50 μM, showed cytotoxicity with inhibition rate of 81.1 %[197]
	MCF-7	MDR reversal fold change is >500 times[197]
Entanutilin O (**1142**)	MCF-7/DOX	MDR reversal fold change value of 18.18[107]
Entanutilin U (**117**)	MCF-7/DOX	MDR reversal fold change value of 7.94[107]
Trichilinin M (**250**)	PANC-1	IC_{50} = 27.06 μM[166]
Meliazedarine E/Ohchinin benzoate (**451**)	PANC-1	IC_{50} = 21.17 μM[166]

Table 59: Inactive Meliaceous Limonoids against Tumor Cell Lines

Limonoid	Cells
Toonaciliatavarin C, B, A, F, G, H (**129**, **116**, **118**, **167**, **168, 422**)	MCF-7, MCF-7/ADM, KB, KB/VCR, SMMC-7721, K562[80]
Azadirahemiacetal (**128**), 7-tigloyl-12-oxo vilasini (**314**), 1-benzoyl-3-deacetyl-1-detigloyl salannin (**449**), Azadiralactone (**1456**), Swietesenin (**119**) and Swieteliacate E, C, D, A (**738**, **802**, **893**, **1410**), Americanolide A, B, D, C (**219-222**), Munronin N, H-M, B-G (**244**, **332**, **335**, **350**, **491**, **501**, **503**, **553**, **555**, **556**, **558**, **559**, **1445**), 12-ethoxynimbolinin H, F (**488**, **490**), Senegalension B (**1405**), Senegalension C (**1406**) , Swietemahalactone (**1407**), Toonayunnanin A, D, C, F, I, J, G, H, K, L, E (**152**, **333**, **344**, **387**, **389**, **395**, **402**, **405**, **408**, **409**, **631**), Aphanamixoid K-P, C-J (**570-572**, **594-596**, **621-623**, **625-629**), Chukfuransin C (**1124**), Heytrijumalin A, D-F (**1193**, **1196-1198**), Swietenine J (**1228**), Cipadesin L, M, J, P, Q, O (**308**, **309**, **547**, **696**, **697**, **862**), 14,15-didehydroruageanin A (**839**), Cipatrijugin F (**1354**)	HL-60, SMMC-7721, A549, MCF-7, SW480[119,188,116,158,169,253,254,457,458,136,203,282,354,407,421,424,444]
Xylogranatumine A, B, C, E, G, D (**107**, **101-104**, **98**)	A549[105]
Entangolensin P, N, M, D, E, I, J, G, H (**255**, **531**, **535**, **707**, **709**, **711-714**)	HepG2, MCF-7[141]
Xylomolin A1, A3, B1, C1, F, L2, K2, G1, H (**759**, **761**, **821**, **824**, **927**, **1144**, **1236**, **1321**, **1330**)	HCT-8, HCT-8/T, A2780 , A2780/T, MDA-MB-231[143]
Dysomollide F, G, E, A-D (**161**, **162**, **376**, **569**, **655**, **656**, **659**), Ciliatonoid A, B (**419**, **420**)	HL-60, P388, A549[144,230,295]
24,25,26,27-tetranorapotirucall- 6α-hydroxy-7α-acetoxy-14-en-3-one-21,23-olide (**163**), 24,25,26,27-tetranor-apotirucall-6α-hydroxy- 7α-acetoxy-14-en-3-one-21,24-anhydride (**170**), 24,25,26,27-tetranor-apotirucall-6α,22-dihydroxy-7α-acetoxy-1,14,20(21)-trien-3-one-21,23-olide (**171**), 24,25,26,27-tetranorapotirucall- 6α,22-dihydroxy-7α-acetoxy-14,20(21)-dien-3-one- 21,23-olide (**172**), 1-tigloylazadirachtol (**437**), 17-desfuran-17-(22-hydroxybut-20(21)-ene-21,23-γ-lactone)- nimbandiol (**1421**) and 17-desfuran-17-(21-hydroxy-20(22)-ene- 21,23-γ-lactone) nimbandiol (**1422**)	HeLa, PC-3[145]
Yunnanolide B (**166**), 11β-hydroxy-1,2-dihydroisowalsuranolide (**216**), 1α,11β-dihydroxy-1,2-dihydroisowalsuranolide (**217**)	HL-60, SMMC-7721, A549, MCF-7, SW480, BEAS-2B[147]
Turrapubin I, E-G, A-D, H, K, J (**245**, **379-381**, **384-386**, **401**, **421**, **438**, **439**)	HL-60[170]
Trichisinlin A-C, E (**269**, **271**, **272**, **290**), Trichisinton A-D (**1273-1276**), 2-dehydroxylswietephragmin C (**1156**)	K562, SGC-7901, BEL-7402[189,413,422]
Ceramicine H, F, E (**297**, **330**, **1414**)	HL-60, A549, MCF-7, HCT-116[199]
Pentendricine (**321**), Walsucochinone B-A (**327-328**), Chuktabularoid E-H, J (**1132**, **1133**, **1086**, **1087**, **1034**) , Chukorthoester A-B, C-D, E, F, G-H (**1027-1028**, **1017-1018**, **1045**, **1024**, **925-926**)	MCF-7 [208,210, 371,393]
Walrobsin A-B (**374-375**)	HepG2, HL-60, MCF-7, HT-29[221]
Toonacilianin E, G-J, D, B, C, A, K, L (**382**, **391**, **396**, **403**, **404**, **410**, **412**, **413**, **416**, **1426**, **1427**), Velutinalide A, B (**1105**, **1106**)	A549, HL-60[227,404]
Toonaciliatone F, G, E, H, A, B, D (**393**, **399**, **400**, **414**, **1418**, **1419**, **1434**)	HepG2, MCF-7, HL-60[229]
3-deacetyl-28-oxosalannolactone (**460**), 3-deacetyl-28-oxoisosalanninolide (**472**), 3-deacetyl-17- defurano-17,28-dioxosalannin (**1453**)	HL-60, A549, AZ521, SK-BR-3[243]
Walsogyne E, F (**520, 521**), Polystanin E (**136**)	HL-60, HepG2, A549, MCF-7[260,124]
Andirolide B, C, E (**747**, **748, 1055**)	P388 , HL-60, L1210, KB[263]
Monadelphin B (**528**)	L5178Y[267]
Toonasinemine I-L, B, E, F, G, C (**540-543**, **1486**, **1490-1493**)	HepG2 MCF-7 U2OS[269]
Aphapolynin B (**566**)	BEL-7402, SGC-7901, BGC-823, HepG2, HeLa, MCF-7[280]
Aphapolynin C-E, B, F-I (**574-576**, **587**, **601-602**, **610-611**)	MCF-7, BEL-7402, BGC-823[284]
Dregeanin DM4 (**578**)	NCI NC59 anticancer screen and showed no significant activity[285]
Aphagranols A, B (**583**, **584**)	MCF-7, A549, SMMC-7721, HL-60[288]
Clauemargine A-L (**658-669**)	HCT-116, HepG2, BGC-823, SK-OV-3[295]
Cipaferen N, O (**681**, **1386**)	HeLa, PANC1, MDA-MB-231, IMR32, HepG2, SKNSH[307]
Andirolide Q (**754**), Ivorenoid G (**916**), Chukvelutilide Z, Y (**1091, 1117**), Chukvelutilide I-P, U-X, Q-T (**1074-1081**, **1096-1099**, **1108-1111**)	MCF-7, SMMC-7721, U2OS[335,401]
Cipadessain I, A, B, K, G, H, D, J, E (**786**, **795**, **796**, **820**, **884**, **885**, **887**, **894**, **913**)	HepG2[343]
Granatumin U, P-T, N, O, L, M (**792**, **943**, **944**, **955**, **956**, **958**) Andhraxylocarpin C, D, A, B, E (**1281**, **1282**, **1286**, **1287**, **1399**)	A2058, MDA-MB-468, DU145[345,434]
Xylorumphiin L (**863**)	NCI-59 human tumour cell line[360]
Xylomexicanin G, H, E (**986, 987, 1476**)	A549, RERF, PC-3, PC-6, QG-56, QG-90[378]

Thaixylomolin Q, O, R (**999, 1135, 1423**)	A375, A549, HCT-8, HCT-8/T, A2780, A2780/T, MDA-MB-231[382]
Carapanolide B (**1004**), Guianolide B (**1119**)	P388, L1210, HL-60[383,406]
Velutabularin B, D, E, I (**1253**, **1255**, **1256**, **1260**)	MCF-7, Hela, SGC-7901, BGC-823, HepG2[426]
Trichiconlide E, F, C, D (**1278**, **1279**, **1289**, **1290**)	A549, Hela[433]
Trichiliton B (**1366**)	HL-60, BEL-7402, Hela, MCF-7[447]
Dysolenticin A, B, D, E, H, I (**51**, **48**, **32**, **31**, **22**, **23**)	HL-60, SMMC-7721[68]
Guareoic acid B (**56**), Guareolide (**58**)	Jurkat, HeLa, MCF-7, PBMC >100 μM[82]
(20S)-3-oxo-tirucalla-25-nor-7-en-24-oic acid (**67**), (20S)-5α,8α-epidioxy-3-oxo-24-nor-6,9(11)-dien-23-oic acid (**68**)	HeLa, HePG2, SW480[84]
Toosendine H, I (**81**, **82**)	U2OS[103]
7-deacetylbrujavanone E (**99**), 21,24,25- triacetyl-7-deacetyl-6-hydroxylbrujavanone E (**100**)	HeLa[108]
Meliazedarine A-C, D, F-H, I (**505-507**, **450**, **452-454**, **248**), Meliazedarine E/Ohchinin benzoate (**451**)	BEL-7402, HCT-116, A549, U251, HT-29[171]
Khaysenelide K (**693**)	MDA-MB-231, HePG2[311]
Encandollen C-E (**1068-1070**)	KB3-1[399]

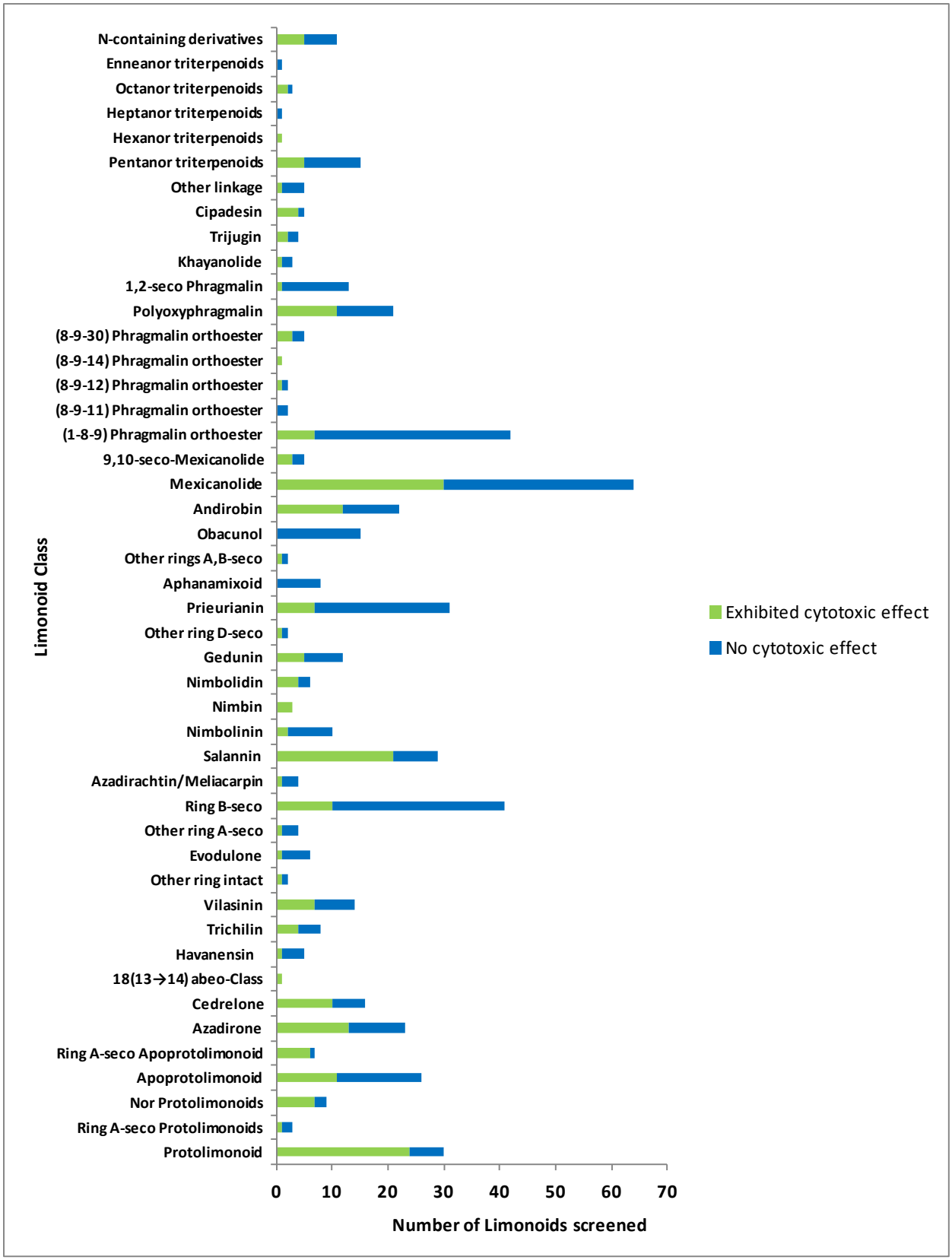


Figure 61. Antineoplastic activities of novel limonoids.

Figure 62. Distribution plot showing the novel limonoids screened against various cancer cell lines.

3.2 Anti-inflammatory/potential inhibitors of macrophage activation

Many Limonoids possess anti-inflammatory activities. During inflammation, macrophages play an important role which become activated, releasing a variety of inflammatory factors. Nitric oxide (NO) and tumor necrosis factor alpha (TNF-α) are the key factors released during inflammation. The anti-inflammatory activities of Limonoids are listed in table 60. The inhibitory activities on lipopolysaccharide (LPS) stimulated inflammation factor-release (NO and TNF-α) of mouse macrophages RAW 264.7 in vitro were evaluated (Table 60). Limonoids **710**, **812**, **813**, **858**, **859**, **1299** and **1420** inhibited NO expression in LPS stimulated RAW 264.7 cells with IC_{50} values of 1.75, 2.2, 2.9 2.85, 1.88, 2.40 and 1.42 μM respectively as compared to IC_{50} values of positive controls dexamethasone (0.06 μM), N-Monomethyl-L-arginine (32.55 μM), hydrocortisone (3.4 μM) and curcumin (5 μM). Compounds (**110**, **111**, **92**) inhibited TNF-α with IC_{50} value of 26.9 μM, 30.7 μM and 47.4 μM respectively and compounds (**83-89**, **91-95**) were inactive (IC_{50} = >100)[104]. Compounds (**130**, **131**, **132**, **133**) showed anti-inflammatory activity on superoxide anion generation with IC_{50} value ranging between 5.79 to >10 μg/mL, as well as the significant inhibition on elastase release with IC_{50} value ranging between of 5.22 to >10 μg/mL by human neutrophils in the presence of FMLP/CB[120]. Compounds (**295**, **493**, **658**, **659**, **665-667**, **679**) inhibited NO production with IC_{50} value of 315.75, 21.95 10.0, 6.7, 8.8, 7.0, 5.1 and 4.97 μM respectively in LPS induced NO production in murine microglial BV-2 microglia cells while compounds (**660-664**, **668**, **669**, **67**, **68**) were inactive[84,192,295,306]. At 100 μM, compounds (**334, 383, 400, 397, 406, 407, 411, 417, 632, 1429, 6**, **24**, **44**, **45**, **46**, **47**) exhibited anti-inflammatory activity by inhibiting cyclooxygenase-1 with inhibition rate of 30.2, 44.3, <0, 92.7, 88.1, 91.1, 53.1, <0, <0, 95.2, <0, <0, 95.3, 94.7 94.2, 94.4 % respectively as well as they inhibited cyclooxygenase-2 with inhibition rate of 19.7, 21.4, <0, 39.3, 35.6, 40.2, 24.4, <0, <0, 40.1, 24.3, 21.1, 43.2, 39.5, 42.1, 41.8 % respectively[62,78,214,229]. Compounds (**720**, **1227**, **1391**, **1392**) exhibited inhibitory effects on NO production in activated macrophages with IC_{50} value of 45.80, 32.26, 35.1 and 75.2 μM respectively[317,453]. Compounds (**921**, **934**, **1282**) exhibited inhibition of LPS induced NO production in J774.1 macrophages with IC_{50} value of 24.5, 31.3 and 20.2 μM respectively while compounds (**919**, **920**, **922**, **923**, **1025**, **1269**, **1271**) were inactive[369,431]. Compounds **1498**, **366**, **364**, **362**, **1499** exhibied anti-NLRP3 inflammasome activity by inhibiting lactate dehydrogenase IC_{50} values of 4.2, 4.9, 3.2, 7.2, 9.7 μM respectively and IL-1β release with IC_{50} values of 3.9, 6.4, 3.4, 6.7, 8.4 respectively with cytotoxic value (CC_{50}) of >20 μM[219]. Compounds (**440, 1014, 1015, 1040, 1120, 723, 786, 795, 796, 820, 885, 894, 913, 1281, 1282, 1286, 1287, 1399, 1394, 1402, 1480, 81, 82**, **1408**, **425**, **426**, **427**, **428-436**, **183**, **185**, **190**, **191**, **398**, **1432**, **1436**) were inactive for anti-inflammatory activity in LPS stimulated RAW 264.7 cells[103,139,232,238,297,318,343,434,454,456].

Table 60: Anti-inflammatory Activities of Meliaceae Limonoids

Limonoid	Cells	Activity NO
Toonaciliatavarin D (**55**)	RAW 264.7	IC_{50} = 33.4 μM[80]
Toonaciliatavarin C (**129**)	RAW 264.7	IC_{50} = 11.0 μM[80]
Toonaciliatavarin B (**116**)	RAW 264.7	IC_{50} = 7.9 μM[80]
Toonaciliatavarin A (**118**)	RAW 264.7	IC_{50} = 9.4 μM[80]
Toonaciliatavarin F (**167**)	RAW 264.7	IC_{50} = 28.8 μM[80]
Toonaciliatavarin G (**168**)	RAW 264.7	IC_{50} = 15.2 μM[80]
Toonaciliatavarin H (**422**)	RAW 264.7	IC_{50} = 20.9 μM[80]
Chisopanin A (**110**)	RAW 264.7	IC_{50} = 5.4 μM[104]
Chisopanin B (**111**)	RAW 264.7	IC_{50} = 7.9 μM[104]
Chisopanin K (**92**)	RAW 264.7	IC_{50} = 33.4 μM[104]
Chisopanin E (**83**)	RAW 264.7	IC_{50} = 6.2 μM[104]
Chisopanin F (**84**)	RAW 264.7	IC_{50} = 6.9 μM[104]
Chisopanin G (**85**)	RAW 264.7	IC_{50} = 5.4 μM[104]
Chisopanin H (**86**)	RAW 264.7	IC_{50} = >50 μM[104]
Chisopanin I (**87**)	RAW 264.7	IC_{50} = 5.3 μM[104]
Chisopanin J (**88**)	RAW 264.7	IC_{50} = 12.3 μM[104]
Chisopanin C (**94**)	RAW 264.7	IC_{50} = 40.0 μM[104]
Chisopanin D (**95**)	RAW 264.7	IC_{50} = >50 μM[104]
Entangolensin O (**155**)	RAW 264.7	IC_{50} = >50 μM[141]
Entangolensin L (**529**)	RAW 264.7	IC_{50} = >50 μM[141]
Entangolensin F (**710**)	RAW 264.7	IC_{50} = 1.75 μM[141]
Entangolensin K (**1485**)	RAW 264.7	IC_{50} = 7.94 μM[141]
Turrapubin I (**245**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin E (**379**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin F (**380**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin G (**381**)	RAW 264.7	IC_{50} = >20 μM[170]

Turrapubin A (**384**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin B (**385**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin C (**386**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin D (**401**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin H (**421**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin K (**438**)	RAW 264.7	IC_{50} = >20 μM[170]
Turrapubin J (**439**)	RAW 264.7	IC_{50} = >20 μM[170]
Meliazedalide B (**294**)	RAW 264.7	IC_{50} = 37.41 μmol/L[191]
Walrobsin A (**374**)	RAW 264.7	IC_{50} = 7.95 μM[221]
Toosendane B (**441**)	RAW 264.7	IC_{50} = 21.3 μM[238]
Toosendane C (**442**)	RAW 264.7	IC_{50} = 20.7 μM[238]
3-deacetyl-28-oxosalannolactone (**460**)	RAW 264.7	IC_{50} = 86.0 μM[243]
3-deacetyl-28-oxoisosalanninolide (**472**)	RAW 264.7	IC_{50} = >100[243]
3-deacetyl-17- defurano-17,28-dioxosalannin (**1453**)	RAW 264.7	IC_{50} = >100[243]
Carapansin C (**523**)	RAW 264.7	IC_{50} = 13.7 μM[262]
Carapanolide J (**527**)	RAW 264.7	IC_{50} = 37.4 μM[266]
Carapanolide L (**1051**)	RAW 264.7	IC_{50} =>100 μM[266]
Carapanolide K (**1192**)	RAW 264.7	IC_{50} = 12.0 μM[266]
Toonasinemine H (**539**)	RAW 264.7	IC_{50} = 12.56 μM[269]
Toonasinemine I (**540**)	RAW 264.7	IC_{50} = 20.68 μM[269]
Toonasinemine J (**541**)	RAW 264.7	IC_{50} = >50 μM[269]
Toonasinemine K (**542**)	RAW 264.7	IC_{50} = >50 μM[269]
Toonasinemine L (**543**)	RAW 264.7	IC_{50} = >50 μM[269]
Toonasinemine B (**1486**)	RAW 264.7	IC_{50} = 20.05 μM[269]
Toonasinemine A (**1487**)	RAW 264.7	IC_{50} = 10.21 μM[269]
Toonasin A/Toonasinemine D (**1488**)	RAW 264.7	IC_{50} = >50 μM[269]
Toonasinemine E (**1490**)	RAW 264.7	IC_{50} = >50 μM[269]
Toonasin C/Toonasinemine F (**1491**)	RAW 264.7	IC_{50} = 12.56 μM[269]
Toonasinemine G (**1492**)	RAW 264.7	IC_{50} = >50 μM[269]
Toonasinemine C (**1493**)	RAW 264.7	IC_{50} = >50 μM[269]
Aphapolynin C (**574**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphapolynin D (**575**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphapolynin E (**576**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphanamolide B (**587**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphapolynin F (**601**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphapolynin G (**602**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphapolynin H (**610**)	RAW 264.7	IC_{50} = >50 μM[284]
Aphapolynin I (**611**)	RAW 264.7	IC_{50} = >50 μM[284]
Trichiconlide A (**630**)	RAW 264.7	IC_{50} = 40.5 μM[291]
Guianofruit C (**672**)	RAW 264.7	IC_{50} = 80.4 μM[297]
Guianofruit D (**673**)	RAW 264.7	IC_{50} = 61.0 μM[297]
Guianofruit B (**674**)	RAW 264.7	At 30 μM, 65.6 % NO was produced with no cytoxicity to the positive control L-NMMA (43.1 % at 30 μM)[298]
Guianofruit A (**675**)	RAW 264.7	At 30 μM, 47.5 % NO was produced with no cytoxicity to the positive control L-NMMA (43.1 % at 30 μM)[298]
Khayandirobilide A (**679**)	RAW 264.7	IC_{50} = 5.04 μM[306]
Thaixylomolin B (**1474**)	RAW 264.7	IC_{50} = 84.3 μM[318]
Carapanosin E (**735**)	RAW 264.7	IC_{50} = 23.9 μM[331]
Carapanosin F **736**)	RAW 264.7	IC_{50} = 11.8 μM[331]
Carapanolide T (**740**)	RAW 264.7	IC_{50} = 22 μM[332]
Carapanolide U (**741**)	RAW 264.7	IC_{50} = 23.3 μM[332]
Carapanolide W (**1010**)	RAW 264.7	IC_{50} = >30 μM[332]
Carapanolide X (**1031**)	RAW 264.7	IC_{50} = >30 μM[332]
Carapanolide V (**1058**)	RAW 264.7	IC_{50} = >30 μM[332]
Trichinenlide B (**858**)	RAW 264.7	IC_{50} = 2.85 μM[342]
Trichinenlide C (**859**)	RAW 264.7	IC_{50} = 1.88 μM[342]
Cipadessain G (**884**)	RAW 264.7	IC_{50} = 20.54 μM[343]
Cipadessain D (**887**)	RAW 264.7	IC_{50} = 23.90 μM[343]
Cipadessain F (**905**)	RAW 264.7	IC_{50} = 6.93 μM[343]
Cipadessain C (**912**)	RAW 264.7	IC_{50} = 5.79 μM[343]
Trichiconnarone A (**812**)	RAW 264.7	IC_{50} = 2.2 μM[349]
Trichiconnarone B (**813**)	RAW 264.7	IC_{50} = 2.9 μM[349]
Swietemacrophin (**848**)	RAW 264.7	IC_{50} = 33.45 μM[358]
Trichiliasinenoid E (**883**)	RAW 264.7	IC_{50} = 88.3 μM[365]
Trichiliasinenoid D (**1483**)	RAW 264.7	IC_{50} = 93.8 μM[365]
Khaysenelide A (**895**)	RAW 264.7	IC_{50} = >50 μM[367]
Khaysenelide B (**896**)	RAW 264.7	IC_{50} = >50 μM[367]
Khaysenelide C (**1340**)	RAW 264.7	IC_{50} = >50 μM[367]

Khaysenelide D (**1341**)	RAW 264.7	IC_{50} = >50 µM[367]
Khaysenelide E (**1342**)	RAW 264.7	IC_{50} = >50 µM[367]
Khaysenelide F (**1343**)	RAW 264.7	IC_{50} = >50 µM[367]
Encandollen B (**1056**)	RAW 264.7	At 50 µmol/L, it exhibited NO inhibition at the rate = 33.6 %[396]
Encandollen A (**1095**)	RAW 264.7	At 50 µmol/L, it exhibited NO inhibition at the rate = 15.6 %[396]
Chukvelutilide I (**1074**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide J (**1075**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide K (**1076**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide L (**1077**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide M (**1078**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide N (**1079**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide O (**1080**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide P (**1081**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide U (**1096**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide V (**1097**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide W (**1098**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide X (**1099**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide Q (**1108**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide R (**1109**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide S (**1110**)	RAW 264.7	IC_{50} = >50 µM[401]
Chukvelutilide T (**1111**)	RAW 264.7	IC_{50} = >50 µM[401]
Tabulalin C (**1084**)	RAW 264.7	IC_{50} = 13.0 µM[402]
Tabulalin E (**1263**)	RAW 264.7	IC_{50} = 17.1 µM[402]
Tabulalin B (**1266**)	RAW 264.7	IC_{50} = 15.3 µM[402]
Velutabularin B (**1253**)	RAW 264.7	IC_{50} = 19.01 µM[426]
Velutabularin D (**1255**)	RAW 264.7	IC_{50} = 10.09 µM[426]
Velutabularin E (**1256**)	RAW 264.7	IC_{50} = 27.08 µM[426]
Velutabularin I (**1260**)	RAW 264.7	IC_{50} = 46.34 µM[426]
Trichiliton G (**1267**)	RAW 264.7	IC_{50} = 46.5 µM[430]
Trichiliton H (**1268**)	RAW 264.7	IC_{50} = 62.1 µM[430]
Trichiliton I (**1272**)	RAW 264.7	IC_{50} = 122.1 µM[432]
12-deacetoxyltrijugin A (**1359**)	RAW 264.7	IC_{50} = 132.3 µM[432]
Chukvelutin E (**1297**)	RAW 264.7	IC_{50} = 10.01 µM[437]
Chukvelutin F (**1304**)	RAW 264.7	IC_{50} = 28.54 µM[437]
Chuktabularin U (**1299**)	RAW 264.7	IC_{50} = 2.40 µM[395]
Chuktabrin D (**1311**)	RAW 264.7	IC_{50} = 3.81 µM[395]
Chuktabrin E (**1312**)	RAW 264.7	IC_{50} = 15.33 µM[395]
Chuktabrin G (**1315**)	RAW 264.7	IC_{50} = 16.90 µM[395]
Chuktabrin H (**1316**)	RAW 264.7	IC_{50} = 7.94 µM[395]
Chuktabrin J (**1317**)	RAW 264.7	IC_{50} = 7.63 µM[395]
Chuktabrin F (**1318**)	RAW 264.7	IC_{50} = 15.33 µM[395]
Chuktabrin I (**1319**)	RAW 264.7	IC_{50} = 7.78 µM[395]
Spirotrichilin A (**1393**)	RAW 264.7	At 25 and 50 µM, it exhibited NO inhibition at the rate = 25.89 % and 37.13 % respectively[454]
Morenolide (**1420**)	RAW 264.7	IC_{50} = 1.42 µg/mL[467]
Aphananoid A (**1443**)	RAW 264.7	IC_{50} = 66.73 µM[469]
Toonayunnanae A (**424**)	RAW 264.7	IC_{50} = 10.68 µM[232]
Carapanin B (**988**)	RAW 264.7	IC_{50} = 12.6 µM[370]
Carapanin C (**924**)	RAW 264.7	IC_{50} = 29.5 µM[370]
Toonayunnanae F (**184**)	RAW 264.7	IC_{50} = 38.45 µM[155]
Khaysenelide K (**693**)	RAW 264.7	IC_{50} = 27.74 µM[311]

3.3 Anti-microbial activity

The anti-microbial activities of Limonoids are listed in table 61. Among the total limonoids isolated in the last decade only about 5.05 % were screened for anti-microbial activity against various gram positive/negative bacteria and fungi. Majority of the limonoids were (69.73 %) were inactive (Table 62) for anti-microbial activity. Swietemahalactone (**1407**) showed very good anti-bacterial activity against *Escherichia coli* (ATCC 25922), *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Staphylococcus epidermidis*, *Bacillus subtilis* with minimum inhibitory concentration of 0.01, 0.16, 0.13, 0.38 and 0.38 µM respectively. This limonoid skeleton may be used to develop structural analogs to enhance the observed anti-microbial activity.

Table 61: Antimicrobial Activities of Meliaceae limonoids

Limonoid	Microorganism	Activity
3β-hydroxytirucalla-7,24-diene-6,23-dione (**18**)	*Staphylococcus aureus*	Zones of inhibition = 22.03[66]
	Staphylococcus epidermidis	Zones of inhibition = 17.62[66]
	Escherichia coli	Zones of inhibition = 22.02[66]
	Enterobacter cloacae	Zones of inhibition = 19.82[66]
	Klebsiella pneumoniae	Zones of inhibition = 24.23[66]
	Pseudomonas aeruginosa	Zones of inhibition = 15.42[66]
	Shigella dysenteriae	Zones of inhibition = 17.62[66]
3β-hydroxytirucalla-7,24-dien-23-one (**16**)	*Staphylococcus aureus*	Zones of inhibition = 29.55[66]
	Staphylococcus epidermidis	Zones of inhibition = 27.27[66]
	Escherichia coli	Zones of inhibition = 15.91[66]
	Enterobacter cloacae	Zones of inhibition = No activity[66]
	Klebsiella pneumoniae	Zones of inhibition = 15.91[66]
	Pseudomonas aeruginosa	Zones of inhibition = No activity[66]
	Shigella dysenteriae	Zones of inhibition = 18.18[66]
3β,26-dihydroxytirucalla-7,24-diene-6,23-dione (**19**)	*Staphylococcus aureus*	Zones of inhibition = 18.52[66]
	Staphylococcus epidermidis	Zones of inhibition = 16.46[66]
	Escherichia coli	Zones of inhibition = 22.63[66]
	Enterobacter cloacae	Zones of inhibition = 18.52[66]
	Klebsiella pneumoniae	Zones of inhibition = 16.46[66]
	Pseudomonas aeruginosa	Zones of inhibition = 24.69[66]
	Shigella dysenteriae	Zones of inhibition = 18.52[66]
Methyl 6-oxomasticadienolate (**20**)	*Staphylococcus aureus*	Zones of inhibition = 16.53[66]
	Staphylococcus epidermidis	Zones of inhibition = 18.60[66]
	Escherichia coli	Zones of inhibition = 20.66[66]
	Enterobacter cloacae	Zones of inhibition = 16.53[66]
	Klebsiella pneumoniae	Zones of inhibition = 16.53[66]
	Pseudomonas aeruginosa	Zones of inhibition = No activity[66]
	Shigella dysenteriae	Zones of inhibition = 18.60[66]
Dysoxylumstatin A (**53**)	*Staphylococcus aureus*	Zones of inhibition/MIC [mM] = 22/0.79[66]
	Staphylococcus epidermidis	Zones of inhibition/MIC [mM] = 20/0.74[66]
	Escherichia coli	Zones of inhibition/MIC [mM] = 20/1.45[66]
	Enterobacter cloacae	Zones of inhibition/MIC [mM] = 21/1.04[66]
	Klebsiella pneumoniae	Zones of inhibition/MIC [mM] = 20/1.26[66]
	Pseudomonas aeruginosa	Zones of inhibition/MIC [mM] = 20/2.55[66]
	Shigella dysenteriae	Zones of inhibition/MIC [mM] = 20/1.04[66]
Dysoxylumstatin B (**54**)	*Staphylococcus aureus*	Zones of inhibition/MIC [mM] = 19/0.58[66]
	Staphylococcus epidermidis	Zones of inhibition/MIC [mM] = 20/0.80[66]
	Escherichia coli	Zones of inhibition/MIC [mM] = 19/1.41[66]
	Enterobacter cloacae	Zones of inhibition/MIC [mM] = 19/1.31[66]
	Klebsiella pneumoniae	Zones of inhibition/MIC [mM] = 18/1.29[66]
	Pseudomonas aeruginosa	Zones of inhibition/MIC [mM] = 18/2.21[66]
	Shigella dysenteriae	Zones of inhibition/MIC [mM] = 20/1.00[66]
Dysoxylumstatin C (**182**)	*Staphylococcus aureus*	Zones of inhibition/MIC [mM] = 17/1.21[66]
	Staphylococcus epidermidis	Zones of inhibition/MIC [mM] = 16/1.48[66]
	Escherichia coli	Zones of inhibition/MIC [mM] = 16/1.70[66]
	Enterobacter cloacae	Zones of inhibition/MIC [mM] = 17/2.14[66]
	Klebsiella pneumoniae	Zones of inhibition/MIC [mM] = 17/1.77[66]
	Pseudomonas aeruginosa	Zones of inhibition/MIC [mM] = 17/2.94[66]
	Shigella dysenteriae	Zones of inhibition/MIC [mM] = 15/2.14[66]
Meliarachin H (**282**)	*Bacillus subtilis*	MIC = 25 μg/mL[177]
Meliarachin D (**291**)	*Staphylococcus aureus*	MIC = 50 μg/mL[177]
	Bacillus subtilis	MIC = 50 μg/mL[177]
7- cinnamoyltoosendanin (**277**)	*Micrococcus luteus* ATCC 9341	MIC = 6.25 μg/mL[190]
	*Bacillus subtilis*ATCC 6633	MIC = 25 μg/mL[190]
Mulavanin D (**562**)	*Microsporum gypseum*	MIC = 25 μg/mL[215]
	Trichophyton rubrum	MIC = 25 μg/mL[215]
1*α*-tigloyloxy-3*α*-acetoxyl-7*α*-hydroxyl-12*β*-ethoxylnimbolinin (**475**)	*Porphyromonas gingivalis* ATCC 33277	MIC= 31.25 μg/mL[252]
Azadirachta R (**502**)	*Bacillus subtilis*	MIC = 25 mg/mL[257]
	Xanthomonas oryzae pv.oryzae (CGMCC 1.3358)	MIC = 50 mg/mL[257]
	Staphylococcus aureus (CMCC(B)26003)	MIC = 50 mg/mL[257]
Aphapolynin C (**574**)	*Uromyces viciae-fabae*	At 100 ppm, inhibtion score = 99[284]
	Pythium dissimile	At 20 ppm, inhibtion score = 55[284]
Aphapolynin D (**575**)	*Uromyces viciae-fabae*	At 100 ppm, inhibtion score = 33[284]

	Pythium dissimile	At 20 ppm, inhibtion score = 27[284]
	Alternaria solani	At 20 ppm, inhibtion score = 55[284]
Aphapolynin E (**576**)	*Uromyces viciae-fabae*	At 100 ppm, inhibtion score = 55[284]
Aphanamolide B (**587**)	*Septoria tritici*	At 100 ppm, inhibtion score = 18[284]
	Pythium dissimile	At 20 ppm, inhibtion score = 27[284]
Aphapolynin H (**610**)	*Uromyces viciae-fabae*	At 100 ppm, inhibtion score = 77[284]
Khayseneganin D (**734**)	*Pseudomonas aeruginosa*	MIC = 25 μg/mL[324]
	Staphylococcus aureus	MIC = 50 μg/mL[324]
	MRSA (methicillin-resistant *Staphylococcus aureus*) 92#	MIC = 25 μg/mL[324]
	MRSA 98#	MIC = 50 μg/mL[324]
Trichiliasinenoid E (**883**)	*Staphylococcus aureus*	MIC = >512 μg/mL[365]
	Candida albicans	MIC = >512 μg/mL[365]
	Escherichia coli	MIC = >512 μg/mL[365]
	Pseudomonas aeruginosa	MIC = >512 μg/mL[365]
Trichiliasinenoid D (**1483**)	*Staphylococcus aureus*	MIC = >512 μg/mL[365]
	Candida albicans	MIC = >512 μg/mL[365]
	Escherichia coli	MIC = >512 μg/mL[365]
	Pseudomonas aeruginosa	MIC = >512 μg/mL[365]
Swietemahalactone (**1407**)	*Escherichia coli* (ATCC 25922)	Zones of inhibition (mm) /MIC (μM) = 20/0.010[458]
	Staphylococcus aureus	Zones of inhibition (mm) /MIC (μM) = 15/0.160[458]
	Pseudomonas aeruginosa	Zones of inhibition (mm) /MIC (μM) = 16/0.130[458]
	Staphylococcus epidermidis	Zones of inhibition (mm) /MIC (μM) = 12/0.380[458]
	Bacillus subtilis	Zones of inhibition (mm) /MIC (μM) = 12/0.380[458]
Morenolide (**1420**)	*Mycobacterium tuberculosis* H37Rv	MIC_{50} = 48.7 μg/mL[467]
	Mycobacterium tuberculosis M299	MIC_{50} = >100 μg/mL[467]

Table 62: Inactive Limonoids against Microbes

Limonoids	Microrganism
Meliarachin A, B, C, G-K, D-F (**257**, **275**, **279**, **281-285**, **291-293**)	*Staphylococcus aureus* (ATCC 25923), *Staphylococcus epidermidis* (ATCC 12228) *Micrococcus luteus* (ATCC 9341), *Bacillus subtilis* (CMCC 63501), *Escherichia coli* (ATCC25922), *Shigella flexneri* (ATCC20222), *Pseudomonas aeruginosa* (ATCC 14502)[177]
Toonaciliatin P, O, N (**392**, **1428**, **1430**), Chisiamol G, H (**91**, **97**)	*Helicobacter pylori*-SS1[228,107]
1*α*, 7*α*-dihydroxyl-3*α*-acetoxyl-12*α*-ethoxylnimbolinin (**474**)	*Streptococcus mutans* (ATCC 25175) *and Porphyromonas gingivalis* (ATCC 33277)[252]
Aphapolynin F, G, I (**601**, **602**, **611**)	*Phytophthora infestans*, *Septoria tritici*, *Uromyces viciae-fabae*, *Pythium dissimile*, *Alternaria solani*, *Botryotinia f uckeliana*, *Gibberella zeae*[284]
Koetjapin A-D (**715-718**)	*Bacillus cereus* (ATCC 11778), *Staphylococcus aureus* (ATCC 29737), *Salmonella enterica* (ATCC 14028), *Citrobacter freundii* (ATCC 43864)[314]
Khayseneganin C, H (**1222**, **1251**) and 3-de(2-methylbutanoyl)-3-propanoylcipadesin (**808**)	*Pseudomonas aeruginosa*, *Staphylococcus aureus*, MRSA (methicillin-resistant *Staphylococcus aureus*) 92#, MRSA 98#[324,346]
Swietenitin Q, N, O, P, R, S, T, U, V, W, X (**1012**, **1029**, **1030**, **1033**, **1049**, **1050**, **1053**, **1054**, **1059**, **1223**, **1224**)	Fungi and gram positive and negative bateria[385]
Velutinalide A, B (**1105**, **1106**)	*Staphylococcus aureus*, *Pseudomonas aeruginosa*[404]
2-dehydroxylswietephragmin C (**1156**)	*Staphylococcus aureus*, *Ralstonia solanaceanum*, *Fusarium oxysporum* f. sp. Cuben, *Fusarium oxysporu* f. sp. Vasinfectum[413]
3-O-detigloyl-3-O-isobutyrylfebrifugin A (**914**), 3-O-detigloyl-3-O-isobutyryl-23-O-methylfebrifugin A (**915**), 3-O-detigloyl-3-O-isobutyrylgranatumin E (**889**), 3-O-detigloyl-3-O-isobutyryl-21-O-methylgranatumin E (**890**), 3-O-detigloyl-3-O-propanoylgranatumin E (**891**), 21-O-methylgranatumin E (**892**), 21-oxo-23-hydroxylruageanin A (**906**), 3-O-detigloyl-3-O-(2′R-methylbutanoyl)-21-oxo-23-hydroxylruageanin A (**907**), 3-O-deisobutyryl-3-O-tigloyl-14,15-dedihydro-21-oxo-23-hydroxylruageanin A (**908**), Cipadessain D/21-deoxo-23-oxofebrifugin A (**887**), 3-O-detigloyl-3-O-isobutyryl-21-deoxo-23-oxofebrifugin A (**888**), Cipaferen R (**1444**)	*Fusarium oxysporum* f. sp. *cubense*, *Ralstonia solanacearum*[366]

3.4 Anti-malarial activity

The life threating disease malaria is caused by *Plasmodium* parasites which are transmitted through female anopheles mosquito. The drug resistance to medicines such as chloroquine quests novel molecules for disease treatment. In this regard limonoids are favourable candidates whose anti-malarial activities of limonoids are listed in table 63. Nearly 1 % of limonoids were tested against different Chloroquine sensitivive/resistant strains of *Plasmodium falciparum*. The notable anti-malarial activity was exhibited by Neemfruitin A (**175**) against both sensitivive/resistant strains (D10/W2) of *Plasmodium falciparum* with IC_{50} value of 2.82 and 1.74 µM respectively, which was due to the absence of double bond at C1/C2 and lactol ring. Compounds **699** -**701**, **705**, **1373**, **1374**, **1377**, **1378**, **1382**-**1385** didn't exhibit anti-malarial activity.

Table 63: Anti-malarial activity of Meliaceae Limonoids

Limonoid	Cells	Chloroquine sensitivity/resistance	Activity
Neemfruitin B (**106**)	D10	Sensitive	IC_{50} = 9.49 µM[110]
	W2	Resistant	IC_{50} = 9.98 µM[110]
Neemfruitin A (**175**)	D10	Sensitive	IC_{50} = 2.82 µM[110]
	W2	Resistant	IC_{50} = 1.74 µM[110]
Rubescin D (**317**)	3D7	Sensitive	IC_{50} = 41.92 µM[206]
Rubescin E (**318**)	3D7	Sensitive	IC_{50} = 1.13 µM[206]
Andirolide H (**525**)	FCR-3 type	Sensitive	EC_{50} = 4.0x10^{-6} mol/L[264]
Andirolide N (**877**)	FCR-3 type	Sensitive	EC_{50} = 9.7x10^{-6} mol/L[264]
Cipaferoid B (**728**)	Dd2	Resistant	IC_{50} = 9.3 µmol/L[319]
Cipaferoid C (**729**)	Dd2	Resistant	IC_{50} = 14.7 µmol/L[319]
Congoensin B (**17**)	NF54	Sensitive	IC_{50} = 6.1 µM[67]
Cibacciferin A (**698**)	Dd2	Resistant	IC_{50} = 20.0 µM[312]
Cibacciferin C (**702**)	Dd2	Resistant	IC_{50} = 16.3 µM[312]
2′-Epi-cibacciferin C (**703**)	Dd2	Resistant	IC_{50} = 12.3 µM[312]
11α-Acetoxycibacciferin C (**704**)	Dd2	Resistant	IC_{50} = 23.1 µM[312]
Cibacciferin F (**1376**)	Dd2	Resistant	IC_{50} = 16.9 µM[312]
6-Dehydroxycibacciferin F (**1375**)	Dd2	Resistant	IC_{50} = 28.0 µM[312]

3.5 Anti-Human Immunodeficiency Viral Activity

Acquired immunodeficiency syndrome (AIDS) is caused by the human immunodeficiency virus (HIV) is a global threat to human lives. Limonoids are most promising molecules in the development of new, more potent anti-HIV drugs. The anti-human immunodeficiency viral activities are listed in table 64. Majority of the tested limonoids such as (**761**, **821**, **824**, **927**, **1144**, **1236**, **1330**, **1350**, **1352**, **1353**, **1362**-**1364**, **1368**-**1372**, **1379**- **1381**, **866**, **941**, **948**, **949**, **1280**, **1328**, **1329**, **1333**) failed to inhibit the invitro growth of HIV[143,281,323,356,439].

Table 64: Anti-Human Immunodeficiency Virus (HIV) Activity of Meliaceae Limonoids

Limonoid	Cells	Activity
Xylomolin A1 (**759**)	HIV-1 virus transfected 293 T cells	At 20 µM, HIV-1 inhibitory rate was 17.49 %[143]
Xylomolin C2 (**825**)	HIV-1 virus transfected 293 T cells	At 20 µM, HIV-1 inhibitory rate was 24.47 %[143]
Xylomolin K1 (**1235**)	HIV-1 virus transfected 293 T cells	At 20 µM, HIV-1 inhibitory rate was 14.34 %[143]
Xylomolin J2 (**1284**)	HIV-1 virus transfected 293 T cells	At 20 µM, HIV-1 inhibitory rate was 14.77 %[143]
Ciparasin P (**568**)	MTT cells infected by HIV-1	EC_{50} = 6.1 µM[281]
Ciparasin B (**1351**)	MTT cells infected by HIV-1	EC_{50} = 5.5 µM[281]
Trichiconin B (**732**)	HIV-1 NL 4-3 infected MT4 cells	EC_{50} = 5.9 µM[323]
Trichiconin C (**733**)	HIV-1 NL 4-3 infected MT4 cells	EC_{50} = 3.6 µM[323]
Sundarbanxylogranin B (**837**)	HIV-I virus transfected 293 T cells	IC_{50} = 23.14 µM and CC_{50} = 78.45 µM[356]
Krishnolide A (**1339**)	HIV-I virus transfected 293 T cells	IC_{50} = 17.45 µM and CC_{50} = 78.45 µM[439]

3.6 Melanogenesis Inhibitory Activity

The melanogenesis gives rise various pigmetary disorders whose inhibitory activity is listed in table 65. Compounds (**147**, **313**, **456**, **461**, **512**, **513**) inhibited melanogenesis at 10 µM with melanin content in B16 melanoma cells ranging from 1.0 to 101.3 % with cell viability ranging from 2.0 to 107.2 %. Compounds (**173, 462**, **469**, **471**, **443**) inhibited melanogenesis at 30 µM with melanin content in B16 melanoma cells ranging from 3.2 to 88.9 % with cell viability ranging from 18.9 to 142.7 %.

Table 65: Melanogenesis Inhibitory Activity of Meliaceae Limonoids

Limonoid	Cells	Activity
7-benzoyl-17-epinimbocinol (**147**)	B16	At 10 μM, melanin content = 1.0 %, cell viability = 2.0 %[138]
3-acetyl-7-tigloylnimbidinin (**313**)	B16	At 10 μM, melanin content = 30.3 % cell viability = 73.7 %[138]
2,3-dihydro-3α-methoxynimbolide (**456**)	B16	At 10 μM, melanin content = 20.5 % cell viability = 69.9 %[138]
1-isovaleroyl- 1-detigloylsalanninolide (**461**)	B16	At 10 μM, melanin content = 96.6 % cell viability = 103.9 %[138]
deacetyl-20,21-epoxy-20,22-dihydro- 21-deoxyisonimbinolide (**512**)	B16	At 10 μM, melanin content = 101.3 % cell viability = 107.2 %[138]
deacetyl-20,21,22,23-tetrahydro-20,22-dihydroxy-21,23-dimethoxynimbin (**513**)	B16	At 10 μM, melanin content =61.6 % cell viability = 98.8 %[138]
7-O-acetyl-7-O-debenzoyl-22-hydroxy-21-methoxylimocinin (**173**)	B16	At 30 μM, melanin content =16.9 % cell viability = 81.0 %[148]
17-defurano-17-(5x-2,5-dihydro-5-hydroxy-2-oxofuran-3-yl)-2',3'-dehydrosalannol (**462**)	B16	At 30 μM, melanin content =65.0 % cell viability = 142.7 %[244]
17-defurano-17-(2x-2,5-dihydro-2- hydroxy-5-oxofuran-3-yl)-28-deoxonimbolide (**469**)	B16	At 30 μM, melanin =3.2 % cell viability = 18.9 %[244]
17- defurano-17-(2,5-dihydro-2-oxofuran-3-yl)-28-deoxonimbolide (**471**)	B16	At 30 μM, melanin content = 28.1 % cell viability = 53.4 %[244]
Azadirachtin J (**443**)	B16	At 30 μM, melanin content = 88.9 % cell viability = 95.4 %[239]

3.7 11β-hydroxysteroid Dehydrogenase Type I Inhibition Limonoids

11β-hydroxysteroid dehydrogenase type I (11β-HSD1) is an NADPH-dependent enzyme highly expressed in liver, central nervous system, adipose tissue thus making it a potential therapeutic target for various metabolic diseases. These are NADPH-dependent enzymes regulating active or inactive forms of glucocorticoids. The inhibition of 11β-HSD1 by various Limonoids are listed in table 66. Compounds (**141**, **211**, **234**, **239**, **240**, **241**, **242**, **243**) exhibited significant inhibitory activities against human and/or mouse 11β-HSD1 with IC_{50} value ranging from 9.6 to >100 nM. At 10 μM, compounds (**148**, **149**, **150**, **304**, **305**, **306**, **307**, **544**) inhibited human and mouse 11β-HSD1 with percent inhibition values ranging from 2.64 to 56.22 %. Compounds (**209**, **41**) inhibited human 11β-HSD1 with IC_{50} values of 9.9 and 3.20 μM respectively. Compound (**41**) inhibited mouse 11β-HSD1 with IC_{50} value of 0.82 μM whereas compound (**209**) was inactive. At 10 μM, compounds (**213**, **214**, **223**, **224**, **225**, **226**, **1415**) inhibited human and mouse 11β-HSD1 with percent inhibition values ranging from 1.53 to 36.11 %. Compounds (**1501**, **1502**) were inactive for 11β-HSD1 inhibitory activity[482].

Table 66: 11β-hydroxysteroid Dehydrogenase type I inhibition Limonoids

Limonoid	Activity
Dysoxylumosin L (**141**)	Human and Mouse 11β-HSD1 is IC_{50} = >100 nM each[135]
Dysoxylumosin H (**211**)	Human 11β-HSD1 IC_{50} = >100 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Dysoxylumosin A (**234**)	Human 11β-HSD1 IC_{50} = 61 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Dysoxylumosin B (**239**)	Human 11β-HSD1 IC_{50} = 54 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Dysoxylumosin E (**240**)	Human 11β-HSD1 IC_{50} = >100 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Dysoxylumosin F (**241**)	Human 11β-HSD1 IC_{50} = 9.6 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Dysoxylumosin C (**242**)	Human 11β-HSD1 IC_{50} = >100 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Dysoxylumosin D (**243**)	Human 11β-HSD1 IC_{50} = >100 nM[135] Mouse 11β-HSD1 IC_{50} = >100 nM[135]
Cochinchinoid H (**148**)	Human 11β-HSD1 at 10 μM = 56.22 %[76] Mouse 11β-HSD1 at 10 μM = 14.49 %[76]
Cochinchinoid I (**149**)	Human 11β-HSD1 at 10 μM = 32.70 %[76] Mouse 11β-HSD1 at 10 μM = 15.25 %[76]
Cochinchinoid J (**150**)	Human 11β-HSD1 at 10 μM = 22.73 %[76] Mouse 11β-HSD1 at 10 μM = 12.78 %[76]
Cochinchinoid A (**304**)	Human 11β-HSD1 at 10 μM = 25.03 %[76] Mouse 11β-HSD1 at 10 μM = -14.77 %[76]
Cochinchinoid B (**305**)	Human 11β-HSD1 at 10 μM = 38.25 %[76] Mouse 11β-HSD1 at 10 μM = 10.59 %[76]
Cochinchinoid C (**306**)	Human 11β-HSD1 at 10 μM = 7.63 %[76] Mouse 11β-HSD1 at 10 μM = 5.56 %[76]
Cochinchinoid D (**307**)	Human 11β-HSD1 at 10 μM = 16.67 %[76] Mouse 11β-HSD1 at 10 μM = 2.64 %[76]

Cochinchinoid E (**544**)	Human 11β-HSD1 at 10 μM = 22.07 %[76] Mouse 11β-HSD1 at 10 μM = -15.05 %[76]
Walsunoid H (**209**)	Human 11β-HSD1 IC_{50} = 9.9 μM[159] Mouse 11β-HSD1 IC_{50} = Not active[159]
Walsunoid F (**213**)	Human 11β-HSD1 at 10 μM = 13.18 %[159] Mouse 11β-HSD1 at 10 μM = 20.12 %[159]
Walsunoid G (**214**)	Human 11β-HSD1 at 10 μM = 16.80 %[159] Mouse 11β-HSD1 at 10 μM = -15.78 %[159]
Walsunoid D (**223**)	Human 11β-HSD1 at 10 μM = 1.53 %[159] Mouse 11β-HSD1 at 10 μM = 19.01 %[159]
Walsunoid E (**224**)	Human 11β-HSD1 at 10 μM = 11.11 %[159] Mouse 11β-HSD1 at 10 μM = 9.06 %[159]
Walsunoid B (**225**)	Human 11β-HSD1 at 10 μM = 13.58 %[159] Mouse 11β-HSD1 at 10 μM = 36.11 %[159]
Walsunoid C (**226**)	Human 11β-HSD1 at 10 μM = 11.09 %[159] Mouse 11β-HSD1 at 10 μM = 6.14 %[159]
Walsunoid A (**1415**)	Human 11β-HSD1 at 10 μM = 32.11 %[159] Mouse 11β-HSD1 at 10 μM = 22.89 %[159]
Cochinchinoid K (**41**)	Human 11β-HSD1 IC_{50} = 3.20 μM[76] Mouse 11β-HSD1 IC_{50} = 0.82 μM[76]

3.8 Miscellaneous activities of Meliaceae Limonoids

At 10 μM, compounds (**181**, **853**, **997**, **1002**, **1005**, **1006**, **1007**, **1243**) were evaluated for neuroprotective effects against H_2O_2-induced neurotoxicity in PC12 cells[154]. At 10 μM, compound (**678**) exhibited neuroprotective activity against glutamate induced injury in primary rat cerebellar granule neuronal cells with increased viability of 83.3 %, while compounds (**530**, **536**, **677**, **739**, **794**, **807**, **819**, **838**, **909**, **910**, **911**) were inactive[268]. Compound (**10**) exhibited significant inhibitory activity with an IC_{50} value of 2.1 μM in the bioassay of inhibitory activity against CDC25B dual specificity phosphatase, which is a key enzyme for cell cycle progression and was observed in a variety of cancers with a striking association with tumor aggressiveness and poor prognosis[61]. Compound (**176**) in vitro showed the antileishmanial activity on L. *donovani promastigotes* with IC_{50} value of 6.044 μg/mL and also, cytotoxicity against RAW 264.7 cells was >200 μg/mL indicating its high selectivity index of >33.09 μg/mL[150]. Compound (**479**) significantly promotes neurite outgrowth from PC12 cells in a dose-dependent manner in the presence of NGF (20 ng/mL) at concentrations ranging from 0.1 to 50.0 μM, possessing strong NGF-potentiating activities on PC12 cells while compounds (**247**, **480**, **481**) were inactive[168]. At 10 μM, compounds (**251**, **263**, **310**, **476**) significantly enhanced the TNFα-induced NF-κβ luciferase activity approximately by two folds to more or less equal in comparison to TNFα-treated positive control group[175]. Compounds (**265**, **266**, **448**, **449**, **458**, **463**, **464**, **465**, **466**, **467**, **468**, **473**, **1454**, **460**, **472**, **1453**, **462**, **469**, **471**, **1455**) exhibited inhibitory effect against the Epstein–Barr virus early antigen (EBV-EA) activation induced by 12-O-tetradecanoylphorbol-13-acetate (TPA) in Raji cells with IC_{50} value of 452, 401, 496, 482, 488, 521, 495, 530, 528, 497, 493, 453, 497, 431, 299, 318, 413, 475, 481 and 418 mol ratio/32 pmol TPA respectively[188,243,244,472]. Compound (**295**) showed the highest potency to increase the nerve growth factor (NGF) production in C6 astrocytes (glioma cells) with the level of secreted NGF of 152.41 % (cell viability is (109.44 %) while in compound (**493**), the level of secreted NGF was 103.61 % (cell viability is (105.09 %)[192]. Compound (**296**) was evaluated for its capacity to protect HC-04 cells against oxidative stress (is thought to be involved in the pathophysiology of malaria and the development of anemia induced by malaria) induced by H_2O_2, upon treatment for 24 h at concentrations of 1, 4, 20 and 50 μg/mL, it induced cell proliferation and cell viability was 129.76, 130.24, 134.63 and 135.12 respectively while compounds (**324**, **325**) remained unchanged for 24 h at the same concentrations[198]. Compound (**296**, **324**) exhibited inhibition of lactase dehydrogenase (LDH) leakage during membrane damage (in cellular lesions) in the culture medium of HC-04 cells at 1 and 4 μg/mL while compound (**325**) exhibited inhibition of LDH at IC_{50} value of 0.0026 μM which was less than the positive control quercetin with IC_{50} value of 0.0030 μM[198]. Compounds (**302**, **323**, **1413**, **1442**) exhibited lipid droplet accumulation (LDA) inhibitory activity on a mouse pre-adipocyte cell line (MC3T3-G2/PA6) with IC_{50} value of 7.1, 3.3, >50, 11.6 μM respectively and cytotoxicity activity CC_{50} value of >50, >50, >50 and 29.4 μM respectively[201]. Compound (**334**, **383**, **388**, **411**, **417**, **632**, **1429**, **6**, **24**) exhibited antiradical activities to the tested radical of 2,2-diphenyl-1-picrylhydrazyl (DPPH) with IC_{50} value of 73.1, 62.1, 59.2, 244.7, 51.3, 71.0, 104.0, 94.1, 99.7 μM respectively and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid ($ABTS^{\cdot+}$) with IC_{50} value of 167.3, 124.7, 119.8, 256.1, 109.7, 160.1, 52.2, 54.6 and 59.2 μM respectively while compounds (**397**, **406**, **407**) were inactive for antiradical activities to the tested radical of DPPH and $ABTS^{\cdot+}$[214,62]. Compounds (**382**, **390**, **391**, **396**, **403**, **404**, **410**, **412**, **413**, **416**, **1426**, **1427**) were inactive for MET tyrosine kinase activity[227]. Compound (**497**) at the concentration of 10^{-5} mol/L exhibited protection to the damaged SH-SY5Y cells induced by H_2O_2 with an inhibition value of 11.7 % while compounds (**447**, **498**) were inactive[242]. Compound (**470**) inhibited the growth of cress roots and shoots (IC_{50} value

of 1.2 and 1.4 μM respectively), while compound (**1459**) inhibited (IC_{50} value of 5.7 and 9.4 μM respectively)[245]. Similarly compound (**470**) inhibited barnyard roots and shoots (IC_{50} value of 3.7 and 39 μM respectively) while compound (**1459**) inhibited (IC_{50} value of 29 and 210 μM respectively), thus exhibiting strong allelopathic activity[245]. At 10 ppm and 32 ppm, compounds (**574**, **575**, **576**, **587**, **601**, **602**, **610**, **611**) didn't exhibit herbicidal activity against *Arabidopsis thaliana* and *Poa annua* respectively[284]. At 30 μM, compounds (**671**, **1298**) exhibited potential inhibition of the delayed rectifier (I_K) K^+ current in Chinese hamster ovary cells with inhibitory rate of 0.49 and 0.38 respectively[296]. At 10 μM, compound (**719**) showed weak protective effect on H_2O_2-induced apoptosis in human umbilical vascular endothelial cells (HUVECs) with the apoptotic rate decreased to ~50 %, compound (**964**) showed significant protective effect with the apoptotic rate decreased to 5.16 % while compounds (**800**, **801**) were inactive[316]. At 10 μM, compounds (**1037**, **1038**) showed triglyceride metabolism-promoting activity in the high glucose-pretreated human hepatocellular carcinoma cell line, HepG2 with percent control of 90.1 and 88.8 % respectively while compounds (**752**, **753**, **1035**, **1036**, **1039**) were inactive[334]. Compounds (**769, 804, 806**) at 50 and 100 μM in vitro, exhibited significant inhibitory effect on adipocyte differentiation in 3T3-L1 cells in dose dependent manner while compounds (**766**, **767**, **768**, **769**, **770**, **805**, **847**) exhibited weak inhibitory effect[339]. At 50 mg/mL compounds (**777**, **791**, **836**, **869**, **914**, **889**, **892**), showed in vitro Acetylcholinesterase inhibitory activity with inhibition rate of 18.8 %, 18.5 %, 21.2 %, 23.7, 25.69, 15.47 and 13.48 % respectively[341,366]. Compounds (**1326**, **1331**, **1337**) exhibited moderate anti-H1N1 activity with IC_{50} values of 113.5, 121.5 and 77.1 μM respectively compared to positive control ribavirin with IC_{50} value of 185.9 μM[352]. Compound (**849**) exhibited anti-viral activity against dengue virus 2 with EC_{50} value of 7.2 μM with selective index (CC_{50}/EC_{50}) value of >27.7[353]. At 50 μM (non toxic concentration), compound (**1358**) exhibited significant activity to reverse multidrug resistance in MCF-7/DOX cells with IC_{50} value of 12.45 μM and reversal index of 3.89 μM[357]. Compound (**878**) displayed significant toxicity to late third instar larvae of *Aedes aegypti* with LC_{50} = 10.20 ppm and LC_{95} = 34.67 ppm (compared to rotenone, a well-known botanical insecticide with LC_{50} = 2.62 ppm and LC_{95} = 16.58 ppm); also displayed significant toxicity to late third instar larvae of *Aedes albopictus* LC_{50} = 12.16 ppm and LC_{95} = 42.79 ppm (compared to rotenone, a insecticide with LC_{50} = 3.03 ppm and LC_{95} = 16.87 ppm) and also to late third instar larvae of *Culex Quinquefasciatus* with LC_{50} = 16.82 ppm and LC_{95} = 46.28 ppm (compared to rotenone with LC_{50} = 3.64 ppm and LC_{95} = 19.02 ppm) while compounds (**963**, **969**, **970**) were inactive[364]. Compound (**1245**) showed affinity towards molecular chaperone Hsp90 with K_D = 6.087 μM compared to well-known Hsp90 inhibitors radicicol (K_D = 0.0018 μM) and 17-N-allylamino-17-demethoxygeldanamycin (K_D = 0.376 μM) while compounds (**897**, **898**, **1244**, **1246**) didn't interact[368]. Compound (**1150**) exhibited inhibition of TCF/β-catenin transcriptional activity (SuperTOP-Flash activity) measured using the cell line STF/293 (a 293 human embryonic kidney cell line stably transfected with SuperTOPFlash) with IC_{50} value of 48.9 nM while compound (**931**) did not decrease TCF/β-catenin transcriptional activity at 2 to 50 μM. At 10 μM, compounds (**1155**, **1241**, **1242**) exhibited inhibitory activity against lipopolysaccharide induced NF-κB activation, but showed no obvious toxicity on RAW264.7 macrophage cells[372,375]. Compounds (**1013**, **1085**, **1090**, **1116**, **1188**, **1190**, **1195**) were inactive for inhibition of in vitro α-glucosidase and acetylcholinesterase activities[386,413]. At 1 μg/mL, compounds (**1021**, **1032**, **1089**, **1113**, **1114**, **1295**, **1296**, **1309**) exhibited inhibitory activity against lipopolysaccharide induced NF-κB production in NF-κB luciferase-expressing human embryonic kidney 293 (HEK293-NF-κB-luc) cells in vitro with relative inhibitory potency of 0.25, 0.18, 0.11, 0.23, 0.23, 0.10, 0.33, 0.69 respectively compared to positive control hydrocortisone with relative inhibitory value of 0.29[390]. At 30 μM, compounds (**1022**, **1023**, **1092**, **1093**, **1094**, **1121**, **1128**, **1129**, **1137**, **1182**, **1183**, **1184**, **1186**, **1305**, **1306**, **1307**, **1308**) exhibited potential inhibition of the delayed rectifier (I_K) K^+ current in Chinese hamster ovary cells with inhibitory rate of 0.40, 0.88, 0.55, 0.75, 0.42, 0.68, 0.94, 0.86, 0.69, 0.51, 0.91, 0.90, 0.72, 0.69, 0.61, 0.51, 0.70 respectively[391]. At 30 μM, compounds (**1132**, **1133**, **1086**, **1087**, **1034**) were tested for reversing multidrug resistance in MCF-7/DOX cells but no significant effect was observed[393]**.** Compounds (**1048**, **1127**, **1178**, **1179**, **1126**, **1130**, **1425**, **1458**) inhibited α-glucosidase in vitro with IC_{50} value of 0.06 mM, 0.04 mM, 0.52 mM, 1.09 mM, 0.15 mM, 0.96 mM, 46.2 μM, 79.7 μM respectively and compounds (**1177, 1187, 1294, 1424**) were inactive[395,409,410,468,478]. In Swiss albino mice after 18-22 mins of administering 3-10 mg/kg of compound (**1066**) induced sleep with a duration of 16–18 min[397]. The in vivo pharmacological tests of compounds (**1073**, **1083**), starting with a treatment from 0.004-0.4mg/kg/day for three consecutive days, over a three hour sampling period, induced a long-lasting augmentation of frequency and sustainment of mounting behavior in male rodents, with an effect lasting for up to 11 days post-treatment[400]. Compounds (**1105**, **1106**) were tested for their inhibitory activities towards several enzymes, such as hPTP1B (human protein tyrosine phosphatase 1B), CDC25B dual specificity phosphatase and pancreatic lipase, but they showed no inhibition[404]. Compound (**114**) exhibited in vitro inhibitory activity against PTP1B with IC_{50} value of 3.93 μg/mL compared to positive control oleanolic acid with IC_{50} value of 1.05 μg/mL[114]. At 50 mg/mL, compounds (**1209**, **1210**, **1211**, **1212**, **1213**, **1214**, **1215**, **1216**, **1273**, **1274**, **1275**, **1276**) showed in vitro acetylcholinesterase inhibitory activity with inhibition rate of <10, 24.4, 19.7,

<10, <10, 17.2, 19.4, 16.9, <10, 10.6, 34.9 and 19.5 % respectively[422]. Protein tyrosine phosphatase 1B (PTP1B) which has significant role in cell regulation, growth, and the onset of human diseases was inhibited in vitro by compound (**1395**) with IC_{50} value of 16.7 µM compared to positive control oleanolic acid with IC_{50} value of 2.3 µM, while compounds (**1396**, **1397**, **1398**) were inactive[455]. Up to 250 µM compound (**1457**) exhibited no obvious self-aggregation but inhibited ADP-induced blood platelet aggregation with the inhibition rate of 24.6 % and platelet maximum aggregation of 33.6 % at 250 µM as compared to aspirin whose inhibition at 250 µM is 22.1 % and platelet maximum aggregation of 34.7 %[474]. At 10 µM, compound (**1469**) significantly inhibited the TNFα-induced NF-κβ luciferase activity by 64 % in HepG2- NF-κβ-Luc cells while compounds (**1461**, **1462**, **1464**, **1468**) were inactive[480]. Compounds (**1501**, **1502**) were inactive for in vitro H_2O_2-induced injury in SH-SY5Y cell damage[482]. At 10 nM, compounds (**76**, **842**) exhibited significant agonistic effect on human pregnane-X-receptor (PXR) to modulate PXR target gene CYP3A4 trans activation in HePG2 cells than positive control rifampicin[47,153] whereas compound (**1220**) showed activation effect. Compounds (**833**, **774**, **549**) showed strong inhibitory activities against human carboxylesterase2 (hCES2) with IC_{50} values of 6.63, 11.35 and 5.05 µM, respectively[153]. Compounds (**261**, **262**, **202**, **195**, **158**) exhibited neuroprotective effects against 6-OHDA-induced cell death in human neuroblastoma SH-SY5Y cells, showing EC_{50} values of 0.27, 0.89, 3.08, 7.16 and 3.42 µM, respectively as compared to positive control curcumin with EC_{50} value of 6.08 µM[142]. At 100 µM, compounds (**1344**, **935**, **775**, **756**-**758**, **1171**, **1172**, **879**, **938**, **936**, **937**, **939**, **798**, **1173**, **1046**, **947**, **178**, **179**), inhibited human carboxylesterase 2 with inhibition rate of 49.4, 54.8, 65.0, 16.8, 55.1, 43.9, 23.7, 39.3, 33.0, 42.0, 59.7, 55.5, 60.0, 58.3, 52.4, 64.2, 46.3, 61.5, 34.7 and 47.9 %, respectively[152,337]. Compounds (**914**, **915**, **889**-**892**, **906**-**908**, **887**, **888**, **1444**) didn't exhibit nematicidal activity against root knot nematode *Meloidogyne incognita*[366]. The autophagic activity of compound (**499**) was evaluated on a U-87 MG glioblastoma cell line which showed a weak cytotoxic effect and severe cell proliferation inhibition at 80 µM[173].

3.9 Insecticidal activities

Several Limonoids are well known for their insecticidal activity. Compounds (**597**, **598**) were inactive for insecticidal activity against brine shrimp (*Artemia salina*) at concentrations of 100, 50 and 10 ppm[63]. At 100 ppm, compounds (**384**, **385**, **386**, **438**, **439**, **1043**, **1131**) exhibited inhibitory activity against brine shrimp larvae with the corrected mortality of 54.7, 81.7, 63.3, 100.0, 71.3, 16 and 47 % respectively while compounds (**379**, **421**) were inactive (<50 % corrected mortality rate)[170,394]. At 0.01 %, compound (**37**) showed highly efficacious inhibitory effects on egg production and hatchability, with 99.2% of product effectiveness on the reproductive cycle of engorged cattle tick female (*R. microplus*) with mean egg conversion value of 4.4 %, hatching value of 6.1 %, which is a promising candidate for the development of a biocontrol agent against engorged females of R. (B.) microplus, as an alternative to environmentally hazardous synthetic acaricides, particularly those against which this cattle tick has developed resistance[73]. Compounds (**357**, **554**) showed moderate insecticidal activity against *Plutella xylostella* (Diamond back moth) on an artificial diet (*Brassica oleracea* var. *capitata*) (200 ppm) with LC_{50} value in the concentration of 200 µg/mL was 53.3 and 23.3 % respectively while compounds (**177**, **356**, **358**, **359**, **360**, **361**, **552**) were inactive[151]. Compounds (**356**, **357**, **359**, **554**) showed moderate antiviral activity against tobacco mosaic virus (TMV) with inhibitory value in the concentration of 500 µg/mL were 25.4, 29.3, 37.2 and 50 % respectively[151]. Compound (**229**) exhibited larvicidal activity on second instar larvae of *Tuta absoluta* with LD_{50} value of 6.6 ppm compared with azadirachtin whose LD_{50} value is 7.8 ppm [Lethal dose with 95% fiducial limits][160]. At 50 µg/mL, compounds (**244**, **332**, **335**, **350**, **351**, **501**, **503**, **553**, **555**, **556**, **558**, **559**, **585**, **1445**) showed antiviral activity against TMV with inhibitory rate of 33.6, 98.9, 97.6, 89.0, 97.9, 98.5, 49.3, 91.8, 50.6, 49.3, 33.8, 32.1, 54.3 and 30.7 % respectively and exhibited inactivation effect against TMV replication at 50 µg/mL with rate of 30.2, 98.2 (IC_{50} = 19.6 µg/mL), 95.3 (IC_{50} = 20.4 µg/mL), 81.8 (IC_{50} = 27.7 µg/mL), 91.4 (IC_{50} = 25.8 µg/mL), 88.9 (IC_{50} = 28.1 µg/mL), 38.5 %, 87.3 (IC_{50} = 33.9 µg/mL), 49.1, 45.4, 36.8, 30.9, 51.8 and 32.5 % respectively[169]. At 200 µg/mL, compounds (**244**, **332**, **335**, **350**, **491**, **501**, **503**, **553**, **555**, **556**, **558**, **559**, **585**, **1445**) showed *in vivo* protective effect on *N. glutinosa* leaves exhibited against TMV were 25.3, 56.7, 60.2, 36.4, 63.8, 63.8, 24.7, 57.2, 40.3, 42.5, 49.7, 35.6, 43.8 and 30.5 % respectively and *in vivo* curative effect on *N. glutinosa* leaves exhibited against TMV at 200 µg/mL were 23.6, 52.8, 57.6, 29.9, 59.6, 44.9, 20.1, 43.9, 30.7, 29.1, 29.8, 25.2, 35.1 and 27.3 % respectively[169]. Compound (**258**) exhibited insecticidal activity against newly hatched larvae of *Spodoptera litura* at the concentration of 20 µg/mL and its corrected mortalities at four exposure times of 7, 10, 14 and 20 days were 66.19, 79.05, 96.67 and 100.00 % respectively. And the corrected mortalities for azadirachtin at four exposure times of 7, 10, 14 and 20 days were 86.67, 93.33, 100.00 and 100.00 %, respectively[178]. At 200 µg/mL, compounds (**299**, **347**, **348**, **349**, **560**) exhibited inhibition activities against TMV replication on *N. glutinosa* with inhibition rate of 24.5, 55.6, 34.6, 29.3 and 50.2 % respectively and at 30 µg/mL they exhibited inhibition activities against TMV replication on *N. tabacum* cv. K326 with an inhibition rate of 30.2, 67.2, 54.4, 45.7 and 64.2 % respectively[200].

Compounds (**299**, **347**, **348**, **349**, **560**) exhibited infection inhibition activity against TMV on *N. glutinosa* in vivo with IC_{50} value of 27.9, 28.3, 34.6, 37.0 and 22.2 µg/mL respectively[200]. At 1000 ppm, compounds (**338**, **343**, **345**, **355**, **1473**) exhibited insecticidal activity against *Sitobion avenae* with mortality score of 33, 66, 0, 33, 99 respectively; at 500 ppm they exhibited insecticidal activity against *Plutella xylostella* with mortality score of 0, 33, 0, 33, 66 respectively; at 500 ppm they exhibited insecticidal activity against *Diabrotica balteata* with mortality score of 99, 33, 33, 66, 99 respectively and at 50 ppm it exhibited insecticidal activity against *Caenorhabditis elegans* with mortality score of 0, 49, 0, 0, 49 respectively[124]. At 100 µg/mL, compounds (**351**, **589**) showed *in vitro* pesticidal activity against brine shrimp with regulated lethality of 16.98 and 41.32 % respectively[218]. Compounds (**447**, **497**, **498**) were inactive for in vitro TMV inhibition[242]. Compounds (**526**, **532**, **690**, **691**, **695**) at 1000 ppm (corresponding to a concentration of ca. 20 µg/leaf cm^2) exhibited weak antifeedant activity against the third-instar larvae of *Spodoptera littoralis* (Boisd.)[265]. At 50 µg/mL, compounds (**550**, **551**, **1438**) exhibited an inactivation effect against TMV replication in systemic infection host *N. tabacum* cv. K326 with an inhibition rate of 70.8 % (IC_{50} = 34 µg/mL), 96.9 % (IC_{50} = 14.8 µg/mL) and 56.5 % (IC_{50} = 48.3 µg/mL) respectively[277]. At 2000 ppm, compounds (**570**, **571**, **572**, **594**, **595**, **596**, **623**, **629**) exhibited antifeedant activity against *Helicoverpa armigera* with antifeedant index of 47.31, 23.39, 34.02, 11.11, 42.80, 28.62, 33.88 and 23.62 % respectively, also compounds (**621**, **622**, **625**, **626**, **628**) exhibited potent antifeedant activity against *Helicoverpa armigera* with EC_{50} value of 0.017, 0.049, 0.008, 0.012 and 0.028 µmol/cm^2 respectively[282]. At 2000 ppm, compound (**579**) showed moderate antifeedant activity against *Spodoptera exigua* with antifeedant index of 17 % and compound (**624**) exhibited potent antifeedant activity against *Spodoptera exigua* and *Helicoverpa armigera* with EC_{50} value of 0.052 and 0.015 µmol/cm^2 respectively[283]. At 1000 ppm, compounds (**574**, **575**) exhibited insecticidal activity against *Sitobion avenae* and *Plutella xylostella* with mortality score of 33 each and at 500 ppm, exhibited insecticidal activity against with mortality score of 33 each while compounds (**576**, **587**, **601**, **602**, **610, 611**) were inactive against both[284]. At 500 ppm, compounds (**574**, **575**, **601**) exhibited insecticidal activity against *Diabrotica balteata* with mortality scores of 99, 66, 33 respectively while compounds (**576**, **587**, **602**, **610**, **611**) were inactive[284]. At 50 ppm, compound (**574**) exhibited insecticidal activity against *Caenorhabditis elegans* with mortality score of 66 while compounds (**575**, **576**, **587**, **601**, **602**, **610**, **611**) were inactive[284]**.** Compound (**681**) at 100 µg/cm^2 and 25 µg/cm^2, exhibited antifeedant activity against *Spodoptera litura* with antifeedancy rate of 62.48 and 28.50 % respectively and compound (**1386**) at 100 and 25 µg/cm^2 exhibited antifeedant activity against *Spodoptera litura* with antifeedancy rate of 90.32 and 59.5 % respectively[307]. At 1 mM, compound (**708**) exhibited insect-resistance ability against *Drosophila melanogaster* with an antifeedant index of 32.8 % while the antifeedant index of blank control and positive control was 14.7 and 28.5 % respectively[313]. At 0.5 mg/mL, compounds (**790**, **871**, **971**) exhibited antifeedant activity against third-instar larvae of *Brontispa longissima* with antifeedancy rate after 24 h exposure of 25.53, 45.07 and 47.20 % respectively also after 48 h exposure the antifeedancy rate was 19.78, 29.13 and 43.48 % respectively[336]. At 0.5 mg/mL, compounds (**790**, **871**, **971**) exhibited insecticidal activity against third-instar larvae of *Brontispa longissima* with corrected mortality rate at 74 h exposure time of 23.13, 6.67 and 7.04 % respectively[336]. At 1.0 mg/mL, compounds (**771**, **772**) exhibited antifeedant activity against third-instar larvae of *Brontispa longissima* with antifeedancy rate after 24 h of 69.6 and 42.3 % respectively also after 48 h exposure the antifeedancy rate was 62.1 % and 44.1 % respectively[340]. At 1.0 mg/mL, compounds (**771**, **772**) exhibited insecticidal activity against third-instar larvae of *Brontispa longissima* with corrected mortality rate at 9 days exposure time of 17.0 and 48.2 % respectively[340]. At 100 ppm, compound (**789**) exhibited insecticidal activity against *Artemia salina* L. with corrected mortality rate of 64.96 %[344]. Compounds (**792**, **893**, **944**, **955**, **956**, **958**, **965**, **966**, **976**, **977**) were inactive for antifeedant and insecticidal screenings against the third to fifth-instar larvae of *Brontispa longissima*[345]. Compounds (**809**, **1152**) at 500 ppm and compounds (**1151**, **1153**) at 1000 ppm exhibited antifeedant activity against the third-instar larvae of *Spodoptera littoralis*[347]. Compounds (**1019**, **1175**, **1217**) exhibited low antifeedant activity against *Spodoptera litura* with antifeedant index of <20, 43.02 and 47.54 µg/cm^2 respectively and compound (**1019**) exhbited low toxicity against *Spodoptera litura* with antifeedant index of <20 µg/cm^2, but compounds (**1175**, **1217**) exhibited toxicity against *Spodoptera litura* with LC_{50} value of 5.4 µg/cm^2 and 7.4 µg/cm^2 respectively[388]. Compounds (**1019**, **1175**, **1217**) exhibited antifeedant activity against *Achaea janata* with antifeedant index of <20, 56.74, 40.31 µg/cm^2 respectively and exhibited low toxicity against *Achaea janata* with antifeedant index of <20, 7.5 and 13.5 µg/cm^2 respectively[388]. Compound (**1060**) showed no significant mortality for insecticidal activity using *Plutella xylostella* on an artificial diet (500 ppm), and *Heliothis virescens* on cotton (1000 ppm)[398]. Compounds (**1100**, **1101**, **1102**, **1103**, **1112**, **1148**, **1180**) exhibited lethality against brine shrimp larvae with LC_{50} value of 84.1, 203.2, 172.3, 227.9, 143.3, 229.1 and 193.2 µM respectively[403]. At 100 ppm, compounds (**1193**, **1194**, **1196**, **1197**, **1198**) exhibited insecticidal activity against brine shrimp larvae with the corrected mortality of 41.0, 13.50, 23.33, 17.10 and 82.94 % respectively[421]. Compounds (**1281**, **1282**, **1286**, **1287**, **1399**) didn't exhibit antifeedant and insecticidal activity against the third to fifth-instar larvae of the coconut leaf beetle

(*Brontispa longissima*)[434]. Compound (**1407**) did not exhibit insecticidal activity against *Artemia salina* L (LD_{50} = >100 μg/mL)[458]. At 2000 μg/mL, compound (**1439**) exhibited antifeedant activity against third-instar larvae of *Plutella xylostella* with antifeedant rate of 28.0 % after 48 hrs with corrected mortality after 6 days is 0.0[465]. Compounds (**105**, **121**) exhibited moderate antifeedant activity against tobacco caterpillar (*S. litura*) with mortality percent LC_{50} (95 % FL) value of 22.40, 41.08 % respectively and castor semilooper (*A.janata*) with mortality percent LC_{50} (95 % FL) value of 30.21, 41.35 % respectively, whereas compounds (**120**, **124**, **125**) did not exhibit activity as antifeedant index was <20[109]. Comopound (**249**) exhibited antifeedant activity against fifth instar larvae of *Pieris rapae* L. with antifeedant effect AFC_{50} value of 1.32 mM[173].. Compounds **834**, **844** showed antifeedant activity against *S. litura* with antifeedant index values of 89.6 and 14.6 % respectively with toxicity values of 84.68 and 8.4 % respectively after 24 h treatment[355]. At 1000ppm, compounds (**642**, **618**) showed insecticidal activity against *Sitobion avenae* with mortality score of 99 and 66 respectivley as compared to positive control thiamethoxam whose mortality score is 99[275]. At 500 ppm compounds (**615**, **635**, **642**, **647**, **618**, **619**) showed insecticidal activity against *Plutella xylostella* with mortality score of 66, 33, 99, 33, 99, 33 respectively as compared to positive controls thiamethoxam and indaxocarb whose mortality rate is 66 and 99 respectivley[275]. At 500 ppm compounds (**635**, **642**, **619**) showed insecticidal activity against *Diabrotica balteata* with mortality score of 33, 33, 33 respectively as compared to positive control thiamethoxam whose mortality score is 99[275]. Compounds (**615 635-648**, **603**, **604**, **618-620**, **605-609**) didn't exhibit insecticidal activities against *Caenorhabditis elegans*[275].

Conclusion and further prospectus

Limonoids are wonder molecules of nature which are highly complex and structurally diversified. This class of plant specialized metabolites came into limelight after the discovery of Azadirachtin from Neem tree[483]. Since then, there is a tremendous curiosity among researchers to exploit more limonoids. Till date over 2500 different limonoids are reported from the Meliaeae family with numerous biological activities. The advancement in the spectroscopic techniques has contributed to the increased number of limonoids isolated from Meliaceae plants with different skeletons. In the last decade, 1502 novel limonoids belonging to 67 species and 28 genera are reported in this review. The highest contribution of novel limonoids was from genus *Xylocarpus* (15.51 %), *Toona* (9.70 %), *Chukrasia* (8.84 %), *Aphanamixis* (8.18 %), *Melia* (8.05 %) and *Trichilia* (7.12 %). The only plants from which the highest number of novel limonoids were reported in the last decade are *Chukrasia tabularis*, *Xylocarpus granatum* and *Toona ciliata*. Among the different classes of limonoids, Phragmalin class constituted the highest number of novel limonoids being reported with 313 followed by the Mexicanolide class with 273. Most of the novel limonoids reported here were exploited majorly for antineoplastic and anti-inflammatory activity. From this review we conclude that limonoids have a great potential to be the drugs of the future for various human ailments and also in the development of biopesticides for sustainable agriculture. The thorough discussion of chemistry of these limonoids paves a way to harness the biosynthetic potential leading to the identification of limonoid biosynthetic genes which will assist the heterologous production of limonoids for commercial use.

Acknowledgment

FAM and SSN acknowledge Council of Scientific and Industrial Research (CSIR), New Delhi and Department of Science and Technology (DST), New Delhi for the fellowship respectively.

Note

This manuscript is submitted to RSC Natural Product Reports journal.

References

(1) Bernay, S. Limonin. *Annalen* **1841**, *40*, 317–319.

(2) X., F.; Y. T., D.; X. J., H. The Advances in the Limonoid Chemistry of the Meliaceae Family. *Curr. Org. Chem.* **2011**, *15* (9), 1363–1391. https://doi.org/10.2174/138527211795378254.

(3) Joshi, B. S.; Hegde, V. R. Extractives of *Balsamodendron pubescens*: Stocks, Hook. Isolation and a New Synthesis of Siderin. *Proc. Indian Acad. Sci. - Chem. Sci.* **1979**, *88* (3). https://doi.org/10.1007/BF02844800.

(4) Ahmad, J.; Wizarat, K.; Shamsuddin, K. M.; Zaman, A.; Connolly, J. D. Jangomolide, a Novel Limonoid from *Flacourtia jangomas*. *Phytochemistry* **1984**, *23* (6). https://doi.org/10.1016/S0031-9422(00)80439-2.

(5) Zheng, S.; Meng, J.; Shen, X.; Wang, D.; Fu, H.; Wang, Q. Two New Limonoids from the Seeds of

Microula sikkimensis. *Planta Med.* **1997**, *63* (04), 379–380. https://doi.org/10.1055/s-2006-957711.
(6) Kubo, I.; Hanke, F. J.; Asaka, Y.; Matsumoto, T.; He, C. H.; Clardy, J. Insect Antifeedants from Tropical Plants I. Structure of Dumsin. *Tetrahedron* **1990**, *46* (5). https://doi.org/10.1016/S0040-4020(01)81960-8.
(7) Nihei, K. I.; Hanke, F. J.; Asaka, Y.; Matsumoto, T.; Kubo, I. Insect Antifeedants from Tropical Plants II: Structure of Zumsin. *J. Agric. Food Chem.* **2002**, *50* (18). https://doi.org/10.1021/jf020245q.
(8) Nihei, K.-I. I.; Asaka, Y.; Mine, Y.; Ito, C.; Furukawa, H.; Ju-Ichi, M.; Kubo, I. Insect Antifeedants from Tropical Plants: Structures of Dumnin and Dumsenin. *J. Agric. Food Chem.* **2004**, *52* (11), 3325–3328. https://doi.org/10.1021/jf049819c.
(9) Nihei, K. I.; Asaka, Y.; Mine, Y.; Kubo, I. Insect Antifeedants from Croton Jatrophoides: Structures of Zumketol, Zumsenin, and Zumsenol. *J. Nat. Prod.* **2005**, *68* (2). https://doi.org/10.1021/np049697i.
(10) Morgan, E. D. Azadirachtin, a Scientific Gold Mine. *Bioorganic Med. Chem.* **2009**, *17* (12). https://doi.org/10.1016/j.bmc.2008.11.081.
(11) Atawodi, S. E.; Atawodi, J. C. *Azadirachta indica* (Neem): A Plant of Multiple Biological and Pharmacological Activities. *Phytochem. Rev.* **2009**, *8* (3), 601–620. https://doi.org/10.1007/s11101-009-9144-6.
(12) Tan, Q. G.; Luo, X. D. Meliaceous Limonoids: Chemistry and Biological Activities. *Chem. Rev.* **2011**, *111* (11), 7437–7522. https://doi.org/10.1021/cr9004023.
(13) Roy, A.; Saraf, S. Limonoids: Overview of Significant Bioactive Triterpenes Distributed in Plants Kingdom. *Biol. Pharm. Bull.* **2006**, *29* (2), 191–201. https://doi.org/10.1248/bpb.29.191.
(14) Paul, R.; Prasad, M.; Sah, N. K. Anticancer Biology of *Azadirachta indica* L (Neem): A Mini Review. *Cancer Biology and Therapy*. 2011. https://doi.org/10.4161/cbt.12.6.16850.
(15) Fu, S.; Liu, B. Recent Progress in the Synthesis of Limonoids and Limonoid-like Natural Products. *Org. Chem. Front.* **2020**, *7* (14), 1903–1947. https://doi.org/10.1039/D0QO00203H.
(16) Mouthé Happi, G.; Tchaleu Ngadjui, B.; Green, I. R.; Fogué Kouam, S. Phytochemistry and Pharmacology of the Genus *Entandrophragma* over the 50 Years from 1967 to 2018: A 'Golden' Overview. *J. Pharm. Pharmacol.* **2018**, *70* (11), 1431–1460. https://doi.org/10.1111/jphp.13005.
(17) Harneti, D.; Supratman, U. Phytochemistry and Biological Activities of *Aglaia* Species. *Phytochemistry* **2021**, *181*, 112540. https://doi.org/10.1016/j.phytochem.2020.112540.
(18) Passos, M. S.; Nogueira, T. S. R.; Azevedo, O. de A.; Vieira, M. G. C.; Terra, W. da S.; Braz-Filho, R.; Vieira, I. J. C. Limonoids from the Genus *Trichilia* and Biological Activities: Review. *Phytochem. Rev.* **2021**. https://doi.org/10.1007/s11101-020-09737-x.
(19) Sun, Y.-P.; Jin, W.-F.; Wang, Y.-Y.; Wang, G.; Morris-Natschke, S.; Liu, J.-S.; Wang, G.-K.; Lee, K.-H. Chemical Structures and Biological Activities of Limonoids from the Genus *Swietenia* (Meliaceae). *Molecules* **2018**, *23* (7), 1588. https://doi.org/10.3390/molecules23071588.
(20) Shilpi, J. A.; Saha, S.; Chong, S. L.; Nahar, L.; Sarker, S. D.; Awang, K. Advances in Chemistry and Bioactivity of the Genus *Chisocheton blume*. *Chem. Biodivers.* **2016**, *13* (5), 483–503. https://doi.org/10.1002/cbdv.201400373.
(21) Bandi, A. K. R.; Lee, D.-U. Secondary Metabolites of Plants from the Genus *Cipadessa*: Chemistry and Biological Activity. *Chem. Biodivers.* **2012**, *9* (8), 1403–1421. https://doi.org/10.1002/cbdv.201100172.
(22) Xu, W.-H. H.; Su, X.-M. M.; Wang, C.; Du, F.; Liang, Q. The Genus *Amoora*: A Phytochemical and Pharmacological Review. *Fitoterapia* **2019**, *137* (July), 104269. https://doi.org/10.1016/j.fitote.2019.104269.
(23) De Leo, M.; Milella, L.; Braca, A.; De Tommasi, N. *Cedrela* and *Toona* Genera: A Rich Source of Bioactive Limonoids and Triterpenoids. *Phytochem. Rev.* **2018**, *17* (4), 751–783. https://doi.org/10.1007/s11101-018-9557-1.
(24) Wang, G.-W. W.; Jin, H.-Z. Z.; Zhang, W.-D. D. Constituents from *Aphanamixis* Species and Their Biological Activities. *Phytochem. Rev.* **2013**, *12* (4), 915–942. https://doi.org/10.1007/s11101-013-9317-1.
(25) Zhang, Y.; Xu, H. Recent Progress in the Chemistry and Biology of Limonoids. *RSC Adv.* **2017**, *7* (56), 35191–35220. https://doi.org/10.1039/c7ra04715k.
(26) Moghadamtousi, S.; Goh, B.; Chan, C.; Shabab, T.; Kadir, H. Biological Activities and Phytochemicals of *Swietenia macrophylla* King. *Molecules* **2013**, *18* (9), 10465–10483. https://doi.org/10.3390/molecules180910465.
(27) Komane, B. M.; Olivier, E. I.; Viljoen, A. M. *Trichilia emetica* (Meliaceae) – A Review of Traditional Uses, Biological Activities and Phytochemistry. *Phytochem. Lett.* **2011**, *4* (1), 1–9. https://doi.org/10.1016/j.phytol.2010.11.002.
(28) Tundis, R.; Loizzo, M. R.; Menichini, F. An Overview on Chemical Aspects and Potential Health Benefits

of Limonoids and Their Derivatives. *Crit. Rev. Food Sci. Nutr.* **2014**, *54* (2), 225–250. https://doi.org/10.1080/10408398.2011.581400.
(29) Hill, R. A.; Connolly, J. D. Triterpenoids. *Nat. Prod. Rep.* **2012**, *29* (7), 780. https://doi.org/10.1039/c2np20027a.
(30) Hill, R. A.; Connolly, J. D. Triterpenoids. *Nat. Prod. Rep.* **2013**, *30* (7), 1028–1065. https://doi.org/10.1039/C3NP70032A.
(31) Hill, R. A.; Connolly, J. D. Triterpenoids. *Nat. Prod. Rep.* **2015**, *32* (2), 273–327. https://doi.org/10.1039/C4NP00101J.
(32) Hill, R. A.; Connolly, J. D. Triterpenoids. *Nat. Prod. Rep.* **2017**, *34* (1), 90–122. https://doi.org/10.1039/C6NP00094K.
(33) Hill, R. A.; Connolly, J. D. Triterpenoids. *Nat. Prod. Rep.* **2018**, *35* (12), 1294–1329. https://doi.org/10.1039/C8NP00029H.
(34) Hill, R. A.; Connolly, J. D. Triterpenoids. *Nat. Prod. Rep.* **2020**, *37* (7), 962–998. https://doi.org/10.1039/C9NP00067D.
(35) Siddiqui, S.; Siddiqui, B. S.; Faizi, S.; Mahmood, T. Tetracyclic Triterpenoids and Their Derivatives from *Azadirachta indica*. *J. Nat. Prod.* **1988**, *51* (1), 30–43. https://doi.org/10.1021/np50055a003.
(36) Ekong, D. E. U.; Ibiyemi, S. A.; Olagbemi, E. O. The Meliacins (Limonoids). Biosynthesis of Nimbolide in the Leaves of *Azadirachta indica*. *J. Chem. Soc. D Chem. Commun.* **1971**, No. 18, 1117. https://doi.org/10.1039/c29710001117.
(37) Nes, W. D.; Wong, R. Y.; Benson, M.; Landrey, J. R.; Nes, W. R. Rotational Isomerism about the 17(20)-Bond of Steroids and Euphoids as Shown by the Crystal Structures of Euphol and Tirucallol. *Proc. Natl. Acad. Sci.* **1984**, *81* (18), 5896–5900. https://doi.org/10.1073/pnas.81.18.5896.
(38) Rani, K.; Akhila, A. Biosynthetic Relationship Between Nemocinol and Nimocinolide in *Azadirachta indica*. *Nat. Prod. Lett.* **1994**, *4* (3), 179–182. https://doi.org/10.1080/10575639408043902.
(39) Akhila, A.; Srivastava, M.; Rani, K. Production of Radioactive Azadirachtin in the Seed Kernels of *Azadirachta indica* (The Indian Neem Tree). *Nat. Prod. Lett.* **1998**, *11* (2), 107–110. https://doi.org/10.1080/10575639808041205.
(40) Aarthy, T.; Mulani, F. A.; Pandreka, A.; Kumar, A.; Nandikol, S. S.; Haldar, S.; Thulasiram, H. V. Tracing the Biosynthetic Origin of Limonoids and Their Functional Groups through Stable Isotope Labeling and Inhibition in Neem Tree (*Azadirachta indica*) Cell Suspension. *BMC Plant Biol.* **2018**, *18* (1), 230. https://doi.org/10.1186/s12870-018-1447-6.
(41) Hodgson, H.; De La Peña, R.; Stephenson, M. J.; Thimmappa, R.; Vincent, J. L.; Sattely, E. S.; Osbourn, A. Identification of Key Enzymes Responsible for Protolimonoid Biosynthesis in Plants: Opening the Door to Azadirachtin Production. *Proc. Natl. Acad. Sci. U. S. A.* **2019**, *116* (34), 17096–17104. https://doi.org/10.1073/pnas.1906083116.
(42) Pandreka, A.; Chaya, P. S.; Kumar, A.; Aarthy, T.; Mulani, F. A.; Bhagyashree, D. D.; B, S. H.; Jennifer, C.; Ponnusamy, S.; Nagegowda, D.; Thulasiram, H. V. Limonoid Biosynthesis 3: Functional Characterization of Crucial Genes Involved in Neem Limonoid Biosynthesis. *Phytochemistry* **2021**, *184*, 112669. https://doi.org/10.1016/j.phytochem.2021.112669.
(43) Puripattanavong, J.; Weber, S.; Brecht, V.; Frahm, A. W. Phytochemical Investigation of *Aglaia andamanica*. *Planta Med.* **2000**, *66* (8), 740–745. https://doi.org/10.1055/s-2000-9901.
(44) K. Purushothaman, K.; Duraiswamy, K.; D. Connolly, J.; S. Rycroft, D. Triterpenoids from *Walsura piscidia*. *Phytochemistry* **1985**, *24* (10), 2349–2354. https://doi.org/10.1016/S0031-9422(00)83040-X.
(45) Jolad, S. D.; Hoffmann, J. J.; Schram, K. H.; Cole, J. R.; Tempesta, M. S.; Bates, R. B. Constituents of *Trichilia hispida* (Meliaceae). 4. Hispidols A and B, Two New Tirucallane Triterpenoids. *J. Org. Chem.* **1981**, *46* (20), 4085–4088. https://doi.org/10.1021/jo00333a037.
(46) Liu, H.; Heilmann, J.; Rali, T.; Sticher, O. New Tirucallane-Type Triterpenes from *Dysoxylum variabile*. *J. Nat. Prod.* **2001**, *64* (2), 159–163. https://doi.org/10.1021/np0002841.
(47) Jiang, Z.-P.; Luan, Z.-L.; Liu, R.-X.; Zhang, Q.; Ma, X.-C.; Shen, L.; Wu, J. Mangrove Tirucallane- and Apotirucallane-Type Triterpenoids: Structure Diversity of the C-17 Side-Chain and Natural Agonists of Human Farnesoid/Pregnane–X–Receptor. *Mar. Drugs* **2018**, *16* (12), 488. https://doi.org/10.3390/md16120488.
(48) Mohamad, K.; Martin, M.-T.; Litaudon, M.; Gaspard, C.; Sévenet, T.; Païs, M. Tirucallane Triterpenes from *Dysoxylum macranthum*. *Phytochemistry* **1999**, *52* (8), 1461–1468. https://doi.org/10.1016/S0031-9422(99)00455-0.
(49) Luo, X.-D.; Wu, S.-H.; Ma, Y.-B.; Wu, D.-G. Tirucallane Triterpenoids from *Dysoxylum hainanense*.

Phytochemistry **2000**, *54* (8), 801–805. https://doi.org/10.1016/S0031-9422(00)00172-2.

(50) Wang, H.; Zhang, X. F.; Yang, S. M.; Luo, X. D.; Wang Huan, Zhang Xiao-Feng, Yang Shu-Min, L.; Xiao-Dong. A New Triterpenoid from *Amoora dasyclada*. *Acta Bot. Sin.* **2004**, *46* (10), 1256–1260.

(51) Merrien, A.; Polonsky, J. The Natural Occurrence of Melianodiol and Its Diacetate in *Samadera madagascariensis* (Simaroubaceae): Model Experiments on Melianodiol Directed towards Simarolide. *J. Chem. Soc. D Chem. Commun.* **1971**, No. 6, 261. https://doi.org/10.1039/c29710000261.

(52) Cortez, D. A. G.; Vieira, P. C.; Fernandes, J. B.; da Silva, G. F. G. F.; Ferreira, A. G. Limonoids from *Trichilia hirta*. *Phytochemistry* **1992**, *31* (2), 625–628. https://doi.org/10.1016/0031-9422(92)90048-U.

(53) Phan, N. H. T.; Thuan, N. T. D.; Ngoc, N. T.; Huong, P. T. M.; Thao, N. P.; Cuong, N. X.; Van Thanh, N.; Nam, N. H.; Van Kiem, P.; Van Minh, C. Two Tirucallane Derivatives from *Paramignya scandens* and Their Cytotoxic Activity. *Phytochem. Lett.* **2014**, *9*, 78–81. https://doi.org/10.1016/j.phytol.2014.04.011.

(54) Xie, B.-J.; Yang, S.-P.; Chen, H.-D.; Yue, J.-M. Agladupols A–E, Triterpenoids from *Aglaia duperreana*. *J. Nat. Prod.* **2007**, *70* (9), 1532–1535. https://doi.org/10.1021/np0702842.

(55) Lavie, D.; Jain, M. K.; Kirson, I. Terpenoids. Part VI. The Complete Structure of Melianone. *J. Chem. Soc. C Org.* **1967**, 1347. https://doi.org/10.1039/j39670001347.

(56) Lavie, D.; Jain, M. K.; Shpan-Gabrielith, S. R. A Locust Phagorepellent from Two *Melia* Species. *Chem. Commun.* **1967**, No. 18, 910. https://doi.org/10.1039/c19670000910.

(57) Salimuzzaman Siddiqui, Bina Shaheen Siddiqui, Shaheen Faizi, T. M. Studies on the Chemical Constituents of *Azadirachta indica* A. Juss (Meliaceae) Part VI {1}. *J. Chem. Soc.* **1986**, *8* (3), 341–347.

(58) Jolad, S. D.; Wiedhopf, R. M.; Cole, J. R. Cytotoxic Agents from *Bursera klugii* (Burseraceae) I: Isolation of Sapelins A and B. *J. Pharm. Sci.* **1977**, *66* (6), 889–890. https://doi.org/10.1002/jps.2600660645.

(59) Niu, K.; Shen, L.; Wu, J. A Tirucallane and Two Pairs of Tetranortriterpene 23-Epimers from the Thai Mangrove *Xylocarpus moluccensis*. *J. Asian Nat. Prod. Res.* **2016**, *18* (1), 36–40. https://doi.org/10.1080/10286020.2015.1075006.

(60) Zhang, L.; Xia, J.; Duan, Y.; Wei, K.; Gao, R.; Li, D.; Liu, X.; Zhang, T.; Qiu, M. Toonamicrocarpavarin, a New Tirucallane-Type Triterpenoid from *Toona ciliata*. *Nat. Prod. Res.* **2021**, *35* (2), 266–271. https://doi.org/10.1080/14786419.2019.1627351.

(61) Wang, J.-R. R.; Liu, H.-L. L.; Kurtán, T.; Mándi, A.; Antus, S.; Li, J.; Zhang, H.-Y. Y.; Guo, Y.-W. W. Protolimonoids and Norlimonoids from the Stem Bark of *Toona ciliata* Var. Pubescens. *Org. Biomol. Chem.* **2011**, *9* (22), 7685–7696. https://doi.org/10.1039/c1ob06150j.

(62) Zou, Y. H.; Liu, W. T.; Zhang, J. X.; Xiang, D. C. Triterpenoids from the Bark of *Dysoxylum hainanense* and Their Anti-Inflammatory and Radical Scavenging Activity. *Fitoterapia* **2017**, *121*, 159–163. https://doi.org/10.1016/j.fitote.2017.07.012.

(63) Liu, W.-X. X.; Tang, G.-H. H.; He, H.-P. P.; Zhang, Y.; Li, S.-L. L.; Hao, X.-J. J. Limonoids and Triterpenoids from the Twigs and Leaves of *Dysoxylum hainanense*. *Nat. Products Bioprospect.* **2012**, *2* (1), 29–34. https://doi.org/10.1007/s13659-011-0030-8.

(64) Zeng, Q.; Guan, B.; Qin, J. J.; Wang, C. H.; Cheng, X. R.; Ren, J.; Yan, S. K.; Jin, H. Z.; Zhang, W. D. 2,3-Seco- and 3,4-Seco-Tirucallane Triterpenoid Derivatives from the Stems of *Aphanamixis grandifolia* Blume. *Phytochemistry* **2012**, *80*, 148–155. https://doi.org/10.1016/j.phytochem.2012.05.017.

(65) Wang, J.; Zhang, Y.; Luo, J.; Kong, L. Complete 1 H and 13 C NMR Data Assignment of Protolimonoids from the Stem Barks of *Aphanamixis grandifolia*. *Magn. Reson. Chem.* **2011**, *49* (7), 450–457. https://doi.org/10.1002/mrc.2768.

(66) Hu, J.; Wang, X.; Shi, X. Triterpenoids and Limonoids from *Dysoxylum lukii* with Cytotoxic and Antimicrobial Activities. *European J. Org. Chem.* **2011**, No. 35, 7215–7223. https://doi.org/10.1002/ejoc.201101182.

(67) Happi, G. M.; Kouam, S. F.; Talontsi, F. M.; Zühlke, S.; Lamshöft, M.; Spiteller, M. Minor Secondary Metabolites from the Bark of *Entandrophragma congoënse* (Meliaceae). *Fitoterapia* **2015**, *102*, 35–40. https://doi.org/10.1016/j.fitote.2015.01.018.

(68) Huang, H.-L.; Wang, C.-M.; Wang, Z.-H.; Yao, M.-J.; Han, G.-T.; Yuan, J.-C.; Gao, K.; Yuan, C. Tirucallane-Type Triterpenoids from *Dysoxylum lenticellatum*. *J. Nat. Prod.* **2011**, *74* (10), 2235–2242. https://doi.org/10.1021/np2006296.

(69) Chen, J.; Chen, J.; Sun, Y.; Yan, Y.; Kong, L.; Li, Y.; Qiu, M. Cytotoxic Triterpenoids from *Azadirachta indica*. *Planta Med.* **2011**, *77* (16), 1844–1847. https://doi.org/10.1055/s-0030-1271197.

(70) Fossen, T.; Rasoanaivo, P.; Manjovelo, C. S.; Raharinjato, F. H.; Yahorava, S.; Yahorau, A.; Wikberg, J. E. S. A New Protolimonoid from *Capuronianthus mahafalensis*. *Fitoterapia* **2012**, *83* (5), 901–906. https://doi.org/10.1016/j.fitote.2012.03.023.

(71) Zhou, F.; Ma, X. H.; Li, Z. J.; Li, W.; Zheng, W. M.; Wang, Z. B.; Zeng, X. M.; Sun, K. H.; Zhang, Y. H. Four New Tirucallane Triterpenoids from the Fruits of *Melia azedarach* and Their Cytotoxic Activities. *Chem. Biodivers.* **2016**, *13* (12), 1738–1746. https://doi.org/10.1002/cbdv.201600149.

(72) Wang, J.-S.; Zhang, Y.; Wei, D.-D.; Wang, X.-B.; Luo, J.; Kong, L.-Y. Novel Tirucallane-Type Triterpenoids from *Aphanamixis grandifolia*. *Chem. Biodivers.* **2011**, *8* (11), 2025–2034. https://doi.org/10.1002/cbdv.201000250.

(73) Miguita, C. H.; Silva Da Barbosa, C.; Hamerski, L.; Sarmento, U. C.; Do Nascimento, J. N.; Garcez, W. S.; Garcez, F. R. 3β-O-Tigloylmelianol from *Guarea kunthiana*: A New Potential Agent to Control Rhipicephalus (Boophilus) Microplus, a Cattle Tick of Veterinary Significance. *Molecules*. 2015, pp 111–126. https://doi.org/10.3390/molecules20010111.

(74) Zhang, Y.; Wang, J. S.; Wang, X. B.; Gu, Y. C.; Kong, L. Y. Polystanins A-D, Four New Protolimonoids from the Fruits of *Aphanamixis polystachya*. *Chem. Pharm. Bull.* **2013**, *61* (1), 75–81. https://doi.org/10.1248/cpb.c12-00332.

(75) Kurimoto, S. I.; Takaishi, Y.; Ahmed, F. A.; Kashiwada, Y. Triterpenoids from the Fruits of *Azadirachta indica* (Meliaceae). *Fitoterapia* **2014**, *92*, 200–205. https://doi.org/10.1016/j.fitote.2013.11.004.

(76) Han, M.-L.; Shen, Y.; Wang, G.-C.; Leng, Y.; Zhang, H.; Yue, J.-M. 11β-HSD1 Inhibitors from *Walsura cochinchinensis*. *J. Nat. Prod.* **2013**, *76* (7), 1319–1327. https://doi.org/10.1021/np400260g.

(77) Yuan, C.-M.; Zhang, Y.; Tang, G.-H.; Li, Y.; He, H.-P.; Li, S.-F.; Hou, L.; Li, X.-Y.; Di, Y.-T.; Li, S.-L.; Hua, H.-M.; Hao, X.-J. Cytotoxic Limonoids from *Melia azedarach*. *Planta Med.* **2012**, *79* (02), 163–168. https://doi.org/10.1055/s-0032-1328069.

(78) Hu, J.; Song, Y.; Li, H.; Yang, B.; Mao, X.; Zhao, Y.; Shi, X. Cytotoxic and Anti-Inflammatory Tirucallane Triterpenoids from *Dysoxylum binectariferum*. *Fitoterapia* **2014**, *99*, 86–91. https://doi.org/10.1016/j.fitote.2014.09.010.

(79) Dong, S. H.; He, X. F.; Dong, L.; Wu, Y.; Yue, J. M. Triterpenoids from *Melia toosendan*. *Helv. Chim. Acta* **2012**, *95* (2), 286–300. https://doi.org/10.1002/hlca.201100323.

(80) Zhang, F.; Wang, J.-S.; Gu, Y.-C.; Kong, L.-Y. Cytotoxic and Anti-Inflammatory Triterpenoids from *Toona ciliata*. *J. Nat. Prod.* **2012**, *75* (4), 538–546. https://doi.org/10.1021/np200579b.

(81) Orisadipe, A. T.; Adesomoju, A. A.; D'Ambrosio, M.; Guerriero, A.; Okogun, J. I. Tirucallane Triterpenes from the Leaf Extract of *Entandrophragma angolense*. *Phytochemistry* **2005**, *66* (19), 2324–2328. https://doi.org/10.1016/j.phytochem.2005.07.017.

(82) Hernandez, V.; De Leo, M.; Cotugno, R.; Braca, A.; De Tommasi, N.; Severino, L. New Tirucallane-Type Triterpenoids from *Guarea guidonia*. *Planta Med.* **2018**, *84* (9–10), 716–720. https://doi.org/10.1055/s-0044-100524.

(83) Zhou, X.-J.; Xu, M.; Li, X.-S.; Wang, Y.-H.; Gao, Y.; Cai, R.; Cheng, Y.-X. Triterpenoids and Sterones from the Stem Bark of *Ailanthus altissima*. *Bull. Korean Chem. Soc.* **2011**, *32* (1), 127–130. https://doi.org/10.5012/bkcs.2011.32.1.127.

(84) Tang, J.; Xu, J.; Zhang, J.; Liu, W. Y.; Xie, N.; Chen, L.; Feng, F.; Qu, W. Novel Tirucallane Triterpenoids from the Stem Bark of *Toona sinensis*. *Fitoterapia* **2016**, *112*, 97–103. https://doi.org/10.1016/j.fitote.2016.05.009.

(85) Zhang, Y.; Wang, J.; Wei, D.; Wang, X.; Luo, J.; Luo, J.; Kong, L. Cytotoxic Tirucallane C26 Triterpenoids from the Stem Barks of *Aphanamixis grandifolia*. *Phytochemistry* **2010**, *71* (17–18), 2199–2204. https://doi.org/10.1016/j.phytochem.2010.08.017.

(86) Hu, W.-M.; Wu, J. Protoxylogranatin B, a Key Biosynthetic Intermediate from *Xylocarpus granatum*: Suggesting an Oxidative Cleavage Biogenetic Pathway to Limonoid. *Open Nat. Prod. J.* **2010**, *3* (1), 1–5. https://doi.org/10.2174/1874848101003010001.

(87) Yuan, T.; Zhang, C.-R.; Yang, S.-P.; Yue, J.-M. Limonoids and Triterpenoids from *Khaya senegalensis*. *J. Nat. Prod.* **2010**, *73* (4), 669–674. https://doi.org/10.1021/np1000158.

(88) Li, M.-Y.; Wu, J.; Zhang, S.; Xiao, Q.; Li, Q.-X. The Absolute Stereochemistry of Protoxylogranatin A – a New Protolimonoid from the Seeds of Chinese Mangrove *Xylocarpus granatum*. *J. Asian Nat. Prod. Res.* **2008**, *10* (6), 503–508. https://doi.org/10.1080/10286020801966690.

(89) Bai, Y.; Jin, X.; Jia, X.; Tang, W.; Wang, X.; Zhao, Y. Two New Apotirucallane-Type Isomeric Triterpenoids from the Root Bark of *Dictamnus dasycarpus* with Their Anti-Proliferative Activity. *Phytochem. Lett.* **2014**, *10*, 118–122. https://doi.org/10.1016/j.phytol.2014.06.017.

(90) Yang, M.-H.; Wang, J.-S.; Luo, J.-G.; Wang, X.-B.; Kong, L.-Y. Four New Triterpenoids from *Chisocheton paniculatus* and Their Anti-Inflammatory Activities. *Can. J. Chem.* **2012**, *90* (2), 199–204. https://doi.org/10.1139/v11-147.

(91) Ning, J.; He, H.-P.; Li, S.-F.; Geng, Z.-L.; Fang, X.; Di, Y.-T.; Li, S.-L.; Hao, X.-J. Triterpenoids from the Leaves of *Toona ciliata*. *J. Asian Nat. Prod. Res.* **2010**, *12* (6), 448–452. https://doi.org/10.1080/10286020.2010.493329.

(92) Luo, X.-D.; Wu, S.-H.; Wu, D.-G.; Ma, Y.-B.; Qi, S.-H. Three New Apo-Tirucallols with Six-Membered Hemiacetal from Meliaceae. *Tetrahedron* **2002**, *58* (33), 6691–6695. https://doi.org/10.1016/S0040-4020(02)00679-8.

(93) Kitagawa, I.; Mahmud, T.; Simajuntak, P.; Hori, K.; Uji, T.; Shibuya, H. Indonesian Medicinal Plants. VIII. Chemical Structures of Three New Triterpenoids, Bruceajavanin A, Dihydrobruceajavanin A, and Bruceajavanin B, and a New Alkaloidal Glycoside, Bruceacanthinoside, from the Stems of Brucea Javanica (Simaroubaceae). *Chem. Pharm. Bull.* **1994**, *42* (7), 1416–1421. https://doi.org/10.1248/cpb.42.1416.

(94) Mulholland, D. A.; Monkhe, T. V.; Taylor, D. A. H.; Rajab, M. S. Triterpenoids from *Turraea holstii*. *Phytochemistry* **1999**, *52* (1), 123–126. https://doi.org/10.1016/S0031-9422(99)00071-0.

(95) Dong, S.-H.; Liu, J.; Ge, Y.-Z.; Dong, L.; Xu, C.-H.; Ding, J.; Yue, J.-M. Chemical Constituents from *Brucea javanica*. *Phytochemistry* **2013**, *85*, 175–184. https://doi.org/10.1016/j.phytochem.2012.08.018.

(96) Omobuwajo, O. R.; Martin, M.-T.; Perromat, G.; Sévenet, T.; Païs, M.; Awang, K. Apotirucallane Triterpenes from *Aglaia argentea*. *J. Nat. Prod.* **1996**, *59* (6), 614–617. https://doi.org/10.1021/np960159i.

(97) Adesanya, S. A.; Païs, M.; Sévenet, T.; Cosson, J. P. Apotirucallane Triterpenes from *Dysoxylum roseum*. *J. Nat. Prod.* **1991**, *54* (6), 1588–1594. https://doi.org/10.1021/np50078a015.

(98) Lyons, C. W.; Taylor, D. R. Stereochemistry of Sapelin B; Correlation with Sapelin D. Anomalies in the Use of Shift Reagents for Determining the Absolute Configurations of α-Glycols. *J. Chem. Soc., Chem. Commun.* **1976**, No. 16, 647–648. https://doi.org/10.1039/C39760000647.

(99) Siddiqui, B. S.; Ali, S. T.; Rasheed, M.; Kardar, M. N. Chemical Constituents of the Flowers of *Azadirachta indica*. *Helv. Chim. Acta* **2003**, *86* (8), 2787–2796. https://doi.org/10.1002/hlca.200390229.

(100) Connolly, J. D.; Phillips, W. R.; Mulholland, D. A.; Taylor, D. A. H. Spicatin, a Protolimonoid from *Entandrophragma spicatum*. *Phytochemistry* **1981**, *20* (11), 2596–2597. https://doi.org/10.1016/0031-9422(81)83107-X.

(101) Xie, B.; Yang, S.; Zhang, C.; Yue, J. Chisiamols A-F, Triterpenoids from *Chisocheton siamensis*. *Chinese J. Chem.* **2009**, *27* (9), 1805–1810. https://doi.org/10.1002/cjoc.200990304.

(102) Liu, J.; Yang, S. P.; Ni, G.; Gu, Y. C.; Yue, J. M. Triterpenoids from *Aglaia odorata* Var. Microphyllina. *J. Asian Nat. Prod. Res.* **2012**, *14* (10), 929–939. https://doi.org/10.1080/10286020.2012.730698.

(103) Hu, Y. lin; Li, Y.; Qiu, L.; Li, J. he; Heng, L.; Wei, S. shan; Gao, H. liang; Wang, X. bing; Luo, J.; Kong, L. yi. New Triterpenoids with Diverse Side-Chains from the Barks of *Melia toosendan*. *Fitoterapia* **2018**, *127* (January), 62–68. https://doi.org/10.1016/j.fitote.2018.01.011.

(104) Yang, M. H.; Wang, J. S.; Luo, J. G.; Wang, X. B.; Kong, L. Y. Chisopanins A-K, 11 New Protolimonoids from *Chisocheton paniculatus* and Their Anti-Inflammatory Activities. *Bioorganic Med. Chem.* **2011**, *19* (4), 1409–1417. https://doi.org/10.1016/j.bmc.2011.01.007.

(105) Zhou, Z. F.; Taglialatela-Scafati, O.; Liu, H. L.; Gu, Y. C.; Kong, L. Y.; Guo, Y. W. Apotirucallane Protolimonoids from the Chinese Mangrove *Xylocarpus granatum* Koenig. *Fitoterapia* **2014**, *97*, 192–197. https://doi.org/10.1016/j.fitote.2014.06.009.

(106) Liu, D.; Wang, R.; Xuan, L.; Wang, X.; Li, W. Two New Apotirucallane-Type Triterpenoids from the Pericarp of *Toona sinensis* and Their Ability to Reduce Oxidative Stress in Rat Glomerular Mesangial Cells Cultured under High-Glucose Conditions. *Molecules* **2020**, *25* (4), 801. https://doi.org/10.3390/molecules25040801.

(107) Zhang, F.; He, X. F.; Wu, W. Bin; Chen, W. S.; Yue, J. M. New Apotirucallane-Type Triterpenoids from *Chisocheton paniculatus*. *Nat. Products Bioprospect.* **2012**, *2* (6), 235–239. https://doi.org/10.1007/s13659-012-0065-5.

(108) Sichaem, J.; Khumkratok, S.; Siripong, P.; Tip-Pyang, S. New Cytotoxic Apotirucallanes from the Leaves of *Walsura trichostemon*. *J. Nat. Med.* **2014**, *68* (2), 436–441. https://doi.org/10.1007/s11418-013-0808-6.

(109) Appa, M. S.; Suresh, G.; Yadav, P. A.; Prasad, K. R.; Rani, P. U.; Rao, C. V.; Babu, K. S. Piscidinols H-L , Apotirucallane Triterpenes from the Leaves of *Walsura trifoliata* and Their Insecticidal Activity. *Tetrahedron* **2015**, *71* (9), 1431–1437. https://doi.org/10.1016/j.tet.2015.01.011.

(110) Chianese, G.; R. Yerbanga, S.; Lucantoni, L.; Habluetzel, A.; Basilico, N.; Taramelli, D.; Fattorusso, E.; Taglialatela-Scafati, O. Antiplasmodial Triterpenoids from the Fruits of Neem, *Azadirachta indica*. *J. Nat. Prod.* **2010**, *73* (8), 1448–1452. https://doi.org/10.1021/np100325q.

(111) Terra, W. D. S.; Vieira, I. J. C.; Braz-Filho, R.; De Freitas, W. R.; Kanashiro, M. M.; Torres, M. C. M. Lepidotrichilins A and B, New Protolimonoids with Cytotoxic Activity from *Trichilia lepidota* (Meliaceae).

Molecules **2013**, *18* (10), 12180–12191. https://doi.org/10.3390/molecules181012180.
(112) Jin, Q.; Lee, C.; Lee, J. W.; Lee, M. S.; Lee, M. K.; Hwang, B. Y. A New Apotirucallane-Type Triterpenoid from the Fruit of *Melia azedarach*. *Nat. Prod. Sci.* **2013**, *19* (4), 342–346.
(113) Wang, W.; Xia, Z.; Tian, Z.; Jiang, H.; Zhan, Y.; Liu, C.; Li, C.; Zhou, H. Chemical Constituents from the Fruits of *Melia azedarach* (Meliaceae). *Biochem. Syst. Ecol.* **2020**, *92*, 104094. https://doi.org/10.1016/j.bse.2020.104094.
(114) Wu, W. Bin; Zhang, H.; Dong, S. H.; Sheng, L.; Wu, Y.; Li, J.; Yue, J. M. New Triterpenoids with Protein Tyrosine Phosphatase 1B Inhibition from *Cedrela odorata*. *Journal of Asian Natural Products Research*. Taylor & Francis 2014, pp 709–716. https://doi.org/10.1080/10286020.2014.919281.
(115) Hu, Y.-L.; Tian, X.-M.; Wang, C.-C.; Olga, Q.; Yan, D.; Tang, P.-F.; Zhang, L.-N.; Kong, L.-Y.; Luo, J. New Triterpenoids, Steroids and Lignan from the Stem Barks of *Entandrophragma utile*. *Fitoterapia* **2020**, *143*, 104546. https://doi.org/10.1016/j.fitote.2020.104546.
(116) Sun, Y. P.; Zhu, L. L.; Liu, J. song; Yu, Y.; Zhou, Z. yu; Wang, G.; Wang, G. K. Limonoids and Triterpenoid from Fruit of *Swietenia macrophylla*. *Fitoterapia* **2018**, *125* (December 2017), 141–146. https://doi.org/10.1016/j.fitote.2018.01.004.
(117) Sichaem, J.; Aree, T.; Khumkratok, S.; Jong-Aramruang, J.; Tip-Pyang, S. A New Cytotoxic Apotirucallane from the Roots of *Walsura trichostemon*. *Phytochem. Lett.* **2012**, *5* (3), 665–667. https://doi.org/10.1016/j.phytol.2012.07.001.
(118) Rao, M. S. A.; Suresh, G.; Yadav, P. A.; Prasad, K. R.; Nayak, V. L.; Ramakrishna, S.; Rao, C. V.; Babu, K. S. Novel Apo-Tirucallane Triterpenoids from *Walsura trifoliata*. *Tetrahedron Lett.* **2012**, *53* (46), 6241–6244. https://doi.org/10.1016/j.tetlet.2012.09.012.
(119) Wang, H. W.; Liu, J. Q.; Chen, J. X.; Yang, Y. F.; Yan, Y. X.; Li, Z. R.; Qiu, M. H. New Triterpenoids from the Kernels of *Azadirachta indica*. *Nat. Products Bioprospect.* **2013**, *3* (1), 33–37. https://doi.org/10.1007/s13659-013-0005-z.
(120) Lin, C. J.; Lo, I. W.; Lin, Y. C.; Chen, S. Y.; Chien, C. Te; Kuo, Y. H.; Hwang, T. L.; Liou, S. S.; Shen, Y. C. Tetranortriterpenes and Limonoids from the Roots of *Aphanamixis polystachya*. *Molecules* **2016**, *21* (9), 3–12. https://doi.org/10.3390/molecules21091167.
(121) Nugroho, A. E.; Okuda, M.; Yamamoto, Y.; Chin-Piow, W.; Hirasawa, Y.; Kaneda, T.; Shirota, O.; Hadi, A. H. A.; Morita, H. Apowalsogynes A and B, Two Highly Oxidized 3,4- Seco -Apotirucallane Triterpenoids from *Walsura chrysogyne*. *Nat. Prod. Commun.* **2017**, *12* (8), 1934578X1701200. https://doi.org/10.1177/1934578X1701200810.
(122) Garcez, F. R.; Garcez, W. S.; Rodrigues, E. D.; Pott, V. J.; Roque, N. F. Seco-Protolimonoids from *Trichilia elegans* Ssp. Elegans. *Phytochemistry* **1996**, *42* (5), 1399–1403. https://doi.org/10.1016/0031-9422(96)00141-0.
(123) Farabi, K.; Harneti, D.; Nurlelasari; Maharani, R.; Hidayat, A. T.; Awang, K.; Supratman, U.; Shiono, Y. New Cytotoxic Protolimonoids from the Stem Bark of *Aglaia argentea* (Meliaceae). *Phytochem. Lett.* **2017**, *21* (September), 211–215. https://doi.org/10.1016/j.phytol.2017.07.006.
(124) Zhang, Y.; Wang, J. S.; Wei, D. D.; Gu, Y. C.; Wang, X. B.; Kong, L. Y. Bioactive Terpenoids from the Fruits of *Aphanamixis grandifolia*. *J. Nat. Prod.* **2013**, *76* (6), 1191–1195. https://doi.org/10.1021/np400126q.
(125) Bentley, M. D.; Gaul, F.; Rajab, M. S.; Hassanali, A. Tetranortriterpenes from *Turraea robusta*. *J. Nat. Prod.* **1992**, *55* (1), 84–87. https://doi.org/10.1021/np50079a012.
(126) Qi, S.-H.; Wub, D.-G.; Zhang, S.; Luo, X.-D. A New Tetranortriterpenoid from *Dysoxylum lenticellatum*. *Zeitschrift für Naturforsch. B* **2003**, *58* (11), 1128–1132. https://doi.org/10.1515/znb-2003-1116.
(127) Mulholland, D. A.; Monkhe, T. V; Coombes, P. H.; Rajab, M. S. Limonoids from *Turraea holstii* and *Turraea floribunda*. *Phytochemistry* **1998**, *49* (8), 2585–2590. https://doi.org/10.1016/S0031-9422(98)00441-5.
(128) Kraus, W.; Cramer, R. 17-EPI-Azadiradion Uno 17-β-Hydroxy-Azadiradion, Zwei Neue Inhaltsstoffe Aus *Azadirachta indica* A. Juss. *Tetrahedron Lett.* **1978**, *19* (27), 2395–2398. https://doi.org/10.1016/S0040-4039(01)94783-5.
(129) Gunning, P. J.; Jeffs, L. B.; Isman, M. B.; Towers, G. H. N. Two Limonoids from *Chisocheton microcarpus*. *Phytochemistry* **1994**, *36* (5), 1245–1248. https://doi.org/10.1016/S0031-9422(00)89645-4.
(130) Li, J.; Li, M.-Y.; Satyanandamurty, T.; Wu, J. Godavarin K: A New Limonoid with an Oxygen Bridge between C(1) and C(29) from the Godavari Mangrove *Xylocarpus moluccensis*. *Helv. Chim. Acta* **2011**, *94* (9), 1651–1656. https://doi.org/10.1002/hlca.201100022.
(131) Lavie, D.; Jain, M. K. Tetranortriterpenoids from *Melia azadirachta* L. *Chem. Commun.* **1967**, No. 6, 278.

https://doi.org/10.1039/c19670000278.
(132) Cortez, D. A. .; Fernandes, J. B.; Vieria, P. C.; Silva, M. F. G. F. d.; Ferreira, A. G.; Cass, Q. B.; Rubens Pirani, J. Meliacin Butenolides from *Trichilia estipulata*. *Phytochemistry* **1998**, *49* (8), 2493–2496. https://doi.org/10.1016/S0031-9422(98)00234-9.
(133) Kraus, W.; Cramer, R.; Sawitzki, G. Tetranortriterpenoids from the Seeds of *Azadirachta indica*. *Phytochemistry* **1981**, *20* (1), 117–120. https://doi.org/10.1016/0031-9422(81)85229-6.
(134) Zhang, Y.; An, F. L.; Huang, S. S.; Yang, L.; Gu, Y. C.; Luo, J.; Kong, L. Y. Diverse Tritepenoids from the Fruits of *Walsura robusta* and Their Reversal of Multidrug Resistance Phenotype in Human Breast Cancer Cells. *Phytochemistry* **2017**, *136*, 108–118. https://doi.org/10.1016/j.phytochem.2017.01.008.
(135) Zhou, B.; Shen, Y.; Wu, Y.; Leng, Y.; Yue, J.-M. Limonoids with 11β-Hydroxysteroid Dehydrogenase Type 1 Inhibitory Activities from *Dysoxylum mollissimum*. *J. Nat. Prod.* **2015**, *78* (8), 2116–2122. https://doi.org/10.1021/acs.jnatprod.5b00442.
(136) Liu, J. Q.; Wang, C. F.; Li, Y.; Chen, J. C.; Zhou, L.; Qiu, M. H. Limonoids from the Leaves of *Toona ciliata* Var. Yunnanensis. *Phytochemistry* **2012**, *76*, 141–149. https://doi.org/10.1016/j.phytochem.2012.01.002.
(137) Jiang, S. Y.; Liu, J. Q.; Xia, J. J.; Yan, Y. X.; Qiu, M. H. Five New Tetranortriterpenoids from the Seeds of *Toona ciliata*. *Helv. Chim. Acta* **2012**, *95* (2), 301–307. https://doi.org/10.1002/hlca.201100325.
(138) Manosroi, A.; Kitdamrongtham, W.; Ishii, K.; Shinozaki, T.; Tachi, Y.; Takagi, M.; Ebina, K.; Zhang, J.; Manosroi, J.; Akihisa, R.; Akihisa, T. Limonoids from *Azadirachta indica* Var. Siamensis Extracts and Their Cytotoxic and Melanogenesis-Inhibitory Activities. *Chem. Biodivers.* **2014**, *11* (4), 505–531. https://doi.org/10.1002/cbdv.201300406.
(139) Zhang, P.; Cui, Z.; Wei, S.; Li, Y.; Yin, Y.; Wang, X.; Luo, J.; Kong, L. Diverse Limonoids from Barks of *Toona ciliata* Var. Yunnanensis and Their Biological Activities. *Ind. Crops Prod.* **2020**, *148*, 112275. https://doi.org/10.1016/j.indcrop.2020.112275.
(140) Nurlelasari; Katja, D. G.; Harneti, D.; Wardayo, M. M.; Supratman, U.; Awang, K. Limonoids from the Seeds of *Chisocheton macrophyllus*. *Chem. Nat. Compd.* **2017**, *53* (1), 83–87. https://doi.org/10.1007/s10600-017-1916-4.
(141) Zhang, W. Y.; An, F. L.; Zhou, M. M.; Chen, M. H.; Jian, K. L.; Quasie, O.; Yang, M. H.; Luo, J.; Kong, L. Y. Limonoids with Diverse Frameworks from the Stem Bark of *Entandrophragma angolense* and Their Bioactivities. *RSC Adv.* **2016**, *6* (99), 97160–97171. https://doi.org/10.1039/c6ra19532f.
(142) Fu, Y.-H.; Xie, Y.-T.; Guo, J.-M.; Wang, X.-P.; Jiang, B.; Zhang, W.; Qiang, L.; Kong, L.-Y.; Liu, Y.-P. Limonoids from the Fresh Young Leaves and Buds of *Toona sinensis* and Their Potential Neuroprotective Effects. *J. Agric. Food Chem.* **2020**, *68* (44), 12326–12335. https://doi.org/10.1021/acs.jafc.0c06352.
(143) Zhang, J.; Li, W.; Dai, Y.; Shen, L.; Wu, J. Twenty-Nine New Limonoids with Skeletal Diversity from the Mangrove Plant, *Xylocarpus moluccensis*. *Mar. Drugs* **2018**, *16* (1), 1–29. https://doi.org/10.3390/md16010038.
(144) Han, M. L.; Zhao, J. X.; Liu, H. C.; Ni, G.; Ding, J.; Yang, S. P.; Yue, J. M. Limonoids and Triterpenoids from *Dysoxylum mollissimum* Var. Glaberrimum. *J. Nat. Prod.* **2015**, *78* (4), 754–761. https://doi.org/10.1021/np500967k.
(145) Gualtieri, M. J.; Malafronte, N.; Vassallo, A.; Braca, A.; Cotugno, R.; Vasaturo, M.; De Tommasi, N.; Dal Piaz, F. Bioactive Limonoids from the Leaves of *Azadirachta indica* (Neem). *J. Nat. Prod.* **2014**, *77* (3), 596–602. https://doi.org/10.1021/np400863d.
(146) Yan, Y. X.; Liu, J. Q.; Chen, J. X.; Chen, J. C.; Qiu, M. H. Three New Limonoids from *Azadirachta indica*. *J. Asian Nat. Prod. Res.* **2015**, *17* (1), 14–19. https://doi.org/10.1080/10286020.2014.962523.
(147) Ji, K. L.; Zhang, P.; Hu, H. Bin; Hua, S.; Liao, S. G.; Xu, Y. K. Limonoids from the Leaves and Twigs of *Walsura yunnanensis*. *J. Nat. Prod.* **2014**, *77* (8), 1764–1769. https://doi.org/10.1021/np400976p.
(148) Kitdamrongtham, W.; Ishii, K.; Ebina, K.; Zhang, J.; Ukiya, M.; Koike, K.; Akazawa, H.; Manosroi, A.; Manosroi, J.; Akihisa, T. Limonoids and Flavonoids from the Flowers of *Azadirachta indica* Var. Siamensis, and Their Melanogenesis-Inhibitory and Cytotoxic Activities. *Chem. Biodivers.* **2014**, *11* (1), 73–84. https://doi.org/10.1002/cbdv.201300266.
(149) Sakamoto, A.; Tanaka, Y.; Inoue, T.; Kikuchi, T.; Kajimoto, T.; Muraoka, O.; Yamada, T.; Tanaka, R. Andirolides Q-V from the Flower of Andiroba (*Carapa guianensis*, Meliaceae). *Fitoterapia* **2013**, *90*, 20–29. https://doi.org/10.1016/j.fitote.2013.07.001.
(150) Kowa, T. K.; Tchokouaha, L. R. Y.; Cieckiewicz, E.; Philips, T. J.; Dotse, E.; Wabo, H. K.; Tchinda, A. T.; Tane, P.; Frédérich, M. Antileishmanial and Cytotoxic Activities of a New Limonoid and a New Phenyl Alkene from the Stem Bark of *Trichilia gilgiana* (Meliaceae). *Nat. Prod. Res.* **2019**, *0* (0), 1–7.

https://doi.org/10.1080/14786419.2018.1553879.
(151) Ge, Y. H.; Zhang, J. X.; Mu, S. Z.; Chen, Y.; Yang, F. M.; Yang, L.; Hao, X. J. Munronoids A-J, Ten New Limonoids from *Munronia unifoliolata* Oliv. *Tetrahedron* **2012**, *68* (2), 566–572. https://doi.org/10.1016/j.tet.2011.11.003.
(152) Zhang, J.-C.; Liao, Q.; Shen, L.; Wu, J. Twenty-Five Limonoids from the Hainan Mangrove, *Xylocarpus granatum*. *Bioorg. Chem.* **2020**, *100*, 103903. https://doi.org/10.1016/j.bioorg.2020.103903.
(153) Ren, Y.-X.; Zou, X.-P.; Li, W.-S.; Wu, J.; Shen, L. Discovery of Thai Mangrove Tetranortriterpenoids as Agonists of Human Pregnane–X–Receptor and Inhibitors against Human Carboxylesterase 2. *Bioorg. Chem.* **2021**, *107*, 104599. https://doi.org/10.1016/j.bioorg.2020.104599.
(154) Zhou, Z. F.; Kurtán, T.; Mándi, A.; Gu, Y. C.; Yao, L. G.; Xin, G. R.; Li, X. W.; Guo, Y. W. Novel and Neuroprotective Tetranortriterpenoids from Chinese Mangrove *Xylocarpus granatum* Koenig. *Sci. Rep.* **2016**, *6* (July), 1–10. https://doi.org/10.1038/srep33908.
(155) Zhang, P.-P.; Bu, Y.-G.; Xue, S.; Cui, Z.-R.; Tang, P.-F.; Luo, J.; Kong, L.-Y. Four New Limonoids from the Barks of *Toona ciliata*. *Nat. Products Bioprospect.* **2021**, *11* (1), 81–86. https://doi.org/10.1007/s13659-020-00274-w.
(156) Zhu, W.; Cheng, J.; Su, S.; Zhang, C.; Akihisa, T.; Manosroi, J.; Manosroi, A.; Feng, F.; Liu, W.; Zhang, J. Limonoids and Tricyclic Diterpenoids from *Azadirachta indica* and Their Antitumor Activities. *Bioorg. Chem.* **2020**, *100*, 103889. https://doi.org/10.1016/j.bioorg.2020.103889.
(157) Supratman, U.; Salam, S.; Naibaho, W.; Fajar, M.; Nurlelasari; Katja, D. G.; Harneti, D.; Maharani, R.; Hidayat, A. T.; Lesmana, R.; Azlan Nafiah, M.; Shiono, Y. New Cytotoxic Limonoids from the Stem Bark of *Chisocheton pentandrus* (Blanco) Merr. *Phytochem. Lett.* **2020**, *35*, 63–67. https://doi.org/10.1016/j.phytol.2019.11.002.
(158) Ji, K. L.; Zhang, P.; Li, X. N.; Guo, J.; Hu, H. Bin; Xiao, C. F.; Xie, X. Q.; Xu, Y. K. Cytotoxic Limonoids from *Trichilia americana* Leaves. *Phytochemistry* **2015**, *118*, 61–67. https://doi.org/10.1016/j.phytochem.2015.08.014.
(159) Wang, G.-C.; Yu, J.-H.; Shen, Y.; Leng, Y.; Zhang, H.; Yue, J.-M. Limonoids and Triterpenoids as 11β-HSD1 Inhibitors from *Walsura robusta*. *J. Nat. Prod.* **2016**, *79* (4), 899–906. https://doi.org/10.1021/acs.jnatprod.5b00952.
(160) Essoung, F. R. E.; Chhabra, S. C.; Mba'ning, B. M.; Mohamed, S. A.; Lwande, W.; Lenta, B. N.; Ngouela, S. A.; Tsamo, E.; Hassanali, A. Larvicidal Activities of Limonoids from *Turraea abyssinica* (Meliaceae) on Tuta Absoluta (Meyrick). *J. Appl. Entomol.* **2018**, *142* (4), 397–405. https://doi.org/10.1111/jen.12485.
(161) Yin, S.; Wang, X.-N.; Fan, C.-Q.; Liao, S.-G.; Yue, J.-M. The First Limonoid Peroxide in the Meliaceae Family: Walsuronoid A from *Walsura robusta*. *Org. Lett.* **2007**, *9* (12), 2353–2356. https://doi.org/10.1021/ol070735+.
(162) Mulholland, D. A.; Taylor, D. A. H. Limonoids from Australian Members of the Meliaceae. *Phytochemistry* **1992**, *31* (12), 4163–4166. https://doi.org/10.1016/0031-9422(92)80434-G.
(163) Dong, S.-H.; Zhang, C.-R.; He, X.-F.; Liu, H.-B.; Wu, Y.; Yue, J.-M. Mesendanins A−J, Limonoids from the Leaves and Twigs of *Melia toosendan*. *J. Nat. Prod.* **2010**, *73* (8), 1344–1349. https://doi.org/10.1021/np100150n.
(164) Arenas, C.; Rodriguez-Hahn, L. Limonoids from *Trichilia havanensis*. *Phytochemistry* **1990**, *29* (9), 2953–2956. https://doi.org/10.1016/0031-9422(90)87113-9.
(165) Ochi, M.; Kotsuki, H.; Tokoroyama, T. Sendanal, a New Limonoid from *Melia azedarach* Linn. Var. Japonica Makino. *Chem. Lett.* **1978**, *7* (6), 621–624. https://doi.org/10.1246/cl.1978.621.
(166) Zhang, Y.; Tang, C.-P.; Ke, C.-Q.; Yao, S.; Ye, Y. Limonoids and Triterpenoids from the Stem Bark of *Melia toosendan*. *J. Nat. Prod.* **2010**, *73* (4), 664–668. https://doi.org/10.1021/np900835k.
(167) Adesogan, E. K.; Okorie, D. A.; Taylor, D. A. H. Limonoids from *Khaya anthotheca* (Welw.) C.DC. *J. Chem. Soc. C Org.* **1970**, No. 2, 205. https://doi.org/10.1039/j39700000205.
(168) Zhang, Q.; Li, J.-K.; Ge, R.; Liang, J.-Y.; Li, Q.-S.; Min, Z.-D. Novel NGF-Potentiating Limonoids from the Fruits of *Melia toosendan*. *Fitoterapia* **2013**, *90*, 192–198. https://doi.org/10.1016/j.fitote.2013.07.019.
(169) Yan, Y.; Zhang, J. X.; Huang, T.; Mao, X. Y.; Gu, W.; He, H. P.; Di, Y. T.; Li, S. L.; Chen, D. Z.; Zhang, Y.; Hao, X. J. Bioactive Limonoid Constituents of *Munronia henryi*. *J. Nat. Prod.* **2015**, *78* (4), 811–821. https://doi.org/10.1021/np501057f.
(170) Yuan, C. M.; Tang, G. H.; Zhang, Y.; Wang, X. Y.; Cao, M. M.; Guo, F.; Li, Y.; Di, Y. T.; Li, S. L.; Hua, H. M.; He, H. P.; Hao, X. J. Bioactive Limonoid and Triterpenoid Constituents of *Turraea pubescens*. *J. Nat. Prod.* **2013**, *76* (6), 1166–1174. https://doi.org/10.1021/np400276q.
(171) Song, M.; Zhang, J.; Chan, G.; Hou, Y.; Chen, X.-P.; Zhang, X.-Q.; Ye, W.-C.; Zhang, Q.-W. Bioactive

Limonoids and Triterpenoids from the Fruits of *Melia azedarach*. *J. Nat. Prod.* **2020**, *83* (12), 3502–3510. https://doi.org/10.1021/acs.jnatprod.9b01151.

(172) Wang, H.; Dong, H.; He, Q.; Liang, J.; Zhao, T.; Zhou, L. Characterization of Limonoids Isolated from the Fruits of *Melia toosendan* and Their Antifeedant Activity against Pieris Rapae. *Chem. Biodivers.* **2020**, *17* (4). https://doi.org/10.1002/cbdv.201900674.

(173) Yan, G.; Li, J.; Chen, S.; Liu, Y.; Wu, J.-L.; Zhu, X.-M.; Li, N. New Limonoids from the Fruits of *Melia toosendan* and Their Autophagic Activities. *Phytochem. Lett.* **2020**, *35*, 15–22. https://doi.org/10.1016/j.phytol.2019.10.012.

(174) Wang, W.; Xia, Z.; Yu, S.; Tian, Z.; Yan, B.; Jiang, H.; Zhou, H. Two New Limonoids from the Fruits of *Melia azedarach* (Meliaceae). *Chem. Biodivers.* **2021**, *18* (2). https://doi.org/10.1002/cbdv.202000822.

(175) Zhu, G. Y.; Bai, L. P.; Liu, L.; Jiang, Z. H. Limonoids from the Fruits of *Melia toosendan* and Their NF-KB Modulating Activities. *Phytochemistry* **2014**, *107*, 175–181. https://doi.org/10.1016/j.phytochem.2014.08.009.

(176) Zhang, Y.; Tang, C. P.; Ke, C. Q.; Li, X. Q.; Xie, H.; Ye, Y. Limonoids from the Fruits of *Melia toosendan*. *Phytochemistry* **2012**, *73*, 106–113. https://doi.org/10.1016/j.phytochem.2011.10.001.

(177) Su, Z. S.; Yang, S. P.; Zhang, S.; Dong, L.; Yue, J. M. Meliarachins A-K: Eleven Limonoids from the Twigs and Leaves of *Melia azedarach*. *Helv. Chim. Acta* **2011**, *94* (8), 1515–1526. https://doi.org/10.1002/hlca.201000444.

(178) Liu, S. B.; Chen, H. Q.; Feng, G.; Guo, Z. K.; Cai, C. hong; Wang, J.; Mei, W. L.; Dai, H. F. A New Insecticidal Havanensin-Type Limonoid from the Roots of *Trichilia sinensis* Bentv. *Nat. Prod. Res.* **2018**, *32* (23), 2797–2802. https://doi.org/10.1080/14786419.2017.1380016.

(179) Macleod, J. K.; Moeller, P. D. R.; Molinski, T. F.; Koul, O. Antifeedant Activity Against *Spodoptera litera* Larvae and [13C]NMR Spectral Assignments of the Meliatoxins. *J. Chem. Ecol.* **1990**, *16* (8), 2511–2518. https://doi.org/10.1007/BF01017474.

(180) Nakatani, M. Limonoids from *Melia toosendan* (Meliaceae) and Their Antifeedant Activity. *ChemInform* **1999**, *30* (20), no-no.

(181) Zhou, J.-B.; Tadera, K.; Minami, Y.; Yagi, F.; Kurawaki, J.; Takzaki, K.; Nakatani, M. New Limonoids from *Melia toosendan*. *Biosci. Biotechnol. Biochem.* **1998**, *62* (3), 496–500. https://doi.org/10.1271/bbb.62.496.

(182) Oelrichs, P. B.; Hill, M. W.; Vallely, P. J.; MacLeod, J. K.; Molinski, T. F. Toxic Tetranortriterpenes of the Fruit of *Melia azedarach*. *Phytochemistry* **1983**, *22* (2), 531–534. https://doi.org/10.1016/0031-9422(83)83039-8.

(183) Xie, J.-X.; Yuan, A.-X. The Structure of Iso-Chuanliansu Isolated from Chinese Medicine--the Bark of *Melia*. *Yao xue xue bao= Acta Pharm. Sin.* **1985**, *20* (3), 188–192.

(184) Ahn, J.-W.; Choi, S.-U.; Lee, C.-O. Cytotoxic Limonoids from *Melia azedarach* Var. Japonica. *Phytochemistry* **1994**, *36* (6), 1493–1496. https://doi.org/10.1016/S0031-9422(00)89749-6.

(185) Nakatani, M.; James, J. C.; Nakanishi, K. Isolation and Structures of Trichilins, Antifeedants against the Southern Army Worm. *J. Am. Chem. Soc.* **1981**, *103* (5), 1228–1230. https://doi.org/10.1021/ja00395a046.

(186) Fukuyama, Y.; Nakaoka, M.; Yamamoto, T.; Takahashi, H.; Minami, H. Degraded and Oxetane-Bearing Limonoids from the Roots of *Melia azedarach*. *Chem. Pharm. Bull. (Tokyo).* **2006**, *54* (8), 1219–1222. https://doi.org/10.1248/cpb.54.1219.

(187) Huang, R. C.; Okamura, H.; Iwagawa, T.; Nakatani, M. The Structures of Azedarachins, Limonoid Antifeedants from Chinese *Melia azedarach* Linn. *Bull. Chem. Soc. Jpn.* **1994**, *67* (9), 2468–2472. https://doi.org/10.1246/bcsj.67.2468.

(188) Akihisa, T.; Pan, X.; Nakamura, Y.; Kikuchi, T.; Takahashi, N.; Matsumoto, M.; Ogihara, E.; Fukatsu, M.; Koike, K.; Tokuda, H. Limonoids from the Fruits of *Melia azedarach* and Their Cytotoxic Activities. *Phytochemistry* **2013**, *89*, 59–70. https://doi.org/10.1016/j.phytochem.2013.01.015.

(189) Liu, S. B.; Mei, W. L.; Chen, H. Q.; Wang, J.; Wang, Z. N.; Dai, H. F. Limonoids from the Roots of *Trichilia sinensis* and Their Cytotoxicities. *Arch. Pharm. Res.* **2018**, *41* (12), 1170–1177. https://doi.org/10.1007/s12272-017-0915-0.

(190) Liu, H. B.; Zhang, C. R.; Dong, S. H.; Dong, L.; Wu, Y.; Yue, J. M. Limonoids and Triterpenoids from the Seeds of *Melia azedarach*. *Chem. Pharm. Bull.* **2011**, *59* (8), 1003–1007. https://doi.org/10.1248/cpb.59.1003.

(191) Qiu, L.; Heng, L.; Xu, R.; Luo, J.; Li, Y. Two New Nimbolinin- and Trichilin-Class Limonoids Isolated from the Fruits of *Melia azedarach*. *Chin. J. Nat. Med.* **2019**, *17* (3), 227–230. https://doi.org/10.1016/S1875-5364(19)30025-1.

(192) Park, S. J.; Nhiem, N. X.; Subedi, L.; Oh, I.; Kim, J. Y.; Kim, S. Y.; Kim, S. H. Isolation of Bioactive Limonoids from the Fruits of *Melia azedarach*. *J. Asian Nat. Prod. Res.* **2020**, *22* (9), 830–838. https://doi.org/10.1080/10286020.2019.1666826.

(193) Mohamad, K.; Hirasawa, Y.; Litaudon, M.; Awang, K.; Hadi, A. H. A.; Takeya, K.; Ekasari, W.; Widyawaruyanti, A.; Zaini, N. C.; Morita, H. Ceramicines B–D, New Antiplasmodial Limonoids from *Chisocheton ceramicus*. *Bioorg. Med. Chem.* **2009**, *17* (2), 727–730. https://doi.org/10.1016/j.bmc.2008.11.048.

(194) Rogers, L. L.; Zeng, L.; Kozlowski, J. F.; Shimada, H.; Alali, F. Q.; Johnson, H. A.; McLaughlin, J. L. New Bioactive Triterpenoids from *Melia volkensii*. *J. Nat. Prod.* **1998**, *61* (1), 64–70. https://doi.org/10.1021/np9704009.

(195) Zhang, Q.; Shi, Y.; Liu, X. T.; Liang, J. Y.; Ip, N. Y.; Min, Z. Da. Minor Limonoids from *Melia toosendan* and Their Antibacterial Activity. *Planta Med.* **2007**, *73* (12), 1298–1303. https://doi.org/10.1055/s-2007-981618.

(196) Mitra, C. R.; Garg, H. S.; Pandey, G. N. Constituents of - II Nimbidic Acid and Nimbidinin. *Tetrahedron Lett.* **1970**, *11* (32), 2761–2764. https://doi.org/10.1016/S0040-4039(01)98335-2.

(197) Rojatkar, S. R.; Bhat, V. S.; Kulkarni, M. M.; Joshi, V. S.; Nagasampagi, B. A. Tetranortriterpenoids From *Azadirachta indica*. *Phytochemistry* **1989**, *28* (1), 203–205. https://doi.org/10.1016/0031-9422(89)85038-1.

(198) Tontsa, A. T.; Mkounga, P.; Njayou, F. N.; Manautou, J.; Kirk, M.; Hultin, P. G.; Nkengfack, A. E. Rubescins A, B and C: New Havanensin Type Limonoids from Root Bark of *Trichilia rubescens* (Meliaceae). *Chem. Pharm. Bull.* **2013**, *61* (11), 1178–1183. https://doi.org/10.1248/cpb.c13-00506.

(199) Wong, C. P.; Shimada, M.; Nagakura, Y.; Nugroho, A. E.; Hirasawa, Y.; Kaneda, T.; Awang, K.; Hadi, A. H. A.; Mohamad, K.; Shiro, M.; Morita, H. Ceramicines E-I, New Limonoids from *Chisocheton ceramicus*. *Chem. Pharm. Bull.* **2011**, *59* (3), 407–411. https://doi.org/10.1248/cpb.59.407.

(200) Ge, Y. H.; Liu, K. X.; Zhang, J. X.; Mu, S. Z.; Hao, X. J. The Limonoids and Their Antitobacco Mosaic Virus (TMV) Activities from *Munronia unifoliolata* Oliv. *J. Agric. Food Chem.* **2012**, *60* (17), 4289–4295. https://doi.org/10.1021/jf205362d.

(201) Nugroho, A. E.; Hashimoto, A.; Wong, C.-P.; Yokoe, H.; Tsubuki, M.; Kaneda, T.; Hadi, A. H. A.; Morita, H. Ceramicines M–P from *Chisocheton ceramicus*: Isolation and Structure–Activity Relationship Study. *J. Nat. Med.* **2018**, *72* (1), 64–72. https://doi.org/10.1007/s11418-017-1109-2.

(202) Ji, K. L.; Li, X. N.; Liao, S. G.; Hu, H. Bin; Li, R.; Xu, Y. K. Cytotoxic Limonoids from the Leaves of *Walsura robusta*. *Phytochem. Lett.* **2016**, *15*, 53–56. https://doi.org/10.1016/j.phytol.2015.11.004.

(203) Ning, J.; Di, Y. T.; Fang, X.; He, H. P.; Wang, Y. Y.; Li, Y.; Li, S. L.; Hao, X. J. Limonoids from the Leaves of *Cipadessa baccifera*. *J. Nat. Prod.* **2010**, *73* (8), 1327–1331. https://doi.org/10.1021/np900852d.

(204) Wong, C. P.; Shimada, M.; Nugroho, A. E.; Hirasawa, Y.; Kaneda, T.; Hadi, A. H. A.; Osamu, S.; Morita, H. Ceramicines J-L, New Limonoids from *Chisocheton ceramicus*. *J. Nat. Med.* **2012**, *66* (3), 566–570. https://doi.org/10.1007/s11418-011-0616-9.

(205) Li, S.; Li, Y.; Xu, R.; Kong, L.-Y.; Luo, J. New Meliacarpin-Type (C-Seco) and C-Ring Intact Limonoids from the Fruits of *Melia toosendan*. *Fitoterapia* **2020**, *144*, 104605. https://doi.org/10.1016/j.fitote.2020.104605.

(206) T. Armelle, T.; K. Pamela, N.; Pierre, M.; B. Müller, I.; Marat, K.; Sass, G.; A. Ephrem, N. Antiplasmodial Limonoids from *Trichilia rubescens* (Meliaceae). *Med. Chem. (Los. Angeles).* **2016**, *12* (7), 655–661. https://doi.org/10.2174/1573406412666160106154357.

(207) Tsamo, A. T.; Pagna, J. I. M.; Nangmo, P. K.; Mkounga, P.; Laatsch, H.; Nkengfack, A. E. Rubescins F-H, New Vilasinin-Type Limonoids from the Leaves of *Trichilia rubescens* (Meliaceae). *Zeitschrift fur Naturforsch. - Sect. C J. Biosci.* **2019**. https://doi.org/10.1515/znc-2018-0187.

(208) Supriatno; Nurlelasari; Herlina, T.; Harneti, D.; Maharani, R.; Hidayat, A. T.; Mayanti, T.; Supratman, U.; Azmi, M. N.; Shiono, Y. A New Limonoid from Stem Bark of *Chisocheton pentandrus* (Meliaceae). *Nat. Prod. Res.* **2018**, *32* (21), 2610–2616. https://doi.org/10.1080/14786419.2018.1428600.

(209) Tsamo, A. T.; Melong, R.; Mkounga, P.; Nkengfack, A. E. Rubescins I and J, Further Limonoid Derivatives from the Stem Bark of *Trichilia rubescens* (Meliaceae). *Nat. Prod. Res.* **2019**, *33* (2), 196–203. https://doi.org/10.1080/14786419.2018.1443087.

(210) Trinh, B. T. D.; Nguyen, H. D.; Nguyen, H. T.; Pham, P. D.; Ngo, N. T. N.; Nguyen, L. T. T.; Nguyen, L. T. T.; Bui, D. N.; Dang, S. V.; Nguyen, L. H. D. Cytotoxic Limonoids from the Bark of *Walsura cochinchinensis*. *Fitoterapia* **2019**, *133* (November 2018), 75–79. https://doi.org/10.1016/j.fitote.2018.11.008.

(211) Kraus, W.; Kypke, K. Surenone and Surenin, Two Novel Tetranortriterpenoids from *Toona sureni* [Blume]

Merrill. *Tetrahedron Lett.* **1979**, *20* (29), 2715–2716. https://doi.org/10.1016/S0040-4039(01)86395-4.
(212) Foyere Ayafor, J.; Kimbu, S. F.; Ngadjui, B. T.; Akam, T. M.; Dongo, E.; Sondengam, B. L.; Connolly, J. D.; Rycroft, D. S. Limonoids from *Carapa grandiflora* (Meliaceae). *Tetrahedron* **1994**, *50* (31), 9343–9354. https://doi.org/10.1016/S0040-4020(01)85511-3.
(213) Musza, L.; Killar, L. M.; Speight, P.; Barrow, C. J.; Gillum, A. M.; Cooper, R. Minor Limonoids from *Trichilia rubra*. *Phytochemistry* **1995**, *39* (3), 621–624. https://doi.org/10.1016/0031-9422(94)00959-W.
(214) Hu, J.; Song, Y.; Mao, X.; Wang, Z.-J. J.; Zhao, Q.-J. J. Limonoids Isolated from *Toona sinensis* and Their Radical Scavenging, Anti-Inflammatory and Cytotoxic Activities. *J. Funct. Foods* **2016**, *20*, 1–9. https://doi.org/10.1016/j.jff.2015.10.009.
(215) Lin, B. D.; Chen, H. D.; Liu, J.; Zhang, S.; Wu, Y.; Dong, L.; Yue, J. M. Mulavanins A-E: Limonoids from *Munronia delavayi*. *Phytochemistry* **2010**, *71* (13), 1596–1601. https://doi.org/10.1016/j.phytochem.2010.06.010.
(216) Dong, X. J.; Zhu, Y. F.; Bao, G. H.; Hu, F. L.; Qin, G. W. New Limonoids and a Dihydrobenzofuran Norlignan from the Roots of *Toona sinensis*. *Molecules* **2013**, *18* (3), 2840–2850. https://doi.org/10.3390/molecules18032840.
(217) Wang, J. S.; Zhang, Y.; Wang, X. B.; Kong, L. Y. Aphanalides A-H, Ring A-Seco Limonoids from the Fruits of *Aphanamixis polystachya*. *Tetrahedron* **2012**, *68* (21), 3963–3971. https://doi.org/10.1016/j.tet.2012.03.083.
(218) Tong, L.; Zhang, Y.; He, H.; Hao, X. Four New Limonoids from *Aphanamixis grandifolia*. *Chinese J. Chem.* **2012**, *30* (6), 1261–1264. https://doi.org/10.1002/cjoc.201200309.
(219) Shi, Q.-Q.; Zhang, X.-J.; Zhang, Y.; Wang, Q.; Amin, M.; Li, Q.; Wu, X.-W.; Li, X.-L.; Zhang, R.-H.; Dai, X.-C.; Xiao, W.-L. Toonaolides A–X, Limonoids from *Toona ciliata*: Isolation, Structural Elucidation, and Bioactivity against NLRP3 Inflammasome. *Bioorg. Chem.* **2020**, *105*, 104363. https://doi.org/10.1016/j.bioorg.2020.104363.
(220) MacLachlan, L. K.; Taylor, D. A. H. Limonoids from *Nymania capensis*. *Phytochemistry* **1982**, *21* (7), 1701–1703. https://doi.org/10.1016/S0031-9422(82)85043-7.
(221) An, F. L.; Sun, D. M.; Li, R. J.; Zhou, M. M.; Yang, M. H.; Yin, Y.; Kong, L. Y.; Luo, J. Walrobsins A and B, Two Anti-Inflammatory Limonoids from Root Barks of *Walsura robusta*. *Org. Lett.* **2017**, *19* (17), 4568–4571. https://doi.org/10.1021/acs.orglett.7b02173.
(222) Hutagaol, R. P.; Harneti, D.; Safari, A.; Hidayat, A. T.; Supratman, U.; Awang, K.; Shiono, Y. Cytotoxic Triterpenoids from the Stem Bark of *Aglaia angustifolia*. *J. Asian Nat. Prod. Res.* **2020**, 1–8. https://doi.org/10.1080/10286020.2020.1776704.
(223) Liao, S.-G.; Yang, S.-P.; Yuan, T.; Zhang, C.-R.; Chen, H.-D.; Wu, Y.; Xu, Y.-K.; Yue, J.-M. Limonoids from the Leaves and Stems of *Toona ciliata*. *J. Nat. Prod.* **2007**, *70* (8), 1268–1273. https://doi.org/10.1021/np070146c.
(224) McFarland, K.; Mulholland, D. A.; Fraser, L.-A. Limonoids from *Turraea floribunda* (Meliaceae). *Phytochemistry* **2004**, *65* (14), 2031–2037. https://doi.org/10.1016/j.phytochem.2004.06.019.
(225) Wang, X.-N.; Yin, S.; Fan, C.-Q.; Lin, L.-P.; Ding, J.; Yue, J.-M. Eight New Limonoids from *Turraea pubescens*. *Tetrahedron* **2007**, *63* (34), 8234–8241. https://doi.org/10.1016/j.tet.2007.05.107.
(226) Wang, X.-N.; Yin, S.; Fan, C.-Q.; Wang, F.-D.; Lin, L.-P.; Ding, J.; Yue, J.-M. Turrapubesins A and B, First Examples of Halogenated and Maleimide-Bearing Limonoids in Nature from *Turraea pubescens*. *Org. Lett.* **2006**, *8* (17), 3845–3848. https://doi.org/10.1021/ol061466a.
(227) Liu, J.; Yang, S. P.; Su, Z. S.; Lin, B. D.; Wu, Y.; Yue, J. M. Limonoids from the Stems of *Toona ciliata* Var. Henryi (Meliaceae). *Phytochemistry* **2011**, *72* (17), 2189–2196. https://doi.org/10.1016/j.phytochem.2011.08.005.
(228) Zhang, F.; Liao, S. G.; Zhang, C. R.; He, X. F.; Chen, W. S.; Yue, J. M. Limonoids and Diterpenoids from *Toona ciliata* Roem.Var. Yunnanensis. *Planta Med.* **2011**, *77* (14), 1617–1622. https://doi.org/10.1055/s-0030-1270969.
(229) Yang, M. S.; Hu, S. M.; Kong, L. Y.; Luo, J. B-Seco-29-nor-Limonoids from the Stem Barks of *Toona ciliata* Var. Yunnanensis. *Tetrahedron* **2015**, *71* (44), 8472–8477. https://doi.org/10.1016/j.tet.2015.09.025.
(230) Liu, C. P.; Wang, G. C.; Gan, L. S.; Xu, C. H.; Liu, Q. F.; Ding, J.; Yue, J. M. Ciliatonoids A and B, Two Limonoids from *Toona ciliata*. *Org. Lett.* **2016**, *18* (12), 2894–2897. https://doi.org/10.1021/acs.orglett.6b01213.
(231) Luo, J.; Huang, W. S.; Hu, S. M.; Zhang, P. P.; Zhou, X. W.; Wang, X. B.; Yang, M. H.; Luo, J. G.; Wang, C.; Liu, C.; Yao, H. Q.; Zhang, C.; Sun, H. Bin; Chen, Y. J.; Kong, L. Y. Rearranged Limonoids with Unique 6/5/6/5 Tetracarbocyclic Skeletons from: *Toona ciliata* and Biomimetic Structure Divergence. *Org.*

Chem. Front. **2017**, *4* (12), 2417–2421. https://doi.org/10.1039/c7qo00678k.
(232) Bu, Y.; Zhang, P.; Li, Y.; Tang, P.; Zhang, W.; Luo, J.; Kong, L. B-Seco Limonoids from the Bark of *Toona ciliata*. *Phytochem. Lett.* **2020**, *40*, 63–66. https://doi.org/10.1016/j.phytol.2020.09.004.
(233) Klenk, A.; Bokel, M.; Kraus, W. 3-Tigloylazadirachtol (Tigloyl = 2-Methylcrotonoyl), an Insect Growth Regulating Constituent of *Azadirachta indica*. *J. Chem. Soc. Chem. Commun.* **1986**, No. 7, 523. https://doi.org/10.1039/c39860000523.
(234) Kumar, C. S. S. R.; Srinivas, M.; Yakkundi, S. Limonoids from the Seeds of *Azadirachta indica*. *Phytochemistry* **1996**, *43* (2), 451–455. https://doi.org/10.1016/0031-9422(96)00226-9.
(235) Takeya, K.; Qiao, Z.-S.; Hirobe, C.; Itokawa, H. Cytotoxic Azadirachtin-Type Limonoids from *Melia azedarach*. *Phytochemistry* **1996**, *42* (3), 709–712. https://doi.org/10.1016/0031-9422(96)00044-1.
(236) Kanokmedhakul, S.; Kanokmedhakul, K.; Prajuabsuk, T.; Panichajakul, S.; Panyamee, P.; Prabpai, S.; Kongsaeree, P. Azadirachtin Derivatives from Seed Kernels of *Azadirachta excelsa*. *J. Nat. Prod.* **2005**, *68* (7), 1047–1050. https://doi.org/10.1021/np050064t.
(237) Bohnenstengel, F. .; Wray, V.; Witte, L.; Srivastava, R. .; Proksch, P. Insecticidal Meliacarpins (C-Seco Limonoids) from *Melia azedarach*. *Phytochemistry* **1999**, *50* (6), 977–982. https://doi.org/10.1016/S0031-9422(98)00644-X.
(238) Hu, Y.; Heng, L.; Xu, R.; Li, J.; Wei, S.; Xu, D.; Luo, J.; Li, Y. Meliacarpinin-Type Limonoids from the Bark of *Melia toosendan*. *Molecules* **2018**, *23* (10), 1–7. https://doi.org/10.3390/molecules23102590.
(239) Su, S.; Cheng, J.; Zhang, C.; Akihisa, T.; Xu, J.; Zhu, W.; Liu, W.; Kikuchi, T.; Feng, F.; Zhang, J. Melanogenesis-Inhibitory Activities of Limonoids and Tricyclic Diterpenoids from *Azadirachta indica*. *Bioorg. Chem.* **2020**, *100*, 103941. https://doi.org/10.1016/j.bioorg.2020.103941.
(240) Cui, B.; Chai, H.; Constant, H. L.; Santisuk, T.; Reutrakul, V.; Beecher, C. W. W.; Farnsworth, N. R.; Cordell, G. A.; Pezzuto, J. M.; Kinghorn, A. D. Limonoids from *Azadirachta excelsa*. *Phytochemistry* **1998**, *47* (7), 1283–1287. https://doi.org/10.1016/S0031-9422(97)00711-5.
(241) Pan, X.; Matsumoto, M.; Nakamura, Y.; Kikuchi, T.; Zhang, J.; Ukiya, M.; Suzuki, T.; Koike, K.; Akihisa, R.; Akihisa, T. Three New and Other Limonoids from the Hexane Extract of *Melia azedarach* Fruits and Their Cytotoxic Activities. *Chem. Biodivers.* **2014**, *11* (7), 987–1000. https://doi.org/10.1002/cbdv.201400052.
(242) Chen, L.; Zhang, J. X.; Wang, B.; Mu, S. Z.; Hao, X. J. Triterpenoids with Anti-Tobacco Mosaic Virus Activities from *Melia toosendan*. *Fitoterapia* **2014**, *97*, 204–210. https://doi.org/10.1016/j.fitote.2014.06.010.
(243) Pan, X.; Matsumoto, M.; Nishimoto, Y.; Ogihara, E.; Zhang, J.; Ukiya, M.; Tokuda, H.; Koike, K.; Akihisa, M.; Akihisa, T. Cytotoxic and Nitric Oxide Production-Inhibitory Activities of Limonoids and Other Compounds from the Leaves and Bark of *Melia azedarach*. *Chem. Biodivers.* **2014**, *11* (8), 1121–1139. https://doi.org/10.1002/cbdv.201400190.
(244) Takagi, M.; Tachi, Y.; Zhang, J.; Shinozaki, T.; Ishii, K.; Kikuchi, T.; Ukiya, M.; Banno, N.; Tokuda, H.; Akihisa, T.; Mio Takagi, Yosuke Tachi, Jie Zhang, Takuro Shinozaki, Kenta Ishii, Takashi Kikuchi, Motohiko Ukiya, Norihiro Banno, Harukuni Tokuda, T. A. Cytotoxic and Melanogenesis-Inhibitory Activities of Limonoids from the Leaves of *Azadirachta indica* (Neem). *Chem. Biodivers.* **2014**, *11* (3), 451–468. https://doi.org/10.1002/cbdv.201300348.
(245) Kato-Noguchi, H.; Salam, M. A.; Ohno, O.; Suenaga, K. Nimbolide B and Nimbic Acid B, Phytotoxic Substances in Neem Leaves with Allelopathic Activity. *Molecules* **2014**, *19* (6), 6929–6940. https://doi.org/10.3390/molecules19066929.
(246) Zhang, Q.; Liang, J. Y.; Li, Q. S.; Da Min, Z. New Limonoids from the Fruits of *Melia toosendan*. *Chinese Chem. Lett.* **2010**, *21* (7), 838–841. https://doi.org/10.1016/j.cclet.2010.02.018.
(247) Tada, K. Limonoids from Fruit of *Melia toosendan* and Their Cytotoxic Activity. *Phytochemistry* **1999**, *51* (6), 787–791. https://doi.org/10.1016/S0031-9422(99)00115-6.
(248) Nakatani, M.; Fukuman, Y.; Sakumoto, T. Nimbolinins, C-Seco Limonoids from the Fruits of *Melia toosendan*. *Heterocycles* **2000**, *53* (3), 689–695.
(249) Zhou, H.; Hamazaki, A.; Fontana, J. D.; Takahashi, H.; Wandscheer, C. B.; Fukuyama, Y. Cytotoxic Limonoids from Brazilian *Melia azedarach*. *Chem. Pharm. Bull.* **2005**, *53* (10), 1362–1365. https://doi.org/10.1248/cpb.53.1362.
(250) Srivastava, S. D.; Srivastava, S. K. ChemInform Abstract: Insect Antifeedant Novel Limonoids from the Roots of *Melia azedarach*. *ChemInform* **2010**, *28* (39), no-no. https://doi.org/10.1002/chin.199739257.
(251) Kraus, W.; Bokel, M. New Tetranortriterpenoids from *Melia azedarach* Linn.(Meliaceae). *Chem. Informationsd.* **1981**, *12* (15).

(252) Zhang, Q.; Zheng, Q. H.; Liang, J. Y.; Li, Q. S.; Min, Z. Da. Two New Limonoids Isolated from the Fruits of *Melia toosendan*. *Chin. J. Nat. Med.* **2016**, *14* (9), 692–696. https://doi.org/10.1016/S1875-5364(16)30082-6.
(253) Zhang, Q.; Zheng, Q. H.; Sang, Y. S.; Sung, H. H. Y.; Min, Z. Da. New Limonoids Isolated from the Bark of *Melia toosendan*. *Chin. J. Nat. Med.* **2018**, *16* (12), 946–950. https://doi.org/10.1016/S1875-5364(18)30136-5.
(254) Zhang, Q.; Zhang, Y. G.; Li, Q. S.; Min, Z. Da. Two New Nimbolinin-Type Limonoids from the Fruits of *Melia toosendan*. *Helv. Chim. Acta* **2016**, *99* (6), 462–465. https://doi.org/10.1002/hlca.201500516.
(255) Su, S.; Shen, L.; Zhang, Y.; Liu, J.; Cai, J.; Hao, L.; Feng, Y.; Yang, S. Characterization of Tautomeric Limonoids from the Fruits of *Melia toosendan*. *Phytochem. Lett.* **2013**, *6* (3), 418–424. https://doi.org/10.1016/j.phytol.2013.05.006.
(256) Jin, Q.; Lee, C.; Woo Lee, J.; Yeon Choi, J.; Tae Hong, J.; Kim, Y.; Kyeong Lee, M.; Yeon Hwang, B. Two New C - Seco Limonoids from the Fruit of *Melia azedarach*. *Helv. Chim. Acta* **2014**, *97* (8), 1152–1157. https://doi.org/10.1002/hlca.201400045.
(257) Gao, Q.; Sun, J.; Xun, H.; Yao, X.; Wang, J.; Tang, F. A New *Azadirachta* from the Crude Extracts of Neem (*Azadirachta indica* A. Juss) Seeds. *Nat. Prod. Res.* **2017**, *31* (15), 1739–1746. https://doi.org/10.1080/14786419.2017.1290616.
(258) Fukuyama, Y.; Miura, I.; Ochi, M. Bitter Limonoids from the Fruit of *Melia azedarach* L. Var. Japonica Makino. *Bull. Chem. Soc. Jpn.* **1983**, *56* (4), 1139–1142. https://doi.org/10.1246/bcsj.56.1139.
(259) Xie, F.; Zhang, C. F.; Zhang, M.; Wang, Z. T.; Yu, B. Y. Two New Limonoids from *Melia toosendan*. *Chinese Chem. Lett.* **2008**, *19* (2), 183–186. https://doi.org/10.1016/j.cclet.2007.12.004.
(260) Nugroho, A. E.; Okuda, M.; Yamamoto, Y.; Hirasawa, Y.; Wong, C. P.; Kaneda, T.; Shirota, O.; Hadi, A. H. A.; Morita, H. Walsogynes B-G, Limonoids from *Walsura chrysogyne*. *Tetrahedron* **2013**, *69* (20), 4139–4145. https://doi.org/10.1016/j.tet.2013.02.095.
(261) Taylor, D. A. H. The Structure of an Extractive from *Khaya ivorensis*. *Phytochemistry* **1977**, *16* (11), 1847–1849. https://doi.org/10.1016/0031-9422(71)85116-6.
(262) Inoue, T.; Ohmori, S.; Kikuchi, T.; Yamada, T.; Tanaka, R. Carapanosins A–C from Seeds of Andiroba (*Carapa guianensis*, Meliaceae) and Their Effects on LPS-Activated NO Production. *Molecules* **2017**, *22*, 502. https://doi.org/10.3390/molecules23071778.
(263) Tanaka, Y.; Yamada, T.; In, Y.; Muraoka, O.; Kajimoto, T.; Tanaka, R. Absolute Stereostructure of Andirolides A-G from the Flower of *Carapa guianensis* (Meliaceae). *Tetrahedron* **2011**, *67* (4), 782–792. https://doi.org/10.1016/j.tet.2010.11.028.
(264) Tanaka, Y.; Sakamoto, A.; Inoue, T.; Yamada, T.; Kikuchi, T.; Kajimoto, T.; Muraoka, O.; Sato, A.; Wataya, Y.; Kim, H. S.; Tanaka, R. Andirolides H-P from the Flower of Andiroba (*Carapa guianensis*, Meliaceae). *Tetrahedron* **2012**, *68* (18), 3669–3677. https://doi.org/10.1016/j.tet.2011.12.076.
(265) Nsiama, T. K.; Okamura, H.; Hamada, T.; Morimoto, Y.; Doe, M.; Iwagawa, T.; Nakatani, M. Rings D-Seco and B,D-Seco Tetranortriterpenoids from Root Bark of *Entandrophragma angolense*. *Phytochemistry* **2011**, *72* (14–15), 1854–1858. https://doi.org/10.1016/j.phytochem.2011.05.014.
(266) Matsui, Y.; Kikuchi, T.; Inoue, T.; Muraoka, O.; Yamada, T.; Tanaka, R. Carapanolides J-L from the Seeds of *Carapa guianensis* (Andiroba) and Their Effects on LPS-Activated NO Production. *Molecules* **2014**, *19* (11), 17137–17140. https://doi.org/10.3390/molecules191117130.
(267) Nangmo, K. P.; Tsamo, T. A.; Zhen, L.; Mkounga, P.; Akone, S. H.; Tsabang, N.; Müller, W. E. G.; Marat, K.; Proksch, P.; Nkengfack, A. E. Chemical Constituents from Leaves and Root Bark of *Trichilia monadelpha* (Meliaceae). *Phytochem. Lett.* **2018**, *23* (November 2017), 120–126. https://doi.org/10.1016/j.phytol.2017.11.020.
(268) Tian, X.; Li, H.; An, F.; Li, R.; Zhou, M.; Yang, M.; Kong, L.; Luo, J. New Structurally Diverse Limonoids from the Seeds of *Khaya senegalensis*. *Planta Med.* **2017**, *83* (3–4), 341–350. https://doi.org/10.1055/s-0042-117114.
(269) Li, J. H.; Li, Y.; An, F. L.; Zhou, M. M.; Luo, J.; Jian, K. L.; Luo, J.; Kong, L. Y. Limonoids with Modified Furan Rings from Root Barks of *Toona sinensis*. *Tetrahedron* **2016**, *72* (47), 7481–7487. https://doi.org/10.1016/j.tet.2016.09.061.
(270) Govindachari, T. R.; Suresh, G.; Krishna Kumari, G. N.; Rajamannar, T.; Partho, P. D. Nymania-3: A Bioactive Triterpenoid from *Dysoxylum malabaricum*. *Fitoterapia* **1999**, *70* (1), 83–86. https://doi.org/10.1016/S0367-326X(98)00036-7.
(271) Lukacova, V.; Polonsky, J.; Moretti, C.; Pettit, G. R.; Schmidt, J. M. Isolation and Structure of 14,15β-Epoxyprieurianin From the South American Tree *Guarea guidona*. *J. Nat. Prod.* **1982**, *45* (3), 288–294.

https://doi.org/10.1021/np50021a010.
(272) Gullo, V. P.; Miura, I.; Nakanishi, K.; Cameron, A. F.; Connolly, J. D.; Duncanson, F. D.; Harding, A. E.; McCrindle, R.; Taylor, D. A. H. Structure of Prieurianin, a Complex Tetranortriterpenoid; Nuclear Magnetic Resonance Analysis at Nonambient Temperatures and X-Ray Structures Determination. *J. Chem. Soc. Chem. Commun.* **1975**, No. 9, 345. https://doi.org/10.1039/c39750000345.
(273) Zhang, H.; Chen, F.; Wang, X.; Wu, D.; Chen, Q. Complete Assignments Of1H And13C NMR Data for Rings A,B-Seco Limonoids from the Seed Of *Aphanamixis polystachya*. *Magn. Reson. Chem.* **2007**, *45* (2), 189–192. https://doi.org/10.1002/mrc.1937.
(274) Luo, X.-D.; Wu, S.-H.; Wu, D.-G.; Ma, Y.-B.; Qi, S.-H. Novel Antifeeding Limonoids from *Dysoxylum hainanense*. *Tetrahedron* **2002**, *58* (39), 7797–7804. https://doi.org/10.1016/S0040-4020(02)00944-4.
(275) Zhang, Y.; Wang, J.-S.; Gu, Y.-C.; Wang, X.-B.; Kong, L.-Y. Diverse Prieurianin-Type Limonoid Derivatives from the Fruits of *Aphanamixis grandifolia* and Their Absolute Configuration Determination. *Tetrahedron* **2014**, *70* (37), 6594–6606. https://doi.org/10.1016/j.tet.2014.07.006.
(276) Brown, D. A.; Taylor, D. A. H. Limonoid Extractives from *Aphanamixis polystachya*. *Phytochemistry* **1978**, *17* (11), 1995–1999. https://doi.org/10.1016/S0031-9422(00)88750-6.
(277) Yan, Y.; Yuan, C. M.; Di, Y. T.; Huang, T.; Fan, Y. M.; Ma, Y.; Zhang, J. X.; Hao, X. J. Limonoids from *Munronia henryi* and Their Anti-Tobacco Mosaic Virus Activity. *Fitoterapia* **2015**, *107*, 29–35. https://doi.org/10.1016/j.fitote.2015.09.016.
(278) Yang, S. P.; Chen, H. D.; Liao, S. G.; Xie, B. J.; Miao, Z. H.; Yue, J. M. Aphanamolide A, a New Limonoid from *Aphanamixis polystachya*. *Org. Lett.* **2011**, *13* (1), 150–153. https://doi.org/10.1021/ol102745h.
(279) Zhang, P.; Xue, S.; Huang, W.; Wang, C.; Cui, Z.; Luo, J.; Kong, L. Diverse Prieurianin-Type Limonoids with Oxygen-Bridged Caged Skeletons from Two *Aphanamixis* Species: Discovery and Biomimetic Conversion. *Org. Chem. Front.* **2021**, *8* (3), 566–571. https://doi.org/10.1039/D0QO01331E.
(280) Zhang, Y.; Wang, J. S.; Wang, X. B.; Wei, D. D.; Luo, J. G.; Luo, J.; Yang, M. H.; Kong, L. Y. Aphapolynins A and B, Two New Limonoids from the Fruits of *Aphanamixis polystachya*. *Tetrahedron Lett.* **2011**, *52* (20), 2590–2593. https://doi.org/10.1016/j.tetlet.2011.03.047.
(281) Yu, J. H.; Wang, G. C.; Han, Y. S.; Wu, Y.; Wainberg, M. A.; Yue, J. M. Limonoids with Anti-HIV Activity from *Cipadessa cinerascens*. *J. Nat. Prod.* **2015**, *78* (6), 1243–1252. https://doi.org/10.1021/acs.jnatprod.5b00025.
(282) Cai, J. Y.; Chen, D. Z.; Luo, S. H.; Kong, N. C.; Zhang, Y.; Di, Y. T.; Zhang, Q.; Hua, J.; Jing, S. X.; Li, S. L.; Li, S. H.; Hao, X. J.; He, H. P. Limonoids from *Aphanamixis polystachya* and Their Antifeedant Activity. *J. Nat. Prod.* **2014**, *77* (3), 472–482. https://doi.org/10.1021/np400678h.
(283) Cai, J. Y.; Zhang, Y.; Luo, S. H.; Chen, D. Z.; Tang, G. H.; Yuan, C. M.; Di, Y. T.; Li, S. H.; Hao, X. J.; He, H. P. Aphanamixoid A, a Potent Defensive Limonoid, with a New Carbon Skeleton from *Aphanamixis polystachya*. *Org. Lett.* **2012**, *14* (10), 2524–2527. https://doi.org/10.1021/ol3008149.
(284) Zhang, Y.; Wang, J. S.; Wang, X. B.; Gu, Y. C.; Wei, D. D.; Guo, C.; Yang, M. H.; Kong, L. Y. Limonoids from the Fruits of *Aphanamixis polystachya* (Meliaceae) and Their Biological Activities. *J. Agric. Food Chem.* **2013**, *61* (9), 2171–2182. https://doi.org/10.1021/jf3049774.
(285) Tsamo, A.; Langat, M. K.; Nkounga, P.; Kamdem Waffo, A. F.; Nkengfack, A. E.; Mulholland, D. A. Limonoids from the West African *Trichilia welwitschii* (Meliaceae). *Biochem. Syst. Ecol.* **2013**, *50*, 368–370. https://doi.org/10.1016/j.bse.2013.04.011.
(286) Xu, J.; Ni, G.; Yang, S.; Yue, J. Dysoxylumasins A-F: Six New Limonoids from *Dysoxylum mollissimum* Bl. *Chinese J. Chem.* **2013**, *31* (1), 72–78. https://doi.org/10.1002/cjoc.201200838.
(287) Zhang, Y.; Wang, J. S.; Gu, Y. C.; Kong, L. Y. Ring A Rearranged Limonoids from the Fruits of *Aphanamixis grandifolia* and Their Cytotoxicity Evaluation. *Phytochem. Lett.* **2013**, *6* (4), 539–543. https://doi.org/10.1016/j.phytol.2013.07.003.
(288) Wang, X. B.; Zhang, Y.; Wang, J. S.; Gu, Y. C.; Kong, L. Y. Novel Ring A Rearranged Isomers with γ-Lactone from the Fruits of *Aphanamixis grandifolia*. *Tetrahedron Lett.* **2013**, *54* (45), 6023–6028. https://doi.org/10.1016/j.tetlet.2013.08.075.
(289) Mulholland, D. A.; Naidoo, N. Limonoids from *Aphanamixis polystachya*. *Phytochemistry* **1999**, *51* (7), 927–930. https://doi.org/10.1016/S0031-9422(99)00157-0.
(290) Kraus, W.; Kypke, K.; Bokel, M.; Grimminger, W.; Sawitzki, G.; Schwinger, G. Surenolactone a Novel Tetranortriterpenoid-A/B-Dilacton Aus *Toona sureni* [Blume] Merrill (Meliaceae). *Liebigs Ann. der Chemie* **1982**, *1982* (1), 87–98. https://doi.org/10.1002/jlac.198219820110.
(291) An, F. L.; Luo, J.; Wang, X. B.; Yang, M. H.; Kong, L. Y. Trichiconlides A and B: Two Novel Limonoids from the Fruits of *Trichilia connaroides*. *Org. Biomol. Chem.* **2016**, *14* (4), 1231–1235.

https://doi.org/10.1039/c5ob02300a.
(292) K. Jogia, M.; J. Andersen, R. Dysoxylin, a Limonoid from *Dysoxylum richii*. *Phytochemistry* **1987**, *26* (12), 3309–3311. https://doi.org/10.1016/S0031-9422(00)82494-2.
(293) Kipassa, N. T.; Iwagawa, T.; Okamura, H.; Doe, M.; Morimoto, Y.; Nakatani, M. Limonoids from the Stem Bark of *Cedrela odorata*. *Phytochemistry* **2008**, *69* (8), 1782–1787. https://doi.org/10.1016/j.phytochem.2007.12.015.
(294) Bennett, R. D.; Hasegawa, S. Limonoids of Calamondin Seeds. *Tetrahedron* **1981**, *37* (1), 17–24. https://doi.org/10.1016/S0040-4020(01)97708-7.
(295) Xia, H. M.; Li, C. J.; Yang, J. Z.; Ma, J.; Chen, X. G.; Zhang, D.; Li, L.; Zhang, D. M. A,D- Seco - Limonoids from the Stems of *Clausena emarginata*. *J. Nat. Prod.* **2014**, *77* (4), 784–791. https://doi.org/10.1021/np400797s.
(296) Liu, H. B.; Zhang, H.; Li, P.; Gao, Z. B.; Yue, J. M. Chukrasones A and B: Potential Kv1.2 Potassium Channel Blockers with New Skeletons from *Chukrasia tabularis*. *Org. Lett.* **2012**, *14* (17), 4438–4441. https://doi.org/10.1021/ol301942v.
(297) Tsukamoto, Y.; Oya, H.; Kikuchi, T.; Yamada, T.; Tanaka, R. Guianofruits C–I from Fruit Oil of Andiroba (*Carapa guianensis*, Meliaceae). *Tetrahedron* **2019**, *75* (9), 1149–1156. https://doi.org/10.1016/j.tet.2018.12.036.
(298) Sasayama, A.; Akita, K.; Oya, H.; Kikuchi, T.; In, Y.; Fujitake, M.; Yamada, T.; Tanaka, R. Guianofruits A and B from the Fruit Oil of Andiroba (*Carapa guianensis*, Meliaceae) and Their Effects on LPS-Activated NO Production. *ChemistrySelect* **2018**, *3* (22), 6056–6060. https://doi.org/10.1002/slct.201801178.
(299) Li, W.; Shen, L.; Bruhn, T.; Pedpradab, P.; Wu, J.; Bringmann, G. Trangmolins A–F with an Unprecedented Structural Plasticity of the Rings A and B: New Insight into Limonoid Biosynthesis. *Chemistry - A European Journal*. 2016, pp 11719–11727. https://doi.org/10.1002/chem.201602230.
(300) Lin, B.-D.; Yuan, T.; Zhang, C.-R.; Dong, L.; Zhang, B.; Wu, Y.; Yue, J.-M. Structurally Diverse Limonoids from the Fruits of *Swietenia mahagoni*. *J. Nat. Prod.* **2009**, *72* (12), 2084–2090. https://doi.org/10.1021/np900522h.
(301) Saewan, N.; Sutherland, J. D.; Chantrapromma, K. Antimalarial Tetranortriterpenoids from the Seeds of *Lansium domesticum* Corr. *Phytochemistry* **2006**, *67* (20), 2288–2293. https://doi.org/10.1016/j.phytochem.2006.07.005.
(302) Lavie, D.; Levy, E. C.; Zelnik, R. The Constituents of *Carapa guianensis* Aubl. and Their Biogenetic Relationship. *Bioorg. Chem.* **1972**, *2* (1), 59–64. https://doi.org/10.1016/0045-2068(73)90007-2.
(303) Ekong, D. E. U.; Olagbemi, E. O. West African Timbers. Part XVII. Correlation of Gedunin, Methyl Angolensate, and Andirobin. *J. Chem. Soc. C Org.* **1966**, 944. https://doi.org/10.1039/j39660000944.
(304) Wu, J.; Yang, S.-X.; Li, M.-Y.; Feng, G.; Pan, J.-Y.; Xiao, Q.; Sinkkonen, J.; Satyanandamurty, T. Limonoids and Tirucallane Derivatives from the Seeds of a Krishna Mangrove, *Xylocarpus moluccensis*. *J. Nat. Prod.* **2010**, *73* (4), 644–649. https://doi.org/10.1021/np900823c.
(305) Fang, X.; Zhang, Q.; Tan, C.-J.; Mu, S.-Z.; Lű, Y.; Lu, Y.-B.; Zheng, Q.-T.; Di, Y.-T.; Hao, X.-J. Cipadonoids B–G, Six New Limonoids from *Cipadessa cinerascens*. *Tetrahedron* **2009**, *65* (36), 7408–7414. https://doi.org/10.1016/j.tet.2009.07.023.
(306) Zhou, M.-M.; Zhang, W.-Y.; Li, R.-J.; Guo, C.; Wei, S.-S.; Tian, X.-M.; Luo, J.; Kong, L.-Y. Anti-Inflammatory Activity of Khayandirobilide A from *Khaya senegalensis* via NF-KB, AP-1 and P38 MAPK/Nrf2/HO-1 Signaling Pathways in Lipopolysaccharide-Stimulated RAW 264.7 and BV-2 Cells. *Phytomedicine* **2018**, *42*, 152–163. https://doi.org/10.1016/j.phymed.2018.03.016.
(307) Siva, B.; Venkanna, A.; Poornima, B.; Divya Reddy, S.; Boustie, J.; Bastien, S.; Jain, N.; Usha Rani, P.; Suresh Babu, K. New Seco-Limonoids from *Cipadessa baccifera*: Isolation, Structure Determination, Synthesis and Their Antiproliferative Activities. *Fitoterapia* **2017**, *117*, 34–40. https://doi.org/10.1016/j.fitote.2017.01.003.
(308) Siva, B.; Poornima, B.; Venkanna, A.; Prasad, K. R.; Sridhar, B.; Lakshma Nayak, V.; Ramakrishna, S.; Babu, K. S. Methyl Angolensate and Mexicanolide-Type Limonoids from the Seeds of *Cipadessa baccifera* Dedicated to the Memory of Our Beloved Colleague Dr. Y. Venkateswarlu. *Phytochemistry* **2014**, *98*, 174–182. https://doi.org/10.1016/j.phytochem.2013.11.006.
(309) Nagakura, Y.; Nugroho, A. E.; Hirasawa, Y.; Hosoya, T.; Rahman, A.; Kusumawati, I.; Zaini, N. C.; Morita, H. Sanjecumins A and B: New Limonoids from *Sandoricum koetjape*. *J. Nat. Med.* **2013**, *67* (2), 381–385. https://doi.org/10.1007/s11418-012-0677-4.
(310) Sakamoto, A.; Tanaka, Y.; Yamada, T.; Kikuchi, T.; Muraoka, O.; Ninomiya, K.; Morikawa, T.; Tanaka, R. Andirolides W-Y from the Flower Oil of Andiroba (*Carapa guianensis*, Meliaceae). *Fitoterapia* **2015**, *100*,

81–87. https://doi.org/10.1016/j.fitote.2014.09.003.
(311) Bu, Y.-G.; Zhang, W.-Y.; Lu, Q.-P.; Luo, J.; Kong, L.-Y. Furan Fragment Isomerized Andirobin-Type Limonoids from the Stem Barks of *Khaya senegalensis*. *J. Asian Nat. Prod. Res.* **2021**, *23* (5), 498–503. https://doi.org/10.1080/10286020.2020.1767080.
(312) Yu, J.-H.; Zhang, H.; Zhou, B.; Zimbres, F. M.; Dalal, S.; Liu, Q.-F.; Cassera, M. B.; Yue, J.-M. Limonoids from *Cipadessa baccifera*. *J. Nat. Prod.* **2020**, *83* (6), 1751–1765. https://doi.org/10.1021/acs.jnatprod.9b00666.
(313) Fu, L. R.; Ma, Q. Y.; Huang, S. Z.; Dai, H. F.; Guo, Z. K.; Yu, Z. F.; Zhao, Y. X. Terpenoids and Their Anti-Feedant Activity from *Cipadessa cinerascens*. *J. Asian Nat. Prod. Res.* **2014**, *16* (11), 1054–1059. https://doi.org/10.1080/10286020.2014.938060.
(314) Bumi, M. B.; Heliawaty, L.; Hermawati, E.; Syah, Y. M. Four Limonoids from the Seeds Extract of *Sandoricum koetjape*. *J. Nat. Med.* **2019**, *73* (3), 641–647. https://doi.org/10.1007/s11418-019-01303-w.
(315) Kadota, S.; Marpaung, L.; Kikuchi, T.; Ekimoto, H. Mahonin and Secomahoganin, New Tetranortriterpenoids from *Swietenia mahogani* (L.) JACQ. *Chem. Pharm. Bull. (Tokyo).* **1989**, *37* (5), 1419–1421. https://doi.org/10.1248/cpb.37.1419.
(316) Ma, Y. Q.; Liu, M. H.; Jiang, K.; Guo, L.; Qu, S. J.; Wan, Y. Q.; Tan, C. H. Limonoids from the Fruits of *Swietenia macrophylla* with Inhibitory Activity against H 2 O 2 -Induced Apoptosis in HUVECs. *Fitoterapia* **2018**, *129* (June), 179–184. https://doi.org/10.1016/j.fitote.2018.07.001.
(317) Ravangpai, W.; Sommit, D.; Teerawatananond, T.; Sinpranee, N.; Palaga, T.; Pengpreecha, S.; Muangsin, N.; Pudhom, K. Limonoids from Seeds of Thai *Xylocarpus moluccensis*. *Bioorganic Med. Chem. Lett.* **2011**, *21* (15), 4485–4489. https://doi.org/10.1016/j.bmcl.2011.06.010.
(318) Li, J.; Li, M.-Y.; Bruhn, T.; Zongwe Katele, F.; Xiao, Q.; Pedpradab, P.; Wu, J.; Bringmann, G. Thaixylomolins A–C: Limonoids Featuring Two New Motifs from the Thai *Xylocarpus moluccensis*. *Org. Lett.* **2013**, *15* (14), 3682–3685. https://doi.org/10.1021/ol401556m.
(319) Yu, J.; Zhou, B.; Dalal, S.; Liu, Q.; Cassera, M. B.; Yue, J. Cipaferoids A–C, Three Limonoids Represent Two Different Scaffolds from *Cipadessa baccifera*. *Chinese J. Chem.* **2018**, *36* (2), 124–128. https://doi.org/10.1002/cjoc.201700627.
(320) Neto, J. O.; Agostinho, S. M. M.; Silva, M. F. D. G. F. D.; Vieira, P. C.; Fernandes, J. B.; Pinheiro, A. L.; Vilela, E. F. Limonoids from Seeds of *Toona ciliata* and Their Chemosystematic Significance. *Phytochemistry* **1995**, *38* (2), 397–401. https://doi.org/10.1016/0031-9422(94)00568-E.
(321) Xia, J. J.; Li, X. Y.; Zhang, S. Z.; Liu, J. Q.; Zhang, W. M.; Yan, Y. X.; Ding, Z. T.; Qiu, M. H. An Unusual 9,11-Seco Limonoid from *Toona ciliata*. *Tetrahedron Lett.* **2014**, *55* (13), 2104–2106. https://doi.org/10.1016/j.tetlet.2014.02.057.
(322) Adesogan, E. K.; Taylor, D. A. H. Methyl Ivorensate, an A-Seco-Limonoid from *Khaya ivorensis*. *J. Chem. Soc. D Chem. Commun.* **1969**, No. 15, 889. https://doi.org/10.1039/c29690000889.
(323) Liu, C. P.; Xu, J. B.; Han, Y. S.; Wainberg, M. A.; Yue, J. M. Trichiconins A-C, Limonoids with New Carbon Skeletons from *Trichilia connaroides*. *Org. Lett.* **2014**, *16* (20), 5478–5481. https://doi.org/10.1021/ol5027552.
(324) Yuan, C. M.; Zhang, Y.; Tang, G. H.; Di, Y. T.; Cao, M. M.; Wang, X. Y.; Zuo, G. Y.; Li, S. L.; Hua, H. M.; He, H. P.; Hao, X. J. Khayseneganins A-H, Limonoids from *Khaya senegalensis*. *J. Nat. Prod.* **2013**, *76* (3), 327–333. https://doi.org/10.1021/np3006919.
(325) Coombes, P. H.; Mulholland, D. A.; Randrianarivelojosia, M. Mexicanolide Limonoids from the Madagascan Meliaceae *Quivisia papinae*. *Phytochemistry* **2005**, *66* (10), 1100–1107. https://doi.org/10.1016/j.phytochem.2005.03.002.
(326) Kadota, S.; Marpaung, L.; Kikuchi, T.; Ekimoto, H. Constituents of the Seeds of *Swietenia mahagoni* Jacq. I. Isolation, Structures, and 1H- and 13C-Nuclear Magnetic Resonance Signal Assignments of New Tetranortriterpenoids Related to Swietenine and Swietenolide. *Chem. Pharm. Bull.* **1990**, *38* (3), 639–651. https://doi.org/10.1248/cpb.38.639.
(327) Taylor, D. A. H. Limonoid Extractives from *Xylocarpus moluccensis*. *Phytochemistry* **1983**, *22* (5), 1297–1299. https://doi.org/10.1016/0031-9422(83)80251-9.
(328) Govindachari, T. R.; Kumari, G. N. K. Tetranortriterpenoids from *Khaya senegalensis*. *Phytochemistry* **1998**, *47* (7), 1423–1425. https://doi.org/10.1016/S0031-9422(97)00708-5.
(329) Li, M.-Y.; Yang, X.-B.; Pan, J.-Y.; Feng, G.; Xiao, Q.; Sinkkonen, J.; Satyanandamurty, T.; Wu, J. Granatumins A−G, Limonoids from the Seeds of a Krishna Mangrove, *Xylocarpus granatum*. *J. Nat. Prod.* **2009**, *72* (12), 2110–2114. https://doi.org/10.1021/np900625w.
(330) Wu, J.; Zhang, S.; Xiao, Q.; Li, Q.; Huang, J.; Long, L.; Huang, L. Xyloccensin L, a Novel Limonoid from

Xylocarpus granatum. *Tetrahedron Lett.* **2004**, *45* (3), 591–593. https://doi.org/10.1016/j.tetlet.2003.10.216.
(331) Inoue, T.; Ohmori, S.; Kikuchi, T.; Yamada, T.; Tanaka, R. Carapanosins D—F from the Seeds of Andiroba (*Carapa guianensis*, Meliaceae) and Their Effects on LPS-Activated NO Production. *Molecules* **2018**, *23* (7), 3–11. https://doi.org/10.3390/molecules23071778.
(332) Miyake, T.; Ishimoto, S.; Ishimatsu, N.; Higuchi, K.; Minoura, K.; Kikuchi, T.; Yamada, T.; Muraoka, O.; Tanaka, R. Carapanolides T-X from *Carapa guianensis* (Andiroba) Seeds. *Molecules* **2015**, *20* (11), 20955–20966. https://doi.org/10.3390/molecules201119737.
(333) Inoue, T.; Matsui, Y.; Kikuchi, T.; In, Y.; Muraoka, O.; Yamada, T.; Tanaka, R. Carapanolides C-I from the Seeds of Andiroba (*Carapa guianensis*, Meliaceae). *Fitoterapia* **2014**, *96*, 56–64. https://doi.org/10.1016/j.fitote.2014.04.006.
(334) Inoue, T.; Matsui, Y.; Kikuchi, T.; Yamada, T.; In, Y.; Muraoka, O.; Sakai, C.; Ninomiya, K.; Morikawa, T.; Tanaka, R. Carapanolides M-S from Seeds of Andiroba (*Carapa guianensis*, Meliaceae) and Triglyceride Metabolism-Promoting Activity in High Glucose-Pretreated HepG2 Cells. *Tetrahedron* **2015**, *71* (18), 2753–2760. https://doi.org/10.1016/j.tet.2015.03.017.
(335) Yi, L.; Zhang, H.; Tian, X.; Luo, J.; Luo, J.; Kong, L. Four New Limonoids from the Seeds of *Chukrasia tabularis* A. Juss. *Phytochem. Lett.* **2017**, *19*, 12–17. https://doi.org/10.1016/j.phytol.2016.11.004.
(336) Li, J.; Li, M. Y.; Feng, G.; Xiao, Q.; Sinkkonen, J.; Satyanandamurty, T.; Wu, J. Limonoids from the Seeds of a Godavari Mangrove, *Xylocarpus moluccensis*. *Phytochemistry* **2010**, *71* (16), 1917–1924. https://doi.org/10.1016/j.phytochem.2010.07.015.
(337) Shen, L.; Liao, Q.; Zhang, M.; Wu, J. Limonoids with Diverse Structures of Rings-A,B from the Thai Mangrove, *Xylocarpus moluccensis*. *Fitoterapia* **2020**, *147*, 104737. https://doi.org/10.1016/j.fitote.2020.104737.
(338) Ma, Y. Q.; Jiang, K.; Deng, Y.; Guo, L.; Wan, Y. Q.; Tan, C. H. Mexicanolide-Type Limonoids from the Seeds of *Swietenia macrophylla*. *J. Asian Nat. Prod. Res.* **2018**, *20* (4), 299–305. https://doi.org/10.1080/10286020.2017.1335715.
(339) Yang, H.; Choi, M.; Lee, D.; Sung, S. Anti-Differentiation Effect of B, D-Seco Limonoids of *Swietenia mahogani*. *Pharmacogn. Mag.* **2017**, *13* (50), 293. https://doi.org/10.4103/0973-1296.204549.
(340) Li, J.; Li, M. Y.; Feng, G.; Zhang, J.; Karonen, M.; Sinkkonen, J.; Satyanandamurty, T.; Wu, J. Moluccensins R-Y, Limonoids from the Seeds of a Mangrove, *Xylocarpus moluccensis*. *J. Nat. Prod.* **2012**, *75* (7), 1277–1283. https://doi.org/10.1021/np300053f.
(341) Liu, S. B.; Mei, W. L.; Chen, H. Q.; Guo, Z. K.; Dai, H. F.; Wang, Z. N. Mexicanolide-Type Limonoids from the Roots of *Trichilia sinensis*. *Molecules* **2016**, *21* (9), 1–8. https://doi.org/10.3390/molecules21091152.
(342) Xu, J. B.; Lin, Y.; Dong, S. H.; Wang, F.; Yue, J. M. Trichinenlides A-T, Mexicanolide-Type Limonoids from *Trichilia sinensis*. *J. Nat. Prod.* **2013**, *76* (10), 1872–1880. https://doi.org/10.1021/np400408s.
(343) Sun, D. M.; An, F. L.; Wei, S. S.; Zhang, Y. Q.; Wang, X. B.; Luo, J.; Kong, L. Y. Cipadessains A-K, Eleven Limonoids from the Fruits of: *Cipadessa cinerascens*. *RSC Adv.* **2018**, *8* (19), 10437–10445. https://doi.org/10.1039/c8ra00728d.
(344) Yang, W.; Kong, L. M.; Li, S. F.; Li, Y.; Zhang, Y.; He, H. P.; Hao, X. J. Five New Mexicanolide Type Limonoids from *Heynea trijuga*. *Nat. Products Bioprospect.* **2012**, *2* (4), 145–149. https://doi.org/10.1007/s13659-012-0040-1.
(345) Li, M. Y.; Xiao, Q.; Satyanandamurty, T.; Wu, J. Limonoids with an Oxygen Bridge between C(1) and C(29) from the Seeds of a Krishna Mangrove, *Xylocarpus granatum*. *Chem. Biodivers.* **2014**, *11* (2), 262–275. https://doi.org/10.1002/cbdv.201300057.
(346) Wang, X. Y.; Yuan, C. M.; Tang, G. H.; Zou, T.; Guo, F.; Liao, J. H.; Zhang, H. Y.; Zuo, G. Y.; Rao, G. X.; Zhao, Q.; Hao, X. J.; He, H. P. Limonoids from the Fruits of *Cipadessa cinerascens*. *J. Asian Nat. Prod. Res.* **2014**, *16* (7), 795–799. https://doi.org/10.1080/10286020.2014.920011.
(347) Abdelgaleil, S. A. M.; Doe, M.; Nakatani, M. Rings B,D-Seco Limonoid Antifeedants from *Swietenia mahogani*. *Phytochemistry* **2013**, *96*, 312–317. https://doi.org/10.1016/j.phytochem.2013.08.006.
(348) Chen, H.; Zhang, J.; Li, M. Y.; Satyanandamurty, T.; Wu, J. New Limonoids from the Seeds of a Krishna Mangrove, *Xylocarpus granatum*. *Chem. Biodivers.* **2013**, *10* (4), 612–620. https://doi.org/10.1002/cbdv.201200021.
(349) Chen, A. H.; Wen, Q.; Ma, Y. L.; Jiang, Z. H.; Liu, Q. L.; Tang, J. Y.; Xu, W.; Liu, Y. P.; Fu, Y. H. Bioactive Mexicanolide-Type Limonoids from the Fruits of *Trichilia connaroides*. *Phytochem. Lett.* **2017**, *20*, 17–21. https://doi.org/10.1016/j.phytol.2017.03.008.
(350) Henrique Miguita, C.; Chaves Sarmento, U.; Hamerski, L.; Silva Garcez, W.; Rodrigues Garcez, F.

Mexicanolide- and Andirobine-Type Limonoids from the Fruits of *Guarea kunthiana*. *Rec. Nat. Prod.* **2014**, *8* (3), 290–293.

(351) Liao, M.; Pedpradab, P.; Wu, J. Thaixylogranins A–H: Eight New Limonoids from the Thai Mangrove, *Xylocarpus granatum*. *Phytochem. Lett.* **2017**, *19*, 126–131. https://doi.org/10.1016/j.phytol.2016.12.019.

(352) Li, W.; Jiang, Z.; Shen, L.; Pedpradab, P.; Bruhn, T.; Wu, J.; Bringmann, G. Antiviral Limonoids Including Khayanolides from the Trang Mangrove Plant *Xylocarpus moluccensis*. *J. Nat. Prod.* **2015**, *78* (7), 1570–1578. https://doi.org/10.1021/acs.jnatprod.5b00151.

(353) Cheng, Y. Bin; Chien, Y. T.; Lee, J. C.; Tseng, C. K.; Wang, H. C.; Lo, I. W.; Wu, Y. H.; Wang, S. Y.; Wu, Y. C.; Chang, F. R. Limonoids from the Seeds of *Swietenia macrophylla* with Inhibitory Activity against Dengue Virus 2. *J. Nat. Prod.* **2014**, *77* (11), 2367–2374. https://doi.org/10.1021/np5002829.

(354) Ji, K. L.; Liao, S. G.; Zheng, X. L.; Na, Z.; Hu, H. Bin; Zhang, P.; Xu, Y. K. Limonoids from the Fruits of *Khaya ivorensis*. *Molecules* **2014**, *19* (3), 3004–3011. https://doi.org/10.3390/molecules19033004.

(355) Solipeta, D. R.; Bandi, S.; Katragunta, K.; Mutheneni, S. R.; Katragadda, S. B. UPLC-MS E Guided Isolation of New Antifeedant Limonoids from Fruits of *Trichilia connaroides*. *J. Agric. Food Chem.* **2020**, *68* (25), 6826–6834. https://doi.org/10.1021/acs.jafc.0c00862.

(356) Dai, Y. G.; Wu, J.; Padmakumar, K. P.; Shen, L. Sundarbanxylogranins A–E, Five New Limonoids from the Sundarban Mangrove, *Xylocarpus granatum*. *Fitoterapia* **2017**, *122* (August), 85–89. https://doi.org/10.1016/j.fitote.2017.08.013.

(357) An, F.-L.; Sun, D.-M.; Wang, R.-Z.; Yang, M.-H.; Luo, J.; Kong, L.-Y. Trijugin- and Mexicanolide-Type Limonoids from the Fruits of *Heynea trijuga* That Reverse Multidrug Resistance in MCF-7/DOX Cells. *Phytochemistry* **2018**, *151*, 42–49. https://doi.org/10.1016/j.phytochem.2018.04.004.

(358) Chen, L. C.; Liao, H. R.; Chen, P. Y.; Kuo, W. L.; Chang, T. H.; Sung, P. J.; Wen, Z. H.; Chen, J. J. Limonoids from the Seeds of *Swietenia macrophylla* and Their Anti-Inflammatory Activities. *Molecules* **2015**, *20* (10), 18551–18564. https://doi.org/10.3390/molecules201018551.

(359) Zhang, Q.; Di, Y. T.; He, H. P.; Fang, X.; Chen, D. L.; Yan, X. H.; Zhu, F.; Yang, T. Q.; Liu, L. L.; Hao, X. J. Phragmalin- and Mexicanolide-Type Limonoids from the Leaves of *Trichilia connaroides*. *J. Nat. Prod.* **2011**, *74* (2), 152–157. https://doi.org/10.1021/np100428u.

(360) Waratchareeyakul, W.; Hellemann, E.; Gil, R. R.; Chantrapromma, K.; Langat, M. K.; Mulholland, D. A. Application of Residual Dipolar Couplings and Selective Quantitative NOE to Establish the Structures of Tetranortriterpenoids from *Xylocarpus rumphii*. *J. Nat. Prod.* **2017**, *80* (2), 391–402. https://doi.org/10.1021/acs.jnatprod.6b00906.

(361) Wu, Y. B.; Wang, Y. Z.; Ni, Z. Y.; Qing, X.; Shi, Q. W.; Sauriol, F.; Vavricka, C. J.; Gu, Y. C.; Kiyota, H. Xylomexicanins i and J: Limonoids with Unusual B/C Rings from *Xylocarpus granatum*. *J. Nat. Prod.* **2017**, *80* (9), 2547–2550. https://doi.org/10.1021/acs.jnatprod.7b00305.

(362) Wang g., Fan y., Shyaula S., Y. J.; Wang, G.-C.; Fan, Y.-Y.; Shyaula, S. L.; Yue, J.-M. Triconoids A−D, Four Limonoids Possess Two Rearranged Carbon Skeletons from *Trichilia connaroides*.Pdf. *Org. Lett.* **2017**, *19* (8), 2182–2185. https://doi.org/10.1021/acs.orglett.7b00873.

(363) Sarigaputi, C.; Nuanyai, T.; Teerawatananond, T.; Pengpreecha, S.; Muangsin, N.; Pudhom, K. Xylorumphiins A-D, Mexicanolide Limonoids from the Seed Kernels of *Xylocarpus rumphii*. *J. Nat. Prod.* **2010**, *73* (8), 1456–1459. https://doi.org/10.1021/np100423w.

(364) Chong, S. L.; Hematpoor, A.; Hazni, H.; Sofian-Azirun, M.; Litaudon, M.; Supratman, U.; Murata, M.; Awang, K. Mosquito Larvicidal Limonoids from the Fruits of *Chisocheton erythrocarpus* Hiern. *Phytochem. Lett.* **2019**, *30* (January), 69–73. https://doi.org/10.1016/j.phytol.2018.12.013.

(365) Cao, D. H.; Sun, P.; Liao, S. G.; Gan, L. S.; Yang, L.; Yao, J. N.; Zhang, Z. Y.; Li, J. F.; Zheng, X. L.; Xiao, Y. D.; Xiao, C. F.; Zhang, P.; Hu, H. Bin; Xu, Y. K. Chemical Constituents from the Twigs and Leaves of *Trichilia sinensis* and Their Biological Activities. *Phytochem. Lett.* **2019**, *29* (December 2018), 142–147. https://doi.org/10.1016/j.phytol.2018.11.020.

(366) Cao, D.-H.; Liao, S.-G.; Sun, P.; Xiao, Y.-D.; Xiao, C.-F.; Hu, H.-B.; Weckwerth, W.; Xu, Y.-K. Mexicanolide-Type Limonoids from the Twigs and Leaves of *Cipadessa baccifera*. *Phytochemistry* **2020**, *177*, 112449. https://doi.org/10.1016/j.phytochem.2020.112449.

(367) Li, Y.; Lu, Q.; Luo, J.; Wang, J.; Wang, X.; Zhu, M.; Kong, L. Limonoids from the Stem Bark of *Khaya senegalensis*. *Chem. Pharm. Bull.* **2015**, *63* (4), 305–310. https://doi.org/10.1248/cpb.c14-00770.

(368) Camero, C. M.; Vassallo, A.; De Leo, M.; Temraz, A.; De Tommasi, N.; Braca, A. Limonoids from *Aphanamixis polystachya* Leaves and Their Interaction with Hsp90. *Planta Med.* **2018**, *84* (12–13), 964–970. https://doi.org/10.1055/a-0624-9538.

(369) Sarigaputi, C.; Sommit, D.; Teerawatananond, T.; Pudhom, K. Weakly Anti-Inflammatory Limonoids from

the Seeds of *Xylocarpus rumphii*. *J. Nat. Prod.* **2014**, *77* (9), 2037–2043. https://doi.org/10.1021/np5003687.

(370) Kikuchi, T.; Akita, K.; Koike, H.; In, Y.; Yamada, T.; Tanaka, R. Carapanins A–C: New Limonoids from Andiroba (*Carapa guianensis*) Fruit Oil. *Org. Biomol. Chem.* **2020**, *18* (45), 9268–9274. https://doi.org/10.1039/D0OB01872D.

(371) Heng, L.; Zhao, M.; Xu, R.; Tao, R.; Wang, C.; Zhang, L.; Bu, Y.; Luo, J.; Li, Y. Phragmalin and Mexicanolide Limonoids with Reversal of Multidrug Resistance from the Seeds of *Chukrasia tabularis* A. Juss. *Phytochemistry* **2021**, *182*, 112606. https://doi.org/10.1016/j.phytochem.2020.112606.

(372) Toume, K.; Kamiya, K.; Arai, M. A.; Mori, N.; Sadhu, S. K.; Ahmed, F.; Ishibashi, M. Xylogranin B: A Potent Wnt Signal Inhibitory Limonoid from *Xylocarpus granatum*. *Org. Lett.* **2013**, *15* (23), 6106–6109. https://doi.org/10.1021/ol4029995.

(373) Wu, Y.-B.; Ni, Z.-Y.; Huo, C.-H.; Su, J.; Dong, M.; Sauriol, F.; Shi, Q.-W.; Gu, Y.-C.; Kiyota, H. Xylomexicanins C and D, New Mexicanolide-Type Limonoids from *Xylocarpus granatum*. *Biosci. Biotechnol. Biochem.* **2013**, *77* (4), 736–740. https://doi.org/10.1271/bbb.120815.

(374) Pan, J.-Y.; Chen, S.-L.; Li, M.-Y.; Li, J.; Yang, M.-H.; Wu, J. Limonoids from the Seeds of a Hainan Mangrove, *Xylocarpus granatum*. *J. Nat. Prod.* **2010**, *73* (10), 1672–1679. https://doi.org/10.1021/np100395w.

(375) Liu, R.-X.; Liao, Q.; Shen, L.; Wu, J. Krishnagranatins A–I: New Limonoids from the Mangrove, *Xylocarpus granatum*, and NF-KB Inhibitory Activity. *Fitoterapia* **2018**, *131*, 96–104. https://doi.org/10.1016/j.fitote.2018.08.011.

(376) Ren, J. L.; Zou, X. P.; Li, W. S.; Shen, L.; Wu, J. Limonoids Containing a C$_1$–O–C 29 Moiety: Isolation, Structural Modification, and Antiviral Activity. *Mar. Drugs* **2018**, *16* (11), 1–16. https://doi.org/10.3390/md16110434.

(377) Chen, W.; Shen, L.; Li, M.; Xiao, Q.; Satyanandamurty, T.; Wu, J. Absolute Configurations of New Limonoids from a Krishna Mangrove, *Xylocarpus granatum*. *Fitoterapia* **2014**, *94*, 108–113. https://doi.org/10.1016/j.fitote.2014.02.001.

(378) Wu, Y. B.; Qing, X.; Huo, C. H.; Yan, H. M.; Shi, Q. W.; Sauriol, F.; Gu, Y. C.; Kiyota, H. Xylomexicanins E-H, New Limonoids from *Xylocarpus granatum*. *Tetrahedron* **2014**, *70* (30), 4557–4562. https://doi.org/10.1016/j.tet.2014.04.062.

(379) Shen, L.-R.; Dong, M.; Yin, B.-W.; Guo, D.; Zhang, M.-L.; Shi, Q.-W.; Huo, C.-H.; Kiyota, H.; Suzuki, N.; Cong, B. Xylomexicanins A and B, New Δ14,15-Mexicanolides from Seeds of the Chinese Mangrove *Xylocarpus granatum*. *Zeitschrift für Naturforsch. C* **2009**, *64* (1–2), 37–42. https://doi.org/10.1515/znc-2009-1-207.

(380) Yin, S.; Fan, C.-Q.; Wang, X.-N.; Lin, L.-P.; Ding, J.; Yue, J.-M. Xylogranatins A−D: Novel Tetranortriterpenoids with an Unusual 9,10-Seco Scaffold from Marine Mangrove *Xylocarpus granatum*. *Org. Lett.* **2006**, *8* (21), 4935–4938. https://doi.org/10.1021/ol062101t.

(381) Wu, J.; Zhang, S.; Bruhn, T.; Xiao, Q.; Ding, H.; Bringmann, G. Xylogranatins F–R: Antifeedants from the Chinese Mangrove,*Xylocarpus granatum*, A New Biogenetic Pathway to Tetranortriterpenoids. *Chem. - A Eur. J.* **2008**, *14* (4), 1129–1144. https://doi.org/10.1002/chem.200700663.

(382) Dai, Y. G.; Li, W. S.; Pedpradab, P.; Liu, J. J.; Wu, J.; Shen, L. Thaixylomolins O-R: Four New Limonoids from the Trang Mangrove,: *Xylocarpus moluccensis*. *RSC Adv.* **2016**, *6* (89), 85978–85984. https://doi.org/10.1039/c6ra14721f.

(383) Inoue, T.; Nagai, Y.; Mitooka, A.; Ujike, R.; Muraoka, O.; Yamada, T.; Tanaka, R. Carapanolides A and B: Unusual 9,10-Seco-Mexicanolides Having a 2R,9S-Oxygen Bridge from the Seeds of *Carapa guianensis*. *Tetrahedron Lett.* **2012**, *53* (49), 6685–6688. https://doi.org/10.1016/j.tetlet.2012.09.108.

(384) Rao, M. M.; Gupta, P. S.; Singh, P. P.; Krishna, E. M. Structure of Febrinin-A, a New Tetranortripenoid from the Heartwood of *Soymida febrifuga*. *Chem. Informationsd.* **1979**, *10* (49).

(385) Lin, B. D.; Zhang, C. R.; Yang, S. P.; Wu, Y.; Yue, J. M. Phragmalin-Type Limonoid Orthoesters from the Twigs of *Swietenia macrophylla*. *Chem. Pharm. Bull.* **2011**, *59* (4), 458–465. https://doi.org/10.1248/cpb.59.458.

(386) Wang, Y. C.; Kong, F. D.; Wang, H.; Mei, W. L.; Liu, S. B.; Zhao, Y. X.; Dai, H. F. Six New Phragmalin Limonoids from the Stems of *Chukrasia tabularis* A. Juss. *Molecules* **2018**, *23* (11). https://doi.org/10.3390/molecules23113024.

(387) Hu, Y.-L.; Tian, X.-M.; Wang, C.-C.; Olga, Q.; Yan, D.; Tang, P.-F.; Zhang, L.-N.; Luo, J.; Kong, L.-Y. Highly Oxygenated and Rearranged Limonoids from the Stem Barks of *Entandrophragma utile*. *Phytochemistry* **2020**, *172*, 112282. https://doi.org/10.1016/j.phytochem.2020.112282.

(388) Yadav, P. A.; Suresh, G.; Rao, M. S. A.; Shankaraiah, G.; Usha Rani, P.; Babu, K. S. Limonoids from the Leaves of *Soymida febrifuga* and Their Insect Antifeedant Activities. *Bioorganic Med. Chem. Lett.* **2014**, *24* (3), 888–892. https://doi.org/10.1016/j.bmcl.2013.12.077.

(389) Luo, J.; Li, Y.; Wang, J. S.; Kong, L. Y. Two New C-15 Enolic Acyl Phragmalin-Type Limonoids from *Chukrasia tabularis* Var. Velutina. *Nat. Prod. Res.* **2013**, *27* (7), 597–602. https://doi.org/10.1080/14786419.2012.682995.

(390) Zhang, F.; Zhang, C. R.; Tao, X.; Wang, J.; Chen, W. S.; Yue, J. M. Phragmalin-Type Limonoids with NF-KB Inhibition from *Chukrasia tabularis* Var. Velutina. *Bioorganic Med. Chem. Lett.* **2014**, *24* (16), 3791–3796. https://doi.org/10.1016/j.bmcl.2014.06.069.

(391) Liu, H. B.; Zhang, H.; Li, P.; Wu, Y.; Gao, Z. B.; Yue, J. M. Kv1.2 Potassium Channel Inhibitors from *Chukrasia tabularis*. *Org. Biomol. Chem.* **2012**, *10* (7), 1448–1458. https://doi.org/10.1039/c1ob06666h.

(392) Ashok Yadav, P.; Suresh, G.; Rajendra Prasad, K.; Suri Appa Rao, M.; Suresh Babu, K. New Phragmalin-Type Limonoids from *Soymida febrifuga*. *Tetrahedron Lett.* **2012**, *53* (7), 773–777. https://doi.org/10.1016/j.tetlet.2011.11.143.

(393) Wang, C.; Li, Y.; Xu, R.; Zhang, P.; Zhang, W.; Wei, S.; Li, Y.; Luo, J.; Kong, L. Phragmalin-Type Limonoids with Structural Diversity at D-Ring from the Fruit Shells of *Chukrasia tabularis*. *Fitoterapia* **2019**, *134* (February), 188–195. https://doi.org/10.1016/j.fitote.2019.02.032.

(394) Liu, W.-X.; Chen, D.-Z.; Ding, J.-Y.; Hao, X.-J.; Li, S.-L. New Phragmalin-Type Limonoid Orthoesters from the Bark of *Chukrasia tabularis* Var. Velutina. *Helv. Chim. Acta* **2015**, *98* (10), 1403–1410. https://doi.org/10.1002/hlca.201400267.

(395) Luo, J.; Li, Y.; Wang, J. S.; Lu, J.; Wang, X. B.; Luo, J. G.; Kong, L. Y. Twelve Novel and Diverse 16-Norphragmalin-Type Limonoids from *Chukrasia tabularis* Var. Velutina. *Chem. Pharm. Bull.* **2012**, *60* (2), 195–204. https://doi.org/10.1248/cpb.60.195.

(396) Quasie, O.; Li, H.; Luo, J.; Kong, L. Y. Two New Phragmalin-Type Limonoids Orthoesters from *Entandrophragma candollei*. *Chin. J. Nat. Med.* **2017**, *15* (9), 680–683. https://doi.org/10.1016/S1875-5364(17)30097-3.

(397) Fossen, T.; Yahorau, A.; Yahorava, S.; Raharinjato, F.; Razafimahefa, S.; Rasoanaivo, P.; Wikberg, J. E. S. New Polyfunctional Phragmalin Limonoids from *Neobeguea mahafalensis*. *Planta Med.* **2016**, *82* (11–12), 1087–1095. https://doi.org/10.1055/s-0042-108741.

(398) Yin, J.-L.; Di, Y.-T.; Fang, X.; Liu, E.-D.; Liu, H.-Y.; He, H.-P.; Li, S.-F. S.-L.; Li, S.-F. S.-L.; Hao, X.-J. Tabulvelutin A, the First 19-nor Limonoid with Unprecedented Ring System from *Chukrasia tabularis* Var. Velutina. *Tetrahedron Lett.* **2011**, *52* (24), 3083–3085. https://doi.org/10.1016/j.tetlet.2011.03.112.

(399) Happi, G. M.; Mouthe Kemayou, G. P.; Stammler, H.-G.; Neumann, B.; Ismail, M.; Kouam, S. F.; Wansi, J. D.; Tchouankeu, J. C.; Frese, M.; Lenta, B. N.; Sewald, N. Three Phragmalin-Type Limonoids Orthoesters and the Structure of Odoratone Isolated from the Bark of *Entandrophragma candollei* (Meliaceae). *Phytochemistry* **2021**, *181*, 112537. https://doi.org/10.1016/j.phytochem.2020.112537.

(400) Razafimahefa, S.; Mutulis, F.; Mutule, I.; Liepinsh, E.; Dambrova, M.; Cirule, H.; Svalbe, B.; Yahorava, S.; Yahorau, A.; Rasolondratovo, B.; Rasoanaivo, P.; Wikberg, J. E. S. Libiguins A and B: Novel Phragmalin Limonoids Isolated from *Neobeguea mahafalensis* Causing Profound Enhancement of Sexual Activity. *Planta Med.* **2014**, *80* (4), 306–314. https://doi.org/10.1055/s-0033-1360390.

(401) Luo, J.; Zhang, H. J.; Quasie, O.; Shan, S. M.; Zhang, Y. M.; Kong, L. Y. Further C-15-Acyl Phragmalin Derivatives from *Chukrasia tabularis* A. Juss. *Phytochemistry* **2015**, *117*, 410–416. https://doi.org/10.1016/j.phytochem.2015.05.014.

(402) Luo, J.; Li, Y.; Wang, J. S.; Kong, L. Y. D-Ring-Opened Phragmalin-Type Limonoids from *Chukrasia tabularis* Var. Velutina. *Chem. Biodivers.* **2011**, *8* (12), 2261–2269. https://doi.org/10.1002/cbdv.201000285.

(403) Yin, J. L.; Fang, X.; Liu, E. De; Yuan, C. M.; Li, S. F.; Zhang, Y.; He, H. P.; Li, S. L.; Di, Y. T.; Hao, X. J. Phragmalin Limonoids from the Stem Barks of *Chukrasia tabularis* Var Velutina. *Planta Med.* **2014**, *80* (15), 1304–1309. https://doi.org/10.1055/s-0034-1382998.

(404) Chen, X. L.; Liu, H. L.; Guo, Y. W. Phragmalin Limonoids from *Chukrasia tabularis* Var Velutina. *Planta Med.* **2012**, *78* (3), 286–290. https://doi.org/10.1055/s-0031-1280403.

(405) Li, Y.; Luo, J.; Wang, Q.; Kong, L. Y. Two New Limonoids from the Stem Barks of *Chukrasia tabularis* Var. Velutina. *J. Asian Nat. Prod. Res.* **2011**, *13* (9), 781–786. https://doi.org/10.1080/10286020.2011.590799.

(406) Inoue, T.; Matsui, Y.; Kikuchi, T.; In, Y.; Yamada, T.; Muraoka, O.; Matsunaga, S.; Tanaka, R. Guianolides A and B, New Carbon Skeletal Limonoids from the Seeds of *Carapa guianensis*. *Org. Lett.* **2013**, *15* (12),

3018–3021. https://doi.org/10.1021/ol400924u.
(407) Hu, K.; Liu, J.-Q.; Li, X.; Chen, J.-C.; Zhang, W.-M.; Li, Y.; Li, L.; Guo, L.; Ma, W.; Qiu, M.-H. Chukfuransins A–D, Four New Phragmalin Limonoids with β-Furan Ring Involved in Skeleton Reconstruction from *Chukrasia tabularis*. *Org. Lett.* **2013**, *15* (15), 3902–3905. https://doi.org/10.1021/ol401650m.
(408) Zhang, C.-R.; Yang, S.-P.; Zhu, Q.; Liao, S.-G.; Wu, Y.; Yue, J.-M. Nortriterpenoids from *Chukrasia tabularis* Var. Velutina. *J. Nat. Prod.* **2007**, *70* (10), 1616–1619. https://doi.org/10.1021/np070345w.
(409) Peng, J.-L.; Wang, J.; Mei, W.-L.; Kong, F.-D.; Liu, Z.-Q.; Wang, P.; Gai, C.-J.; Jiang, B.; Dai, H.-F. Two New Phragmalin-Type Limonoids from *Chukrasia tabularis* and Their α -Glucosidase Inhibitory Activity. *J. Asian Nat. Prod. Res.* **2016**, *18* (7), 629–636. https://doi.org/10.1080/10286020.2015.1136291.
(410) Peng, J. L.; Jun-Wang; Kong, F. D.; Liu, Z. Q.; Wang, P.; Gai, C. J.; Jiang, B.; Mei, W. L.; Dai, H. F. Two New Phragmalin-Type Limonoids from Stems of *Chukrasia tabularis*. *Phytochem. Lett.* **2016**, *15*, 230–233. https://doi.org/10.1016/j.phytol.2016.01.003.
(411) Lin, B.-D.; Zhang, C.-R.; Yang, S.-P.; Zhang, S.; Wu, Y.; Yue, J.-M. D-Ring-Opened Phragmalin-Type Limonoid Orthoesters from the Twigs of *Swietenia macrophylla*. *J. Nat. Prod.* **2009**, *72* (7), 1305–1313. https://doi.org/10.1021/np900139c.
(412) Adesida, G. A.; Taylor, D. A. H. The Chemistry of the Genus *Entandrophragma*. *Phytochemistry* **1967**, *6* (10), 1429–1433. https://doi.org/10.1016/S0031-9422(00)82885-X.
(413) Mi, C. N.; Li, W.; Chen, H. Q.; Wang, J.; Cai, C. H.; Li, S. P.; Mei, W. L.; Dai, H. F. Two New Compounds from the Roots of *Swietenia macrophylla*. *J. Asian Nat. Prod. Res.* **2018**, *6020*, 1–8. https://doi.org/10.1080/10286020.2018.1488831.
(414) Wu, Y.; Wang, L.; Wei, X.; Shi, X.; Sauriol, F.; Gu, Y.; Shi, Q.; Qi, J. Granaxylocartin A, New Limonoid from the Seeds of *Xylocarpus granatum*. *Chem. Nat. Compd.* **2017**, *53* (5), 901–903. https://doi.org/10.1007/s10600-017-2151-8.
(415) Pamplona, S.; Arruda, M.; Castro, K.; e Silva, C.; Ferreira, A.; da Silva, M.; Ohashi, O.; da Silva, M. Phragmalin Limonoids from *Swietenia macrophylla* and Their Antifeedant Assay against Mahogany Predator. *J. Braz. Chem. Soc.* **2018**, *29* (8), 1621–1629. https://doi.org/10.21577/0103-5053.20180033.
(416) Abdelgaleil, S. A. .; Okamura, H.; Iwagawa, T.; Sato, A.; Miyahara, I.; Doe, M.; Nakatani, M. Khayanolides, Rearranged Phragmalin Limonoid Antifeedants from *Khaya senegalensis*. *Tetrahedron* **2001**, *57* (1), 119–126. https://doi.org/10.1016/S0040-4020(00)00994-7.
(417) Nakatani, M.; Abdelgaleil, S. A. M.; Saad, M. M. G.; Huang, R. C.; Doe, M.; Iwagawa, T. Phragmalin Limonoids from *Chukrasia tabularis*. *Phytochemistry* **2004**, *65* (20), 2833–2841. https://doi.org/10.1016/j.phytochem.2004.08.010.
(418) Pudhom, K.; Sommit, D.; Nuclear, P.; Ngamrojanavanich, N.; Petsom, A. Moluccensins H−J, 30-Ketophragmalin Limonoids from *Xylocarpus moluccensis*. *J. Nat. Prod.* **2010**, *73* (2), 263–266. https://doi.org/10.1021/np900583h.
(419) Yin, S.; Wang, X.-N.; Fan, C.-Q.; Lin, L.-P.; Ding, J.; Yue, J.-M. Limonoids from the Seeds of the Marine Mangrove *Xylocarpus granatum*. *J. Nat. Prod.* **2007**, *70* (4), 682–685. https://doi.org/10.1021/np060632k.
(420) Zhang, W. M.; Liu, J. Q.; Deng, Y. Y.; Xia, J. J.; Zhang, Z. R.; Li, Z. R.; Qiu, M. H. Diterpenoids and Limonoids from the Leaves and Twigs of *Swietenia mahagoni*. *Nat. Products Bioprospect.* **2014**, *4* (1), 53–57. https://doi.org/10.1007/s13659-014-0006-6.
(421) Yang, W.; Kong, L.; Zhang, Y.; Tang, G.; Zhu, F.; Li, S.; Guo, L.; Cheng, Y.; Hao, X.; He, H. Phragmalin-Type Limonoids from *Heynea trijuga*. *Planta Med.* **2012**, *78* (15), 1676–1682. https://doi.org/10.1055/s-0032-1315210.
(422) Liu, S. B.; Chen, H. Q.; Guo, Z. K.; Dong, W. H.; Wang, J.; Mei, W. L.; Dai, H. F. Phragmalin-Type Limonoids from the Roots of *Trichilia sinensis*. *RSC Adv.* **2017**, *7* (46), 28994–29003. https://doi.org/10.1039/c7ra01785e.
(423) Li, J.; Li, M. Y.; Xiao, Q.; Pedpradab, P.; Wu, J. Thaixylomolins D-F, New Limonoids from the Thai True Mangrove, *Xylocarpus moluccensis*. *Phytochem. Lett.* **2013**, *6* (3), 482–485. https://doi.org/10.1016/j.phytol.2013.06.005.
(424) Liu, J. Q.; Wang, C. F.; Chen, J. C.; Qiu, M. H. Limonoids from the Leaves of *Swietenia macrophylla*. *Nat. Prod. Res.* **2012**, *26* (20), 1887–1891. https://doi.org/10.1080/14786419.2011.625499.
(425) Yuan, C. M.; Tang, G. H.; Wang, X. Y.; Zhang, Y.; Guo, F.; Liao, J. H.; Zou, T.; Zuo, G. Y.; Hua, H. M.; He, H. P.; Hao, X. J. Two New Compounds from *Khaya senegalensis*. *J. Asian Nat. Prod. Res.* **2013**, *15* (6), 638–643. https://doi.org/10.1080/10286020.2013.794419.
(426) Luo, J.; Wang, J. S.; Luo, J. G.; Wang, X. B.; Kong, L. Y. Velutabularins A-J, Phragmalin-Type Limonoids

with Novel Cyclic Moiety from *Chukrasia tabularis* Var. Velutina. *Tetrahedron* **2011**, *67* (16), 2942–2948. https://doi.org/10.1016/j.tet.2011.02.049.

(427) Li, Y.; Luo, J.; Li, H.; Kong, L. Y. Two New Phragmalin-Type Limonoids from *Chukrasia tabularis* Var. Velutina. *Molecules* **2013**, *18* (1), 373–380. https://doi.org/10.3390/molecules18010373.

(428) Fang, X.; Di, Y.; Geng, Z.; Tan, C.; Guo, J.; Ning, J.; Hao, X. Trichiliton A, a Novel Limonoid from *Trichilia connaroides*. *European J. Org. Chem.* **2010**, *2010* (7), 1381–1387. https://doi.org/10.1002/ejoc.200901245.

(429) Nakatani, M.; Abdelgaleil, S. A. .; Okamura, H.; Iwagawa, T.; Sato, A.; Doe, M. Khayanolides A and B, New Rearranged Phragmalin Limonoid Antifeedants from *Khaya senegalensis*. *Tetrahedron Lett.* **2000**, *41* (33), 6473–6477. https://doi.org/10.1016/S0040-4039(00)01080-7.

(430) Wang, H. Y.; Wang, J. S.; Zhang, Y.; Luo, J.; Yang, M. H.; Wang, X. B.; Kong, L. Y. Inhibitory Effect of Four Triterpenoids from *Trichilia connaroides* on Nitric Oxide Production in Lipopolysaccharide-Stimulated RAW264.7 Cells. *Chem. Pharm. Bull.* **2013**, *61* (10), 1075–1080. https://doi.org/10.1248/cpb.c13-00286.

(431) Najmuldeen, I. A.; Hadi, A. H. A.; Awang, K.; Mohamad, K.; Ketuly, K. A.; Mukhtar, M. R.; Chong, S. L.; Chan, G.; Nafiah, M. A.; Weng, N. S.; Shirota, O.; Hosoya, T.; Nugroho, A. E.; Morita, H. Chisomicines A-C, Limonoids from *Chisocheton ceramicus*. *J. Nat. Prod.* **2011**, *74* (5), 1313–1317. https://doi.org/10.1021/np200013g.

(432) Ji, K. L.; Cao, D. H.; Li, X. F.; Guo, J.; Zhang, P.; Xu, Y. K. Two New Limonoids from the Roots of *Trichilia connaroides* with Inhibitory Activity against Nitric Oxide Production in Lipopolysaccharide-Stimulated RAW 264.7 Cells. *Phytochem. Lett.* **2015**, *14*, 234–238. https://doi.org/10.1016/j.phytol.2015.10.020.

(433) An, F. L.; Sun, D. M.; Wang, X. B.; Yang, L.; Yin, Y.; Luo, J.; Kong, L. Y. Trichiconlides C–F, Four New Limonoids with 1,2-Seco Phragmalin-Type Carbon Skeleton from the Fruits of *Trichilia connaroides*. *Fitoterapia* **2018**, *125* (October 2017), 72–77. https://doi.org/10.1016/j.fitote.2017.12.023.

(434) Li, J.; Li, M. Y.; Bruhn, T.; Götz, D. C. G.; Xiao, Q.; Satyanandamurty, T.; Wu, J.; Bringmann, G. Andhraxylocarpins A-E: Structurally Intriguing Limonoids from the True Mangroves *Xylocarpus granatum* and *Xylocarpus moluccensis*. *Chem. - A Eur. J.* **2012**, *18* (45), 14342–14351. https://doi.org/10.1002/chem.201202356.

(435) Chong, S. L.; Awang, K.; Martin, M. T.; Mokhtar, M. R.; Chan, G.; Litaudon, M.; Gueritte, F.; Mohamad, K. Malayanines A and B, Two Novel Limonoids from *Chisocheton erythrocarpus* Hiern. *Tetrahedron Lett.* **2012**, *53* (40), 5355–5359. https://doi.org/10.1016/j.tetlet.2012.07.067.

(436) Zhang, C.-R.; Yang, S.-P.; Liao, S.-G.; Fan, C.-Q.; Wu, Y.; Yue, J.-M. Chuktabularins A−D, Four New Limonoids with Unprecedented Carbon Skeletons from the Stem Bark of *Chukrasia tabularis*. *Org. Lett.* **2007**, *9* (17), 3383–3386. https://doi.org/10.1021/ol701437h.

(437) Luo, J.; Li, Y.; Wang, J. S.; Lu, J.; Kong, L. Y. Three New C-15-Isobutyryl 16-Norphragmalin-Type Limonoids from *Chukrasia tabularis* Var. Velutina. *Phytochem. Lett.* **2012**, *5* (2), 249–252. https://doi.org/10.1016/j.phytol.2012.01.005.

(438) Zhang, B.; Yang, S.-P.; Yin, S.; Zhang, C.-R.; Wu, Y.; Yue, J.-M. Limonoids from *Khaya ivorensis*. *Phytochemistry* **2009**, *70* (10), 1305–1308. https://doi.org/10.1016/j.phytochem.2009.07.016.

(439) Zhang, Q.; Satyanandamurty, T.; Shen, L.; Wu, J. Krishnolides A–D: New 2-Ketokhayanolides from the Krishna Mangrove, *Xylocarpus moluccensis*. *Mar. Drugs* **2017**, *15* (11). https://doi.org/10.3390/md15110333.

(440) Wang, X.-N.; Fan, C.-Q.; Yin, S.; Gan, L.-S.; Yue, J.-M. Structural Elucidation of Limonoids and Steroids from *Trichilia connaroides*. *Phytochemistry* **2008**, *69* (6), 1319–1327. https://doi.org/10.1016/j.phytochem.2008.01.018.

(441) Purushothaman, K. K.; Venkatanarasimhan, M.; Sarada, A.; Connolly, J. D.; Rycroft, D. S. Trijugins A and B , Tetranortriterpenoids with a Novel Rearranged Carbon Skeleton from *Heynea trijuga* (Meliaceae). *Can. J. Chem.* **1987**, *65* (1), 35–37. https://doi.org/10.1139/v87-008.

(442) Geng, Z.-L.; Fang, X.; Di, Y.-T.; Zhang, Q.; Zeng, Y.; Shen, Y.-M.; Hao, X.-J. Trichilin B, a Novel Limonoid with Highly Rearranged Ring System from *Trichilia connaroides*. *Tetrahedron Lett.* **2009**, *50* (18), 2132–2134. https://doi.org/10.1016/j.tetlet.2009.02.147.

(443) Madhusudana Rao, M.; Meshulam, H.; Zelnik, R.; Lavie, D. Structure and Stereochemistry of Limonoids of *Cabralea eichleriana*. *Phytochemistry* **1975**, *14* (4), 1071–1075. https://doi.org/10.1016/0031-9422(75)85189-2.

(444) Ning, J.; Di, Y. T.; Wang, Y. Y.; He, H. P.; Fang, X.; Li, Y.; Li, S. L.; Hao, X. J. Cytotoxic Activity of

Trijugin-Type Limonoids from *Cipadessa baccifera*. *Planta Med.* **2010**, *76* (16), 1907–1910. https://doi.org/10.1055/s-0030-1249979.

(445) Zhang, Z.; Cheng, Y.; Hu, G.; Li, G. Two New Trijugin-Type Limonoids from *Cipadessa cinerascens*. *Helv. Chim. Acta* **2013**, *96* (12), 2228–2232. https://doi.org/10.1002/hlca.201300228.

(446) Jiang, C. S.; Li, Y.; Wang, Z. Z.; Huang, X. Y.; Xiao, W.; Guo, Y. W. Cipatrijugin G, a New Trijugin-Type Limonoid Bearing an Uncommon γ-Hydroxybutenolide Unit from the Aerial Parts of *Cipadessa cinerascens*. *Natural Products and Bioprospecting*. 2013, pp 267–270. https://doi.org/10.1007/s13659-013-0074-z.

(447) Geng, Z.-L.; Fang, X.; Di, Y.-T.; Zhang, Q.; Shen, Y.-M.; Hao, X.-J. A New Limonoid From*Trichilia connaroides*. *Zeitschrift für Naturforsch. B* **2010**, *65* (6), 762–764.

(448) Leite, A. C.; Placeres Neto, A.; Ambrozin, A. R. P.; Fernandes, J. B.; Vieira, P. C.; Silva, M. F. das G. F. da; de Albuquerque, S. Trypanocidal Activity of Flavonoids and Limonoids Isolated from Myrsinaceae and Meliaceae Active Plant Extracts. *Rev. Bras. Farmacogn.* **2010**, *20* (1), 01–06. https://doi.org/10.1590/S0102-695X2010000100002.

(449) Fang, X.; Di, Y.-T.; Li, C.-S.; Geng, Z.-L.; Zhang, Z.; Zhang, Y.; Lu, Y.; Zheng, Q.-T.; Yang, S.-Y.; Hao, X.-J. Tetranortriterpenoids from the Leaves of *Cipadessa cinerascens*. *J. Nat. Prod.* **2009**, *72* (4), 714–718. https://doi.org/10.1021/np800656r.

(450) Zhang, Z.-G.; Yao, K.; Hu, G.-L.; Zhang, J. Three New Limonoids from the Leaves of *Cipadessa cinerascens*. *Helv. Chim. Acta* **2010**, *93* (4), 698–703. https://doi.org/10.1002/hlca.200900283.

(451) Siva, B.; Suresh, G.; Poornima, B.; Venkanna, A.; Suresh Babu, K.; Rajendra Prasad, K.; Prasanna Anjaneya Reddy, L.; Sreedhar, A. S.; Venkata Rao, C. Cipadessin-Type Limonoids from the Leaves of *Cipadessa baccifera*. *Tetrahedron Lett.* **2013**, *54* (23), 2934–2937. https://doi.org/10.1016/j.tetlet.2013.03.103.

(452) Mulholland, D. A.; Schwikkard, S. L.; Sandor, P.; Nuzillard, J. M. Delevoyin C, a Tetranortriterpenoid from *Entandrophragma delevoyi*. *Phytochemistry* **2000**, *53* (4), 465–468. https://doi.org/10.1016/S0031-9422(99)00546-4.

(453) Higuchi, K.; Tani, Y.; Kikuchi, T.; In, Y.; Yamada, T.; Muraoka, O.; Tanaka, N.; Tanaka, R. Guianolactones A and B, Two Rearranged Pentacyclic Limonoids from the Seeds of *Carapa guianensis*. *Chem. - An Asian J.* **2017**, *12* (23), 3000–3004. https://doi.org/10.1002/asia.201701298.

(454) An, F. L.; Luo, J.; Li, R. J.; Luo, J. G.; Wang, X. B.; Yang, M. H.; Yang, L.; Yao, H. Q.; Sun, H. Bin; Chen, Y. J.; Kong, L. Y. Spirotrichilins A and B: Two Rearranged Spirocyclic Limonoids from *Trichilia connaroides*. *Org. Lett.* **2016**, *18* (8), 1924–1927. https://doi.org/10.1021/acs.orglett.6b00738.

(455) Yu, J. H.; Liu, Q. F.; Sheng, L.; Wang, G. C.; Li, J.; Yue, J. M. Cipacinoids A-D, Four Limonoids with Spirocyclic Skeletons from *Cipadessa cinerascens*. *Org. Lett.* **2016**, *18* (3), 444–447. https://doi.org/10.1021/acs.orglett.5b03487.

(456) Luo, J.; Tian, X.; Zhang, H.; Zhou, M.; Li, J.; Kong, L. Two Rare Limonoids from the Stem Barks of *Entandrophragma utile*. *Tetrahedron Lett.* **2016**, *57* (48), 5334–5337. https://doi.org/10.1016/j.tetlet.2016.10.055.

(457) Yuan, C. M.; Zhang, Y.; Tang, G. H.; Li, S. L.; Di, Y. T.; Hou, L.; Cai, J. Y.; Hua, H. M.; He, H. P.; Hao, X. J. Senegalensions A-C, Three Limonoids from *Khaya senegalensis*. *Chem. - An Asian J.* **2012**, *7* (9), 2024–2027. https://doi.org/10.1002/asia.201200320.

(458) Liu, J. Q.; Peng, X. R.; Zhang, W. M.; Shi, L.; Li, X. Y.; Chen, J. C.; Qiu, M. H. Swietemahalactone, a Rearranged Phragmalin-Type Limonoid with Anti-Bacterial Effect, from *Swietenia mahagoni*. *RSC Adv.* **2013**, *3* (15), 4890–4893. https://doi.org/10.1039/c3ra23401k.

(459) Mohamad, K.; Hirasawa, Y.; Lim, C. S.; Awang, K.; Hadi, A. H. A.; Takeya, K.; Morita, H. Ceramicine A and Walsogyne A, Novel Limonoids from Two Species of Meliaceae. *Tetrahedron Lett.* **2008**, *49* (27), 4276–4278. https://doi.org/https://doi.org/10.1016/j.tetlet.2008.04.145.

(460) Luo, X.-D.; Wu, S.-H.; Ma, Y.-B.; Wu, D.-G. Tetranortriterpenoids from *Walsura yunnanensis*. *J. Nat. Prod.* **2000**, *63* (7), 947–951. https://doi.org/10.1021/np990607x.

(461) Kraus, W.; Cramer, R. Pentanortriterpenoide Aus *Azadirachta indica* A. Juss (Meliaceae). *Chem. Ber.* **1981**, *114* (7), 2375–2381. https://doi.org/10.1002/cber.19811140703.

(462) Ishida, M.; Serit, M.; Nakata, K.; Raj Juneja, L.; Kim, M.; Takahashi, S. Several Antifeedants from Neem Oil, *Azadirachta indica* A. Juss., against *Reticulitermes speratus* Kolbe (Isoptera: Rhinotermitidae). *Biosci. Biotechnol. Biochem.* **1992**, *56* (11), 1835–1838. https://doi.org/10.1271/bbb.56.1835.

(463) Chen, H.-D.; Yang, S.-P.; Wu, Y.; Dong, L.; Yue, J.-M. Terpenoids from *Toona ciliata*. *J. Nat. Prod.* **2009**, *72* (4), 685–689. https://doi.org/10.1021/np800811b.

(464) Chen, Y.-Y.; Wang, X.-N.; Fan, C.-Q.; Yin, S.; Yue, J.-M. Swiemahogins A and B, Two Novel Limonoids from *Swietenia mahogani*. *Tetrahedron Lett.* **2007**, *48* (42), 7480–7484. https://doi.org/10.1016/j.tetlet.2007.08.066.

(465) Yan, Y. X.; Liu, J. Q.; Wang, H. W.; Chen, J. X.; Chen, J. C.; Chen, L.; Zhou, L.; Qiu, M. H. Identification and Antifeedant Activities of Limonoids from *Azadirachta indica*. *Chem. Biodivers.* **2015**, *12* (7), 1040–1046. https://doi.org/10.1002/cbdv.201400282.

(466) Katja, D. G.; Farabi, K.; Nuraini, V. A.; Nurlelasari, N.; Hidayat, A. T.; Mayanti, T.; Harneti, D.; Supratman, U. A New 30-nor Trijugin-Type Limonoid, Chisotrijugin, from the Bark of *Chisocheton cumingianus* (Meliaceae). *Int. J. Chem.* **2016**, *8* (3), 30. https://doi.org/10.5539/ijc.v8n3p30.

(467) Passos, M. de S.; Carvalho, A. R. d.; Boeno, S. I.; Virgens, L. de L. G. das; Calixto, S. D.; Ventura, T. L. B.; Lassounskaia, E.; Braz-Filho, R.; Vieira, I. J. C. Terpenoids Isolated from *Azadirachta indica* Roots and Biological Activities. *Rev. Bras. Farmacogn.* **2019**, *29* (1), 40–45. https://doi.org/10.1016/j.bjp.2018.12.003.

(468) Nguyen, N. Y. T.; Dang, P. H.; Thien Nguyen, V. T.; Vo, T. T.; Nguyen, D. A. T.; Nguyen, M. D. H.; Dang, P. H.; Tran, Q. Le. Nimbandiolactone-21 and Nimbandioloxyfuran, Two New 28-Norlimonoids from the Leaves of *Azadirachta indica* (Meliaceae). *J. Asian Nat. Prod. Res.* **2019**, *21* (9), 867–872. https://doi.org/10.1080/10286020.2018.1476498.

(469) Yang, B.-J.; Fan, S.-R.; Cai, J.-Y.; Wang, Y.-T.; Jing, C.; Guo, J.-J.; Chen, D.-Z.; Hao, X.-J. Aphananoid A Is an Anti-Inflammatory Limonoid with a New 5/6/5 Fused Ring Featuring a C 24 Carbon Skeleton from *Aphanamixis polystachya*. *J. Org. Chem.* **2020**, *85* (13), 8597–8602. https://doi.org/10.1021/acs.joc.0c00922.

(470) Daniewski, W. M.; Gumułka, M.; Danikiewicz, W.; Sitkowski, J.; Jacobsson, U.; Norin, T. Entilin D, a Heptanortriterpenoid from the Bark of *Entandrophragma utile*. *Phytochemistry* **1995**, *40* (3), 903–905. https://doi.org/10.1016/0031-9422(95)00177-9.

(471) Siddiqui, B. S.; Faizi, S.; Siddiqui, S. Triterpenoids from the Fresh Coats of *Azadirachta indica*. *Phytochemistry* **1992**.

(472) Akihisa, T.; Takahashi, A.; Kikuchi, T.; Takagi, M.; Watanabe, K.; Fukatsu, M.; Fujita, Y.; Banno, N.; Tokuda, H.; Yasukawa, K. The Melanogenesis-Inhibitory, Anti-Inflammatory, and Chemopreventive Effects of Limonoids in *n*-Hexane Extract of *Azadirachta indica* A. Juss. (Neem) Seeds. *J. Oleo Sci.* **2011**, *60* (2), 53–59. https://doi.org/10.5650/jos.60.53.

(473) Zhao, P. H.; Sun, L. M.; Liu, X. J.; Cao, M. A.; Yuan, C. S. Limonoids from the Root of *Dictamnus radicis* Cortex. *Chem. Pharm. Bull. (Tokyo).* **2008**, *56* (1), 102–104. https://doi.org/10.1248/cpb.56.102.

(474) Sun, J. B.; Qu, W.; Wang, P.; Wu, F. H.; Wang, L. Y.; Liang, J. Y. Degraded Limonoids and Quinoline Alkaloids from *Dictamnus angustifolius* G. Don Ex Sweet. and Their Anti-Platelet Aggregation Activity. *Fitoterapia* **2013**, *90*, 209–213. https://doi.org/10.1016/j.fitote.2013.07.023.

(475) Kraus, W.; Klenk, A.; Bokel, M.; Vogler, B. Tetranortriterpenoid-Lactame Mit Insektenfraßhemmender Wirkung Aus *Azadirachta indica* A. Juss (Meliaceae). *Liebigs Ann. der Chemie* **1987**, *1987* (4), 337–340. https://doi.org/10.1002/jlac.198719870331.

(476) Daniewski, W. M.; Gumulka, M.; Danikiewicz, W.; Gluziński, P.; Krajewski, J.; Sitkowski, J.; Błoszyk, E.; Drożdż, B.; Jacobsson, U.; Szafrański, F. A Tetranortriterpenoid from the Bark of *Entandrophragma utile*. *Phytochemistry* **1994**, *36* (4), 1001–1003. https://doi.org/10.1016/S0031-9422(00)90479-5.

(477) Koul, O.; M. Daniewski, W.; Singh Multani, J.; Gumulka, M.; Singh, G. Antifeedant Effects of the Limonoids from *Entandrophragma candolei* (Meliaceae) on the Gram Pod Borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae). *J. Agric. Food Chem.* **2003**, *51* (25), 7271–7275. https://doi.org/10.1021/jf0304223.

(478) Nguyen, N. Y. T.; Dang, P. H.; Nguyen, V. T. T.; Dang, P. H.; Tran, Q. L. A New Lactam 28-Norlimonoid from the Leaves of *Azadirachta indica* A. Juss. (Meliaceae). *Nat. Prod. Res.* **2018**, *6419* (May), 1–6. https://doi.org/10.1080/14786419.2018.1479700.

(479) Zhu, J.; Lu, X.; Fan, X.; Wu, R.; Diao, H.; Yu, R.; Xu, H.; Zi, J. A New Cytotoxic Salannin-Class Limonoid Alkaloid from Seeds of *Azadirachta indica* A. Juss. *Chinese Chem. Lett.* **2018**, *29* (8), 1261–1263. https://doi.org/10.1016/j.cclet.2017.11.042.

(480) Zhu, G.-Y.; Chen, G.; Liu, L.; Bai, L.-P.; Jiang, Z.-H. C-17 Lactam-Bearing Limonoids from the Twigs and Leaves of *Amoora tsangii*. *J. Nat. Prod.* **2014**, *77* (4), 983–989. https://doi.org/10.1021/np401089h.

(481) Meng, Q. Q.; Peng, X. R.; Lu, S. Y.; Wan, L. S.; Wang, X.; Dong, J. R.; Chu, R.; Zhou, L.; Li, X. N.; Qiu, M. H. Lactam Triterpenoids from the Bark of *Toona sinensis*. *Nat. Products Bioprospect.* **2016**, *6* (5), 239–245. https://doi.org/10.1007/s13659-016-0108-4.

(482) Han, M. L.; Zhang, H.; Yang, S. P.; Yue, J. M. Walsucochinoids A and B: New Rearranged Limonoids from

Walsura cochinchinensis. *Org. Lett.* **2012**, *14* (2), 486–489. https://doi.org/10.1021/ol203082c.
(483) Butterworth, J. H.; Morgan, E. D. Isolation of a Substance That Suppresses Feeding in Locusts. *Chem. Commun.* **1968**, No. 1, 23–24. https://doi.org/10.1039/C19680000023.