Arabian Journal of Chemistry (2015) 8, 614–623

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Arabian Journal of Chemistry

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REVIEW

# Phytochemical review of *Juncus* L. genus (Fam. Juncaceae)

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Received 16 June 2011; accepted 14 July 2012
Available online 22 July 2012

**KEYWORDS**

*Juncus* genus;
Cytotoxic;
Antioxidant;
Anti-eczematic;
Hepatoprotective;
Phenanthrenes

**Abstract** This review surveys the various naturally occurring compounds that have been isolated from different species of *Juncus* genus. This is the first review published on this topic. The present study furnishes an overview of all naturally isolated compounds, flavonoids, coumarines, terpenes, stilbenes, sterols, phenolic acids, carotenes, phenanthrenes derivatives (monomeric and dimeric) and biological activities of these species. These plants have often been used in traditional medicine, and also have therefore been studied for their antitumor, antioxidant, antiviral, anti-algal, antimicrobial, cytotoxic and anti-inflammatory, significant anti-eczematic and hepatoprotective activity. On the basis of 48 references, this review covers the phytochemistry and pharmacology of *Juncus* species, describing compounds previously reported.


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Peer review under responsibility of King Saud University

Production and hosting by Elsevier

1878-5352 
http://dx.doi.org/10.1016/j.arabjc.2012.07.007

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## 1. Introduction

### 1.1. Botany

Family Juncaceae consists of eight genera, of which namely *Juncus* L. is by far the most important. The most famous species of this genus are eleven species namely: *Juncus acutus* L., *Juncus bufonus* L., *Juncus effusus* L., *Juncus inflexus* L., *Juncus fontanessi* Gay in Lah. *Juncus littoralis* C.A.May., *Juncus punctoritus* L.f., *Juncus rigidus* C.A.May., *Juncus subulatus* Forssk, *Juncus roemerianus* L., *Juncus inflexus* L. and *Juncus alpinus* V. (Tackholm, 1974).

#### 1.1.1. Occurrence of Juncus species

Juncaceae is a very large family distributed all over the world; it holds a rather unique position among angiosperms. *Juncus* L. (Tackholm and Drar, 1950; Snogerup, 1958) species are a widespread genus and present in many parts of both hemispheres (Snogerup, 1960, 1978; Tyler, 1969; Weimarck, 1946). These species usually grow in the salty marshes or badly-drained soils under different climatic conditions (Tackholm and Drar, 1950; Boyko, 1966).

#### 1.1.2. Botanical description

*Juncus* L. species comprises marsh herbs usually with sympodial rhizomes developing leafy shoots (culms) which are typically slender, unbranched and nodeless (Mansour et al., 1986).

#### 1.1.3. Economic importance

Tackholm and Drar (Tackholm and Drar, 1950) stated that the mat industry of *Juncus* have been described by Abu Hanifa (895 a.d.) and Ibn El-Beitar (1248 a.d.), with Cairo being the center for rush mat industry. Writing implements, sandals and baskets were manufactured from culms of *J. rigidus* during the ancient times in Egypt. Recently, the culms of *J. acutus* and *J. rigidus* are used in the paper industry (Boyko, 1966; Zahran and Abdel-wahib, 1982). Cellulose (Benner et al., 1987) and nitrocellulose (Liu, 1991) are manufactured from *J. roemerianus* and *J. alpinus* (Chinese alpine) respectively.

## 2. Secondary metabolites of *Juncus* species

It was concluded that Juncaceae plants are chemically specialized, in spit of the fact that the family has been regarded as ancestral to the Cyperaceae and Gramineae (Williams and Harborne, 1975). Members of the genus *Juncus* L. have been reported to contain several groups of natural compounds, including flavonoids, coumarins, terpenes, sterols, phenolic acids, stilbenes, dihydro-dibenzoxepin, carotenoids and phenanthrenes (monomeric and dimeric). Also the seeds of *Juncus* species were found to be rich in fatty acids (Osman et al., 1975) and amino acids (Zahran and El-Habib, 1979). These reported secondary metabolites are summarized in Tables 1–5.

### 2.1. Flavonoids

This class of secondary metabolites is rarely isolated compounds from the species of *Juncus* genus. It is clear that several flavonoid classes, free flavonoids, their O– or C– glycosides and glucoronide and their O– or C– alkylated, were reported. As, Isocutellarein pent methyl ether was isolated from medulla of *J. effuses*, quercetin and its 3-O-rutinoside were isolated from rhizomes of *J. subulatus* (Dawidar et al., 2004), aerial parts of *J. acutus* and *J. rigidus* (Mansour et al., 1986). Also, apigenin, its 7-methyl ether, 7-methyl ether-4′-O-glucoside, 7-O-glucoside, 4′-O-glucoside and 7-glucouronide were reported from aerial parts of *J. acutus* and *J. rigidus* (Mansour et al., 1986; Abdel-Razik et al., 2009) and inflourcences of *J. effuses* and *J. inflexus*. This class is summarized in Table 1.

### 2.2. Coumarins and coumarinic acid esters

There are few of reported coumarins and coumarinic acid esters from *Juncus* species. Most of isolated coumarines are benzocoumarine derivatives that reported from the aerial parts of *J. acutus* (Dellagreca et al., 2003). Two coumarinic acid esters are reported from the medullae of *J. effusus* (Dong-Zhea et al., 1996) and is shown in Table 2.

**Table 1** Reported flavonoids from *Juncus* species.

| Compound name | Plant name |
|---|---|
| Apigenin Abdel-Mogib (2001) | *Juncus acutus* (A.P) |
| Apigenin-7-methyl ether(Abdel-Mogib (2001) | *J. acutus* (A.P) |
| Apigenin-7-methyl ether-4‘-O-glucoside Abdel-Mogib (2001) | *J. acutus* (A.P) |
| Apigenin-7-O-glucoside Mansour et al. (1986) and Abdel-Razik et al. (2009) | *J. acutus* (A.P) *J. rigidus* (A.P) |
| Apigenin-4′-O-glucosideWilliams and Harborne (1975) | *J. inflexus* (I.) *J. effuses* (I.) |
| Apigenin-7-glucouronide Mansour et al. (1986) | *J. acutus* (A.P) *J. rigidus* (A.P) |
| Luteolin Mansour et al. (1986), Abdel-Razik et al. (2009), Abdel-Mogib (2001) and Shan et al. (2008) | *J. acutus* (A.P) *J. subulatus* (Rh.) *J. rigidus* (A.P) |
| Luteolin-5-glucoside Williams and Harborne (1975) and Abd-Alla et al. (1981) | *J. inflexus* (I.) |
| Luteolin-5-methyl ether Mansour et al. (1986) and Abd-Alla et al. (1981) | *J. acutus* (A.P) |
| Luteolin-5-methyl ether-7-O-glucoside Mansour et al. (1986) and Abd-Alla et al. (1981) | *J. acutus* (A.P) *J. rigidus* (A.P) |
| Luteolin-4‘-O-glucoside Williams and Harborne (1975) and Shan et al. (2008) | *J. inflexus* (I.) *J. effusus* (I.) |
| Luteolin-6,8-di-C-glucoside Mansour et al. (1986) | *J. acutus* (A.P) *J. rigidus* (A.P) |
| Quercetin Mansour et al. (1986), Abdel-Razik et al. (2009) and Dong-Zhea et al. (1996) | *J. effusus* (M) *J. acutus* (A.P) *J. subulatus* (Rh.) |
| Quercetin-3-O-rutinoside Mansour et al. (1986) and Abdel-Razik et al. (2009) | *J. acutus* (A.P) *J. rigidus* (A.P) *J. subulatus* (Rh.) |
| Isocutellarein pent methyl ether Dong-Zhea et al. (1996) | *J. effusus* (M) |
| Luteolin-5,3′-dimethyl ether Li et al. (2007) | *J. effusus* (S) |
| Eriodictyol Shan et al. (2008) | *J. effuses* |
| 2’,5’,5,7-tetrahydroxyflavone Shan et al. (2008) | |
| Chrysoeriol-7-glucosidesulphate Williams and Harborne (1975) | *J. inflexus* (I) |

### 2.3. Terpenes and terpene glycerides

The reported terpenes are rare from the species of this genus. As, betulin, betulinalaldehyde, phytol, dreminin, P-cymen-7-ol acetate, α-cyclogeraniol acetate, *E*-ionone and kaurene were reported from *J. subulatus* (Dawidar et al., 2004; Abdel-Razik et al., 2009). Thymol, pulegone, sabinol and camphor from *J. roemerianus* (Howard et al., 1973). Effusenone (A) from *J. effusus* L (Shan et al., 2008).

Terpene glycerides isolated from species of *Juncus* species were only as triterpene glycerides. Only five triterpene glycerides, Juncoside I–V, were isolated from the aerial parts of *J. effusus* (Corsaro et al., 1994) and is shown in Table 3.

### 2.4. Stilbenes

Stilbenes and their derivatives are very rare secondary metabolites in this genus. Only two stilbene glycosides, oxyresveratrol-2-O-β-D-glucopyranoside and resveratrol-3′,4′-O,O′-di-β-D-glucopyranoside, were isolated from the aerial parts of *J. acutus* (Awaad, 2006).

### 2.5. Phenolic acids

Few numbers of phenolic acids were isolated from only two *Juncus* plants. P-Coumaric acid, vanillic acid, methyl p-hydroxybenzoate, markhamioside F, canthoside B and caffeic acid-3‘-O-glucorhamnoside were reported from medullae of *J. effusus* and aerial parts of *J. acutus* (Shan et al., 2008; Dong-Zhea et al., 1996).

### 2.6. Sterols

Only six sterol compounds, β-Sitosterol, stigmasta-4-en-3-one, Stigmast-4,22-dien-3-one, 5-α-Spinasterol, stigmasterol, β-sitosteroyl-β-D-glyceride were isolated from *J. subulatus* and medullae of *J. effuses* (Dawidar et al., 2004; Abdel-Razik et al., 2009; Dong-Zhea et al., 1996).

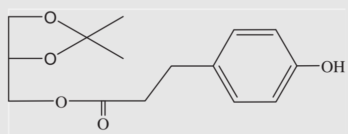
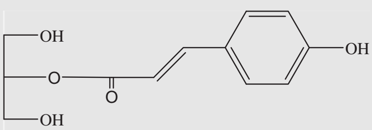
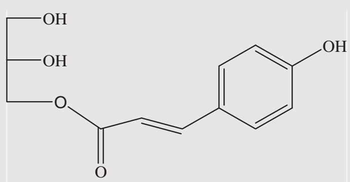
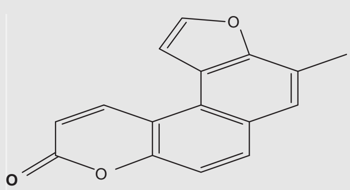
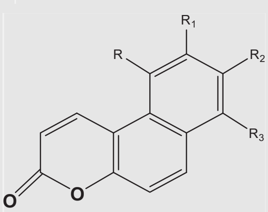
### 2.7. Dihydro-dibenzoxepin

This class of secondary metabolites is phytochemically very rare but there are two reported derivatives from this genus from *J. effuses* (Dellagreca et al., 1993) as described in Table 4, These compounds are very closed to phenanthrenes.

### 2.8. Phenanthrenes

The most characteristic type of natural compounds for this genus is phenanthrenes, both monomeric and dimeric, where the greatest number of phenanthrene derivatives has been described from *Juncus* species (Kovacs et al., 2008). All types of monomeric phenanthrenes (normal and dihydro) derivatives were reported. Also, there are dimeric phenanthrenes derivatives reported from different species of *Juncus*. Most of isolated phenanthrenes from *Juncus* species are 5-vinyl derivatives. A lot of derivatives of both phenanthrene and dihydrophenanthrene were reported, as, hydroxylated, alkylated, formylated, carboxylated, hydroxalkylated and also linked with hetero compound as pyrane and furane ring. In addition to the dihydrophenanthrene glucosides and glycerides. But glycosides are relatively rare:

**Table 2** Reported coumarins and coumarinic acid esters from *Juncus* species.

| | | |
|---|---|---|
|  | Juncusyl ester A Dong-Zhea et al. (1996) | *J. effusus* (M) |
|  | Juncusyl ester B Dong-Zhea et al. (1996) | |
|  | (2s)-1-O-p-coumaroyl glyceride Dong-Zhea et al. (1996) | |
| Dephnetin Bate-Smith (1968) | | *J. effusus* (W.P) |
|  | 7-methyl-[5,6-b] furo-5a,8a-benzo-coumarin Dellagreca et al., 2003 | *J. acutus* (A.P) |
|  | (R = vinyl, $R_1$, $R_3$ = H, $R_2$ = Me) Dellagreca et al., 2003<br>(R = vinyl, $R_1$ = Me, $R_2$ = OH, $R_3$ = H) Dellagreca et al., 2003<br>(R = vinyl, $R_1$ = H, $R_2$ = OH, $R_3$ = Me) Dellagreca et al., 2003<br>(R = vinyl, $R_1$ = $CH_2OH$, $R_2$, $R_3$ = H) Dellagreca et al., 2003 | |

they were reported only in *J. effusus* (effusides I–V) Dellagreca et al., 1995. Dimeric phenanthrenes are also very rare in this genus. Only five dimeric phenanthrenes were reported from only one plant named *J. acutus* (Dellagreca et al., 1997, 2002). These compounds are reported in the Table 5. From the above, it is clear that the most isolated phenanthrenes from this genus are dihydrophenanthrenes. That mean dihydrophenanthrenes derivatives are markers for this genus. *Juncus* dihydrophenanthrenes are obviously derived from a specific biosynthetic pathway. The starting amino acid in this pathway is phenylalanine and acetic acid until obtaining the stilbene skeleton. Internal rearrangement of stilbene skeleton with ring closure occurred to give dihydrophenanthrene derivativies (Scheme 1) Pryce, 1971.

## 3. Biological activity of *Juncus* species

### 3.1. Traditional medicine

The seeds of *Juncus* are employed in oriental as a remedy for diarrhea (Tackholm and Drar, 1950). The infusion of fruits of *J. acutus* mixed with barley grains is useful for cold (Bellakhdar, 1978). The rhizomes of *J. maritimus* are recommended for insomnia (Namba in colored illustration of waken-yaku 2, 19, 1980). The medulla of *J.* effusus (L.) is used in traditional medicine as an antipyretic and also as sedative agent in Japan and China (Miles et al., 1977).

### 3.2. Cytotoxicity and antitumor activity

Some of the isolated phenanthrenes from *J. effusus* have exhibited good cytotoxic and *in vitro* antitumor activities (Dellagreca et al., 1993; Chapatwala et al., 1997). Miles, Bhattacharyya have investigated the cytotoxic activity of the ethanolic extract of *J. roemerianus* which resulted in confirmed level activity against the National Cancer Institute's murine P388 lymphocytic leukemia (PS system) Dellagreca et al., 1992. Many 9,10-dihydrophenanthrene metabolites isolated from *J. effusus* have antitumor activity *in vitro* (Oyazu et al., 1991). Dihydrophenanthrenes with cytotoxic activity have been reported from *J. effuses* (Dellagreca et al., 1998).

**Table 3** Reported terpene glycerides from *Juncus* species.

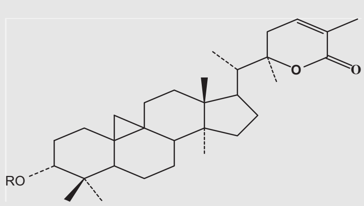
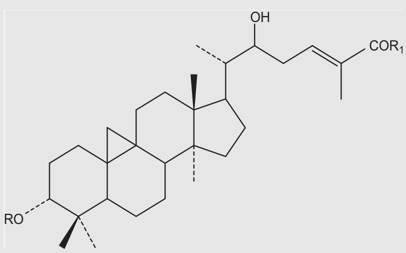
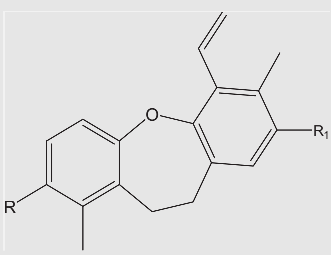
| | | |
|---|---|---|
|  | (R = β-Glc$_{2-1}$β-Glc$_{2-1}$β–Glc) Juncoside I Corsaro et al. (1994)<br>(R = β-D-Glc$_{2-1}$β-D-Glc$_{2-1}$β-D-Glc, R$_1$ = $_1$-O-β-Glc) Juncoside II Corsaro et al. (1994) | *J. effusus* (A.P) |
|  | (R = β-D-Glc$_{2-1}$β-D-Glc$_{2-1}$β-D-Glc, R$_1$ = 6-O-α-Glc) Juncoside III Corsaro et al. (1994)<br>(R = β-D-Glc$_{2-1}$β-D-Glc$_{2-1}$β-D-Glc, R$_1$ = 6-O-β-Glc) Juncoside IV Corsaro et al. (1994)<br>(R = β-D-Glc$_{2-1}$β-D-Glc$_{2-1}$β-D-Glc, R$_1$ = O-p-$C_6H_4$-O-β-D-Glc) Juncoside V Corsaro et al. (1994) | |

**Table 4** Reported dihydro-dibenzoxepin from *Juncus* species.

| | | |
|---|---|---|
|  | (R, R$_1$ = OH) 2,8-dihydroxy-1,7-dimethyl-6-vinyl-10, 11-dihydro-dibenzo[b,f]oxepin Dellagreca et al. (1993)<br><br>(R, R$_1$ = $OCH_3$) 2,8-dimethoxy-1,7-dimethyl-6-vinyl-10, 11-dihydro-dibenzo[b,f]oxepin Dellagreca et al. (1993) | *J. effusus* (W.P) |

### 3.3. Antioxidant and hepatoprotective activity

Antioxidant activity has been reported in an ethyl acetate extract of *J. effuses* (Dellagreca et al., 1998). Hepatoprotective, antioxidant and hypolipidemic activities against alcohol-induced hepatic injury have been reported for ethyl acetate, *n*-butanol and total alcoholic extracts in addition to volatile oil of the tubers of *J. subulatus* (Abdel-Razik et al., 2009).

### 3.4. Antiviral and antimicrobial activities

Antiviral activity has been reported for ethyl acetate extract and dihydrophenanthrenes of *J. effusus* (Dellagreca et al., 1993, 1998). It has been found that the isolated dihydrophenanthrenes from the marsh plant of *J. roemerianus* has potential antimicrobial activity (Chapatwala et al., 1997).

### 3.5. Anti-algal activity

Anti-algal activity of benzo-coumarins isolated from *J. acutus* has been evaluated on the green alga *Pseudo-kirchneriella subcapitata* (Dellagreca et al., 2003). Also the anti-algal activity of dihydrophenanthrenes isolated from *J. effusus* has been reported (Dellagreca et al., 1997, 1998). Dimeric dihydrophenanthrenes with anti-algal activity have been reported from rhizomes of *J. acutus* (Dellagreca et al., 2002, 2005). Also it was reported that Phenylpropane Glycerides isolated from *J. effusus* have been reasonable for antialgal activity on *Selenastrum capricornutum* (Dellagreca et al., 1998).

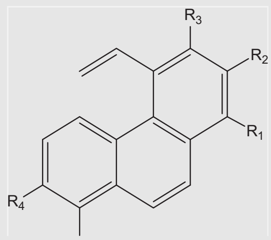
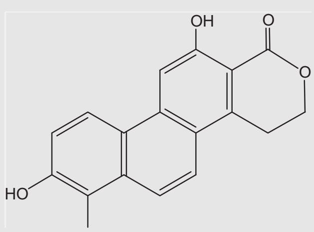
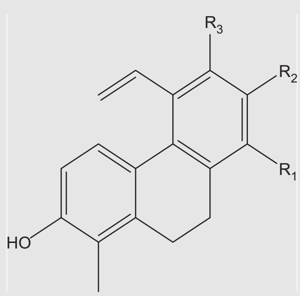
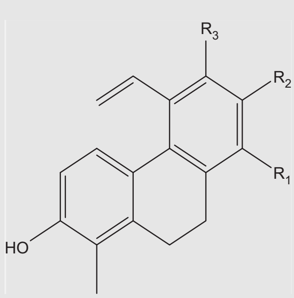
### 3.6. Anti-inflammatory effects

Anti-inflammatory effects of the isolated phenanthrenoids from *J. acutus* have been evaluated *in vitro* by measuring the inhibition percent of pro-inflammatory inducible nitric oxide synthase (iNOS) protein expression in lipopolysaccharide (LPS)-stimulated RAW264.7 macrophage cells (Fathi et al., 2007).

### 3.7. Anti-eczematic activity

The total alcoholic extract of aerial parts of *J. acutus* has exhibited significant anti-eczematic activity (Awaad, 2006).

**Table 5** Reported phenanthrenes from *Juncus* species.

| | | |
|---|---|---|
|  | ($R_1$ = OH, $R_2$ = H, $R_3$ = Me, $R_4$ = OMe) 8-hydroxy-1,6-dimethyl-2-methoxy-5-vinyl phenanthrene Dellagreca et al. (1993, 2002, 2004) | *J. acutus* (A.P)<br>*J. effusus* (A.P) |
| | ($R_1$, $R_3$ = H, $R_2$ = OH, $R_4$ = OMe) 7-hydroxy-1-methyl-2-methoxy-5-vinyl phenanthrene Dellagreca et al. (2004) | *J. acutus* (A.P) |
| | ($R_1$, $R_3$ = H, $R_2$ = Me R4 = OMe) 1,7-dimethyl-2-methoxy-5-vinyl phenanthrene Dellagreca et al. (2004) | |
| | ($R_1$ = H, $R_2$ = OH, R3 = Me, $R_4$ = OH) Dehydrojuncusol Dellagreca et al. (2002, 2004), Sarkar et al. (1988) and Shima et al. (1991) | *J. acutus* (A.P)<br>*J. effusus* (A.P)<br>*J. roemerianus* (A.P,Rh) |
| | ($R_1$ = H, $R_2$ = H, $R_3$ = Me, $R_4$ = OH) 1,6-dimethyl-2-hydroxy-5-vinyl phenanthrene Dellagreca et al. (2002, 2004) | *J. acutus* (A.P)<br>*J. effusus* (A.P) |
| | ($R_1$ = H, $R_2$ = OMe, R3 = Me, $R_4$ = OMe) 2,7-dimethoxy-1,6-dimethyl-5-vinyl phenanthrene Dellagreca et al. (2002, 2004) | |
| | ($R_1$,$R_3$ = H, $R_2$, $R_4$ = OH) Dehydroeffusol Shima et al. (1991) | *J. effusus* (A.P) |
| | ($R_1$ = H, $R_3$ = Me, $R_2$ , $R_4$ = OH)2,7-dihydroxy-1,6-dimethyl-5-vinyl phenanthrene Fathi et al. (2007) | *J. acutus* (Rh.) |
| | (R1, $R_2$ = H, R3 = $CH_2OH$, $R_4$ = OH) 1-methyl-2-hydroxy-6-hydroxymethyl-5-vinyl-phenanthrene Dellagreca et al. (2004) and Fathi et al. (2007) | *J. acutus* (A.P) |
| | ($R_1$, $R_3$ = H, $R_2$ = OH, $R_4$ = CHO) Dehydroeffusal Shima et al. (1991) | *J. effusus* (A.P) |
| | ($R_1$ = $C_2H_3$, $R_3$ = OH, $R_2$ = $CH_3$, $R_4$ = H) dehydrojuncuenins A Wang et al. (2009) | *J. setchuensis* |
|  | Dehydrojuncuenins C Wang et al. (2009) | *J. setchuensis* |
|  | ($R_1$, $R_2$ = H, $R_3$ = COOH) 2-hydroxy-1-methyl-5-vinyl-9,10-dihydrophenanthrene-8-carboxylic acid Dellagreca et al. (2004) | *J. acutus* (A.P) |
| | ($R_1$ = Me, $R_2$ = OH, $R_3$ = H) 2,6-dihydroxy-1,8-diymethyl-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) and Shima et al. (1991) | *J. acutus* (A.P)<br>*J. effusus* (A.P) |
| | ($R_1$ = OH, $R_2$ = H, $R_3$ = Me) 2,8-dihydroxy-1,6-diymethyl-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) and Shima et al. (1991) | |
| | ($R_1$ = Me, $R_2$ = OMe, $R_3$ = H) 2-hydroxy-1,8-dimethyl-6-methoxy-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) and Shima et al. (1991) | |
| | ($R_1$, $R_2$ = H, OMe, $R_3$ = $CH_2OH$) 2-hydroxy-6-hydroxymethyl-1-methyl-5-vinyl-9,10-dihydrophenanthrene Fathi et al. (2007) | *J. acutus* (Rh.) |
| | ($R_1$, $R_3$ = H, OMe, $R_2$ = CHO) 2-Hydroxy-7-formyl-1-methyl-5-vinyl-9,10-dihydrophenanthrene Dawidar et al. (2004) | *J. subulatus* (A.P) |
| | ($R_1$ = H, $R_2$ = O-D-gluc, R3 = Me) 1,6-dimethyl-2-hydroxy-5-vinyl-9,10-dihydrophenanthrene-7-O-D-glucoside Dellagreca et al. (1995) | *J. effuses* (W.P) |
| | ($R_1$ = H , $R_2$ = Me, $R_3$ = OH) 2,6-dihydroxy-1,7-dimethyl-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (2004) and Chapatwala et al. (1997) | *J. acutus* (A.P)<br>*J. effusus* (A.P) |
|  | ($R_1$ = H , $R_2$ = $CH_2OH$, $R_3$ = H) 2-hydroxy-7-hydroxymethyl-1-methyl-5-vinyl-9,10-dihydrophenanthrene Abdel-Razik et al. (2009) and Dellagreca et al. (1997, 2004) | *J. acutus* (A.P)<br>*J. effusus* (W.P) *J. subulatus* (Rh) |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = H) Juncunol Abdel-Razik et al. (2009), Abdel-Mogib (2001), Dellagreca et al. (2002, 2004) and Sarkar et al. (1988) | *J. acutus* (A.P)<br>*J. effusus* (A.P)<br>*J. roemerianus* (A.P, Rh)<br>*J. subulatus* (Rh) |
| | ($R_1$ = H , $R_1$ = OH, $R_2$ = Me) Juncusol Abdel-Razik et al. (2009), Dellagreca et al. (2002, 2004), Sarkar et al. (1988), Fathi et al. (2007), Shima et al. (1991) and Chapatwala et al. (1997) | *J. acutus* (A.P)<br>*J. effusus* (A.P)<br>*J. roemerianus* (A.P, Rh)<br>*J. subulatus* (Rh) |

(*continued on next page*)

**Table 5** (*continued*)

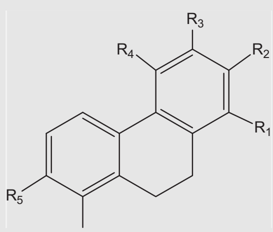
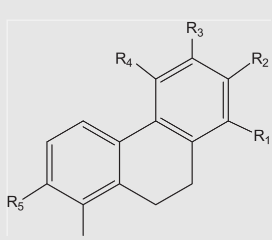
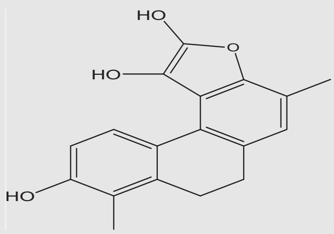
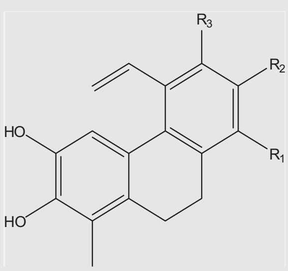
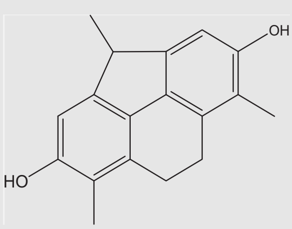
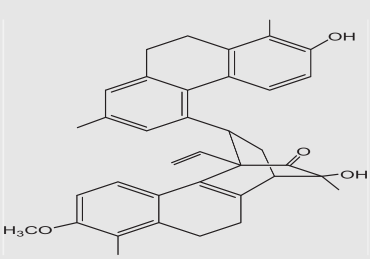
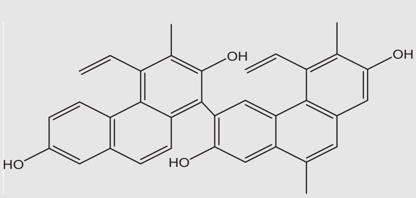
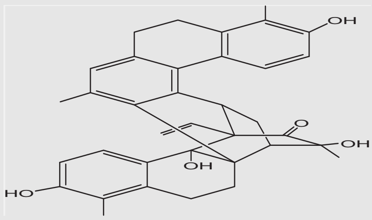
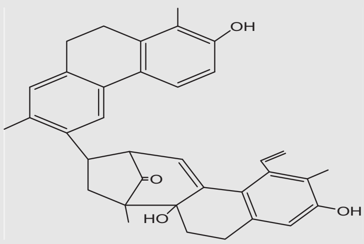
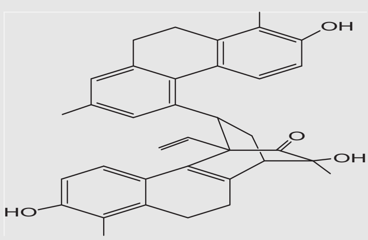
| | | |
|---|---|---|
| | ($R_1$ = H , $R_2$ = OH, $R_3$ = H) Effusol Abdel-Razik et al. (2009), Dellagreca et al. (1993, 2004) and Shima et al. (1991) | *J. acutus* (A.P), *J. effusus* (A.P) *J. subulatus* (Rh) |
| | ($R_1$ = H , $R_2$ = H, $R_3$ = Me) 1,6-dimethyl-2-hydroxy-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (2004) | *J. acutus* (A.P) |
| | ($R_1$ = H , $R_2$ = OH, $R_3$ = $CH_2OH$) 2,7-dihydroxy-6-ydroxymethyl-1-methyl-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (2004) | |
| | ($R_1$ = H , $R_2$ = H, $R_3$ = $CH_2OH$) 2-hydroxy-6-hydroxymethyl-1-methyl-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (1997, 2004) | *J. acutus* (A.P) *J. effusus* (W.P) |
| | ($R_1$ = COOH, $R_2$ = H, $R_3$ = H) 2-hydroxy-1-methyl-5-vinyl-9,10-dihydrophenanthrene-6-carboxylic acid Dellagreca et al. (1997, 2004) | |
| | ($R_{1,}$ $R_3$ = H, $R_2$ = COOH) 2-hydroxy-1-methyl-5-vinyl-9,10-dihydrophenanthrene-7-carboxylic acid Dellagreca et al. (1997, 2004) | |
|  | ($R_1$ = Me, $R_2$ = OH, $R_3$ = H, $R_4$ = $CH_2OH$, $R_5$ = OH) 2,7-dihydroxy-1,8-dimethyl-5-hydroxymethyl-9,10-dihydrophenanthrene Dellagreca et al. (1997) | *J. effusus* (A.P) |
| | ($R_1$ = Me, $R_2$ = OMe, $R_3$ = H, $R_4$ = $CH_2OH$, $R_5$ = OH) 2-hydroxy-1,8-dimethyl-7-methoxy-5-hydroxymethyl-9,10-dihydrophenanthrene Dellagreca et al. (1997) | |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = H, $R_4$ = $CH_2OH$, $R_5$ = OH) 2-hydroxy-1,7-dimethyl-5-hydroxymethyl-9,10-dihydrophenanthrene Dellagreca et al. (1997) | |
| | ($R_1$ = Me, $R_2$ = OH, $R_3$ = H, $R_4$ = $C_2H_4OH$, $R_5$ = OH) 2,7-dihydroxy-1,8-dimethyl-5-hydroxymethyl-5-isoproanoyl-9,10-dihydrophenanthrene Dellagreca et al. (1997) | |
| | ($R_1$ = H, $R_2$ = OH, $R_3$ = Me, $R_4$ = $C_2H_3$, $R_5$ = O-D-glu) 1,6-dimethyl-7-hydroxy-5-vinyl-9,10-dihydrophenanthrene-2-O-D-glucoside Dellagreca et al. (1995) | *J. effuses* W.P) |
| | ($R_1$ = H, $R_2$ = O-D-glu, $R_3$ = Me, $R_4$ = $C_2H_3$, $R_5$ = O-D-glu) 1,6-dimethyl-5-vinyl-9,10-dihydrophenanthrene-2,7-O-D- diglucoside | |
| | ($R_1$ = Me, $R_2$ = O-D-glu, $R_3$ = H, $R_4$ = $C_2H_3$, $R_5$ = O-D-glu) 1,8-dimethyl-5-vinyl-9,10-dihydrophenanthrene-2,7-O-D-diglucoside Dellagreca et al. (1995) | |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = OH, $R_4$ = Ac, $R_5$ = OH) Juncunone Sarkar et al. (1988) | *J. roemerianus* (A.P, Rh) |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = OH, $R_4$ = H $R_5$ = OH) 2,6-dihydroxy-1,7-dimethyl-9,10-dihydrophenanthrene Dellagreca et al. (1993) | *J. effusus* (A.P) |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = $CH_3$, $R_4$ = $CH_3CH_2OH$, $R_5$ = OH) 2,6-dihydroxy-1,7-dimethyl-5-isoproanoyl-9,10-dihydrophenanthrene Dellagreca et al. (1997,1993, 2002, 2004) | *J. acutus* (A.P) *J. effusus* (A.P) |
| | ($R_1$ = OH, $R_2$ = Me, $R_3$ = H, $R_4$ = $CH_3CH_2OH$, $R_5$ = OH) 2,8-dihydroxy-1,7-dimethyl-5-isoproanoyl-9,10-dihydrophenanthrene Dellagreca et al. (1997,1993, 2002, 2004) | |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = $CH_3$, $R_4$ = $CH_3CH_2OH$, $R_5$ = OH) 2,6-dihydroxy-1,7-dimethyl-5-isoproanoyl-9,10-dihydrophenanthrene Dellagreca et al. (1997, 1993, 2002, 2004) | |
|  | ($R_1$ = Me, $R_2$ = OMe, $R_3$ = H, $R_4$ = $C_2H_5OC_2H_4$, $R_5$ = OH) 5-(1-ethoxy-ethyl)-2-hydroxy-7-methoxy-1,8-dimethyl-9,10-dihydrophenanthrene Dellagreca et al. (2002, 2004) | *J. acutus* (A.P) *J. effusus* (A.P) |
| | ($R_1$ = Me, $R_2$ = OMe, $R_3$ = H, $R_4$ = $C_{22}H_{45}O$, $R_5$ = OH) 5-(1-Phytoxy-ethyl)-2-hydroxy-7-methoxy-1,8-dimehyl-9,10-dihydrophenanthrene Dellagreca et al. (2002, 2004) | |
| | ($R_1$ = H, $R_2$ = Me, $R_3$ = OH, $R_4$ = $CH_3CH_2OMe$, $R_5$ = OH) 2,6-dihydroxy-1,7-dimethyl-5- [2-methoxyproanoyl]-9,10-dihydrophenanthrene | *J. acutus* (A.P) |
| | ($R_1$ = H, $R_2$ = OH, $R_3$ = H, $R_4$ = $CH_2OH$, $R_5$ = OH) 2,7-dihydroxy-1-methyl-5-hydroxymethyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) | |
| | ($R_1$ = Me, $R_2$ = OH, $R_3$ = H, $R_4$ = $CH_2OH$, $R_5$ = OH) 2,7-dihydroxy-1,8-dimethyl-5-hydroxymethyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) | |
| | ($R_1$ = H, $R_2$, $R_3$ = OH, $R_4$ = MeCO, $R_5$ = OH) 2,6-dihydroxy-1,7-dimethyl-5-ethoxy-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) | |

**Table 5** (*continued*)

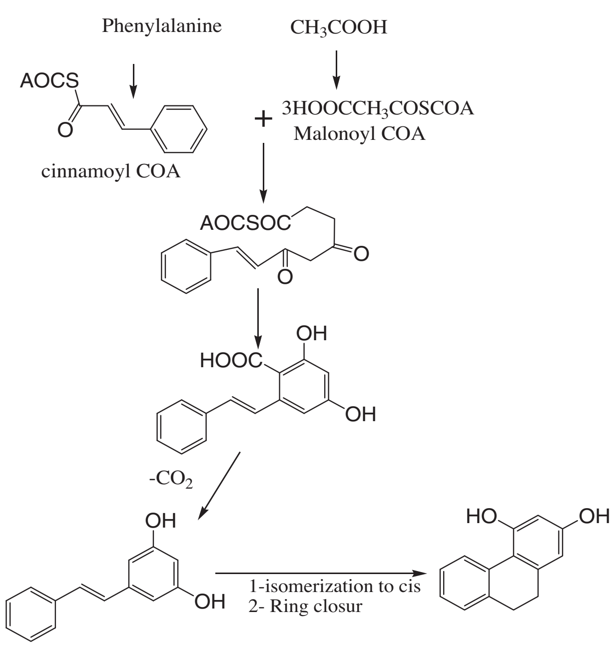
| | | |
|---|---|---|
| | ($R_1$ = Me, $R_2$ = OMe, $R_3$ = H, $R_4$ = CHO, $R_5$ = OH) 2-hydroxy-1, 8-dimethyl-7-methoxy-5-formyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) | |
| | ($R_1$ = H, $R_2$ = Me, $R_4$ = CHO, $R_3$,$R_5$ = OH)2,6-dihydroxy-1, 7-dimethyl-5-formyl-9,10-dihydrophenanthrene Dellagreca et al. (1993, 2004) | |
| | ($R_1$ = Me, $R_2$ = Oglc, $R_3$ = H, $R_4$ = $CH_2OMe$, ,$R_5$ = OH) Effuside I Dellagreca et al. (1995) | *J. effuses* (W.P) |
| | ($R_1$ = Me, $R_2$ = Oglc, $R_3$ = H, $R_4$ = $CH_2OH$, ,$R_5$ = OH) Effuside II Dellagreca et al. (1995) | |
| | ($R_1$ = Me, $R_3$ = H, $R_4$ = $CH_2Oglc$, , $R_2$, $R_5$ = OH) Effuside III Dellagreca et al. (1995) | |
| | ($R_1$ = Me, $R_2$ = OH, $R_3$ = H, $R_4$ = $CH_2OH$ , $R_5$ = Oglc) Effuside IV Dellagreca et al. (1995) | |
| | ($R_1$ = Me, $R_3$ = H, $R_4$ = $CH_2OH$ , $R_2$, $R_5$ = Oglc) ($R_1$, $R_2$ = Glc, $R_3$ = H) Effuside V Dellagreca et al. (1995) | |
|  | 1,7-dimethyl-2-hydroxy [5,6-b] 4‘,5‘-dihydroxy-furo-9,10-dihydrophenanthrene Dellagreca et al. (1997) | *J. effusus* (A.P) |
|  | ($R_1$ = OH, $R_2$ = H, $R_3$ = Me) 1,6-dimethyl-2,3,8-trihydroxy-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (2004) | *J. acutus* (A.P) |
| | ($R_1$, $R_3$ = H, $R_2$ = Me) 2,3-dihydroxy-1,7-dimethyl-5-vinyl-9,10-dihydrophenanthrene Dellagreca et al. (1993) | *J. effusus* (A.P) |
|  | Juncutol Fathi et al. (2007) | *J. acutus* (Rh.) |
|  | Dimeric Phenanthrenes Dellagreca et al. (1995) and Dellagreca et al. (2005) M.F $C_{37}H_{38}O_4$) | *J. acutus* (A.P) |
|  | Dimeric Phenanthrenes Dellagreca et al. (1995) and Dellagreca et al. (2005) (M.F $C_{36}H_{36}O_4$) | |

(*continued on next page*)

**Table 5** (*continued*)

| | | |
|---|---|---|
|  | Dimeric Phenanthrenes Dellagreca et al. (1995) and Dellagreca et al. (2005) M.F $C_{36}H_{36}O_5$) | |
|  | Dimeric Phenanthrenes Dellagreca et al. (1995) and Dellagreca et al. (2005) (M.F $C_{36}H_{36}O_4$) | |
|  | Dimeric Phenanthrenes Dellagreca et al. (2002) (M.F $C_{36}H_{36}O_4$) | *J. acutus* (Rh) |

A. P. = Arial parts – I. = Inflourcences - Rh. = Rhizomes – S. = Stems – W. P. = Whole plant – M = Medulla.




**Scheme 1**

## 4. Conclusion

In this review, chemically, many classes of natural metabolic compounds were reported from the species of *Juncus* genus. Phenanthrenes are very characteristic for this genus especially 2-methyl-5-vinyl substituted diphenanthrenes and phenanthrenes. Biologically, most of *Juncus* species were used in traditional medicine. Also several biological activities were reported for these species such as, cytotoxicity, antitumor anti-eczematic, anti-inflammatory, anti-algal, antioxidant and hepatoprotective activity.

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