ETHNOPHARMACOLOGY OF THE PLANTS OF GENUS *AJUGA*

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ABSTRACT

The plants of genus *Ajuga* are evergreen, clump-forming rhizomatous perennial or annual herbaceous flowering species, with *Ajuga* being one of the 266 genera of the family Lamiaceae. There are at least 301 species of the genus *Ajuga* with many variations. These plants, growing in Europe, Asia, Africa, Australia and North America, are used in gardens as ground cover or border for their foliage and beautiful flowers. Many of these plants have been used in traditional medicine as a remedy for fever, toothache, dysentery, malaria, high blood pressure, diabetes, gastrointestinal disorders, as anthelmintic, diuretic and antifungal, anti-inflammatory, and antimycobacterial agents. They are also used as insect growth inhibitor s. A large number of compounds have been isolated from the *Ajuga* plants, including phytoecdysteroids, *neo*-clerodane-diterpenes and diterpenoids, triterpenes, sterols, anthocyanidin-glucosides and iridoid glycosides, withanolides, flavonoids, triglycerides and essential oils. These compounds possess a broad spectrum of biological, pharmacological and medicinal properties, such as anabolic, analgesic, antibacterial, antiestrogenic, antifungal, anti-inflammatory, antihypertensive, antileukemic, antimalarial, antimycobacterial, antioxidant, antipyretic, cardiotonic, cytotoxic, hypoglycemic, and vasorelaxing activity, as well as antifeedant and insect growth-inhibitory properties. Thus, genus *Ajuga* has significant medicinal and economic importance.

Keywords: Genus Ajuga, ethnopharmacology, ethnobotany, traditional medicine, pharmacological activity, biological activity, compounds, phytoecdysterols, neo-clerodanes, iridoids, withanolides, sterols, flavonoids.

INTRODUCTION

The plants of genus *Ajuga* are evergreen, clump-forming rhizomatous annual or perennial herbaceous flowering species in the mint family, Lamiaceae, with most plants native to Europe, Asia, and Africa, but also growing in Australia and North America (Flora of China, 1994; Coll and Tendrón, 2008). There are at least 301 species of the genus *Ajuga* with many variations (some are listed in table 1; http-1); *ajuga* is one of the 266 genera of the family Lamiaceae. The *Ajuga* plants grow to 5-50 cm tall, with opposite leaves, which are attractive. The flowers are two lipped and tubular, and mostly blue, purple or yellow in color. Many *Ajuga* plants are used in horticulture as groundcover or border, and in rock gardens, but some are regarded as weeds. Some *ajuga* species have a large number of varieties (cultivars) (table 2), which are used in gardens because of their varied blooms of different colors. Many plants of the *Ajuga* genus and some compounds isolated from these plants have medicinal value and of ecological and economic importance.

The use of Ajuga plants in traditional medicine

Ethnopharmacological surveys have revealed that some 20 species of *Ajuga* plants are used in traditional medicine mostly in Africa, Asia and China (table 3). The pharmacology and therapeutic value of plants including *Ajuga reptans* has been described as early as 1948 (Newman, 1948). In East Africa, plants of genus *Ajuga* have been used as a remedy for fever, toothache, dysentery, and high blood pressure (Kokwaro, 1976; Baytop, 1984; Githinji and Kokwaro, 1993). In North Africa, *Ajuga* plants are used to treat diabetes and hypertension (Ziyyat *et al*., 1997; Jouad *et al*., 2001; Bnouham *et al*., 2002; El-Hilaly and Lyoussi, 2002; Eddouks *et al*., 2002; El-Hilaly *et al*., 2003; Tahraoui *et al*., 2006; Eddouks *et al*., 2007), as a panacea (cure-all) (Hassar, 1999), specifically for gastrointestinal disorders (Baytop, 1984; Bellakhdar *et al*., 1991), and as an anthelmintic (Wessner *et al*., 1992; Rodriguez-Hahn *et al*., 1994; Yun *et al*., 1998). In traditional Chinese pharmacopoeia, plants of the genus *Ajuga* are known to produce a diuretic effect (Aliotta and Pollio, 1994). Other reported activities of *Ajuga* plants include antibacterial (Chen *et al*. 1996a; Chen *et al*., 1997; Anon, 2000; Bennaghmouch *et al*. 2001), antifungal (Anon, 2000; Kariba, 2001), antihypertensive (Odek-Ogunde, *et al*., 1993), anti-inflammatory (Shimomura *et al*., 1992; Marc *et al*., 2008), antimalarial/antiplasmodial (Kuria *et al*., 2001a, Kuria *et al*., 2002; Njoroge and Bussmann, 2006, Kareru *et al*., 2007), antimycobacterial (Cantrell *et al*., 1999), antioxidant (Chenni *et al*., 2007), antipyretic (Baytop, 1984), antitumor (Wessner *et al*., 1992; Rodriguez-Hahn *et al*., 1994), larvae and insect antifeedant (Camps *et al*., 1981a; Camps and Coll, 1993; Bremner *et al*., 1998; Ben Jannet *et al*. 2000; Bondì *et al*., 2000; Ben Jannet *et al*., 2001; Fekete *et al*., 2004), and insect growth inhibitor (Camps and Coll, 1993) activity.

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Compounds isolated from plants of genus Ajuga

Chemical investigations have led to the isolation of a large number of compounds (table 4), including phytoecdysteroids, *neo*-clerodane- diterpines and diterpinoids, triterpines (Camps *et al*., 1979; Camps *et al*., 1981b; Shimomura *et al*., 1981; Camps *et al*., 1982a; Camps *et al*., 1982b; Camps *et al*., 1984a; Camps *et al*., 1984b; Camps *et al*., 1987; Camps *et al*., 1990; Camps, 1991; Shen *et al*., 1993; Chen *et al*., 1995; Beauchamp *et al*., 1996; Chen *et al*., 1996a; Chen *et al*., 1996b; Chen *et al*., 1997; Bremner *et al*., 1998; Malakov and Papanov, 1998; Cantrell *et al*., 1999; Ben Jannet *et al*., 1999; Ben Jannet *et al*., 2000; Chaari *et al*., 2000; Kökdil *et al*., 2002; Castro *et al*., 2008; Coll & Tandrón, 2008), specific sterols (Cantrell *et al*., 1999; Fujimoto *et al*., 2000; Akbay *et al*., 2003a; Chan *et al*., 2005), anthocyanidin-glucosides and iridoid glycosides (Shimomura *et al*., 1987; Kotenko *et al*., 1993; Takasaki *et al*., 1998; Konoshima *et al*., 2000; Terahara *et al*., 2001; Chaari *et al*., 2002; Akbay *et al*., 2003b), quinols (Khan *et al*., 1999a), withanolides (Khan *et al*., 1999b; Khan *et al*., 1999c; Khan *et al*., 1999d; Nawaz *et al*., 1999), flavonoids, triglycerides and essential oils. Among the many plants containing phytoecdysteroids, the plants belonging to *Ajuga* genus are unique for the great variety of such compounds produced (Camps, 1991; Camps and Coll, 1993; Aliotta and Pollio, 1994; Arfan *et al*., 1996; Baltaev, 2000; Báthori and Pongrâcz, 2005), which exert a broad spectrum of biological and pharmacological actions (table 5). The structures of these compounds are presented in figs. 1-8.

Biological and pharmacological studies with the plant extracts/compounds isolated from the Ajuga plants

A number of studies carried out with the crude extracts of the plant or phytochemicals isolated show that the members of the genus *Ajuga* (table 5) possess a wide variety of biological, pharmacological and medicinal properties, such as anabolic, analgesic, anti-arthritic, antibacterial, antiestrogenic, antifungal, anti-inflammatory, antihypertensive, antileukemic, antimalarial antimycobacterial, antioxidant, antipyretic, cardiotonic, cytotoxic, hypoglycemic, and vasorelaxing activity, as well as antifeedant and insect growth-inhibitory properties (table 5). These investigations provide experimental support for the empiric ethnopharmacological use of these plants in folk medicine.

DISCUSSION

The plants of genus *Ajuga* are widespread in nature; some are used in gardens because of their beautiful flowers and some have diverse medicinal uses in indigenous system of medicine (Manjunath, 1948; Perry & Metzger, 1980; see also table 3), especially in Asia, North Africa and China. Many species belonging to the genus *Ajuga* have been used in folk medicine as diuretics and as a remedy for fever, toothache, dysentery, insect bite, skin and eye

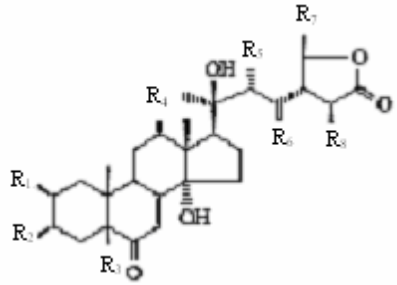


Fig. 1: Phytoecdysteroids

Phytoecdysteroid	R^1	R^2	R^3	R^4	R^5	R^6	R^7	R^8
Cyasterone	OH	OH	H	H	OH	H	CH_3	CH_3
Cyasterone-22-OAc	OH	OH	H	H	OAc	H	CH_3	CH_3
Sengostreone	OH	OH	OH	H	OH	H	CH_3	CH_3
29-Norcyasterone	OH	OH	H	H	OH	H	H	CH_3
29-Norcyasterone-2-OAc	OAc	OH	H	H	OH	H	H	CH_3
29-Norcyasterone-3-OAc	OH	OAc	H	H	OH	H	H	CH_3
3-Epicyasterone	OH	OH (α)	H	H	OH	H	CH_3	CH_3
3-Epi-22-acetylcyasterone	OH	OH (α)	H	H	OAc	H	CH_3	CH_3
28-Episengosterone	OH	OH	OH	H	OH	H	CH_3(α)	CH_3
29-Norsengosterone	OH	OH	OH	H	OH	H	H	CH_3
22-Dehydro-12-hydroxycyasterone	OH	OH	H	OH	= O	H	CH_3	CH_3
22-Dehydro-12-hydroxy- 29-norsengosterone	OH	OH	OH	OH	= O	H	CH_3	CH_3
22-Dehydro-12-hydroxysengosterone	OH	OH	H	OH	= O	H	H	CH_3
22-Dehydro-12-hydroxy- 29-norsengosterone	OH	OH	OH	OH	= O	H	H	CH_3
22-Oxocyasterone	OH	OH	H	H	= O	H	CH_3	CH_3
23-Hydroxycyasterone	OH	OH	H	H	OH	OH	CH_3	CH_3

diseases, bladder and intestinal disorders, hypertension, malaria, pneumonia, edema, as anthelmintic, antifungal, hypoglycemic, anti-inflammatory, antitussive, expectorant, antitumor and antimicrobial agents (Baytop, 1984; Wessner *et al*., 1992; Camps and Coll, 1993; Kokwaro, 1993; Odek-Ogunde *et al*., 1993; Rodriguez-Hann, *et al*., 1994; Muhammad *et al*., 1999; Takasaki *et al*., 1999). Some plants, such as *A. iva,* have a wide spectrum of biological effects including hypoglycemic (Kutepova *et al*., 2001; El Hilaly and Lyoussi, 2002), vasorelaxant (El Hilaly *et al*., 2004), hypolipidemic (El Hilaly *et al*., 2006; Lacaille-Dubois *et al*., 2006), hypotensive, antioxidant (Lacaille-Dubois *et al*., 2006; Chenni *et al*., 2007), anti-inflammatory, antifungal,

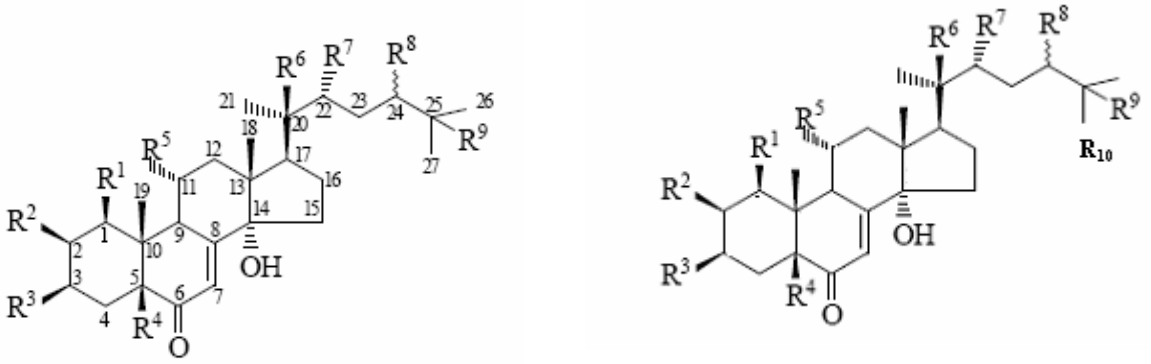
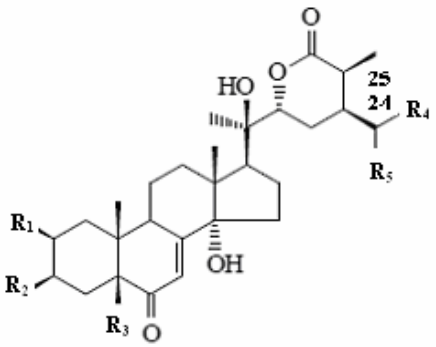


Fig. 1: Phytoecdysteroids (cont.)

Phytoecdysteroid	R^1	R^2	R^3	R^4	R^5	R^6	R^7	R^8	R^9	R^{10}
Ajugasterone A	H	OH	OH	OH	H	OH	OH	H	OH	CH_3
Ajugasterone B	H	OH	OH	H	H	OH	OH	CH_2CH_3	CH_2 OH	C= CH_2
Ajugasterone C	H	OH	OH	H	OH	OH	OH	H	H	CH_3
20-Hydroxy-2-deoxyecdysone 22- acetate	H	H	OH	H	H	OH	OAc	H	OH	CH_3
20-Hydroxy-2-deoxyecdysone-3-*O*-glycoside	H	H	OGlc	H	H	OH	OH	H	OH	CH_3
20-Hydroxy-2-deoxy-3-epi-α-ecdysone	H	H	OH(α)	H	H	OH	OH	H	OH	CH_3
20-Hydroxy-22-oxo-α-ecdysone	H	OH	OH	H	H	OH	= O	H	OH	CH_3
20-Hydroxy-5α-ecdysone	H	OH	OH	H(α)	H	OH	OH	H	OH	CH_3
20-Hydroxyecdysone-2,20-diacetate	H	OAc	OH	OH	H	O Ac	H	H	OH	CH_3
2-Deoxy -integristerone A	OH	H	OH	H	H	OH	OH	H	OH	CH_3
2-Deoxyecdysone	H	H	OH	H	H	H	OH	H	OH	CH_3
2-Deoxyecdysone-1-acetate	H	H	OAc	H	H	H	OH	H	OH	CH_3
2-Deoxyecdysone-22-acetate	H	H	OH	H	H	H	OAc	H	OH	CH_3
2-Deoxy-ecdysterone	H	H	OH	H	H	OH	OH	H	OH	CH_3
2-Deoxyecdysterone-3-acetate	H	H	OAc	H	H	H	OH	H	OH	CH_3
2-Deoxyecdysterone-22-acetate	H	H	OH	H	H	H	OAc	H	OH	CH_3
Carthamasterone A	H	OH	OH	OH	H	OH	OH	H	OH	COO CH_3
Carthamasterone B	H	OH	OH	H	H	OH	OH	H	OH	COO CH_3
Dacrysterone	H	OH	OH	OH	H	OH	OH	CH_3(α)	OH	CH_3
Integristerone A	OH	OH	OH	H	H	OH	OH	H	OH	CH_3
Integristerone B	OH	OH	OH	OH	H	OH	OH	H	OH	CH_3
Podecdysone C	H	OH	OH	H	H	OH	OH	H	OH	CH_2OH
Polypodine B	H	OH	OH	OH	H	OH	OH	H	OH	CH_3
5-α-Polypodine B	H	OH	OH	OH(α)	H	OH	OH	H	OH	CH_3
26-Hydroxy-polypodine B	H	OH	OH	OH	H	OH	OH	H	OH	CH_2OH
Ponasteroside A	H	OH	GLcO	H	H	OH	OH	H	H	CH_3
Ponasterone A	H	OH	OH	H	H	OH	OH	H	H	CH_3
Ponasterone B	H	OH(α)	OH(α)	H	H	OH	OH	H	H	CH_3
Ponasterone C	H	OH	OH	OH	H	OH	OH	OH (ξ)	H	CH_3

Silenoside A	H	OH	OH	H	H	OH	GlcO	H	OH	CH_3
Silenoside B	H	OH	GlcO	H	H	OH	GlcO	H	OH	CH_3
Silenoside C	OH	OH	OH	H	H	OH	GlcO	H	OH	CH_3
Silenoside D	H	OH	GlcO	H	H	OH	OH	H	OH	CH_3
Stachysterone B	H	OH	OH	H	$C^{12}H = C^{13}$	OH	OH	H	H	CH_3
Stachysterone C	H	OH	OH	H	H	OH	OH	$C^{24}H = C^{25}$	H	CH_3
Turkesterone	H	OH	OH	H	OH	OH	OH	H	OH	CH_3
Cheilanthone A	H	OH	OH	H, C^7H_2 - C^8H	H	H	OH	H	OH	CH_3
Cheilanthone B	H	OH	OH	H, C^7H_2 - C^8H	H	H	OH	H	H	CH_3
α-Ecdysone	H	OH	OH	H	H	H	OH	H	OH	CH_3
β-Ecdysone	H	OH	OH	H	H	OH	OH	H	OH	CH_3
Ecdysterone	H	OH	OH	H	H	OH	OH	H	OH	CH_3
Ecdysterone-2-acetate	H	OAc	OH	H	H	OH	OH	H	OH	CH_3
Ecdysterone-3-actate	H	OH	OAc	H	H	OH	OH	H	OH	CH_3
Makisterone A	H	OH	OH	H	H	OH	OH	CH_3 (α)	OH	CH_3
Makisterone B	H	OH	OH	H	H	OH	OH	CH_3 (α)	OH	CH_2 OH
Makisterone C (Podecdysone A)	H	OH	OH	H	H	OH	OH	C_2H_5(α)	OH	CH_3
Makisterone D	H	OH	OH	H	H	OH	OH	$CH(OH)CH_3$	H	CH_2 OH
Sidasterone A	H	OH	OH	H	H	OH	OH	CH_3	C= CH_2	CH_2 OH
Amarasterone A	H	OH	OH	H	H	OH	OH	C_2H_5 (α)	H	CH_2 OH
Amarasterone B	H	OH	OH	H	H	OH	OH	CH_2 -CH_2OH	H	CH_3



Phytoecdysteroid	R^1	R^2	R^3	R^4	R^5	C^{24} - C^{25}
Precyasterone	OH	OH	H	CH_3	OH	CH_2CH_2
24,25-Dehydro-precyasterone	OH	OH	H	CH_3	OH	CH=CH
Capitasterone	OH	OH	H	CH_3	H	CH_2CH_2
Ajugalactone	OH	OH	H	CH_3	H	CH=CH
2-Dehydroajugalactone	= O	OH(β)	H	CH_3	H	CH=CH
3-Dehydroajugalactone	OH(β)	= O	H	CH_3	H	CH=CH
5,29-Dihydroxy-capysterone	OH	OH	OH	CH_2OH	H	CH_2CH_2
5,29-Dihydroxy-capitasterone	OH	OH	OH	CH_2OH	H	CH=CH

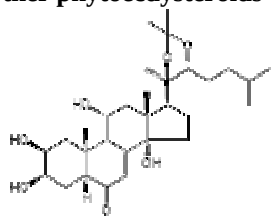
antimicrobial, antipyretic, antihelmintic, and vulnerary activity (Wessner *et al*., 1992; Bondí *et al*., 2000; El-Hilaly and Lyoussi, 2002; El-Hilaly *et al*., 2004b; El-Hilaly *et al*., 2006; El-Hilaly *et al*., 2007). Many of the therapeutic effects of these plants are borne out by experimental studies (Table 5). On the other hand, some ajuga species have a large number of cultivars, sometime more than 100, which are used in horticulture because of their varied blooms of different colors (tables 2 & 3).

Almost all plants produce a variety of chemicals, such as phytoecdysteroids and clerodane diterpenoids and iridoids, for self-defense against insects, and ecdysones, which are involved in plant growth. The ecdysteroids, also called ecdysones (α- and β-), are a group of chemically related polyhydroxylated steroids present in plants (phytoecdysteroids) and arthropods (zooecdysteroids); some ecdysteroids, such as ecdysone, 20-hydroxyecdysone, makisterone A and ajugasterone C, are

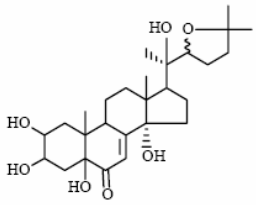
present in both plants and arthropods. The zooecdysteroids control the molting and metamorphorphosis of arthropods (Slama, *et al*., 1974), however, the function of phytoecdysteroids, found in at least 176 plant species (The Ecdysone Handbook; Lafont and Wilson, 1996; Lafont, 1998), is still not fully known. The phytoecdysteroids stimulate protein synthesis in plants and activate cell mitosis, and possibly act as plant growth regulators (Ramazanov, 2005). They also provide some degree of protection against non-adapted phytophagous insects and/or soil nematodes (Sláma *et al*., 1974; Bergamasco and Horn, 1983; Kubo and Hanke, 1986; Sláma and Lafont, 1995; Dinan, 2001; Soriano *et al*., 2004). The plants synthesize phytoecdysterones from mevalonic acid, and in many cases, the biosynthesis occurs via cholesterol and/or lathosterol (Adler and Grebenok, 1995; Lafont, 1998). α-Ecdysone is biosynthesized from cholesterol and it is a precursor of β-ecdysone (Nakanishi, 1971), while clerosterol is the precursor phytosterol for some phytosteroids, such as cyasterone and isocyasterone (Fujimoto *et al*., 2000; Nomura *et al*., 2000). The phytoecdysteroids, which accumulate in various plant organs, such as flowers, stems, leaves, roots, and fruits (Lafont, 1998; Dinan *et al*., 2001; Ramazanov, 2005), are usually present in 0.01-0.1% of the plant dry weight, but in some, may be as high as 2.5-2.9% (Chou and Lu, 1980; Satov *et al*., 1993); they may occur in the free state as well as derivatives (ethers, esters, and glycosides). Ecdysterone is the most widely distributed phytoecdysteroid, and is present in 147 plant species, including *Ajuga* (Baltaev, 2000; Ramazanov, 2005). Many phytoecdysones induce molting in insects, however, some have antimolting effect, such as ajugalactone, isolated from *A. decumbens* (Koreeda *et al*., 1970). The phytoecdysteroids have agricultural and biomedical importance. Feeding some phytosteroids to silkworm (*Bombyx mori*) improves silk yield, while other phytosteroids are effective in controlling insects and thus protecting crops (Dinan, 2001).

The phytoecdysteroids **(**phytoecdysones) isolated from the *ajuga* species, including 2-acetyl-20-hydroxyecdysone, 3-acetyl-20-hydroxyecdysone, ajugalactone, ajugalide, ajugasterone B, C & D, amarasterone, capitasterone, cheilanthone A and B, cyasterone, cyasterone-22-acetate, decumbesterone, 2- dehydroajugalactone, 3- dehydroajugalactone, 22-dehydro-12-hydroxynorcyasterone, 22-dehydro-12-hydroxy-29-norcyasterone, 22-dehydro-12-hydroxy-29-norsengosterone, 22-dehydro-12-hydroxysengosterone, 24,25-dehydro-precyasterone, 5,29-dihydroxycapitasterone, α-ecdysone, β-ecdysone, α-ecdysterone, ecdysterone, ecdysterone 2,3-monoacetonide, epicyasterone, 28-episengosterone, 23-hydroxycyasterone, integristerone B, isocyasterone, makisterone A, norcyasterone, 29-norsengosterone, 22-oxocyasterone, polypodine B, ponasterone, reptansterone, sengosterone, sidasterone A and B, turkesterone, and their derivates (Ramazanov, 2005; table 4), have been studied extensively for their anabolic effect, including growth promotion by increased protein synthesis (in body builders and in patients with AIDS, neoplastic disease or critical malnutrition, etc), improving physical and sexual

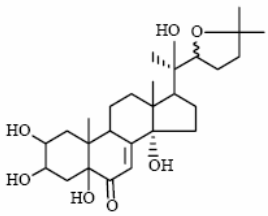
Other phytoecdysteroids



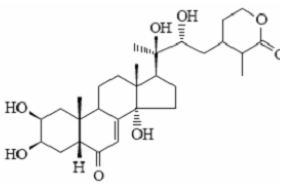
Ajugasterone-C 20,22-monoacetonide



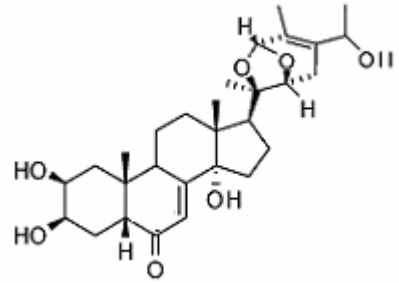
Ajugasterone D



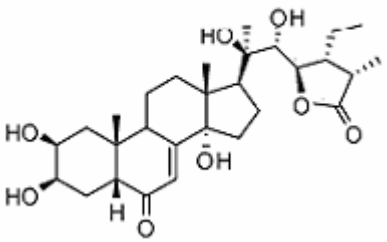
Stachysterone D



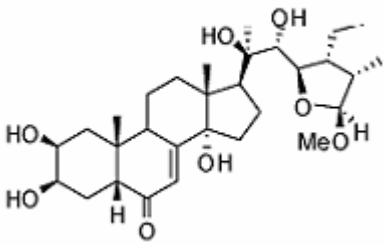
Reptansterone



Ajugacetalsterone C

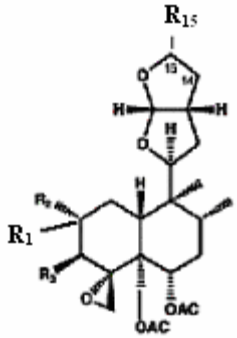


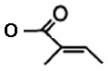
Breviflorasterone



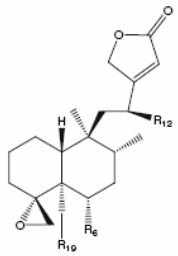
Ajugacetalsterone D

performance, wound healing, enhancing immune function to prevent infection and disease, improvement in kidney and liver functions, and increased red cell production (Dinan, 2001; Syrov, 2001; Syrov *et al*., 2001a; Syrov *et al*., 2001b; Báthori and Pongrâcz, 2005; Dinan and Lafont, 2006; Cheng *et al*., 2008). Some



Compound	R_1	R_2	R_3	R_{15}	C_{14}-C_{15}
Clerodin	H	H	H	H	CH=CH
Dihydroclerodin	H	H	H	H	CH_2 - CH_2
Ajugapitin	H	OH	EtCH(Me)COO	H	CH=CH
14,15-dihydroajugapitin	H	OH	EtCH(Me)COO	H	CH_2 -CH_2
14-hydro-15-hydroxyclerodin	H	H	H	OH	- CH -CH_2
14-hydro-15-hydroxyajugapitin	H	OH	EtCH(Me)COO	OH	- CH -CH_2
14-hydro-15-ethoxyajugapitin	H	OH	EtCH(Me)COO	OEt	- CH -CH_2
Ivain III	H	OH	Me_2CHCOO	H	- CH_2 - CH_2
Ivain IV	H	OH	EtCH(Me)COO	H	- CH_2 - CH_2
Ajugaorientin		H	OH	H	CH_2 -CH_2
Ajugareptansin		H	OH	H	CH_2 -CH_2

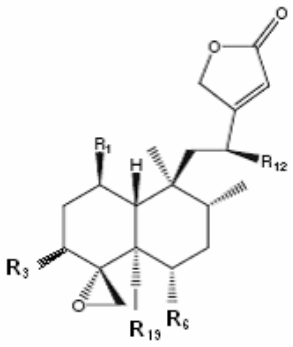
Me = -CH_3; Et =CH_2CH_3



Compound	R_6	R_{12}	R_{19}
Ajugarin I	OAc	H	OAc
Ajugarin II	OH	H	OAc
Deacetylajugarin II	OH	H	OH
Ajugarin V	OAc	H	H
Ajugacumbin A	OAc	H	OTig
Ajugacumbin B_1	OH	H	OTig
Ajugalide C	OAc	OH	OAc
Ajugamarin F_1	OH	OMB	OH
Ajugamarin F_2	OAc	OMB	OH
Ajugamarin F_3	OH	OMB	OAc
Ajugamarin F_4	OAc	OMB	OAc
Ajugacumbin G	OAc	H	OHMB

Ac = acetyl;
HMB = 3-hydroxy-2-methylene-butyryl;
MB = 2-methylene-butyryl;
Tig = tigloyl = Σ-2-methyl-2-butenoyl

Fig. 2: *Neo*-Clerodanes



Compound	R_1	R_3	R_6	R_{12}	R_{19}
Ajugacumbin C	OAc (α)	OAc	OAc	H	OTig
Ajugacumbin D	H	OH	OAc	H	OTig
Ajugacumbin E	OAc	OAc	OAc	H	OHMB
Ajugalide A	OH	H	OAc	OAc	OAc
Ajugalide B	OAc	H	OAc	H	OAc
Ajugamacrin A	OAc	H	OAc	OiBu	OAc
Ajugamacrin B	OAc	H	OAc	OMB	OAc
Ajugamacrin C	OiBu	H	OAc	OiBu	OAc
Ajugamacrin D	OiBu	H	OAc	OMB	OAc
Ajugamacrin E	OMB	H	OAc	OiBu	OAc
Ajugamarin A_1	OTig	H	OAc	OH	OAc
Ajugamarin A_2	OTig	H	OAc	OAc	OAc
Ajugamarin B_1	OMB	H	OAc	OH	OAc
Ajugamarin B_2	OMB	H	OAc	OAc	OAc
Ajugamarin B_3	OMB	H	OH	OH	OAc
Ajugamarin B_4	OMB	H	OAc	OH	OH
Ajugamarin B_5	OMB	H	OAc	OAc	OH

phytoecdysteroids have inhibitory effect on Epstein-Barr virus early antigen and chemopreventive effect against tumor promoters (Takasaki *et al*., 1999).

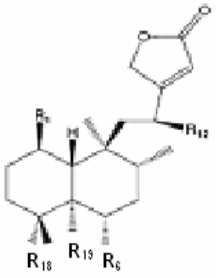
Although no thorough toxicological study appears to have been performed for any phytoecdysteroid, there is evidence that the acute toxicity of these compounds to mammals is extremely low (Ogawa *et al*., 1974; Kosar *et al*., 1997; Dinan, 2001).

Another major group of compounds isolated from the *Ajuga* plants are the *neo*-clerodane diterpenoids (Arfan *et al*., 1996; Coll *et al*., 2007; Coll and Tandrón, 2008), which are ajugarin-like compounds (ajugacumbin A, B,

Continued

Compound	R_1	R_3	R_6	R_{12}	R_{19}
Ajugamarin C	OiBu	H	OAc	OiBu	OAc
Ajugamarin C_1	OH	H	OAc	OH	OAc
Ajugamarin D	OiBu	H	OAc	OMB	OAc
Ajugamarin E	OMB	H	OAc	OiBu	OAc
Ajugamarin E_1	OH	H	OAc	OMB	OH
Ajugamarin E_2	OH	H	OH	OMB	OAc
Ajugamarin E_3	OH	H	OH	OMB	OAc
Ajugamarin G_1	OTig	H	OH	OMB	OAc
Ajugamarin H_1	OMB	H	OH	OTig	OAc
Ajugapantin A	OAc	H	OH	OAc	OAc
Ajugareptansone A	(C_1)=O	OMB	OAc	H	OAc
Ajugareptansone B	(C_1)=O	(C_2)=CH	OAc	H	OAc
Ajugareptone	(C_1)=O	OH	OAc	OMB	OAc
Ajugatakasin A	OTig	H	OH	OTig	OAc
Ajugatakasin B	OMB	H	OH	OMB	OAc
Ajugatansin A_1	OH	OMB	OAc	OTig	OAc
Ajugatansin B_1	H	OH	OAc	OMB	OAc

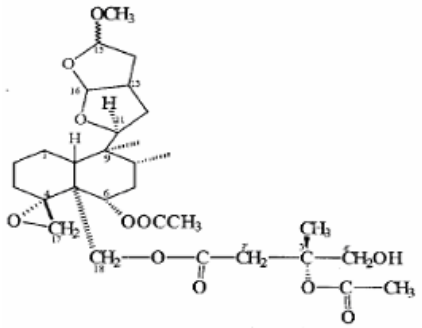
Ac = acetyl; iBu = isobutyryl; MB = 2-methylene-butyryl; Tig = tigloyl = Σ-2-methyl-2-butenoyl



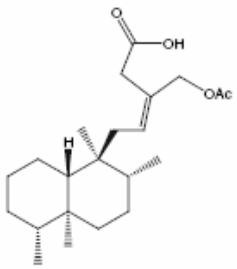
Compound	R_1	R_6	R_{12}	R_{18}	R_{19}
Ajugacumbin F	H	OH	H	CH_2OH	OH
Ajugamarin A_1-chlorohydrin	OTig	OAc	OH	CH_2Cl	OAc
Ajugamarin D_1	OMB	OH	OH	CH_2OAc	OAc
Ajugarin I-chlorohydrin	H	OAc	H	CH_2Cl	OAc
Ajugarin III	H	OAc	H	CH_2OH	OAc
Ajugarin IV	H	OAc	H	COO CH_3	H
Deacetylajugarin IV	H	OH	H	COO CH_3	H
Ajugalide D	H	OH	OH	COO CH_3	H

Ac = acetyl; iBu = isobutyryl; MB = 2-methylene-butyryl; Tig = tigloyl = Σ-2-methyl-2-butenoyl

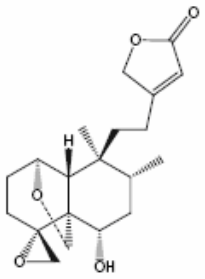
Other *neo*-clerodane diterpenoids



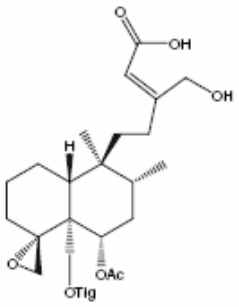
Bracteonin A



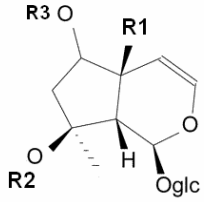
Ajugalaevigatic acid



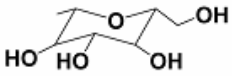
1,19-epoxy-ajugarin II



Ajugacumbin hydroxyacid

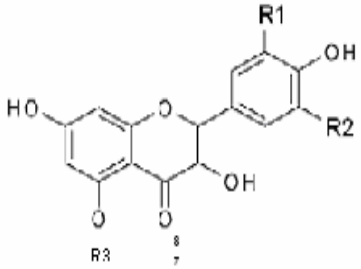


Compound	R_1	R_2	R_3
8-O-acetyl-harpagide	OH	Ac	H
Ajugol	H	OH	H
Ajugoside	H	OAc	H
6,8-diacetyl-harpagide	OH	Ac	Ac
Harpagide	OH	OH	H
Harpagoside	OH	OtC	H



Ac = acetyl; tC = *trans*-cinnamoyl; glc =

Fig. 3: Iridoid glycosides



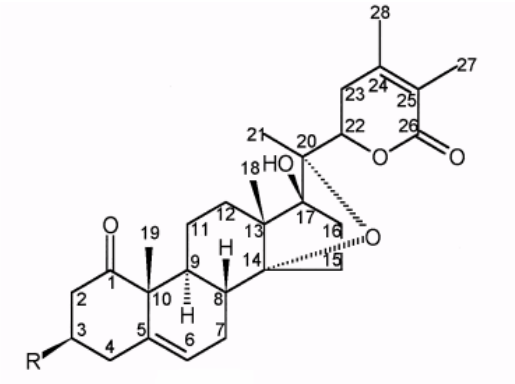
Compound	R_1	R_2	R_3	C^7-C^8
Kaempferol	H	H	H	C=C
5-Methyl-kaempferol	H	H	CH_3	C=C
5-Methyl-myricetin	OH	OH	CH_3	C=C
Myricetin	OH	OH	OH	C=C
Quercetin	OH	H	OH	C=C
Dihydrokaempferol	H	H	H	CH-CH
Dihydromyricetin	OH	OH	OH	CH-CH
Dihydroquercetin	OH	H	OH	CH-CH

Fig. 4: Flavonoids (also, isolated were several flavonol glycosides based upon the above structures)

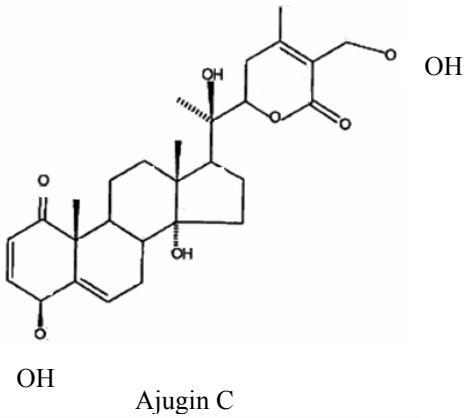
C, D, E, F & G, ajugalide A, B, C & D, ajugamacrin A, B, C, D, & E, ajugamarin A1, A2, B1, B2, B3, B4, B5, C1, D1, E1, E2, E3, F1, F2, F3, F4, G1, H1 & L2, ajugamarin A1-chlorohydrin, ajugapantin A, ajugareptansone A & B, ajugareptone, ajugarin I, II, III, IV & V, ajugarin I chlorohydrin, ajugasterone A, B, C, D and F, ajugatakasin A & B, and ajugatansin A1 & B1) and clerodin-like compounds (3-β-acetoxyclerodinin C, 2-acetylivain, ajugachin A & B, ajugaorientin, ajugapitin, ajugareptansin, ajugatensin D1, ajugavensin A, B & C, areptin A & B, chamaepitin, clerodin, clerodinin A, B & C, 14,15-dehydroajugareptansin, 14,15-dehydroajugapitin, 14,15-dihydroclerodin, 15-α-ethoxy-14-hydroajugapitin, 15-β-ethoxy-14-hydroajugapitin, hativene A, B & C, 14-hydro-15-hydroxyajugachin A, 14-hydro-15-hydroxyajugapitin, 14-hydro-15-hydroxyclerodin, 3-β-hydroxyajugavensin B, ivain I, II & III, lupulin A, B & D). Also present are ajugalaevigatic acid, ajugapyrin A, bracteonin A & lupulin C. These compounds mostly show antifeedant activity against pest insects (Bellés *et al*., 1985; Min *et al*., 1989; Bremner *et al*., 1998; Ben Jannet *et al*., 2000; Bondí *et al*., 2000; Caballero *et al*., 2001; Klein Gebbinck *et al*., 2002; Koul, 2005), but some possess antibacterial (Chen *et al*., 1996b; Chen *et al*., 1997 ; Ben Jannet *et al*., 1999a), antimalarial (Kuria *et al*., 2001a; Kuria *et al*., 2001b; Kuria *et al*., 2002), antimycobacterial (Cantrell *et al*., 1999), antifungal (Topcu *et al*., 2004) and cancer chemopreventive (Takasaki *et al*., 1999) activities (table 5).

In addition to the phytoecdysteroids and neoclerodane diterpenoids, the *Ajuga* plants produce a variety of other compounds including anthocyanins, flavonoids, ionones, iridoids, quinols, sterols, triglycerides, withanolides and carbohydrates (Imai *et al*., 1969a; Imai *et al*., 1969b; Koreeda *et al*., 1970; Chung *et al*., 1980; Takeda *et al*., 1987; Min *et al*., 1989; Shimomura *et al*., 1989; Min *et al*., 1990; Callebaut *et al*., 1993; Camps and Coll, 1993; Wessner *et al*., 1993; Muhammad *et al*., 1999; Akbay *et al*., 2002; Akbay *et al*., 2003a; Akbay *et al*., 2003b; Riaz *et al*., 2004; Riaz *et al*., 2007), which have a wide range of biological and pharmacological activity (table 5).

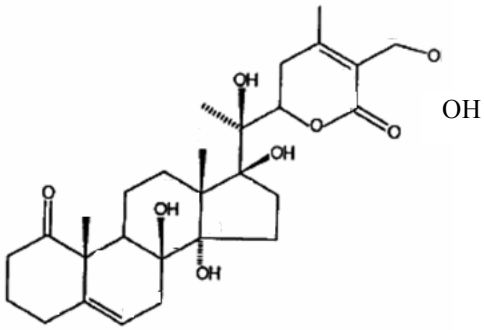
Iridoids are a class of secondary metabolites found in a wide variety of plants and in some animals. They are monoterpenes biosynthesized from isoprene and they are often intermediates in the biosynthesis of alkaloids. The iridoids are produced by plants primarily as a defense against herbivores or against infection by micro-organisms. To humans and other mammals, iridoids are often characterized by a deterrent bitter taste and are toxic to herbivores. These compounds exhibit a wide range of



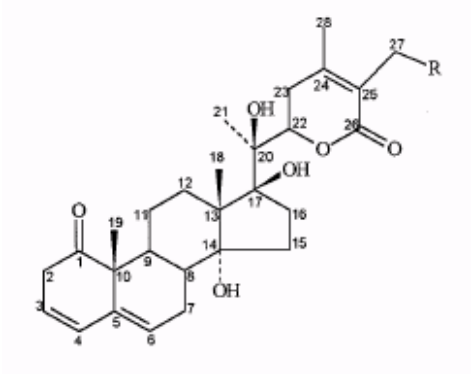
Ajugin 1 (R = OH)



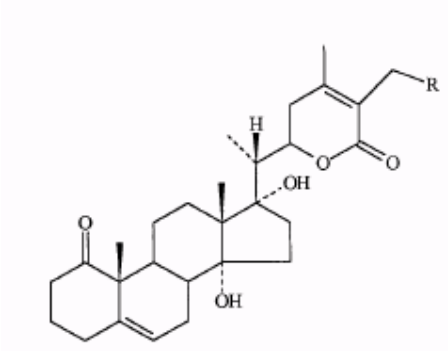
Ajugin C



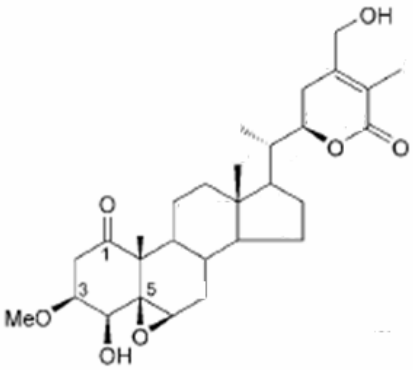
Ajugin D



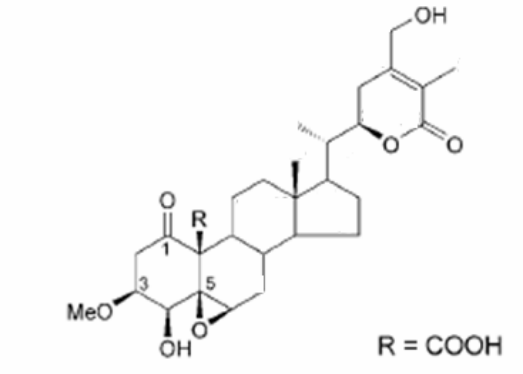
Ajugin E (R = OH)



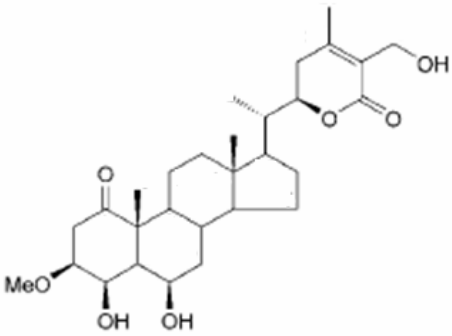
Ajugin F (R = OH)



Bracteosin A



Bracteosin B



Bracteosin C

Fig. 5: Withanolides.

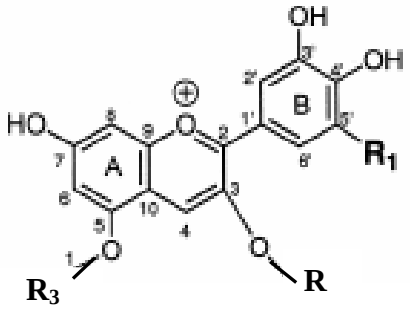
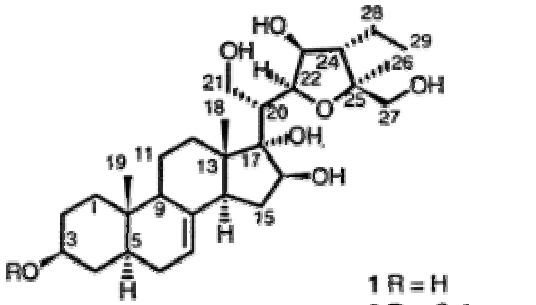
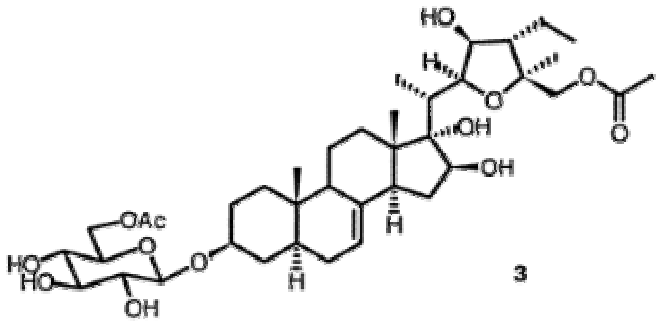
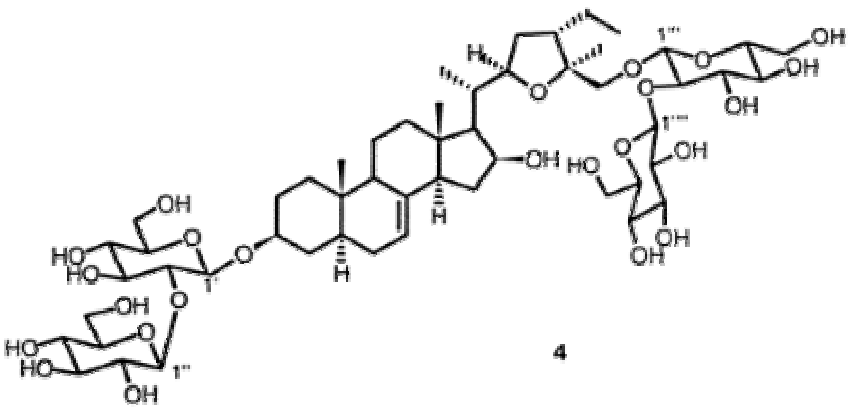


Fig. 6: Anthocyanins (cyanidine and delphinidine glycosides based upon the above structure).

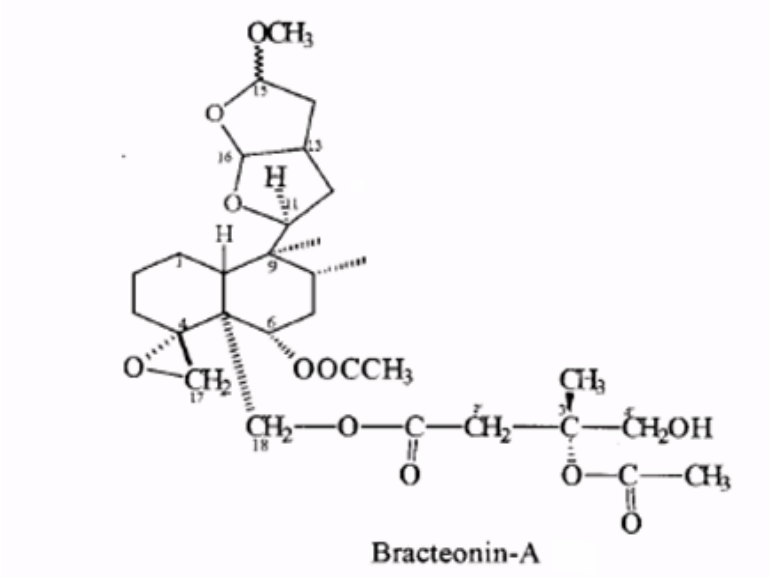


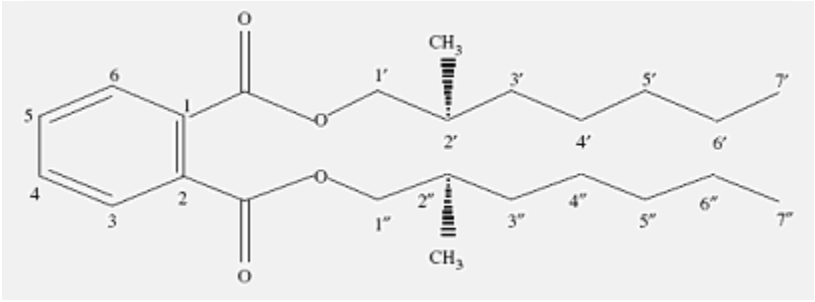




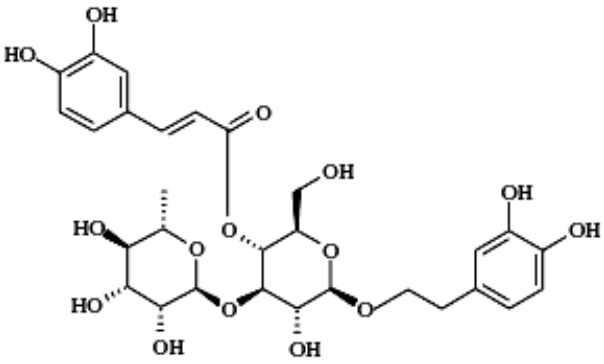
1. Ajugasalicigenin 2, 3 & 4. Ajugasaliciosides F, G & H

Fig. 7: Sterols





Phthalic acid ester



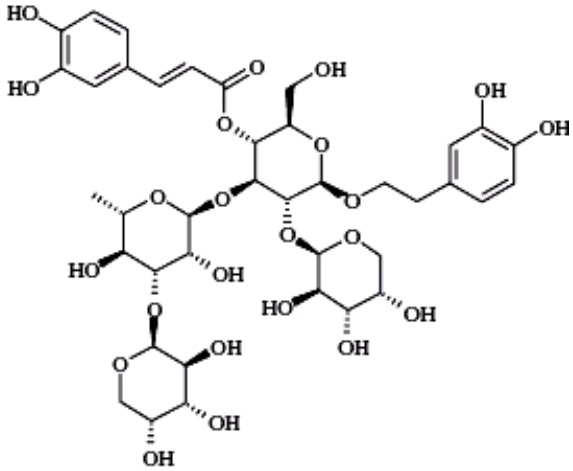


Fig. 8: Miscellaneous compounds

Table 1: Species of genus *Ajuga*

A. abnormis Rouy, *A. acaulis* Brocchi, *A. adulterina* Wallr., *A. africana* Pers., *A. alba* (Gürke) Robyns., *A. album* (Gürke) Robyns., *A. alpestris* Dumort., *A. alpicola* Dalla Torre, *A. alpina* Fries, *A. alpina* Linn., *A. alpina* Vill., *A. amurica* Freyn., *A. arabica* P. H. Davis, *A. arenosa* Steven ex Ledeb., *A. argyrea* Stapf., *A. astolonosa* Schur, *A. australis* R. Br., *A. australis* var. *australis* R.Br., *A. australis* var. *diemenica* (Benth.) Domin; *A. australis* var. *sinuata* (R.Br.) Domin, *A. australis* var. *tridentata* (Benth.) Domin, *A. australis* var. *typica* Domin, *A. austroiranica* K.H. Rechinger f., *A. barrelieri* Tenore, *A. bastarda* Makino, *A.*subsect. *biflorae* C.Y. Wu & C. Chen, *A. bombycina* Boiss., *A. boninsimae* Maxim., *A. borbasiana* Rouy, *A. brachystemon* Maxim., *A. bracteosa* Benth., *A. bracteosa* Wall. ex Benth., *A. bracteosa* var. *bracteosa* Wall. ex Benth., A. *bracteosa* var. *densiflora* Wall. ex Benth., *A. breviproles* Borbás, *A. breviproles* Barb., *A.* sect. *bugula* Benth., *A. caespitosa* Schleich., *A. caespitosa* Schleich. ex Steud., *A. calantha* Diels, *A. calantha* Diels ex Limpricht, *A. campylantha* Diels, *A. campylanthoides* C.Y. Wu & C. Chen, *A. campylanthoides* var. *subacaulis* C.Y.Wu & C.Chen, *A. candolleana* Rouy, *A. capensis* Pers., *A. chamaecistus* Boiss., *A. chamaecistus* Ging. ex Benth., *A. chamaecistus* Ging. ssp. *chamaecistus, A. chamaecistus* Ging. ex Benth. subsp. *bamianica* Rech.f., *A. chamaecistus* subsp. *euphrasioides* (Boiss.) Rech.f., *A. chamaecistus* Ging. ex Benth. subsp. *multisecta* (Rech.f.) Rech.f., *A. chamaecistus* Ging. ex Benth. subsp. *scoparia* (Boiss.) Rech.f., *A. chamaecistus* Ging. ex Benth. subsp.*tomentella* (Boiss.) Rech.f., *A. chamaepytis* (Linnaeus) Schreber, *A. chamaepytis* (Linnaeus) Guss., *A. chamaepitys* ssp. *chia* (Schreber) Archang., *A. chamaepytis* (Linnaeus) Schreber ssp. *euphratica* Davis, *A. chamaepitys chia* (Schreber) Holob., *A. chamaepitys* ssp. *chia* (Schreber) Murb., *A. chamaepitys* (Linnaeus) Schreber subsp. *cuneatifolia* (Stapf), *A. chamaepitys* (Linnaeus) Schreber subsp. *cypria* (P. H. Davis), *A. chamaepitys* (Linnaeus) Schreber subsp. *euphratica* (P. H. Davis), *A. chamaepitys* f. *biennis* (Linnaeus) Schreber, *A. chamaepitys* (Linnaeus) Schreber *glareosa* (P. H. Davis), *A. chamaepitys* (Linnaeus) Schreber subsp. *laevigata* (Banks & Sol), *A. chamaepitys* (Linnaeus) Schreber subsp. *libanotica* (P. H. Davis), *A. chamaepitys* (Linnaeus) Schreber subsp. *mardinensis* (P. H. Davis), *A. chamaepitys* (Linnaeus) Schreber subsp. *mesogitana*, *A. chamaepitys* (Linnaeus) Schreber *palaestina, A. chamaepitys* (Linnaeus) Schreber subsp. *rechingeri* (M. Bilik) P.H. Davis, *A. chamaepitys* (Linnaeus) Schreber subsp. *suffrutescens* (Pottier-Alap. ex Greuter & Burdet), *A. chamaepitys* (Linnaeus) Schreber subsp. *tridactylites* (Gingins ex Benth.) P. H. Davis, *A. chanetti* H. Léveillé & Vaniot, *A. chasmophila* P. H. Davis, *A. chia* Schreber, *A. chias* Poir, *A. ciliata* Bunge, *A. ciliata* Bunge f. *pauciflora* C.Y. Wu & C.Chen, *A. ciliata* Bunge var. *chanetti* (H. Léveillé & Vaniot) C.Y. Wu & C.Chen, *A. ciliata* Bunge var. *chanetti* f. *pauciflora* C.Y. Wu & C.Chen, *A. ciliata* Bunge var. *hirta* C.Y. Wu & C.Chen, *A. ciliata* Bunge var. *ovatisepala* C.Y. Wu & C.Chen, *A. ciliata* Bunge f. *pauciflora* C.Y. Wu & C.Chen, *A. ciliata* (Bunge) var**.** *villosior* A. Gray, *A. coerulia, A. comata* Stapf, *A. controversa* Bor., *A. crenata* Hochst. ex Benth., *A. crenata* Hochst. ex Chiov., *A. cryptostylon* Lagreze-Fossat ex Nyman, *A. cuneatifolia* Stapf, *A. davisiana* Kit Tan & B. Yildiz, *A. decaryana* Danguy ex R. A. Clement, *A. decumbens alba, A. decumbens* D. Don, *A. decumbens* Robusta, *A. decumbens* Rosea, *A. decumbens* Tenore, *A. decumbens* Thunberg, *A. decumbens* C.P. Thunberg ex A. Murray, *A. decumbens* (Thunberg) var. *glabrata* Hatus., *A. decumbens* var. *pallescens*, *A. decumbens* Variegata, *A. decumbens* (Thunberg) var. *rosa* Y.N.Lee, *A. decumbens* var. *vegeta* Honda, *A. densiflora* Benth., *A. densiflora* Tenore, *A. densiflora* Wall., *A. depressa* Maxim., *A. devestita* H. Léveillé & Vaniot, *A. dictyocarpa* Hayata, *A. diemenica* Benth., *A. disticha* Roxb., *A. elatior* Ohwi, *A. euphrasioides* Boiss., *A. fauriei* H. Léveillé & Vaniot, *A. flaccida* Baker, *A. foliosa* Tratt., *A. formosana* Hayata, *A. forrestii* Diels, *A. fruticosa* Roxb., *A. furcata* Link, *A. genevensis* Linn., *A.* subsect. *genevensis* (Maxim.) C.Y. Wu & C. Chen, *A. genevensis* Withering, *A. geniculata* Maxim., *A glabra* C.Presl, *A glabra* Benth., *A. glabrata* Benth., *A. glabrescens* Makino, *A. glabrifolia* (St.Lager) Bonnier, *A. grandiflora* Stapf, *A. grosse-serrata* Franch. & Sav., *A. halacsysna* Zahlbr., *A. hampeana* A.Braun & Vatke, *A. hildebrandtii* Briq., *A. humilis* Borbás, *A. humilis* Miq., *A. humilis* Porta & Rego, *A. hybrida* Kerner, *A. hyosciami* Wall. ex Bentham, *A. incisa* Maxim., *A. integrifolia* Buch.-Ham., *A. integritalia, A. intermedia* Boiss. & Orph.ex Boiss., *A. interrupta* Dulac, *A. iva* (L.) Schreber; *A. iva* f. *punctata* Radic, *A. japonica* Miq., *A. kerneri* Rouy, *A. knafii* Rouy, *A. labordei* Vaniot, *A. laevigata* Boiss., *A. lanata* F.Mart. ex Steud., *A. lanosa* Sun, *A. lanosa* A.I.S.S. Chien & Y.Z. Sun, *A. latifolia* Host, *A. latifolia* Schur, *A. laxa* Buch.-Ham.ex D.Don, *A. laxmannii* (L.) Bentham, *A. linearifolia* Pampanini, *A. lobata* D.Don, *A. lucida* Bor., *A. lupulina* Maxim., *A.*ser. *lupulina* C.Y. Wu & C. Chen, *A. lycia* Stapf, *A. lycopsiformis* Lojac., *A. macrosperma* Wallich ex Bentham, *A. macrosperma* var. *breviflora* Wallich ex Bentham, *A. macrosperma* var. *macrosperma* Wallich ex Bentham, *A. macrosperma* var. *thomsonii* Maxim., *A. macrosperma* var. *thomsonii* Wallich ex Bentham, *A. mairei* H. Lévéille, *A. makinoi* Nakai, *A. matsumurana* Kudo, *A. mesogitana* Boiss., *A. metallica* hort., *A. microphylla* Hegetschw., *A. mixta* Makino, *A. mollis* Gladkova, *A. mollissima* Wall.ex Steud., *A. Montana* Reichb., *A. morii* Nakai, *A. moschata* Mill. ex Schreber, *A. multiflora* Bunge, *A. multiflora* Bunge var. *brevispicata* C.Y.Wu & C.Chen, *A. multiflora* Bunge var**.** *multiflora, A. multiflora* Bunge f. *rosea* Y. N. Lee, *A. multiflora* Bunge var. *serotina, A. multisecta* K.H.Rechinger f., *A. nana* Gilib., *A. nanti* Bor., *A. nipponensis* Makino, *A. nipponensis* Makino var *pallescens* (Maxim.) C. Y. Wu & C. Chen, *A. novoguineensis* A.J.Paton & R.J.Johns, *A. nubigena* Diels, *A. oblongata* Bieb., *A. occidentalis* Braun-Blanquet, *A. oocephala* Baker, *A. ophrydris* Burch. ex Bentham, *A. orientalis* Linn., *A. orientalis* (L.) subsp. *aenesia* (Heldr.) Phitos & Damboldt, *A. ovalifolia* Bureau et Franch.-China, *A.* ser. *ovalifolia* C.Y. Wu & C. Chen, *A. ovalifolia* Bureau et Franch. f. *albiflora* Sun ex C. Y. Wu & C. Chen, *A. ovalifolia* Bureau et Franch. f. *augustifolia* (Diels) C. Y. Wu & C. Chen, *A. ovalifolia* Bureau et Franch. var. *calantha* Diels ex Limpricht C.Y.Wu & C. Chen, *A. ovata* Wall., *A. pachyrrhiza* Kitagawa, *A. palaestina* Boiss., *A. pallescens* Makino, *A. pallescens* (Maxim.) Price & F. P. Metcalf, *A. pantantha* Hand.-Mazz., *A. parviflora* Benth., *A. parviflora* var. *depressa* Hook., *A. perbracteata* Borbás, *A. pianta, A. piskoi* Degen & Baldacci, *A. postii* Briq., *A.* sect. *pseudoanisomeles* Benth., *A. pseudochia* Roussine, *A. pseudochia* Des.-Shost., *A. pseudoiva* Robill & Castagne ex DC., *A. pseudo-pyramidalis* Schur, *A. pumila* Schur, *A. pygmaea* A. Gray, *A. pyraidalis* Shost., *A. pyramidalis* M. Bieb., *A. pyramidalis* Huds, *A. pyramidalis* Linn., *A. pyramidalis* (L.) subsp. *rotundifolia* (Willk. & Cutanda ex Willk.) Rivas Martinez, *A. rechingeri* Bilik, *A. relicta* P.H. Davis, *A. remota* Benth., *A. remota* Wall. ex Benth., *A. repens* Gueldenstern ex Ledebour, *A. repens* Roxb., *A. reptans* Linn., *A. reptans* f. *albiflora, A. reptans* var. *atropurpurea*; *A. reptans* Braunherz, *A. reptans* Catlins Giant, *A. reptans* Rosea, *A. reptans* Variegata, *A. rhodopea* Velen., *A. robusta* Baker, *A. rotundifolia* Willk. & Cut.ex Willk., *A. rugosa* Host, *A. rupestris* Schleich.ex Steud., *A. salicifolia* (L.) Schreber, *A. salicifolia* (L.) Steven, *A. salicifolia* Steven subsp. *bassarabica* (Savul. & Zahar) P.W.Ball, *A. salicifolia bessarabica, A. saxicola* M.Assadi & Z.Jamzad, *A. schurii* Rouy., *A. sciaphila* W. W. Smith, *A. sect. Bugula* Benth., *A.* ser. *sciaphila* C.Y. Wu & C. Chen, *A. scoparia* Boiss., *A. sebreb, A. shikotanensis* Miyabe & Tatewaki, *A. sikkimensis* Miq., *A. sinuata* R.Br., *A. spectabilis* Nakai, *A. stolonifera* Jeanb. & Timb., *A. suffrutescens* Lange, *A. taiwanensis* Nakai ex Murata, *A. tenorei* C. Presl, *A. tenorii* C. Presl, *A. thomsonii* Maxim., *A. tomentella* (Boiss.) K. H. Rechinger f., *A. tridactylites* Ging. ex Benth., *A. tridentata* Benth., *A. trifida* Dulac, *A. trifidifolia* Stokes, *A. sect. Bugula* Benth. *A. turkestancia* Briq., *A. turkestanica* Regel, *A. tsubana* Okuyama, *A. typica* Matsum. & Kudo, *A. vesiculifera* Herder, *A. vestita* Boiss., *A. virgata* Benth., *A. vulgaris* Rouy, *A. x hybrida, A. xylorriza* Kit Tan, *A. yesoensis* Maxim. ex Franch. & Sav., *A. yesoensis* Maxim. var. *yesoensis, A. zakhoensis* K. H. Rechinger f.
(References: http-1; http-2; http-3; http-4; http5; http-6; http-7; http-8; Wu and Li, 1977)

Table 2: Varieties (cultivars) of *Ajuga reptans*

Alba, Arboretum Giant, Arctic Fox, Argentea, Atropurpurea, Binblaska, Black Scallop, Blue Bugle, Braunherz, Brean Down, Brockbankii, Bronze, Bronze Beauty, Burgundy Glow, Burgundy Lace, Burgundy Red, Carol, Caroli, Catlin's Giant, Cavalier, Compacta White' Cotswold, Crispa, Cristata, Delight, Delightful, Ebony, Emerald Chip, Ermine, Evening Glow, Flisteridge, Forestbrook, Frosted jade, Gaiety, Giant Bronze, Golden Beauty, Golden Glow, Golden Splash, Grey Lady, Harlequin, John Pierpoint, Julia, Jumbo, Jungle Beauty, Jungle Bronze, Jungle Fever, Jungle Queen, Klose's White, Kurt's Compact, Linda Applegate, Little Pink Court, Loie's Lavender, Macrophylla, Mahogany, Marble Glow, Min Crispa Red, Multicoloris, Nana Compacta, Palisander, Pallida, Pat's Selection, Pink Beauty, Pink Elf, Pink Silver, Pink Spire, Pink Splendour, Pink Starlight, Pink Surprise, Pink Towers, Planet Zork, Purple Brocade, Purple Spinach, Purple Torch, Purpurea, Rainbow, Renick, Rosea, Rowden Amethyst, Rowden Appleblossom, Rowden Blue Mist, Rowden Royal Purple, Royalty, Rubra Metallica, Ruffled Lace, Sanne, Schneekerz, Silver Beauty, Silver Carpet, Silver Princess, Silver Queen, Silver Shadow, Silver Sheen, Simon, Stozi, Tortoiseshell, Tricolor, Variegata, Violin, Valfredda' Chocolate Chip, Vanilla Chip, Variegata, Variegated Glacier, and Velen. (Reference: http-10)

Table 3: Ethnobotany and traditional use of plants of genus *Ajuga*

Name	Other names	Flowers	Traditional use	Origin
A. alba (Gürke) Robyns	*Ajuga bracteosa* Benth. var. *alba* (Gürke) Engl.	White	Common cold, fatigue, haemorrhoids, ear ache, ascariasis, rabies (Hamill *et al*., 2003; Yineger *et al*., 2008)	Africa, Ethiopia, Uganda
A. amurica Freyn.	*A. multiflora* var. *multiflora;* *A. lanosa* Sun; *A. multiflora* var. *frevispicata* C.Y.Wu & C.Chen	Greenish		Russia, Taiwan, China, Korea, Siberia
A. argyrea Stapf.	*A. bombycina* Boiss.	Yellow, orange		Europe, Turkey
A. australis R. Br.	*A. diemenica* Benth. (var.) *A. sinuate* R. Br. (var.) *A. tridentata* Benth. (var.); Southern buglewood; Australian bugle; austral bugle	Deep violet, blue	External: boils, sores, wounds (His-wen and Hedge, 1994; Brown, 1995; Johnson, 1999; Lassak and McCarthy, 2001)	Australia, Tasmania, Hawaii
A. bombycina Boiss.	*A. argyrea* Stapf**.,** *Chamaepitys bombycina* (Boiss.) Holub	Yellow, orange		Europe, Asia Minor, Turkey, W. Asia
A. boninsimae Maxim.		White, light blue		Japan
A. brachystemon Maxim.		Pale yellow, pink-white		Nepal, India
A. bracteosa Wallace ex Benth.	*A. integrifolia* Buch.-Ham. ex D. Don; Bracted buglewood; Nilkanthi	Purple-yellowish, pale blue, lilac	Astringent, tonic blood purifier, anti-inflammatory, depurative, diuretic, for fever, bronchitis, pneumonia, typhoid fever, agues, diarrhea, dysentery, colic, gout, palsy, jaundice, amenorrhea (Manjunath, 1948; Chopra *et al*., 1986 His-wen and Chopra *et al*., 1986; Hedge, 1994; CRC, 1999; Manandhar, 2002; Sharma *et al*., 2004a; Islam *et al*., 2006; Singh *et al*., 2006); External use: burns, boils syphilis (Johnson, 1999; Sharma *et al*., 2004a)	E. Asia, Nepal, Afghanistan, India, Pakistan, Kashmir, Sino-Himalaya, China (Yunnan), Nepal, Japan, Myanmar, Ethiopia

Continued

Name	Other names	Flowers	Traditional use	Origin
A. bracteosa Benth. (L.) var. *alba* (Gürke) Engl.	*A. alba* (Gürke) Robyns	White		
A. calantha Diels	*A. calantha* Diels ex Limpricht; *A. ovalifolia* Bureau & Franch.	Deep blue		Sichuan (China), Sino-Himalaya, Yunnan (China)
A. campylantha Diels		White, striate purple		Sino-Himalaya, China (Yunnan)
A. campylanthoides C.Y.Wu & C.Chen		Reddish white		China (Gansu, Sichuan, Xizang, Yunnan), Sino-Himalaya
A. chamaepitus	Forget-me-not, vergissmeinnicht	Blue, white		Europe, Asia
A. chamaepitys (L.) Schreb.	*A. piñata; Teucrium chamaepitys* L.; *A. chia* Schreb.; ground pine; yellow bugle	Yellow	Diuretic, stimulant and emmenagogue (menstrual flow stimulant), for women's complaints (Grieve, 1984; Brown, 1995; Lassak and McCarthy, 2001); rheumatism, gout, dropsy, jaundice, sclerosis (Johnson, 1999)	S. Britain and other parts of Europe (France), N. Africa, Middle East, E. Asia, Hawaii, Israel, Turkey, Spain
A. chamaepitys subsp. *chia*		Yellow		Turkey
A. chia (Poir.)/Schreb.	*A. chamaepitys* ssp. *chia* (Schreb.) Arcang.; *A. chamaepitys* ssp. chia (Schreb.) Murb.; *Chamaepitys chia* (Schreb.) Holob; *Teucrium chium* (Schreb.) J.F.Gmel Ground pine	Bright yellow	Cancer (Johnson, 1999); antiarthritic (Marc, *et al*., 2008; external: wound healing (Khalil *et al*., 2007)	Eurasia, Jordan, Europe
A. ciliata var. *chanetii* (H. Léveillé & Vaniot) C. Y. Wu & C. Chen	*A. chaneti* H. Léveillé & Vaniot; *A. ciliata* f. *chanetii* (H. Léveillé & Vaniot) Kudô; *A. ciliata* var. *chanetii* f. *pauciflora* C. Y. Wu & C. Chen.; ciliated bugle	Whitish-purple-blue		China, Taiwan
A. ciliata (Bung.) var. *villosior* A. Gray		Purple-red, rose, indigo, white, blue	Hemolysis, tonsillitis, and sore throat (Hiswen and Hedge, 1994; Johnson, 1999)	China, Taiwan, Japan
A. decumbens Thunb.	Kiransou; creeping buglewood	Purple, blue	Analgesic, anti-coagulant, anti-inflammatory, antipyretic, antitussive, expectorant, for bladder ailments, depurative, diarrhea, eye troubles, febrifuge, hemostatic, joint pain, sore throat, stomach ache (Duke and Ayensu, 1985; Ono *et al*., 2008);	East Asia, China, Japan, Taiwan, Korea

Continued

Name	Other names	Flowers	Traditional use	Origin
			external use: burns, cuts, etc.. (Duke and Ayensu, 1985; Johnson, 1999; Konoshima *et al*., 2000)	
A. dictyocarpa Hayata		White, pink		China, Japan, Taiwan, Vietnam, Ryukyus
A. forrestii Diels	*A. mairei* H. Léveillé ; forest bugle	Blue-purple	Dysentery and ascariasis (His-wen and Hedge, 1994; Johnson, 1999)	China (Gansu, Sichuan, Yunnan), Sino-Himalaya, Korea, Nepal
A. furcata Link	*Craniotome furcata* (Link) Kuntze *Anisomeles* (Link) *furcata* Sweet; *Anisomeles nepalensis* Sprengel; *C. versicolor* Reichenbach; *Nepeta versicolor* Trevisan de Saint-Léon	Reddish, purple-red		China (Sichuan, Xizang, Yunnan), Bhutan, India, Korea, Laos, Myanmar, Nepal, Sikkim, Taiwan, Vietnam
A. genevensis L.	*A. alpina* (L.); *A. rugosa* Host.; Hammasakankaali; blue bugle; Geneva bugle; standing bugle; Kritsuga; blue bugleweed	Blue, pink, white	Anticancer (Graham *et al*., 2000)	Southern Europe, England, Belgium, France, Germany, Italy,Sweden, S.W. Asia, China, No America
A. grandiflora Stapf.	Mallee Bugle	Purple-blue		Hawaii
A. humilis Porta & Rego	*A. iva* Schreb	Pink, purple, blue		N. Africa, N. America
A. incisa Maxim.		Bluish purple		China, Japan
A. integrifolia Buch-Ham	*A. bracteosa* Wallich ex Bentham	Purple-yellow	For diarrhea, stomach disorders, malaria, swollen legs, hypertension (Asres *et al*., 2001; Gedif & Hahn, 2003); External use: wound healing (Gedif & Hahn, 2003); veterinary use	Etiophia, Kenya, N Africa
A. iva (L.) Schreber	*A. humilis* Porta & Rego; *A. pseudoiva* Robill & Castagne ex. DC.; *Teucrium iva* L.; ground pine; French ground pine; Herb Eve; Musky Bugle; Xantkura	Pink, purple, yellow	Asthma, bronchitis, earache, fever, phthisis, diabetes, hypertension, anti-ulcer, antimalarial, mental disorders, skin disease (Guide N. Afr; Brown, 1995; González-Tejero *et al*., 2008); gastrointestinal disorders, anthelmintic (depurative, worming, vermifuge) (Bellakhdar *et al*., 1991; Brown, 1995; Ziyyat *et al*., 1997; Johnson, 1999; Hassar, 1999; Tahraoui *et al*., 2007); antiarthritic (Marc, *et al*., 2008; External use: wound healing (Boulos, 1983)	S.E. Europe, S. W. Europe, Spain, Mediterranean countries, Israel, Near East, N. Africa, Malta, Malaysia, Hawaii

Continued

Name	Other names	Flowers	Traditional use	Origin
A. japonica Miq.		Blue, purple		E. Asia, Japan
A. labordei Vaniot	*A. nipponensis* Makino	Pale blue		China
A. lanosa Sun/S. S. Chien & Y. Z. Sun	*A. multiflora var. Multiflora;* *A. amurica* Freyn.; bird of Paradise flower	Green, blue, purple		Russia, Taiwan, China. Korea, Siberia
A. laxmannii (L.) Bentham	*Teucrium laxmannii* (L.) Benth.	White, yellow		Europe, Mediterranean. Balkans, Caucasus, Asia Minor
A. linearifolia Pampanini	*A. pachyrrhiza* Kitagawa	White-bluish, purple spots		China, Taiwan
A. lobata D. Don	Lobed bugle	Purple, red-purple		Myanmar, Nepal, Sino-Himalaya, China (Yunnan) Bhutan, India
A. lupulina Maxim.	White bracteole bugle	White, whitish-green, whitish-yellow		Sino-Himalaya, N. C. China, W. China, Qinghai, Xizang, Nepal, Assam
A. macrosperma Wallich ex Bentham	*A. repens* Roxb.	Blue-purple	Fever, phlegm (Yunnan, 1977)	China (Yunnan), Bhutan, India, Sikkim, Laos, Myanmar, Nepal, Thailand, Vietnam,Taiwan
A. macrosperma var. *macrosperma* Wallich ex Bentham		Blue-purple	Nephritis (Yunnan, 1977; His-wen and Hedge, 1994; Johnson, 1999); antipyretic, removes phlegm, (Yunnan, 1977)	China (Yunnan), Bhutan, India, Sikkim, Laos, Myanmar, Nepal, Thailand, Vietnam,Taiwan
A. macrosperma var. *thomsonii* Wallich ex Bentham	*A. thomsonii* Maxim.	Blue-purple		India (Sikkim), Nepal
A. mairei H. Léveillé	*A. forrestii* Diels	Blue-purple		China, Taiwan
A. makinoi Nakai		Blue-purple		Asia, Japan
A. multiflora Bunge	*A. multiflora var. frevispicata* C.Y.Wu & C.Chen	Blue-purple, blue		E. Asia, China. Korea, Siberia, Russia
A. multiflora var. *multiflora*	*A. amurica* Freyn.; *A. lanosa* Sun.	Green	Diuretic (His-wen and Hedge, 1994; Johnson, 1999)	Russia, Taiwan, China. Korea, Siberia, Mongolia
A. nipponensis Makino	*A. labordei* Vaniot. ; *A. pallescens* Maxim.; *A. pallescens* Price & Metcalf; *A. macrosperma* Kudo; *A. decumbens* Thunb. var. *pallescens* (Maxim.) Han.-Mazz.; *A. genevensis* L. var. *pallescens* Maxim.; *A. matsumurana* Kudô; *A. nipponensis* Makino var. *pallescens* (Maxim.) C. Y. Wu & C. Chen; Japanese bugle	Pale blue, Purple blue with white streaks, pink	Traumatic injury; inflammation (His-wen and Hedge, 1994; Johnson, 1999)	Asia, China, Japan, Korea, Taiwan

Continued

Name	Other names	Flowers	Traditional use	Origin
A. nubigena Diels		Purple		China (Sichuan, Yunnan, Xizang), Sino-Himalaya
A. occidentalis Braun-Blanq.	*A. pyramidalis* L.	Blue-violet, pink, white		N. & C. Europe, England, the Alps, Mediterranean, Balkans, Asia Minor N. America, Hawaii
A. ophrydris Burch. ex Benth.		Blue, pink, purple, white	Dysmenorrhea, sterility (Johnson, 1999)	Lesotho, So. Africa, Natal, Cape
A. orientalis L.	Oriental bugle; Eastern bugle	Dark purple, blue-violet	External use: skin disorders; wound healing (Boulos, 1983; Ali-Shtayeh *et al*., 2000)	Europe, Hawaii, Israel, Greece, Palestine, Iran
A. ovalifolia Bureau & Franch.	*A. calantha* Diels (var.)	Deep blue		China (Sichuan, Yunnan), Sino-Himalaya
A. ovalifolia var. *calantha* Diels ex Limpricht C.Y. Wu & C. Chen	*A. calantha* Diels ex Limpricht; *albiflora* Sun ex C. Y. Wu & C. Chen; *A. ovalifolia* var. *calantha* f. *angustifolia* (Diels) C. Y. Wu & C. Chen; *A. calantha* var. *angustifolia* Diels; *A. ovalifolia* var. *angustifolia* (Diels ex Limpricht) Hand.-Mazz.	Red-purple		China, Taiwan
A. pachyrrhiza Kitagawa	*A. linearifolia* Pampanini	White, bluish, purple spots		China, Taiwan
A. pallescens (Maxim.) Price & Metcalf	*A. nipponensis* Makino	Pale blue		Asia, China, Japan, Korea
A. panthanta Hand.-Mazz.		Purple-rose, purple-blue	Fever, phlegm, used medicinally (Yunnan, 1977; His-wen and Hedge, 1994; Johnson, 1999).	China (Sichuan, Yunnan), Sino-Himalaya
A. parviflora Benth.		Blue, purple	For fever, stomach disorder, ulcer, colic, jaundice and throat diseases (Khan *et al*., 1999c; Islam *et al*., 2006)	Afghanistan, Pakistan, Kashmir, Nepal, Himalayan region
A. pianta	*Teucrium chamaepitys* L.; *A. chamaepitys* (L.) Schreb.; Yellow bugle	Yellow		S. Britain and other parts of Europe, N. Africa, Middle East, E. Asia, Hawaii
A. piskoi Degen & Bald.		Pink		Mediterranean, S.E. Europe, Albania
A. postii Briq.		Blue, purple, yellow		Turkey
A. pseudoiva Robill & Castagne ex DC.	*Ajuga iva* subsp. *Pseudoiva;* Yellow Southern bugle; French ground pine; Xantkura Safra	Yellow	Antibacterial, antipyretic, anthelmin-thic, hypoglycemic, insect antifeedant, External use: wound healing (Boulos, 1983; Ali-Shtayeh *et al*., 2000)	Malta, Tunisia, Hawaii

Continued

Name	Other names	Flowers	Traditional use	Origin
A. pseudopyramidalis Schur.	Bugle	Blue-white		England
A. pygmaea A. Gray		Sky blue, purple		Russia, China, Taiwan, Japan
A. pyramidalis L.	*A. metallica* hort.; *A. occidentalis* Braun-Blang.; Pyramidal bugle; erect bugle; kartioakankaali; Blåsuga	Blue-violet, white, pink, red		N. & C. Europe, England, the Alps, N. America, Hawaii
A. relicta P.H. Davis	Buglewood	Pink, blue, purple		Turkey
A. remota Wall. ex Benth.		Yellow	Fever, infection, malaria, antimycobacterial (Kokwaro, 1976; Cantrell *et al*., 1999; Kuria *et al*., 2001a; Matu & van Staden, 2003; Debella *et al*., 2005; Njoroge and Bussman, 2006; Muregi *et al*., 2007)	Africa (Congo, Kenya, Ethiopia), Nepal, India
A. repens Roxb.	*A. macrosperma* Wall. ex Benth.	Blue		China (Yunnan), Bhutan, India, Sikkim, Laos, Myanmar, Nepal, Thailand, Vietnam,Taiwan
A. reptans L.	*A. repens* Roxb.; Blue carpet Ajuga; border Ajuga; carpet Ajuga; bugle; common Bugle; bugula; carpet buglewood; common buglewood; middle comfrey; middle confound; sicklewort; carpenter's herb; Suikertava akankaali; Revsuga; Rönsyakankaali Gu¨ nsel; Seiyo-Kiransou	Blue, pink, purple, white, bluish-purple, reddish-purple	Hemorrhage, cough, spitting of blood (TB?), (Stuart, 1987; Breschi *et al*., 1992; Chevallier, 1996); biliary disorders, jaundice, high pulse, ulcers, sores, alcoholism, (Stuart, 1987; Chiej, 1984); narcotic, hallucinogenic, toxic (Diggs *et al*., 1999) antibacterial, antipyretic, antimycobacterial astringent, diuretic, heart tonic, gout, cardiovascular disease, skin disease, carminative, vulnerary, cancer, fever (Chiej, 1984; Johnson, 1999; González-Tejero *et al*., 2008) External use: wound healing (Chiej, 1984; Breschi *et al*., 1992); anthelmintic (Kuria *et al*., 2002)	Europe (Britain, Wales, Spain, Czech Republic), Mediterranean, Turkey, Asia Minor, N. Africa, W. Asia, Iran, N.E. America, N. & C. America, Hawaii
Ajuga reptans var. *alba*	Bugle flower	White		
A. salicifolia (L.) Schreber		Yellow		Mediterranean, Bulgaria, Greece, Asia Minor
A. sciaphla W.W. Smith		Blue, purple-blue		China (Sichuan, Yunnan)
A. shikotanensis Miyabe & Tatewaki		Pale purple-blue		E. Asia, Russia, Far East, Japan

Continued

Name	Other names	Flowers	Traditional use	Origin
A. spectabilis Nakai	Korean bugle	Pink	Stimulates smooth and cardiac muscles (Chung *et al*., 1980)	Korea
A. taiwanensis Nakai ex Murata (L.)		Purple	Hepatitis and hepatoma (Hou, 1996)	Taiwan, Philippines and Ryukyus
A. tenorii C. Presl	*A. acaulis* Brocchi Bugleweed 'chocolate chip'	Pale purple Pale blue		Asia, Japan, Kurilen S.E. Europe, Italy
A. thomsonii Maxim.	*A. macrosperma var. thomsonii* (Maxim.)			Sikkim, India
A. tsukubana Okuyama		Rose		E. Asia, Japan
A. turkestanica (Rgl.) Brig.			Heart disease, muscle aches, stomach problems (Mamatkhanov *et al*., 1998; Abdukadirov *et al*., 2004)	Turkey, Uzbekistan
A. *vestita* Boiss.		Purple, pink, white		Asia Minor, Anatolia (Turkey)
A. xylorrhiza Kit Tan		white		Turkey
A. yesoensis Maxim.	*A. yezoensis* Maximovicz ex Franchet & Savatiev var. *tsukubana* Nakai	Rose, light blue		E. Asia, Japan

E. = East, eastern; N. = North, northern; S. = South, southern; W. = West, western; Additional references: http-4; Yunnan 1977; Flora, 1994.

Table 4: Compounds isolated from some plants of genus *Ajuga*

Name	Compounds	Reference
A. austrialis R. Br. Prod.	*neo*-Clerodane diterpenoids (ajugapitin, 14,15-dihydro-15-hydroxyajugapitin); phytoecdysteroids (α-ecdysone, ecdysterone, cyasterone, makisterone A)	de la Torre *et al*., 1997 Bergamasco and Horn, 1983; Ramazanov, 2005
A. bombycina Boiss.	Carvacrol, germacrene D, β-phellandrene, limonene, myrtenol, α-pinene, β-pinene, pinocarone, α-thujone	Baser *et al*., 2001
A. bracteosa Wall.	*neo*-Clerodane diterpenoids (ajugarin I, II, III, IV &V, ajugapitin, bracteonin A, 12-bromo-ajugarin I, clerodin, clerodinin A, deacetylajugarin IV, 14,15-dihydroajugapitin, dihydroclerodin-1, 14-hydro-15-hydroxyclerodin,14,15-dihydroxyajugapitin, 14-hydroxy-15-hydroxyajugapitin, lupulin A); phytoecdysteroids (22-acetylcyasterone, ajugalactone, ajugasterone A, B &C, cyasterone, 3-epicyasterone, 20-hydroxyecdysone); iridoid glycosides (8-O-acetylharpagide, reptoside); sterols (β-sitosterol, stigmasterol); withanolides (bracteosin A, B & C), bractin A &B, bractic acid, sphingolipids, phthalic acid ester, lignoceric acid, linalyl acetate, sitoglucoside	Kubo *et al*., 1976; Kubo *et al*., 1980; Kubo *et al*., 1982; Kubo *et al*., 1983; Bhakuni *et al*., 1990; Bhakuni *et al*., 1991; Odek-Ogunde *et al*., 1993; Cantrell *et al*., 1999; Khan *et al*., 1999a; Khan *et al*., 1999c; Nawaz *et al*., 1999 Kuria *et al*., 2002; Verma *et al*., 2002; Fekete *et al*., 2004; Riaz *et al*., 2004 ; Shafi *et al*., 2004; Coll *et al*., 2005; Ramazanov, 2005 ; Singh *et al*., 2006; Riaz *et al*., 2007

Continued

Name	Compounds	Reference
A. austrialis R. Br. Prod.	*neo*-Clerodane diterpenoids (ajugapitin, 14,15-dihydro-15-hydroxyajugapitin); phytoecdysteroids (α-ecdysone, ecdysterone, cyasterone, makisterone A)	de la Torre *et al*., 1997 Bergamasco and Horn, 1983; Ramazanov, 2005
A. bombycina Boiss.	Carvacrol, germacrene D, β-phellandrene, limonene, myrtenol, α-pinene, β-pinene, pinocarone, α-thujone	Baser *et al*., 2001
A. bracteosa Wall.	*neo*-Clerodane diterpenoids (ajugarin I, II, III, IV &V, ajugapitin, bracteonin A, 12-bromo-ajugarin I, clerodin, clerodinin A, deacetylajugarin IV, 14,15-dihydroajugapitin, dihydroclerodin-1, 14-hydro-15-hydroxyclerodin,14,15-dihydroxyajugapitin, 14-hydroxy-15-hydroxyajugapitin, lupulin A); phytoecdysteroids (22-acetylcyasterone, ajugalactone, ajugasterone A, B &C, cyasterone, 3-epicyasterone, 20-hydroxyecdysone); iridoid glycosides (8-O-acetylharpagide, reptoside); sterols (β-sitosterol, stigmasterol); withanolides (bracteosin A, B & C), bractin A &B, bractic acid, sphingolipids, phthalic acid ester, lignoceric acid, linalyl acetate, sitoglucoside	Kubo *et al*., 1976; Kubo *et al*., 1980; Kubo *et al*., 1982; Kubo *et al*., 1983; Bhakuni *et al*., 1990; Bhakuni *et al*., 1991; Odek-Ogunde *et al*., 1993; Cantrell *et al*., 1999; Khan *et al*., 1999a; Khan *et al*., 1999c; Nawaz *et al*., 1999 Kuria *et al*., 2002; Verma *et al*., 2002; Fekete *et al*., 2004; Riaz *et al*., 2004 ; Shafi *et al*., 2004; Coll *et al*., 2005; Ramazanov, 2005 ; Singh *et al*., 2006; Riaz *et al*., 2007
A. chamaecistus	Phytoecdysteroids (ajugasterone C, cyasterone, 20-hydroxyecdysone)	Kubo *et al*., 1983b
A. chamaecistus Ging. ssp. *chamaecistus*	α-Pinene, linalool	Mazloomifar *et al*., 2003
A. chamaepitus	Phytoecdysteroids (ajugalactone, cyasterone, ecdysterone, makisterone A)	Fekete *et al*., 2004 Ramazanov, 2005
A. chamaepytis (L.) Schreber	*neo*-Clerodane diterpenoids (ajugapitin, chamaepitin, 14,15-dihydroajugapitin, 14,15-dihydro-15-hydroxyajugapitin, 15-ethoxy-14-hydroajugapitin, 14-hydro-15-hydroxyajugapitin); phytoecdysteroids (ajugachin A & B, ajugalactone, cyasterone, ecdysterone, 20-hydroxyecdysone, makisterone A, 29-norcyasterone); diterpene bitter, caffeic acid derivatives, rosemaric acid, volatile oils	Hernández *et al*., 1982 ; Kubo *et al*., 1983b ; Camps *et al*., 1984b ; Camps *et al*., 1987 ; PDR-HM, 1998 ; pp. 619-120 ; Fekete *et al*., 2004 ; Coll and Tandrón, 2008
A.chamaepitys subsp. *chia*	Germacrene D, β-pinene	Baser *et al*., 2001
A.chamaepitys subsp. *chia* var. *chia*	Germacrene D, β-pinene	Baser *et al*., 2001
A.chamaepitys subsp. *chia* var. *ciliata*	*neo*-Clerodane diterpenoids (ajugachin A &B, ajugapitin, 14,15-dihydroajugapitin); caffeic acid, β-carophylline, germacrene D, isovitexin, luteolin, orientin, β-pinene	Boneva *et al*., 1990 ; Mericli *et al*., 1994 ; Baser *et al*., 2001
A.chamaepitys ssp. *laevigata* L. Schreb.	*neo*-Clerodane diterpenoids (ajugalaevigatic acid)	Topçu *et al*., 2004
A.chamaepitys var. *pseudochia*	*neo*-Clerodane diterpenoids (ajugachin A & B, ajugamarin B4, B5, E1, E3, F1, F2, F3, ajugapitin, ajugarin IV, deacetoxyajugarin, 14,15-dihydroajugapitin, laevigatic acid)	Boneva *et al*., 1990
A. chia Schreb.	Phytoecdysteroids (cyasterone, ecdysterone); phenolics and flavonoids esculetin (coumarin)	Ikin & Ravid, 1971a; Ikin & Ravid, 1971b; Prokopenko, 1974; Usmanov *et al*., 1974b ;

Continued

Name	Compounds	Reference
		Usmanov *et al*., 1975a ; Wessner *et al*., 1992 ; Malikov and Saidkhodzhaev, 1998; Ramazanov, 2005 Khalil *et al*., 2007
A. ciliata	Phytosteroids (ajugasterone A, polypodine B)	Ramazanov, 2005
A. ciliata Bunge var. *villosior* A. Gray	*neo*-Clerodane diterpenes (ajugarin IV, ajugamarin B4, B5, E1, E2, E3, F1, F2 & F3, deacetylajugarin IV)	Shimomura *et al*., 1989a; Shimomura *et al*., 1989b
A. decumbens Thunberg	*neo*-Clerodane diterpenoids (ajugacubin H, ajugacumbin A, B, C, D, E, F, G and H, ajugadecumbenin A & B, ajugamacrin A2, ajugamarin A1, A2, B1, B2, F4, G1 & H1, ajugapantin A, ajugapitin, ajugatakasin A & B, clerodane, clerodendrin, 6-O-deacetyl-ajugamarin, dihydroajugamarin, 14,15-dihdroajugapitin, 15-epilupulin A, hativene A, B & C); phytoecdysteroids (ajugalactone, ajugasterone- B, C, D & F, cyasterone, 3-ecdysone, ecdysterone, decumbesterone A, 20-hydroxyecdysone, polypodine B, sidasterone A & B); iridoid glycoside (8-O-acetylharpagide, harpagide, reptoside); diterpene glycoside (ajugaside A); glycosides (darenoside, decumboside A, B, C & D, martynoside); gentisin, flavones, calonysterone, abutasterone, loliolide	Imai *et al*., 1969a; Imai *et al*., 1969b; Koreeda *et al*., 1970 Nakanishi *et al*., 1971; Min *et al*., 1989; Shimomura *et al*., 1987; Shimomura *et al*., 1989c; Min *et al*., 1990; Zhi-da *et al*., 1990; Tang *et al*., 1994; Chen *et al*., 1995; Chen *et al*., 1996b; Amano *et al*., 1997; Takasaki *et al*., 1998; Takasaki *et al*., 1999; Tusuji *et al*., 1999; Konoshima *et al*., 2000; Terahara *et al*., 2001; Nishida *et al*., 2004; Ramazanov, 2005; Sang *et al*., 2005; Huang *et al*., 2008
A. forrestii Diels	Ajugaforrestin A & B	Coll and Tandrón, 2008
A. genevensis L.	*neo*-Clerodane diterpenois (Ajugavensin A, B & C); phytosteroids (ajugalactone, cyasterone, ecdysone, 20-hydroxyecdysone); iridoids; flavone (rutoside); anthocyanin (cyanidin chloride), caffeic acid, tannins, carotenoids, coumarins, triterpenes, non-alkaloid nitrogen containing compounds, monosaccharides and polysaccharides.	Malakov *et al*., 1991 ; Malakov *et al*., 1992 ; Fekete *et al*., 2004 ; Ramazanov, 2005 ; Popescu *et al*., 2006
A. incisa Maximovicz	Phytoecdysteroids (ajugasterone A &B, cyasterone, 20-hydroxyecdysone, ecdysterone, polypodine B)	Hikino *et al*., 1968; Imai *et al*., 1969a; Imai *et al*., 1969b; Ramazanov, 2005
A. iva Schreber	*neo*-Clerodane diterpenoids (14,15-dihydroajugapitin, ivain I, II, III & IV) ; phytoecdysteroids (ajugasterone C, cyasterone, cyasterone diglycerides, 24,25-dehydrocyasterone, 24-dehydro-precyasterone, ecdysone, ecdysterone, 23-hydroxycyasterone, 20-hydroxyecdysone, makisterone A, 22-oxo-cyasterone, polypodine B) ; iridoids (barpagide, 8-O-acetylharpagide) ; flavonoids (naringin, apigenin-7-O- neohesperidoside), sterols (polyhydroxylated sterols) ; ivaide A (1,3- di-(R)-β-hydroxy-glyceride glycerol), essential oil, tannins, diacylglycerides, , myristic acid, palmitic acid	Ikan and Ravid, 1971a; Khafagy *et al*. 1978; Khafagy *et al*. 1979; Sabri *et al*., 1981; Camps *et al*., 1982a; Ghedira *et al*., 1991 Wessner *et al*., 1992 ; Ben Jannet *et al*., 1997 ; Ben Jannet *et al*., 1999b ; Bondì *et al*., 2000 ; Ramazanov, 2005 ; Chenni *et al*., 2007
A. japonica Miguel	Phytoecdysteroids (ajugasterone C, cyasterone, ecdysterone)	Imai *et al*., 1969a; Ramazanov, 2005
A. laxmanii Benth.	*neo*-Clerodane diterpenoids (14,15-dihydro-15-hydroxy-ajugachin A); phytoecdysteroids (ajugalactone, makisterone A) ; coumarins	Malakov *et al*., 1998c; Ramazanov, 2005

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Name	Compounds	Reference
A. linearifolia Pampanini	Phytosteroids (ajugalactone, cyasterone)	Ramazanov, 2005
A. lupulina (Maxim.)	*neo*-Clerodane diterpenoids (14,15-dihydroxyajugapitin, lupulin A, B, C, D, E &F, clerodinin A)	Chen *et al.,* 1996a ; Chen *et al.,* 1997 ; Ben Jannet *et al.,* 2000
A. macrosperma Wall.	*neo*-Clerodane diterpenoids (ajugacumbin B, ajugamacrin A, B, C, D &E, ajugapantin A); triterpenes (betulinic and 3-*epi*-betulinic acids); fatty acids	Dinda *et al.,* 1990; Shen *et al.,* 1993a; Shen *et al.,* 1993b; Dinda *et al.,* 1997
A. macrosperma var. *breviflora*	Phytoecdysteroids (ajugacetalsterone C & D, breviflorasterone, cyasterone, 20-hydroxyecdysone, 20-hydroxyecdysone 2-acetate, 20-hydroxyecdysone 3-acetate , makisterone A)	Castro *et al.,* 2008
A. multiflora Bunge	Phytoecdysterone (cyasterone, ecdysterone); iridoid glycosides (8-O-acetylharpagide and harpagide); flavonoid (apigenin)	Bergamasco and Horn, 1983 ; Yu *et al.,* 1998 ; Ramazanov, 2005
A. nipponensis Makino	*neo*-Clerodane diterpenoids (ajugamarin A1, B1, B2, B3, C1, D1, I, & L2, ajugarin I, 14,15-dihydroajugamarin); phytoecdysteroids (ajugacetalsterone A & B, ajugasterone A, C & D, cyasterone, cyasterone 22-acetate, 22-dehydrocyasterone, ecdysterone, 20-hydroxyecdysone, polypodine B, stachysterone D)	Imai *et al.,* 1969b; Chou and Lu, 1980; Shimomura *et al.,* 1981; Camps *et al.,* 1981a; Shimomura *et al.,* 1983; Liu *et al.,* 1995; Zeng *et al.,* 2000; Ramazanov, 2005; Coll *et al.,* 2007
A. orientalis L.	*neo*-Clerodane diterpenoid (ajugaorientin); germacrene-D, α-cubebene, ß-cubebene, ß-caryophyllene	de la Torre *et al.,* 1997 Yunnan, 1997; Sajjadi & Ghannadi, 2004
A. pantantha Handel-Mazzetti	*neo*-Clerodane diterpenoids (ajugacumbin B, ajugamacrin A, B, C, D &E, ajugamarin C1, ajugapantin A); pyrrolizidine alkaloids (senecionine, integrrimine)	Shimomura *et al.,* 1987; Shen *et al.,* 1993b
A. parviflora	*neo*-Clerodane diterpenoids (13-β-acetoxy-clerodinin C, ajugamarin F4, ajugarin I & II, ajugarin I chlorohydrin , clerodinin C & D, deoxyajugarin I, dihydroclerodin I, 15- α-ethoxy-14-hydroajugapitin, 15- β-ethoxy-14-hydroajugapitin); withanolides (ajugin A, B, C, D, E,F,G, H & I); acetylated quinols	Beauchamp *et al.,* 1996; Khan *et al.,* 1999a; Khan *et al.,* 1999b; Khan *et al.,* 1999c; Khan *et al.,* 1999d; Muhammad *et al.,* 1999; Nawaz *et al.,* 1999b; Khan *et al.,* 1999c; Nawaz *et al.,* 2000; Choudhary *et al.,* 2005
A. postii	iridoid glucoside (reptoside); triterpenes(α-amyrin, ursolic acid); β-sitosterol, steroids,	Gören *et al.,* 2005a; Gören *et al.,* 2005b
A. pseudoiva	*neo*-Clerodane diterpenoids (2-acetylivain I, ajugareptansin, ajugarin, clerodendrin, clerodinin A, 14,15-dihydroajugapitin, hativene A, B & C, lupulin A); phytoecdysteroids; iridoids (glucosides & esters); diglycerides, β-hydroxy fatty acid methyl ester	Camps *et al.,* 1984a ; Camps *et al.,* 1987 ; Ben Jannet *et al.,* 1999a ; Ben Jannet *et al.,* 2000 ; Ben Jannet *et al.,* 2001 ; Chaari *et al.,* 2000 ; Chaari *et al.,* 2002 ; Ben Jannet *et al.,* 2006
A. pyramidalis	*neo*-Clerodane diterpenoid (ajugapyrin A)	Boneva *et al.,* 1998
A. pyramidalis Metallica Crispa	Anthcyanin (cyanidin); ferulic acid	Madhavi *et al.,* 1996
A. relicta	Steroids, terpenoids (monoterpene, diterpenoids and triterpenoids), iridoids	Kökdil *et al.,* 2002
A. remota Wall. ex Benth.	*neo*-Clerodane diterpenoids (ajugarin I, II, III, IV &V, ajugapitin, bromoajugarin I, clerodin, deacetylajugarin IV, dihydroajugapitin, dihydroclerodin, 14-hydro-5-hydroxy-	Imai *et al.,* 1969b; Kubo *et al.,* 1976; Kubo *et al.,* 1980;

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Name	Compounds	Reference
	ajugapitin); phytoecdysteroids (ajugalactone, ajugasterone C, cyasterone, ecdysterone, 20-hydroxyecdysone); iridoid glycosides (8-O-acetylharpagide, 8-acetylharpagide-6-O-β-glucoside, 6,7-dehydro-8-acetylharpagide, 7,8-dehydro-harpagide, 6,8-diacetylharpagide, 6-keto-8-acetyl-harpagide, harpagide-6-O- β-glucoside); flavonol glycosides (myricetin 3-O-rutinoside-4'-O-rutinoside, myricetin 3-O-rutinoside-3'-O-rutinoside, isorhamnetin 3-O-rutinoside-7-O-rutinoside-4'-O-beta-glucoside, myricetin 3-O-rutinoside, 3-O-α-rhamnoside-4'-O-rutinoside); ergosterol 5,8-endoperoxide, kaempferol 3-O- α-rhamnoside, quercetin 3-O- β-glucoside, quercetin 3-O- rutinoside	Kubo *et al.*, 1981; Kubo *et al.*, 1982; Kubo *et al.*, 1983; Manguro *et al.*, 2006; Cantrell *et al.*, 1999; Kuria *et al.*, 2001b; Kuria *et al.*, 2002; Coll *et al.*, 2005; Ramazanov, 2005; Magnuro *et al.*, 2006; Lemmen, 2007; Manguro *et al.*, 2007
A. reptans L.	*neo*-clerodane diterpenoids (ajugarin I, areptins A and B, ajugachin A, ajugacumbins C, D & E, ajugamarin A2, ajugaorientin, ajugareptansin A1 & B1, ajugareptone, ajugatansins A1, B1 & D1, ajugareptansone A & B, ajugavensin A & B, areptin A & B, 14,15-dehydroajugareptansin, 2-oxoivain I); phytoecdysteroids (3-acetyl-norcyastarone, ajugalactone, ajugasterone A,B &C, capitasterone, cyasterone, cyasterone 22-acetate, 2-dehydroajugalactone, 3-dehydroajugalactone, 22-dehydrocyasterone, 5,29-dihydroxycapitasterone, β-ecdysone, ecdysterone, 28-episengosterone , 20-hydroxyecdysone, 20-hydroxyecdysone-22-acetate, 20-hydroxyecdysone-25-acetate, integristerone, makisterone A, 29-norcyasterone-2-acetate, 29-norcyasterone-3-acetate, 29-norsengosterone, polypodine B, reptansterone, sengosterone); iridoid glycosides (8-O-acetylharpagide, harpagide); flavonols, ajugareptoside, verbascoside, teupolioside; anthocyanins (anthocyanidin glucosides, anthocyanin-flavonoids, cyanidin glycosides, delphinidin glycosides,); carbohydrates (fructose, glucose, raffinose, sucrose); caffeic acid derivatives, including rosemary acid, tannins	Koreeda *et al.*, 1970; Guiso *et al.*, 1974; Camps *et al.*, 1979; Camps *et al.*, 1981b; Kubo *et al.*, 1981a; Camps *et al.*, 1982b; Miravitlles *et al.*, 1982; Miravitlles *et al.*, 1985; Camps *et al.*, 1987; Camps *et al.*, 1990; Breschi *et al.*, 1992; Shoji *et al.*, 1992; Callebaut *et al.*, 1993; Calcagno *et al.*, 1996; Terahara *et al.*, 1996 Bremner *et al.*, 1998; Malakov and Papanov, 1998; Alekseeva *et al.*, 1999; Tsuji *et al.*, 1999; Carbonell and Coll, 2001; Terahara *et al.*, 2001; Glyad, 2002; Tomas *et al.*, 1992; Tomas *et al.*, 1993; Nishida *et al.*, 1994; Filippova *et al.*, 2003; Fekete *et al.*, 2004; Ramazanov, 2005; Manguro *et al.*, 2006; Coll *et al.*, 2007; Korkina *et al.*, 2007
A. reptans var. *atropurpurea*	Phytoecdysteroids (2-O-acetyl-20-hydroxyecdysone, 3-O-acetyl-20-hydroxyecdysone, 3-O-acetyl-29-norcyasterone, clesterol, cyasterone, dehydroajugalacone, 22-dehydroclerosterol, dehydrosengosterone, 28-epicyasterone, 12-hydroxy-22-dehydrocyasterone, 20-hydroxyecdysone, 12-hydroxy-22-dehydro-29-norcyasterone, 12-hydroxy-22-dehydro-29-norsengosterone, 12-hydroxy-22-dehydrosengosterone, isocyasterone, 29-norcyasterone, 22-oxocyasterone, reptansterone)	Calcagno *et al.*, 1995a; Calcagno *et al.*, 1995b; Calcagno *et al.*, 1996; Fujimoto *et al.*, 2000
A reptans var. Catlin Giant	*neo*-Clerodane diterpenoids (14,15-dihydroajugareptansin, 3-α-hydroxyajugamarin F4, 3-β-hydroxyajugavensin B)	Bremner *et al.*, 1998
A. salicifolia L. Schreber	*neo*-Clerodane diterpenoids (14,15-dihydro-15-hydroxyajugachin A); iridoid glycosides (8-O-acetyharpagide, 8-O-acetylmioporoside, ajugol, harpagide); ionone glycoside (3-β-hydroxy-7,8-dihydro-4-oxo-β-ionol-9-O- β-D-glucopyranoside); glycosides (lavandulifolioside,	Litvinenko *et al.*, 1970; Çalis *et al.*, 1991; Bozov *et al.*, 1993; Akcos *et al.*, 1998; Didry *et al.*, 1999;

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Name	Compounds	Reference
	leonosides A & B, phenethanoid glycosides); cyclitols (corchoionoside C); sterol glycosides (ajugasalicigenin, ajugasaliciosides F, G &H, three ajugasalcrium); catechin, diterpene, flavonoid glycoside	Akbay *et al.,* 2002; Akbay *et al.,* 2003a; Akbay *et al.,* 2003b
A. spectabilis Nakai	Iridoids (jaranidoside)	Chung *et al.,* 1980
A. taiwanensis (L.) Nakai ex Murata	*Neo*-Clerodane diterpenoids (ajugalide A, B, C, D & E, ajugamacrin B, ajugamarin C1 &L2, ajugapantin A); phytoecdysteroids (acetylcasterone, ajugalactone, cyasterone, 22-acetylcyasterone, isocyasterone); iridoids (O-acetylharpagide, harpagide), galiridoside, teuhircoside, sterols (β-sitosterol, stigmasterol, β-sitosteryl-D-glucoside); vanillic acid, kaempferol, nicotinic acid, triterpenes, pheophytin-α, pheophytin-β, 2-hydroxy(*R*)-pheophytin-α, 2-hydroxy(*S*)-pheophytin-α-22-acetylcasterone	Hikino *et al.,* 1971 ; Shimomura *et al.,* 1981; Camps *et al.,* 1987; Liu *et al.,* 1995 ; Chen *et al.,* 1995 ; Chen *et al.,* 1996b ; Bremner *et al.,* 1998; Malakov and Papanov, 1998; Ben Jannet *et al.,* 1999; Ben Jannet *et al.,* 2000 ; Chan, 2005; Chan, *et al.,* 2005
A. turkestanica (Rgl.) Brig.	*Neo*-Clerodane diterpenoids (ajugachin B, ajugapitin, chamaepitin, 14,15-dihydroajugachin B, 14-hydro-15-methoxyajugachin B, lupulin A); phytoecdysteroids (ajugalactone, ajugasterone B, cyasterone, cyasterone-22-acetate , α-ecdysone, ecdysterone, 20-hydroxyecdysone, turkesterone) ; cheilanthrone A ; iridoids (harpagide, 8-O-acetylharpigide); carbohydrates (fructose, galactose, glucose, fructose, galactouronic acid, glucofructose, inulin, pectin)	Usmanov *et al.,* 1971; Usmanov *et al.,* 1973; Usmanov *et al.,* 1974c; Usmanov *et al.,* 1975b; Usmanov *et al.,* 1977; Usmanov *et al.,* 1978a; Usmanov *et al.,* 1978b; Nakatani *et al.,* 1981; Jensen *et al.,* 1988; Shimomura *et al.,* 1989a; Shimomura *et al.,* 1989b; Kotenko *et al.,* 1993; Syrov *et al.,* 1997; Tajasaki *et al.,* 1998; Wu *et al.,* 1998; Sebastien *et al.,* 1999; Tsuji *et al.,* 1999; Wu *et al.,* 2000; Abdukadirov *et al.,* 2004; Abdukadirov *et al.,* 2005; Ramazanov, 2005 ; Ramazanov & Syrov, 2006 ; Grace *et al.,* 2008

Table 5: Medicinal/Pharmacological/biochemical properties of plant extract and compounds isolated from *Ajuga* species

Medicinal/pharmacological/ biological property	Plant extract/chemicals isolated from the plant	Ajuga species	Reference
Analgesic activity	Aq.- and EtOH-extract (mice)	*A. remota* Benth. (L.)	Debella *et al.,* 2003 Makonnen *et al.,* 2003
Anti-arthritic activity	Aq. extract (rats)	*A. decumbens* Thunberg	Ono *et al.,* 2005; Ono *et al.,* 2008
Antibacterial activity	*neo*-Clerodane diterpenoids (lupulins A, B and D), and phytoecdysteroid (in vitro); Steroids, cinnamic acid derivatives, Phytoecdysteroids (in vitro); Plant products (in vitro) 8-O-acetylharpagide (in vitro) Phytoecdysteroids (in vitro)	*A. lupulina* Maxim. *A. pseudoiva* Robill & Castagne ex DC. *A. iva* L. Schreb.	Chen *et al.,* 1996a; Chen *et al.,* 1997; Chaari *et al.,* 2000 ; Ben Jannet *et al.,* 2006 ; Bennaghmouch et al. 2001 Shafi *et al.,* 2004

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Medicinal/pharmacological/ biological property	Plant extract/chemicals isolated from the plant	Ajuga species	Reference
	8-O-acetylharpagide (in vitro) Phytoecdysteroids (in vitro)	*A. bracteosa* Wall. *A. turkestanica* (Rgl.) Brig.	Shafi *et al.*, 2004 Ulukanli *et al.*, 2005
Anti-estrogenic effect		*A. genevensis*	Chang *et al.*, 1997b ; Hostettmann *et al.*, 2000
Antifungal activity	Aq. extract (in vitro) 8-O-acetylharpagide (in vitro)	*A. remota* Benth. (L.) *A.bracteosa* Wall.	Kariba, 2001 Shafi *et al.*, 2004
Antihyperglycemic activity (see hypoglycemic activity)			
Antihypertensive activity	Aq. extract (rat) Clerodane diterpene ajugarin I (rat)	*A. remota* Benth. (L.) *A. remota* Benth. (L.)	Odek-Ogunde *et al.*, 1993 Odek-Ogunde *et al.*, 1994
Anti-inflammatory effect	Phenylpropanoid glycosides (verbascoside, teupolioside) (in vitro) Aq.-,MeOH- & hexane-extract (in vitro) Aq. extract (rats)	*A. reptans* L. *A. remota* Benth. (L.) *A. decumbens Thunberg*	Korkina *et al.*, 2007 Debella *et al.*, 2003; Matu & van Staden, 2003; Makonnen *et al.*, 2003 Ono *et al.*, 2008
Antileukemic activity	Sterol glycosides	*A. salicifolia* Schreber	Akbay *et al.*, 2002
Antimalarial/antiplasmodial activity	Ajugarin-1 and ergosterol-5,8-endoperoxide Aq. , EtOH & MeOH-plant extract (mice & in vitro)	*A. remota* Benth. (L.)	Kuria *et al.*, 2001a; Kuria *et al.*, 2001b; Kuria *et al.*, 2002; Muregi *et al.*, 2004; Fennell *et al.*, 2004; Muregi *et al.*, 2007; Sharma *et al.*, 2004b
Antimicrobial	Aq. extract	*A. alba* (Gtrke) Robyns	Hamill *et al.*, 2003
Antimycobacterial activity	ergosterol 5,8-endoperoxide	*A. remota* Benth. (L.)	Cantrell *et al.*, 1999
Anti-osteoporosis activity	Aq. extract (mice)	*A. decumbens* Thunberg	Ono *et al.*, 2008
Antioxidant /oxygen scavenging activity	Aq. extract (rats) Aq. extract in diet; Anthocyanins; ecdysteroids; verbascoside and teupolioside in diet (piglets) Aq.-,MeOH- & hexane-extract (in vitro) Aq. extract	*A. iva* L. Schreb. . *A. reptans* L. *A. remota* Benth. (L.) *A. decumbens* Thunb.	El-Hilaly *et al.*, 2006; Lacaille-Dubois *et al.*, 2006 Chenni *et al.*, 2007; Bouderbala *et al.*, 2008 Li *et al.*, 1999; Terahara *et al.*, 2001; Liu *et al.*, 2003; Corino *et al.*, 2007 Matu & van Staden, 2003 Ohsugi *et al.*, 1999
Antipyretic activity	Aq. Extract 8-O-acetylharpagide (mouse)	*A. remota* Benth. (L.) *A.bracteosa* Wall.	Debella *et al.*, 2005 Shafi *et al.*, 2004
Antispasmodic action	8-O-acetylharpagide	*A.bracteosa* Wall.	Shafi *et al.*, 2004
Antiviral action Anti-Human Immunodeficiency Virus Type 1 (HIV-1) and Type 2 (HIV-2) Human immunodeficiency virus transcriptase inhibition	Aq- plant extract (mouse) Aq.- & MeOH- extract (in vitro) flavones (in vitro)	*A. decumbens* Thunb. *A. integrifolia* Ham.-Buch. *A. decumbens* Thunb.	Ma *et al.*, 2002 Asres *et al.*, 2001 Tang *et al.*, 2004

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Medicinal/pharmacological/ biological property	Plant extract/chemicals isolated from the plant	Ajuga species	Reference
Antitumor-promotor and cancer-chemopreventive effect	Cyasterone, 8-O-acetylharpagide, polypodine B, decumbesterone A, and loliolide (in vitro/mouse)	*A. decumbens* Thunb.	Tang *et al.,* 1994 ; Takasaki *et al.,* 1998 ; Takasaki *et al.,* 1999; Konoshima *et al.,* 2000**;** Kuria *et al.,* 2002
Cancer prevention (2-step mouse skin cancer and pulmonary tumors)	8-O-acetylharpagide (mouse)	*A. remota* Benth.	
Cholinesterase inhibition / calcium antagonist action	Withanolides (bractin A and B; bracteosin A, B and C) (in vitro)	*A. bracteosa* Wall.	Riaz *et al.,* 2004; Choudhary *et al.,* 2005; Riaz *et al.,* 2007
	Diterpenoids (in vitro)	*A. bracteosa* Wall.	Nawaz *et al.,* 1999b
	Ajugin E, ajugin F (in vitro)	*A. parviflora* Benth.	
Xanthine oxidase inhibition	Aq. plant extract (in vitro)	*A. australis* R. Br. (L.)	Sweeney *et al.,* 2001
Cytochrome P450 activity	Ecdysone (in vitro)	*A. reptans* L.	Alekseeva, 2004
Growth promotion	Verbascoside, teupolioside (piglets)	*A. reptans* L.	Corino *et al.,* 2007
Hypoglycemic activity	Ecdysteroids (rat)	*A. turkestanica* (Rgl.) Brig.	Kutepova *et al.,* 2001
	Aq. extract (diabetic rat)	*A. iva* L. Schreber	El-Hilaly and Lyoussi, 2002; El-Hilaly *et al.,* 2006; Chenni *et al.,* 2007; El-Hilaly *et al.,* 2007
Hypolipidemic action	Aq. extract	*A. iva* L. Schreb.	El-Hilaly *et al.,* 2006; El-Hilaly *et al.,* 2007 Chenni *et al.,* 2007
	Aq. extract in diet	*A. iva* L. Schreb.	Syrov *et al.,* 1983
	Ecdysteroids	*A. turkestanica* (Rgl.) Brig.	
Lipoxygenase inhibition	Withanolides (bractin A and B, bractic acid) (in vitro)	*A. bracteosa* Wall.	Riaz *et al.,* 2007
Stimulation of aquaporins – human skin hydration	Aq.- and EtOH-extract; phytoecdysteroids (in vitro)	*A. turkestanica* (Rgl.) Brig.	Dumas *et al.,* 2002; Dumas *et al.,* 2007
Vasoconstrictor effect	Aq. extract, MeOH-extract Acetylharpagide 8-O-acetylharpagide (in vitro)	*A. reptans* L.	Breschi *et al.,* 1992
Vasodilator effect	Aq. extract (in vitro, rats)	*A. iva* L. Schreb.	El-Hilaly *et al.,* 2004b
Toxicology	Aq. extract (rats/mice)	*A. iva* L. Schreb.	El-Hilaly *et al.,* 2004a ; El-Hilaly *et al.,* 2006 ; El-Hilaly *et al.,* 2007 Lia *et al.,* 2005 ; Coll *et al.,* 2007
	Oral consumption of plant (human)	*A. Nipponensis* Makino	
DNA damaging effect	MeOH extract, iridoid glucoside reptoside (in vitro)	*A. postii* Briq.	Gören *et al.,* 2005b
Toxicity against cancer cells (KB HeLa) and Jurkat T-cells	Ajugasalicigenin, ajugasaliciosides F,G &H (in vitro)	*A. salcifolia* Schreber	Akbay *et al.,* 2003a
Stimulation of erythropoesis (experimental anemia)	Silenoside A, turkesterone (in rats)	*A. turkestanica* (Rgl.) Brig.	Syrov *et al.,* 1997
Renoprotection (in experimental uremia)	Phytoecdysterone (ecdysterone and turkesterone) (in rats)	*A. turkestanica* (Rgl.) Brig.	Syrov and Khushbaktova, 2001
Anabolic activity: Growth promotion	Turkesterone; 2-deoxy-alpha-ecdysone (rat)	*A. turkestanica* (Rgl.) Brig.	Syrov *et al.,* 2001

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Medicinal/pharmacological/ biological property	Plant extract/chemicals isolated from the plant	Ajuga species	Reference
Stimulation of protein synthesis in the liver	Phytoecdysteroids (cyasterone, ecdysterone, turkesterone) (in mouse) Phytosteroids (in vitro and in vio in rats)	*A. turkestanica* (Rgl.) Brig.	Syrov *et al.,* 1978
Increase in protein synthesis in skeletal muscle cells	Turkesterone (mouse)	*Ajuga*	Gorelick-Feldman *et al.,* 2008
Increase in protein synthesis in liver		*A. turkestanica* (Rgl.) Brig.	Syrov *et al.,* 1978
Hepatoprotection (against liver toxins)	Ecdysterone, turkesterone, cyasterone, iridoid glycosides (rats)	*A. turkestanica* (Rgl.) Brig.	Syrov *et al.,* 1986; Syrov *et al.,* 1992a; Syrov *et al.,* 1998; Syrov and Khushbaktova, 2001
Increase in blood flow	Ecdysteroids (rat)	*A. decumbens* Thunb. *A. reptan* L. *A. turkestanica* (Rgl.) Brig.	Tsuji *et al.,* 1999
Normalization of cell energetics and lipid metabolism in the liver in experimental diabetes	Phytoecdysteroides, ecdysterone and turkesterone (rats)	*A. turkestanica* (Rgl.) Brig.	Tashmukhamedova *et al.,* 1985; Syrov *et al.,* 1992b
Reversal of mitochondrial dysfunction in experimental hepatitis and diabetes	Phytoecdysteroids (ecdysterone, turkesterone and cyasterone)(rats)	*A. turkestanica* (Rgl.) Brig.	Tashmukhamedova *et al.,* 1986a; Tashmukhamedova *et al.,* 1986b; Syrov *et al.,* 1992b
Increase in insulin sensitivity in experimental diabetes	Ecdysterone, ecdysteroid (rats)	*A. turkestanica* (Rgl.) Brig.	Kosovskii *et al.,* 1989
Cardiac stimulant	Plant extract (in vivo) 8-O-acetylharpagide	*A. remota* Benth. (L.) *A. bracteosa* Wall.	Kuria and Muriuki, 1984 Shafi *et al.,* 2004
Biliary secretagogue	Phytoecdysteroids (ecdysterone, turkesterone and cyasterone)(rat)	*A. turkestanica* (Rgl.) Brig.	Syrov *et al.,* 1986
Wound healing	Phenylpropanoid glycosides (verbascoside, teupolioside) (in vitro/mouse) Aq. Extract (mouse) Aq. Extract (mouse) Plant products (in vitro/mouse) Plant products (in vitro/mouse) Lipids (mice)	*A. reptans* L. *A. chia* Schreb. *A. orientalis* L. *A. pseudoiva* Robill & Castgne ex DC. *A. turkestanica*	PDR-HM, 1990; Korkina *et al.,* 2007 Khalil *et al.,* 2007 Boulos, 1983; Ali-Shtayeh *et al.,* 2000; Boulos, 1983; Ali-Shtayeh *et al.,* 2000 Boulos, 1983; Ali-Shtayeh *et al.,* 2000 Syrov *et al.,* 1994
Larvae and insect antifeedant	*neo*-clerodane diterpenoids ; clerodane diterpenoids (14,15-dihydroajugapitin, lupulin A) (in vitro) ; diglycerides (in vitro) ; ajugarin/ clerodane diterpenoids (in vitro)	*A. reptans* ev Catlins Giant; *A. psuedoiva* Robill & Castagne ex DC. *A. iva* L. Schreb. *Ajuga*	Belles *et al.,* 1985 ; Bremner *et al.,* 1998; Ben Jannet et al. 2000; Ben Jannet *et al.,* 2001 Bondì *et al.,* 2000 Caballero *et al.,* 2001
Larvicide (mosquito)	Pet-ether extract (in vitro) *Neo*-clerodane diterpenes	*A. remota*	Sharma *et al.,* 2004b ; Coll and Tandrón, 2008
Inhibition of insect ecdysis (molting)	ajugalactone (in vivo)	*A. decumbens* Thunb. *A. reptans* L.	Koreeda *et al.,* 1970; Kubo *et al.,* 1981; Kubo *et al.,* 1986

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Medicinal/pharmacological/ biological property	Plant extract/chemicals isolated from the plant	Ajuga species	Reference
Insecticidal effect	MeOH-extract	*A. iva* L. Schreb.	Jbilou *et al.,* 2006; Jbilou *et al.,* 2008
Antihelmintic activity	Aq-root-extract (in vitro)	of *A. macrosperma* var. *breviflora*	
Anti-nematode activity	Phytoecdysone, 20-hydroxyecdysone (in vitro)	*Ajuga*	Soriano *et al.,* 2004

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