Table 3.1 List of lichen secondary metabolites used to evaluate antimicrobial activity

Lichen compounds	References
Lecanoric acid	Gomes et al. (2003), Ranković and Mišić (2008), Honda et al. (2010), Ristić et al. (2016a)
Atranorin	Kumar and Müller (1999), Yilmaz et al. (2004), Turk et al. (2006), Ranković et al. (2008, 2014a, b), Kosanić et al. (2014a)
Zeorin	Kosanić et al. (2010)
Gyrophoric acid	Candan et al. (2006), Ranković et al. (2008), Kosanić et al. (2014c)
Stenosporic acid	Candan et al. (2006)
Protocetraric acid	Tay et al. (2004), Ranković and Mišić (2008), Manojlović et al. (2012)
Fumarprotocetraric acid	Yilmaz et al. (2004), Ranković et al. (2008), Kosanic et al. (2014)
Stictic acid	Ranković and Mišić (2008)
Salazinic acid	Candan et al. (2007), Manojlović et al. (2012)
Usnic acid	Lauterwein et al. (1995), Perry et al. (1999), Yilmaz et al. (2004), Ivanova et al. (2004), Tay et al. (2004), Ranković et al. (2008, 2012, 2014a, b), Schmeda-Hirschmann et al. (2008), Paudel et al. (2010), Ramos and Almeida da Silva (2010)
Vulpinic acid	Whiton and Lawrey (1982), Lawrey (1986), Lauterwein et al. (1995)
Evernic acid	Whiton and Lawrey (1982), Lawrey 1986; Halama and Van Haluwin (2004), Kosanić et al. (2013)
Lobaric acid	Ingolfsdottir et al. (1998), Piovano et al. (2002), Sundset et al. (2008).
Physodic acid	Turk et al. (2006), Ranković et al. (2008, 2014a, b), Kosanić et al. (2013)
Protolichesterinic acid	Ingolfsdottir et al. (1998), Türk et al. (2003)
Norstictic acid	Tay et al. (2004), Honda et al. (2010), Ranković et al. (2014a, b)
Ramalin	Paudel et al. (2008, 2010)
Barbatic acid	Martins et al. (2010)
Divaricatic acid	Piovano et al. (2002), Kosanić et al. (2010), Oh et al. (2018)
Difractaic acids	Piovano et al. (2002), Honda et al. (2010)
Umbilicaric acid	Buçukoglu et al. (2013).
Homosekikaic acid	Sisodia et al. (2013)
Sekikaic acid	Sisodia et al. (2013)
Parietin	Manojlović et al. (2002, 2005)
Parietinic acid	Manojlović et al. (2002)
Emodin	Manojlović et al. (2002)
Fallacinal	Manojlović et al. (2002)
Fallacinol	Manojlović et al. (2002)
Isodivaricatic acid	Schmeda-Hirschmann et al. (2008)
Divaricatinic	Schmeda-Hirschmann et al. (2008)
Hirtusneanoside	Rezanka and Sigler (2007)
Neuropogonines A, B and C	Ivanova et al. (2002)
Hypostictic acid	Honda et al. (2010)
Norstictic acid	Honda et al. (2010)
Secalonic acid	Honda et al. (2010)

(continued)

Table 3.1 (continued)

Lichen compounds	References
Psoromic acid	Tasdemir and Franzblau (2007)
Vulpic acid	Tasdemir and Franzblau (2007)
Parietin	Basile et al. (2015)
Obtusatic acid	Ristić et al. (2016a)
Methyl evernate	Ristić et al. (2016a)
2′-O-methyl anziaic acid	Ristić et al. (2016a)
Barbatolic acid	Sariozlu et al. (2016)
Usimine A, B and C	Paudel et al. (2010)

antimicrobial agent (comparable to streptomycin), and physodic and stictic acids the weakest.

The antifungal activity of ten depsidones and five depsides was evaluated, as well as the antibacterial of these compounds and three additional depsides and the one diaryl ether; all of them were isolated from lichens growing in Chile (Piovano et al. 2002). Obtained results showed, in general, negative activity against yeast and filamentous fungi at concentrations of 250 mg/mL. However, divaricatic and difractaic acids, and to a lesser degree lobaric acid, presented activity against *Microsporum gypseum, Trichophyton mentagrophytes, T. rubrum* and *Epidermophyton floccosum*, all of them being dermatophyte fungi which cause skin infections. Regarding antibacterial activity, results indicated that against Gram-negative bacteria the 19 compounds are inactive. In contrast against Gram-positive bacteria, a marked action can be observed for seven compounds.

Anthraquinones (parietin, parietinic acid, emodin, fallacinal and fallacinol) from *Caloplaca schaereri* were tested for antimicrobial activity using *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas fluorescens, Candida albicans, Trichoderma harzianum, Aspergillus niger* and *Penicillium verrucosum* (Manojlović et al. 2002). All the anthraquinones tested showed potent antibacterial activity against *B. subtilis, S. aureus* and *P. fluorescens* (MIC 20–320 μg/mL), but only parietinic acid showed any activity against *E. coli* (MIC 160 μg/mL). Their effects are generally most potent on *B. subtilis* and *P. fluorescens*. Fallacinol was most potent against *S. aureus*. Fallacinol was the most active (potent) of the isolated compounds against all the fungi tested but was particularly active against *T. harzianum, A. niger* and *P. verrucosum* (MIC 10–40 μg/mL). Parietinic acid also showed potent antifungal effects on the fungi tested (MIC 20–80 μg/mL), while parietin had MIC values of 80, 40 and 20 μg/mL for *C. albicans, P. verrucosum, A. niger* and *T. harzianum*, respectively. Emodin showed MIC values of 20–40 μg/mL for *A. niger, T. harzianum* and *P. verrucosum* but was much less effective against *C. albicans* (MIC 80 μg/mL).

According to Schmeda-Hirschmann et al. (2008), isodivaricatic acid, divaricatinic acid and usnic acid, the main lichen metabolites in *Protousnea poeppigii*, displayed antifungal action against *Microsporum gypseum*, *Trichophyton*