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BOERHAVIA AND ITS PHYTOCHEMISTRY

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Nyctagenaceae is a family of 30 genera and c. 290 species in tropical and subtropical parts of both the hemisphere especially in America. In Pakistan it is represented by 5 genera and 10 or 11 species. Plants are trees, herbs. Some plants are ornamental e.g. *Mirabilis jalapa*. *Boerhavia* (*Boerhaavia*) is genus of this family with c. 40 species. Plants are mostly herbs with opposite leaves, found in tropical and subtropical regions, S. Europe, and S. United States. In Pakistan it is represented by 4 or 5 species. Anthocarp of *Boerhavia* is 5-ribbed, which is the main difference in the *Boerhavia* and *Commicarpus*, having 10-ribbed anthocarp. A mini review is presented which cover data upto 2008.

BOERHAVIA AND ITS PHYTOCHEMISTRY

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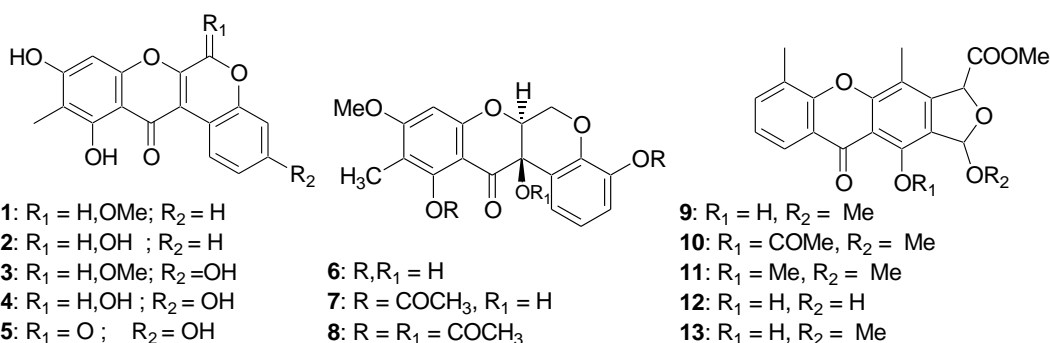
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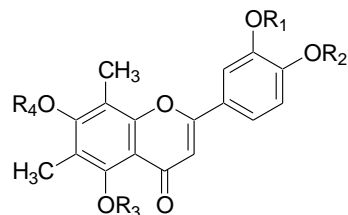
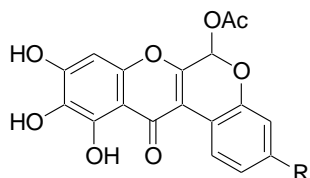
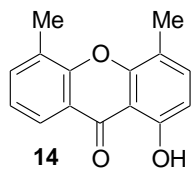
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INTRODUCTION

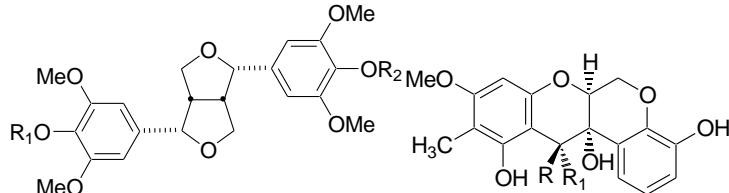
Nyctagenaceae is a family of 30 genera and c. 290 species in tropical and subtropical parts of both the hemisphere especially in America. In Pakistan it is represented by 5 genera and 10 or 11 species. Plants are trees, herbs. Some plants are ornamental e.g. *Mirabilis jalapa*. *Boerhavia* (*Boerhaavia*) is genus of this family with c. 40 species. Plants are mostly herbs with opposite leaves, found in tropical and subtropical regions, S. Europe, and S. United States. In Pakistan it is represented by 4 or 5 species. Anthocarp of *Boerhavia* is 5-ribbed, which is the main difference in the *Boerhavia* and *Commicarpus*, having 10-ribbed anthocarp [3]. Recently nutritive and antinutritve properties of *B. diffusa* has been published [35]. Hypoglycaemic effect of the aqueous extract of *B. diffusa* has been reported by Chude et al [36]. *Diffusa* leaves *boerhavia diffusa* is of great medicinal and ayurvedic importance. Red variety of *B. diffusa* is used as astringent to the bowel, used in biliousness, blood impurities, leucorrhea, anemia, and inflammation. Leaves of dark variety are used in dyspepsia, tumors, and enlargement of the spleen, abdominal pains, ophthalmia, eyes wounds, and pain of the joints. Seeds are tonic, expectorant, carminative, muscular pain, lumbago, scabies, scorpion-sting, purify blood, hasten and delivery. Root has diuretic properties and also good expectorant, jaundice, ascites, anasarca, scanty urine internal inflammations, laxative and stomachic. When mixed with dried ginger, used in urticaria. The extract is used in dropsical swellings, gonorrhoea, snake-bite, strangury, emetic, cardiac stimulant, myalgia, constipation,

bronchitis, and cough [2]. Plants are also used as pot-herb with succulent leaves, fodder for cattle. The leaves are given to hogs in Jamaica, in Bengal, given to cattle to increase the milk quantity [1]. A large number of compounds belonging to flavonoids, alkaloids, carbohydrates, lipids, sterols, cyanine etc have been reported from the plants of this genus which are given in the table 1. The phytochemical studies on genus *Boerhavia* trace back to 1947, when Basu [34] et al first isolated punarnavine, an alkaloid. In 1954, Lightelm reported the presence of triacontenoic acid (**63**) in *B.repens* [29]. In 1968, T.N. Bhalla and M.L. Gupta reported the presence of punarnavine, an alkaloid of great medicinal importance, from *B.diffusa* [28]. In the same year Ahmad et al [27] isolated Hypoxanthine-9-L-arabinofuranoside (**28**) from the same plant. Hentriacontane (**65**) was reported by A.N. Misra and H.P. Tiwari in 1971. After three year later, Khalique et al reported the presence of myristic acid and myricyl alcohol from *B.repens* [26]. Myristic alcohol was also reported by Suri et al in 1982 by the name of triacontanol from *B.diffusa* [20]. During 1975-75, Proteins, Carbohydrates and Lipids Glycoprotein (an Antiviral agent) Protein and free Amino acids were reported by different authors [21-24]. Then a lot of compounds have been isolated and reported [4] and the story is still at run.

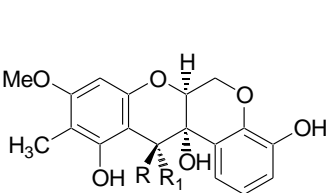




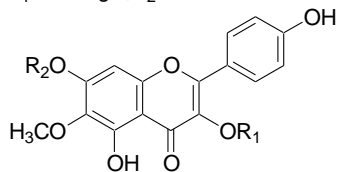
- 17:** R₁, R₂ = CH₃; R₃, R₄ = H
18: R₁, R₂ = CH₃; R₃, R₄ = COCH₃
19: R₁, R₂, R₃, R₄ = H
20: R₁, R₂, R₃, R₄ = COCH₃



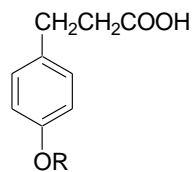
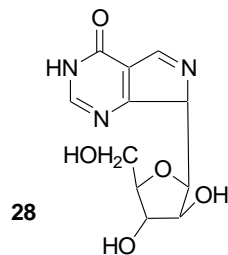
- 21:** R₁ = R₂ = β-D-glc
22: R₁ = β-D-glc, R₂ = H



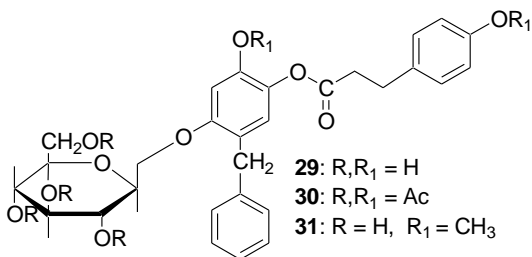
- 23:** R = H, R₁ = OH
24: R = OH, R₁ = H



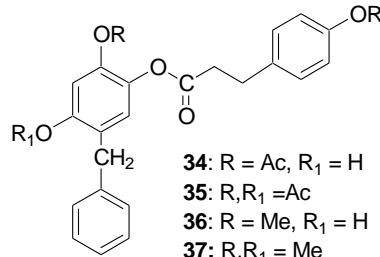
- 25:** R₁ = β-D-gal-β-D-glc, R₂ = CH₃
26: R₁ = β-D-gal, R₂ = CH₃
27: R₁ = β-D-(1→6)-robinoside, R₂ = H



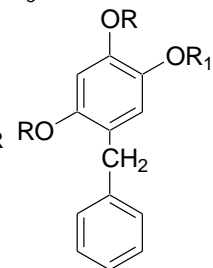
- 32:** R = H
33: R = CH₃



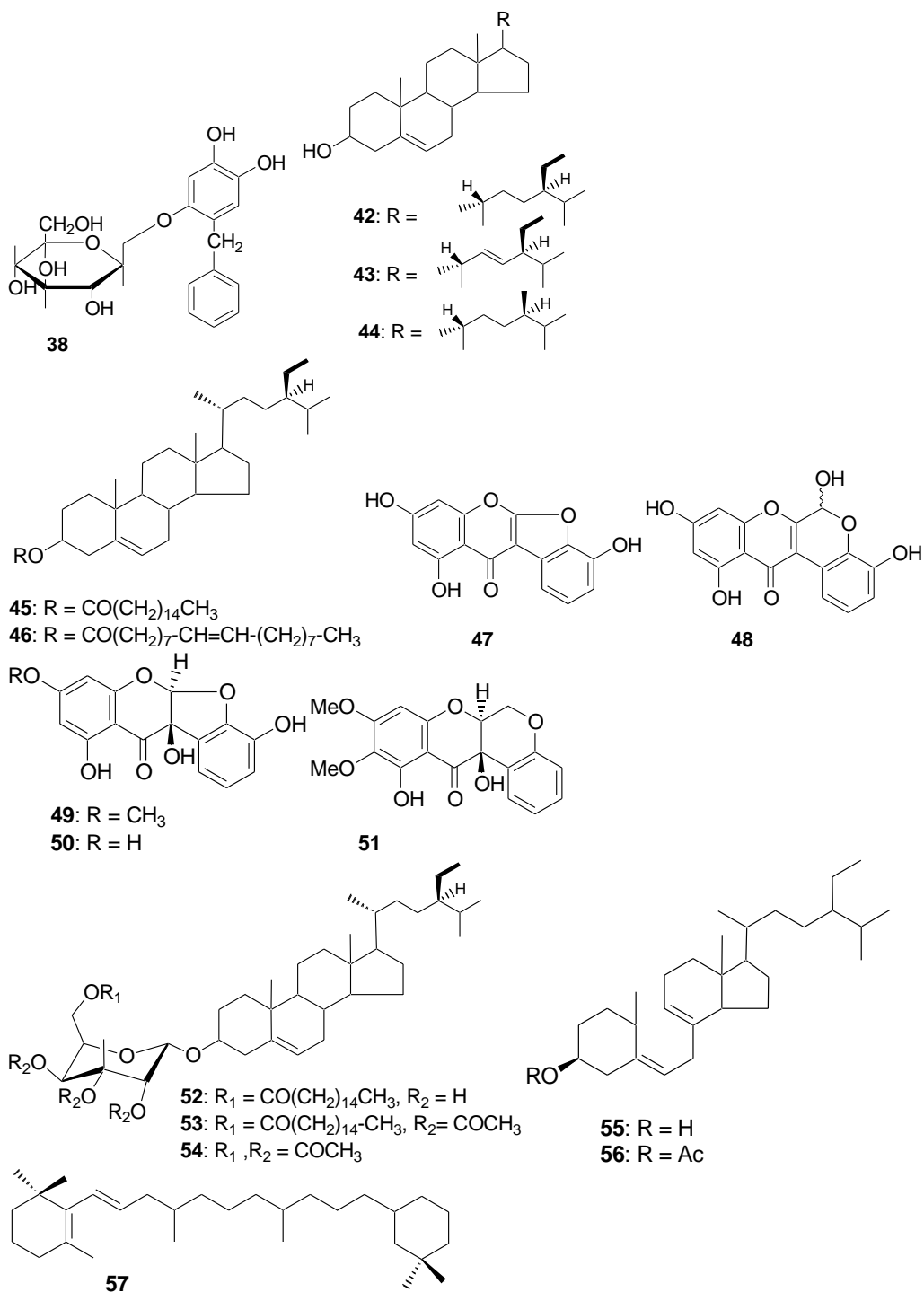
- 29:** R, R₁ = H
30: R, R₁ = Ac
31: R = H, R₁ = CH₃



- 34:** R = Ac, R₁ = H
35: R, R₁ = Ac
36: R = Me, R₁ = H
37: R, R₁ = Me



- 39:** R = Me, R₁ = H
40: R, R₁ = Me
41: R, R₁ = H



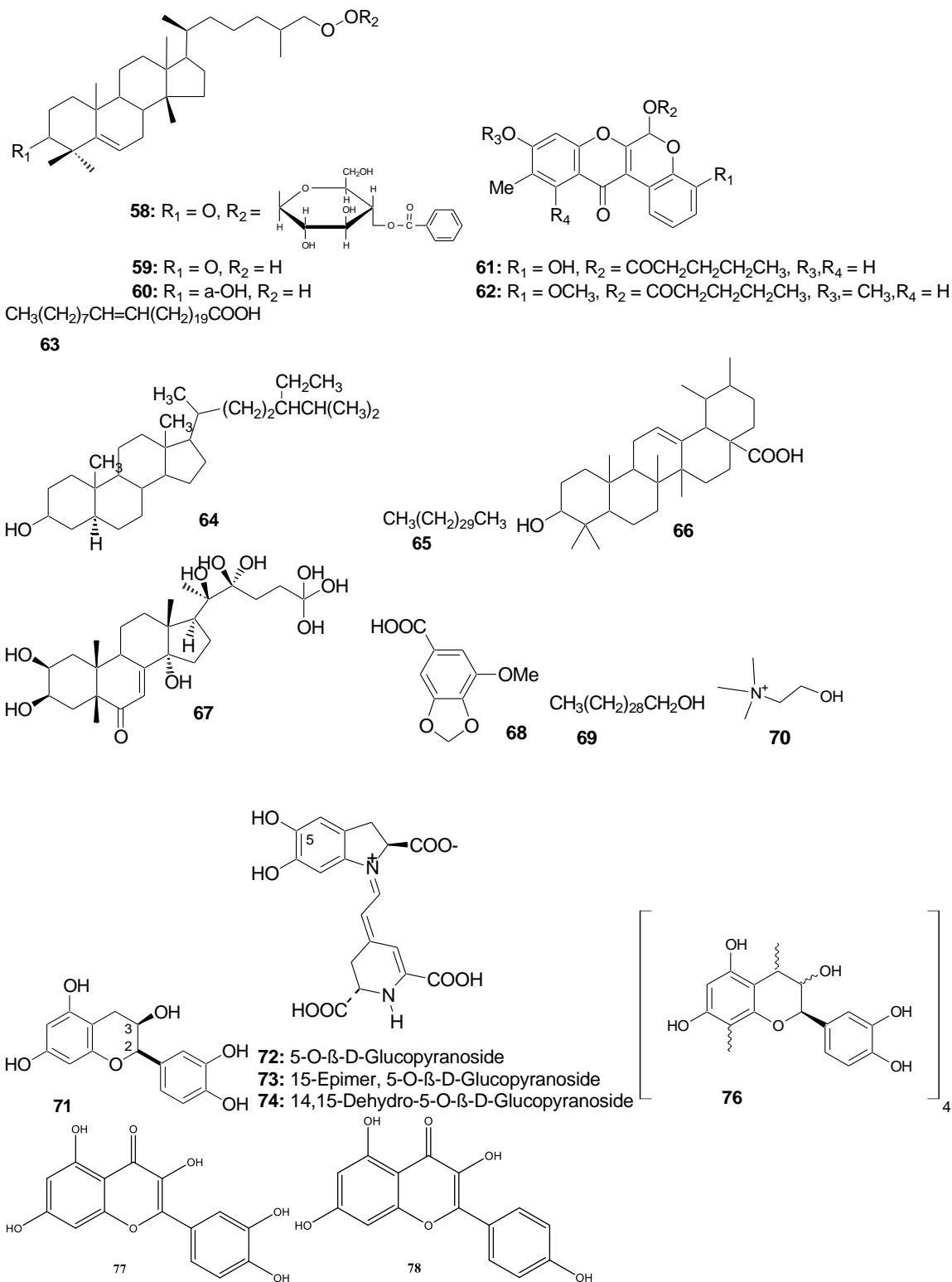


Table 1: List of different compounds isolated from different species of Boerhavia

S.No.	Name of compound	Mol. Formula	Mol. Wt.	Physical and spectral data [mp °C/[α] _D (°)/IR cm ⁻¹ /UV nm]	Source	Ref.
1	Isorhamnetin glycosides			-/-/-	<i>B. erecta</i>	4
	Kaempferol (78)	C ₁₅ H ₁₀ O ₆	286.24	276-278/-/-/204, 265, 365	<i>B. erecta</i>	4
	Quercetin (77)	C ₁₅ H ₁₀ O ₇	302.24	313-314 dec/-/-/258, 375	<i>B. erecta</i>	4
2	Catechin (71)	C ₁₅ H ₁₄ O ₆	290.272	93-96/+17/-/-	<i>B. erecta</i>	4
3	Betanin (72)	C ₂₄ H ₂₆ N ₂ O ₁₃	550.475	-/-/-	<i>B. erecta</i>	4
4	Isobetanin (73)	C ₂₄ H ₂₆ N ₂ O ₁₃	550.475		<i>B. erecta</i>	4
5	Neobetanin (74)	C ₂₄ H ₂₄ N ₂ O ₁₃	548.459	-/-/-/267, 306, 470	<i>B. erecta</i>	4
6	Procynidins (75)	[C ₁₇ H ₁₈ O ₆] ₄	1273.28	-/-/-	<i>B. erecta</i>	4
7	5-Methyleicos-4-ene, Eicos-4-ene, 4-Methyloctadec-3-ene and 4-Methylnonadecylbenzene			-/-/-	<i>B. diffusa</i>	5
8	Tannins, Saponins and Calcium oxalate			-/-/-	<i>B. coccinea</i> <i>B. erecta</i> <i>B. diffusa</i>	6
9	Protein, β-Carotene, Ascorbic acid			-/-/-	<i>B. diffusa</i>	7
10	Boerhavisterol (55)	C ₂₉ H ₅₀ O	414.713	128-139/-/3480, 2955, 2880, 1600, 1455, 1340/265 (MeOH)	<i>B. diffusa</i>	8
11	Boerhavisterol acetate (56)	C ₃₁ H ₅₂ O ₂	456.74	81-82/-/1725, 1600/-	<i>B. diffusa</i>	8
12	Boerhadiffusene (57)	C ₃₀ H ₅₄	414.757	103-104/-/2940,2855,1625, 1455, 1445/272 (MeOH)	<i>B. diffusa</i>	8
13	Boerhavianosteryl benzoate (58)	C ₄₃ H ₆₄ O ₈	708.974	250-251dec/-/3400, 2935, 2870, 1725, 1710, 1640, 1585, 1440/217, 280	<i>B. diffusa</i>	8
14	Aglycone (59)	C ₃₀ H ₅₀ O ₃	458.72	202-203/-/-	<i>B. diffusaa</i>	8
15	Lanost-ene-3,27-diol (60)	C ₃₀ H ₅₂ O ₃	460.73	161-162/-/-	<i>B. diffusa</i>	8
16	Diffusarotenoid (61)	C ₂₂ H ₂₀ O ₇	396.396	261-263 (dec.)/-/3300, 2965, 1730, 1645, 1615, 1585, 1440 / 218, 264, 291, 355	<i>B. diffusa</i>	8
17	Methyl diffusarotenoid (62)	C ₂₄ H ₂₄ O ₇	424.44	241-242/-/1730, 1710, 1640, 1610/-	<i>B. diffusa</i>	8
18	Coccineone E (51)	C ₁₈ H ₁₆ O ₇	344.32	206-209/-25.5 (CHCl ₃)/3366, 2971,1638, 1580, 1491, 1451/203, 282,	<i>B. coccinea</i>	9
19	Choline (70)	C ₅ H ₁₄ NO ⁺	104.172	-/-/-	<i>B. diffusa</i>	10
20	Eupalitin 3-O-β-D-galactopyranosyl-(1→2)-β-D-glucopyranoside (25)	C ₂₉ H ₃₅ O ₁₇	655.187	-/-19.2 (MeOH)/ 3350, 2900,2200, 1650, 1590, 1440/-	<i>B. repens</i>	11
21	Eupalitin 3-O-β-D-galactopyranoside (26)	C ₂₃ H ₂₅ O ₁₂	493.135	-/-24.0(MeOH) /3400, 2900, 2200, 1600, 1507, 1440/-	<i>B. repens</i>	11
22	6-methoxykaempferol-3-O-β-D-(1→6)rhamnoside (27)	C ₂₈ H ₃₃ O ₁₆	625.177	-/-30.6 (MeOH) /3400, 2900, 2200,1600,	<i>B. repens</i>	11

				1507,1440/-		
23	Borhavine (9)	C ₂₀ H ₁₈ O ₇	370.358	230-232/-/ 2940, 1660, 1630,1610,1590,1500,1480/225, 275, 314, 355	<i>B. diffusa</i>	12
24	Acetylborhavine (10)	C ₂₂ H ₂₀ O ₈	412.389	210-212/-/ 2940, 2820, 1870, 1655, 1620, 1480, 1400,1380,1300,1215/-	<i>B. diffusa</i>	12
25	11-methoxyborhavine (11)	C ₂₁ H ₂₀ O ₇	384.379	220-222/-/-/-	<i>B. diffusa</i>	12
26	Demethylatedborhavine (12)	C ₁₉ H ₁₆ O ₇	356.326	215-218/-/-/-	<i>B. diffusa</i>	12
27	Diacetylborhavine (13)	C ₂₀ H ₁₈ O ₇	370.353	214-215/-/-/-	<i>B. diffusa</i>	12
28	1-Hdroxy-4,5-dimethylxanthone (14)	C ₁₅ H ₁₂ O ₃	240.254	-/-/-/-	<i>B. diffusa</i>	12
29	Coccineone C (49)	C ₁₇ H ₁₄ O ₇	330.293	-/-339 (MeOH)/-/-	<i>B.coccinea</i>	13
30	Boeravinone D (3)	C ₁₈ H ₁₄ O ₇	342.304	-/0 (acetone)/3350, 1645, 1619, 1597, 1510, 1465/217, 277, 301, 348	<i>B. diffusa</i>	14
31	Boeravinone E (4)	C ₁₇ H ₁₂ O ₇	328.278	-/0 (acetone)/-/217, 278, 300, 349	<i>B. diffusa</i>	14
32	Boeravinone F (5)	C ₁₇ H ₁₀ O ₇	326.262	-/-/1721,1646/217, 265, 294, 330	<i>B. diffusa</i>	14
33	Liriodendrin (21)	C ₃₄ H ₄₆ O ₁₈	742.27	256-259 /-13.5 (pyridine)/3450, 1597, 1510, 1465/272, 281	<i>B. diffusa</i>	15
34	Syringaresinol-β-D-glucoside (22)	C ₂₈ H ₃₆ O ₁₃	580	-/-10 (MeOH) / 3350, 1590, 1510, 1460/270	<i>B. diffusa</i>	15
35	Ursolic acid (66)	C ₃₀ H ₄₈ O ₃	456.36	291/+66 (EtOH+KOH)/-/-	<i>B.diffusaa</i>	15
36	Repenone (15)	C ₁₈ H ₁₂ O ₈	356.288	-/-/ 3520, 3600, 1730,1610/-	<i>B.repens</i>	16
37	Repenol (16)	C ₁₈ H ₁₂ O ₉	372.287	-/-/ 3420, 3520, 1720,1640,1610/-	<i>B.repens</i>	16
38	Punarnavoside (29)	C ₂₈ H ₃₀ O ₁₀	526.539	185-186/-/ 3400-3350,2900, 1735,1650,1510,1460,1420,1330,1270,1230,1180,160,1120,1070,920,900,830/-	<i>B. diffusa</i>	17
39	Peracetylpunarnavoside (30)	C ₄₀ H ₄₂ O ₁₆	778.25	118-20/-/ 2850, 1740, 1600, 1500,1450/-	<i>B.diffusaa</i>	17
40	Methyl punarnavoside (31)	C ₃₀ H ₃₄ O ₁₀	554.215	156-57/-/ 3300, 2900, 2850, 1710-1700, 1620, 1525, 1440/-	<i>B.diffusaa</i>	17
41	p-Hydroxyphenylpropionic acid (32)	C ₁₀ H ₁₂ O ₃	180.08	132-133/-/-/-	<i>B.diffusaa</i>	17
42	p-methoxyphenylpropionic acid (33)	C ₉ H ₁₂ O ₃	168.079	90-95/-/-/-	<i>B.diffusaa</i>	17
43	Aglycone A (34)	C ₂₆ H ₂₄ O ₇	448.152	88-90/-/3400, 2900, 1735, 41640,1600,1520,1410/-	<i>B.diffusaa</i>	17
44	Aglycone A acetate (35)	C ₂₈ H ₂₆ O ₈	490.163	110-12/-/2850, 1740-1735, 1620,1590,1540,1420/-	<i>B.diffusaa</i>	17
45	Aglycone B (36)	C ₂₄ H ₂₄ O ₅	392.162	102-5/-/3400, 2850, 1725,	<i>B.diffusaa</i>	17

46	Aglycone B methyl (37)	C ₂₅ H ₂₆ O ₅	406.178	1640, 1590, 1520, 1470, 1430/-	<i>B.diffusaa</i>	17
47	1-glucopyrano-2-benzyl-4,5-dihydroxybenzene (38)	C ₁₈ H ₂₂ O ₈	366.13	131-132/-/ 2900,1730, 1635, 1590,1540,1570,1490/-	<i>B.diffusaa</i>	17
48	Aglycone C (39)	C ₁₅ H ₁₆ O ₃	244.110	158-159/-/ 3550, 2900, 1600, 1510, 1460, 1420, 1250,1210,1150,1120,930,830,780/-	<i>B.diffusaa</i>	17
49	Aglycone C methyl (40)	C ₁₆ H ₁₈ O ₃	258.126	185-86/-/3450, 1640, 1610, 1570,1550,1470/-	<i>B.diffusaa</i>	17
50	2,4,5-Trihydroxydiphenyl methane (41)	C ₁₃ H ₁₂ O ₃	216.233	195-97/-/1640, 1610, 1590, 1550,1510,1495,1485/-	<i>B.diffusaa</i>	17
51	Boeravinone A (1)	C ₁₈ H ₁₄ O ₆	326.305	-/-/-	<i>B. diffusa</i>	18
52	Boeravinone B (2)	C ₁₇ H ₁₂ O ₆	312.278	215-217/0 (acetone)/3600, 3250, 1650, 1620, 1595, 1495/217, 276, 300, 340	<i>B. diffusa</i>	18
53	Methylarachidate, Methylbehenic acid, Methylbehenate, Methylheptadecyclate, Methyloleate, Methylpalmitate, and Methylstearate			-/0 (acetone)/3250, 1650, 1620, 1595, 1495/217, 273, 300, 345	<i>B.diffusaa</i>	18
54	β-Sitosterol (42)	C ₂₉ H ₅₀ O	414.71	-/-/3000, 1710/-	<i>B.diffusaa</i>	18
55	Stigmasterol (43)	C ₂₉ H ₄₈ O	412.70	140/ -37 (CHCl ₃)/ 3450-2450, 1650, 815/-	<i>B.diffusaa</i>	18
56	Campesterol (44)	C ₂₈ H ₄₈ O	400.69	170/ -51 (CHCl ₃)/ 3400,3015,1615,810/-	<i>B.diffusaa</i>	18
57	Sitosteryl palmitate (45)	C ₄₅ H ₈₀ O ₂	653.116	157-158/-33 (CHCl ₃)/ 3440,3045,1620, 815/-	<i>B.diffusaa</i>	18
58	Sitosteryl oleate (46)	C ₄₇ H ₈₂ O ₂	679.153	-/-/-	<i>B.diffusaa</i>	18
59	Palmitoyl glucosyl sitosterol (52)	C ₅₁ H ₉₀ O ₇	815.256	-/-/1720, 1669/-	<i>B.diffusaa</i>	18
60	Palmitoylglucosyltriacetate sitosterol (53)	C ₅₇ H ₉₆ O ₇	893.368	-/-47.7(CHCl ₃) /3595-3399, 1733/-	<i>B.diffusaa</i>	18
61	Palmitoylglucosyltetraacetate sitosterol (54)	C ₄₃ H ₆₈ O ₆	680.996	-/-/1755/-	<i>B.diffusaa</i>	18
62	Boeravinone C (6)	C ₁₈ H ₁₆ O ₇	344.320	-/-/-	<i>B. diffusa</i>	18
63	Boerhavinone C diacetate (7)	C ₂₂ H ₂₀ O ₉	428.389	248-249/- 47(acetone)/3550, 3440, 1630, 1580, 1510, 1480 /331,293,212,207	<i>B. diffusa</i>	19
64	Boerhavinone C triacetate (8)	C ₂₄ H ₂₂ O ₁₀	470.425	-/-/1760/-	<i>B. diffusa</i>	19
65	Alcohol (23)	C ₁₈ H ₁₈ O ₇	346.11	-/-/1760,1745/-	<i>B. diffusa</i>	19
66	Epimeric Alcohol (24)	C ₁₈ H ₁₈ O ₇	346.11	208-209/-/-	<i>B.diffusaa</i>	19
				203-205/-/-	<i>B.diffusaa</i>	19

67	Linolenate, Palmitate, and Linoleate			-/-/-	<i>B.diffusa</i> <i>B.erecta</i> <i>B.repens</i>	20
68	5,23-Stigmastadienol and 5,24(25)Stigmastadienol,			-/-/-	<i>B.diffusa</i> <i>B.erecta</i> <i>B.repens</i>	20
69	Stigmastanol (64)	C ₂₉ H ₅₂ O	416.72	136-137/+24.8/-/-	<i>B.diffusa</i> <i>B.erecta</i> <i>B.repens</i>	20
70	Coccineone A (47)	C ₁₅ H ₈ O ₆	284.225	310/-/-/222, 254, 320	<i>B.coccinea</i>	21
71	Coccineone B (48)	C ₁₆ H ₁₀ O ₆	298.251	>310/recemic/-/214, 268, 300, 330/	<i>B.coccinea</i>	21
72	Coccineone D (50)	C ₁₆ H ₁₂ O ₇	316.267	237-240/-440 (MeOH)/-/-	<i>B.coccinea</i>	21
73	Borhavone / C-Methylflavone (17)	C ₁₉ H ₁₈ O ₆	342.348	222-223/(MeOH) /-/3460, 2900, 1650, 1600, 1200/ 275,314,350	<i>B. diffusa</i>	22
74	Borhavone diacetate (18)	C ₂₃ H ₂₂ O ₈	426.416	-/-/1780, 1200/-	<i>B. diffusa</i>	22
75	Demethylated borhavone (19)	C ₁₇ H ₁₄ O ₆	314.289	283-85/-/- /275, 300, 350 (MeOH)	<i>B. diffusa</i>	22
76	Borhavone tetraacetate (20)	C ₂₅ H ₂₂ O ₉	466.337	166-67/-/-/-	<i>B. diffusa</i>	22
77	β-Ecdysone (67)	C ₂₇ H ₄₄ O ₇	480.31	240-241/-/3500,1650/240	<i>B.diffusaa</i>	23
78	Triacontanol / Myricyl alcohol (69)	C ₃₀ H ₆₂ O	438.819	87/-/3500,1650/240 (MeOH)	<i>B.diffusa</i> <i>B.repens</i>	23 28
79	Proteins, Carbohydrates and Lipids			-/-/-	<i>B.diffusa</i>	24
80	Glycoprotein (an Antiviral agent)		16000-20000 daltons	-/-/-	<i>B.diffusa</i>	25
81	Protein and free Amino acids			-/-/-	<i>B.diffusa</i>	26
82	D-glucose, D-xylose, D-glucuronic acid, D-galactose, L-arabinose, and L-Rhamnose,			-/-/-	<i>B.repens</i>	27
83	Myristic acid (68)	C ₉ H ₈ O ₅	196.037	212/-/-/-	<i>B.repens</i>	28
84	Hentriacontane (65)	C ₃₁ H ₆₄	436.847	65.9/-/-/-	<i>B.diffusaa</i>	29
85	Hypoxanthine-9-L-arabinofuranoside (28)	C ₁₁ H ₁₃ N ₃ O ₅	267.24	-/-/-	<i>B.diffusa</i>	30
86	Punarnavine	C ₁₇ H ₂₂ N ₂ O	270.374	236-237dec./-/-/-	<i>B. diffusa</i>	31, 34
87	(Z)-24-Triacontenoic acid (63)	C ₃₀ H ₅₈ O ₂	450.787	60.8-61.2/-/-/-	<i>B.repens</i>	32
88	Alanine Arachidic Acid Aspartic Acid Behenic Acid Virus Inhibitor Boerhaavic Acid Daucosterol 5-7-dihydroxy-3'-4'-dimethoxy-6-8-dimethyl Fructose Glutamic Acid			-/-/-	<i>B. diffusa</i>	33

Glutamine
Glycerol
Glycine
Heptadecyclic Acid
Histidine
Leucine
Methionine
Oleic Acid
Oxalic Acid
Palmitic Acid
Proline
Proline, hydroxy
Serine
Stearic Acid
Sucrose
Threonine
Tyrosine
Valine

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