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REVIEW PAPER

Wild olive in Oman and its Conservation: A Review

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الزيتون البري في عمان والمحافظة عليه: مراجعة

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ABSTRACT.

The wild olive, *Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif. is one of the three dominant species of the common tree that exits in the ecosystem of the mountains of northern and southern Oman. There are insufficient studies about the use, ecology and preservation of this species in Oman. The mountain ecosystem habitation is highly sensitive to disturbances and not easy to rehabilitate. These disturbances are caused by range of anthropogenic effects, such as urbanisation, climate change, overgrazing, introducing non-native species, as well as naturally occurring insect pests and diseases. Introduction of cultivated olive orchards (*Olea europaea* L. subsp. *europaea*) in Oman was introduced in 2001 for oil production and its consumption in western Hajar Mountains has added a genetic threat where wild olives are grown. This paper highlights the importance of this subspecies in Oman and the threats that Oman is currently facing. The question is rising here "Do we need to be concerned about wild olive in Oman?" This paper gives a clear picture of the wild olive in Oman including its description, distribution, ecology and current conservation status.

KEYWORDS: Wild Olive; Threats, Genetic Erosion; Introgression, Mountains; Oman; Conservation.

الخلاصة:

يعتبر الزيتون البري (العتم او ميطان) *Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif من اهم الأشجار الرئيسية التي تستوطن الجبال في شمال عمان (جبال الحجر الشرقي والغربي) وجنوب عمان (جبال ظفار). يمثل الزيتون البري أحد الأنواع الرئيسية في النظام البيئي للموئل الجبلي وله قيمة مهمة للسكان المحليين. لا توجد دراسات كافية حول استخدام هذا النوع وبيئته والحفاظ عليه في عمان. تعتبر موائل النظام الإيكولوجي للجبال شديدة الحساسية للاضطرابات وليس من السهل إعادة تأهيلها. هذه الاضطرابات ناتجة عن مجموعة من المصادر مثل التحضر، والتأثيرات البشرية، وتغير المناخ، والرعي الجائر، وإدخال أنواع غير محلية والأضرار الناجمة عن الحشرات والآفات. أدى إدخال الزيتون المزروع المستورد من دول البحر المتوسط (*Olea europaea* subsp. *europaea* L) في عمان في عام 2001 لغرض استهلاك الزيت في جبال الحجر الغربي إلى إضافة تهديد وراثي حيث ينمو الزيتون البري. تقدم هذه الورقة لمحة عامة واضحة عن أشجار الزيتون البرية في عمان، بما في ذلك خصائصها، ومكان نموها، وبيئتها، وحالة الحفاظ عليها الحالية

الكلمات المفتاحية: الزيتون البري، التهديدات، التآكل الوراثي، التهجين، الجبال، عمان، الصون

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Introduction

Oman is located at the south-eastern tip of the Arabian Peninsula and features a wide range of terrain. In general, Oman is a dry to semi-dry region, with an average of 117.4 mm of precipitation recorded each year (Kwarteng et al., 2009). The annual average air temperature from 1991 to 2020 in summer (June to August) is 32.7°C and in winter (December to February) is 20.8 °C (World Bank Group, 2021). Within this variety of terrain and climate, Oman is home of 1407 different species of native plants, 191 of which are range-restricted (i.e. endemics, near endemics and regional endemics) (Patzelt, 2015b, Patzelt, 2015c). An additional 72 species are threatened (Patzelt, 2015c). The Western Hajar mountains include 21% of the total flora of Oman, of which 13 species are endemic and nine are near endemic (Patzelt, 2015a). Above 1500 m (a.s.l), the natural vegetation consists of open woodlands, shrub lands and ground cover grasses (Patzelt, 2015a). The woodlands are formed by three main wild plant species, *Olea europaea* subspecies *cuspidata*, *Sideroxylon mascatense*, and *Juniperus seravschanica* (Patzelt, 2015a). The mountains of southern Oman (Dhofar), the northern Hajar Mountains (Eastern and Western Hajar) and the coastal regions of the central desert are considered as one of local richest biodiversity areas and comprises a large number of endemic and are therefore especially important for conservation (Patzelt, 2015c).

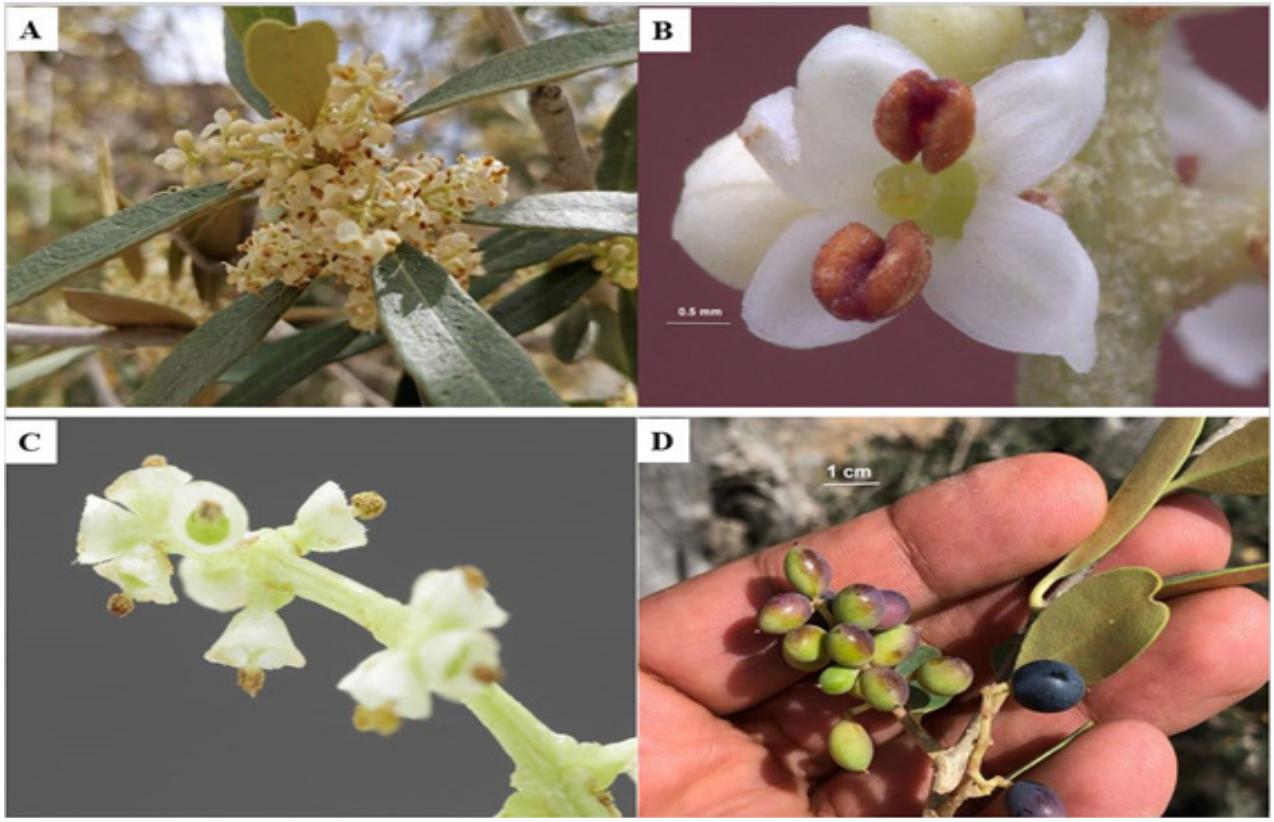
Historically, the Arabian Peninsula acted as a bridge connecting Ethiopia and Somalia with southwest Asia (Pickering and Patzelt, 2008). Consequently, the vegetation in Oman incorporates elements from both of these regions. The northern Hajar Mountains are home to plants similar to those found in southwest Asia, while the desert and Dhofar in the south have flora more typical of northeast and east Africa (Pickering and Patzelt, 2008). Despite this, there is a considerable amount of overlap between the flora found in different parts of the country, with many species occurring in multiple locations (Pickering and Patzelt, 2008). The wild olive (*Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif.) is one of the key dominant species in the mountains of northern and southern Oman. However, wild olive trees are often in poor condition with little or no new growth visible (Ghazanfar, 2015). Whilst currently listed as Least Concern (LC) on the National Red List, wild olive is close to becoming classified as Near Threatened (NT) (Ghazanfar, 2015). According to the General Directorate of Agricultural Research at Jabal Akhdar, wild olive used as rootstocks with grafted one of the cultivars of cultivated olive, therefore wild olive could be potential wild crop in relation to the future of Oman.

Olea europaea subsp. *cuspidata* is used in Oman (Miller and Morris, 1988), although its commercial value is negligible compared with cultivated olive. The wood is used as timber (Aerts et al., 2007), and many products could be made, such as a short heavy staff (thrown as a weapon), hair combs and dental tools from smaller twigs (Miller and Morris, 1988). It burns slowly with no smoke and is used for firewood and charcoal, and ash could be used as a fertiliser. Leaves and other plant organs are used medicinally (Long et al., 2010): to treat snakebite (Miller & Morris, 1988); to relieve stomach pains and colic or treat severe constipation (Miller and Morris, 1988; Ghazanfar and Al-Al-Sabahi, 1993); to treat eye infections (Miller and Morris, 1988; Ghazanfar and Al-Al-Sabahi, 1993); and to relieve skin rashes (Ghazanfar and Al-Al-Sabahi, 1993). The foliage may be cut as fodder for livestock, and it is browsed by goats during droughts. The fruits at some sites in the western Hajar Mountains are sweet and edible (Ghazanfar, 2015), whilst honey (Figure 1) from bees frequenting wild olive flowers is a valuable product (Miller and Morris, 1988).

Figure 1. Honey produced by bees frequenting *Olea europaea* subsp. *cuspidata* in Al Awabi region of the Western Hajar Mountains (Photograph by Shikha Al Kharousi, reproduced with permission)

Many plant species have been lost globally with others close to their extinction (Humphreys et al., 2019; Antonelli et al., 2020) due to habitat degradation, invasive species, and climate change (Murphy and Romanuk, 2014). Ex-situ genetic resources conservation can support in-situ conservation (Mounce et al., 2017; Abeli et al., 2020), but both require prioritisation and planning. We aim to provide an overview of the available knowledge on the botanical description of *Olea europaea subsp. cuspidata*. This will be followed by an exploration of its global distribution, the ecology, and habitat of wild olive trees in Oman. Additionally, we will discuss the threats facing the wild olive in Oman and examine its conservation status in the region.

Figure 2. (A) *Olea europaea* subsp. *cuspidata* inflorescence (panicle), (**B**) perfect flower (hermaphrodite), (**C**) flower after petal abscission (Photograph by Ali Al Raisi, reproduced with permission), (D) fruit of *O. europaea* subsp. *cuspidata*



Taxonomy, Botany and Nomenclature

The genus *Olea* (Oleaceae) is distributed widely with 34 accepted species (POWO, 2020) including wild and cultivated olive. *Olea europaea subsp. cuspidata* (synonyms O. africana Mill., O. chrysophylla Lam., O. cuspidata Wall., O. ferruginea Royle) is one of six subspecies of olive (Green, 2002; Green & Wickens 1989; Vargas et al., 2000). Its common names include brown olive, African olive, Indian olive, and Zambujeiro da india (Hannachi et al., 2009), "'Itm" in Northern Oman (Ghazanfar, 2015; Pickering and Patzelt, 2008) and "'Mitan" (Dhofari Arabic) or "Motin"' (Jibbali) in Southern Oman (Miller & Morris, 1988). It is an evergreen tree up to 7 m tall with rough grey bark and several stems. It has simple opposite leaves with flowers creamy white in colour and grouped in panicles (Figure 2A, 2B; 2C). Flowering is observed from May to June, and the fruits, ellipsoid drupes (Figure 2D), mature in August in the region (Ghazanfar, 2015, Miller and Morris, 1988, Pickering and Patzelt, 2008). This tree species, which is diploid (2n = 46) and monoecious (Sheidai et al., 2009), is primarily pollinated by wind (McGregor, 1976), although insect pollination has also been observed.

Distribution of *Olea europaea subsp. cuspidata*

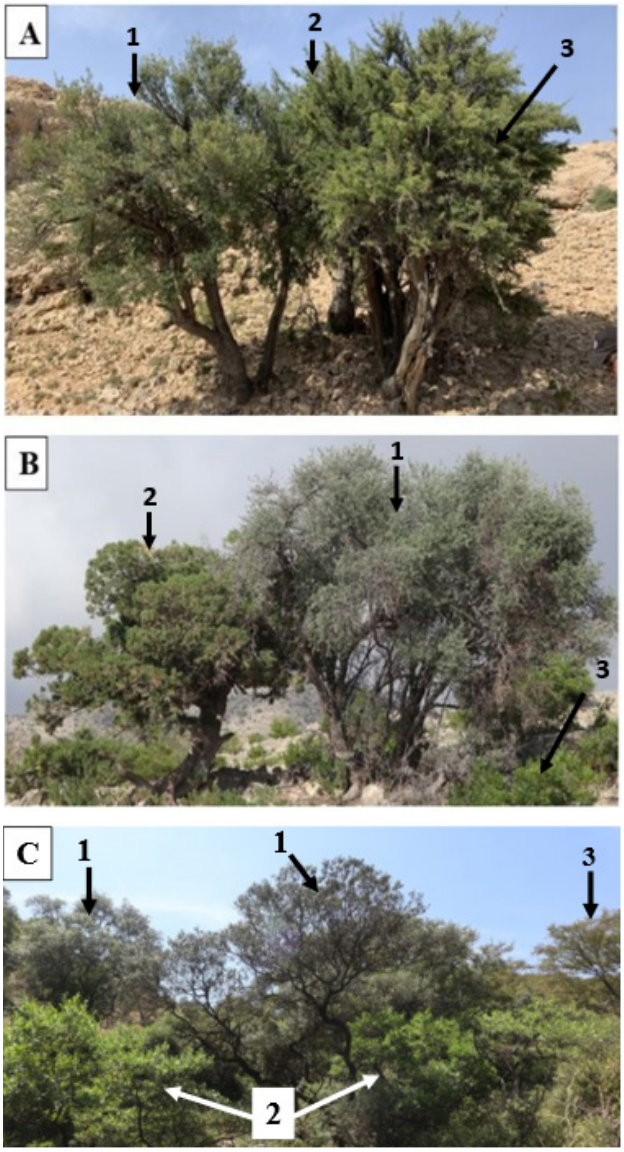
Olea europaea subsp. *cuspidata* is separated geographically from its Mediterranean relatives in different climates (Zohary, 1995) and it is found across an arc stretching from South Africa through East Africa into the Arabian Peninsula and on to Iran, Pakistan, and India (Figure 3). Its distribution may also extend further north-eastward to the drier parts of Yunan and Sichuan provinces in China (Green, 2002). Within Oman, it is only found at altitudes from 900 to 2900 m (Ghazanfar, 2015) in the Western and Eastern Hajar mountains in the north and the Dhofar Mountains in the south.

Figure 3. Distribution of *Olea europaea* subsp. *cuspidata* (Wall. & G.Don) Cif. (wild olive) (data from GBIF database; https://www.gbif.org)

Ecology and habitat of wild olive trees in Oman

Olea europaea subsp. *cuspidata* is one of the dominant species in the high altitude plant communities of the Western Hajar Mountains of Oman where it is associated with *Juniperus seravschanica* Kom, *Dodonaea viscosa* (L.) Jacq., *Ziziphus hajarensis* Duling, Ghaz. & Prend., *Ceratonia oreothauma* Hillc. & al. and *Sideroxylon mascatense* (A.DC.) T.D.Penn. (Ghazanfar, 2015; Patzelt, 2015a) (Figure 4**).** In Dhofar, it is found on escarpments in ***Anogeissus*** *dhofarica* A.J. Scott and ***Delonix*** *elata* (L.) Gamble woodland (Ghazanfar, 2015).

Figure 4. Species associated with wild olive (1) in Oman. (A) (1) *O. europaea subsp. cuspidata* (Wall. & G.Don) Cif, (2) *Ceratonia oreothauma* Hillc. & al., and (3) *Ziziphus hajarensis* Duling, Ghaz. & Prend. growing together on Jabal Bani Jabir (Eastern Hajar Mountains). (B) (1) wild olive, (2) *Juniperus seravschanica Kom.* (3) *Dodonaea viscosa* (L.) Jacq. growing together on Jabal Al Akhdar (Western Hajar Mountains). (C) (1) wild olive, (2) *Anogeissus dhofarica* A.J.Scott (3) *Dodonaea viscosa (L.)* Jacq.growing together on Jabal Qamar (Dhofar mountains) (Photographs by Thuraiya Al Jabri).



Threats to wild olive

The annual growth of urban population in Oman was the highest percentage in the world in 2016 (6.43%) and in 2017 (83.56%) (Mansour et al., 2020). Economic development with road and house building in Oman is changing its landscapes (Ghazanfar, 1998), with consequences for its flora. The Ministry of Agriculture has established land use regulations to prohibit conversion of agriculture land to other uses (MAF, 2019), but urbanization on agricultural land has changed several settlements in the mountains from rural to urban (Mansour et al., 2020). Overgrazing by goats, camels, and cattle in rural Oman (Figure 5) was due to greater stocking densities is a serious threat to plant diversity. A previous study described the vegetation along a gradient of grazing pressure (Brinkmann et al., 2009). Uncontrolled overgrazing has been associated with a decrease in the regeneration of plant populations, including *Olea europaea* subsp. *cuspidata* and *Dracaena serrulata* in Oman, which has been identified as a potential risk (Maděra et al., 2019; Habib et al., 2021). The traditional system of "hema" controlled grazing in selected areas when vegetation was poor with the plants cut for fodder (Lancaster & Lancaster, 1990) but this practice is no longer applied (Ghazanfar,1998) and unpalatable species dominate rangelands (Anon., 1982).

Cutting wild olive to make sticks (Figure 6) or for fuel is also damaging trees and fragmenting habitats, reducing habitat and dispersal corridors for plant colonisation (Zhu et al., 2012). Insect damage to wild olive trees by the olive psyllid (*Euphyllura olivina* Costa), grasshoppers and termites (Figure 7) is widespread and large numbers of trees are reported to be lost. Grasshopper damage is common in all wild olive habitats, while olive psyllid damage is common in the Western Hajar Mountains and the Dhofar Mountains.

Figure 5. Grazing in wild olive habitats by (**A**) camels and (**B**) cattle in the Dhofar mountains, (C) donkeys in the Eastern Hajar mountains, and (D) goats in the Western Hajar mountains (Photographs by Thuraiya Al Jabri).

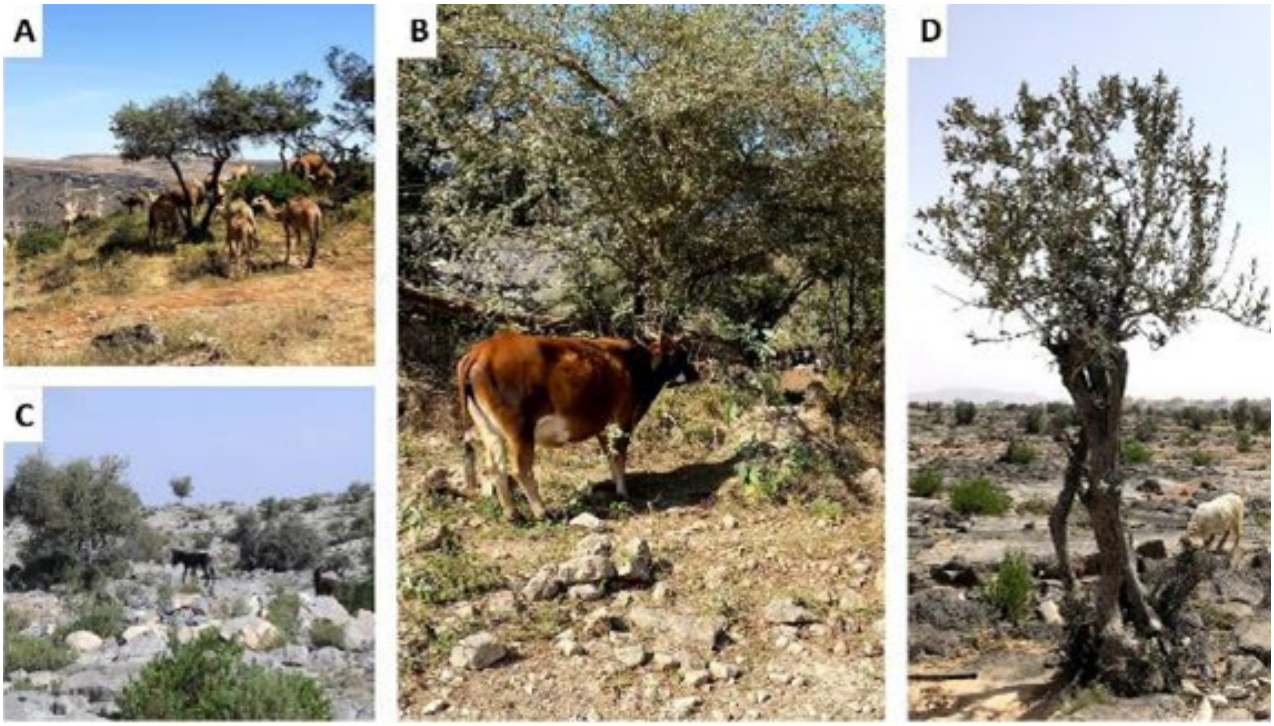
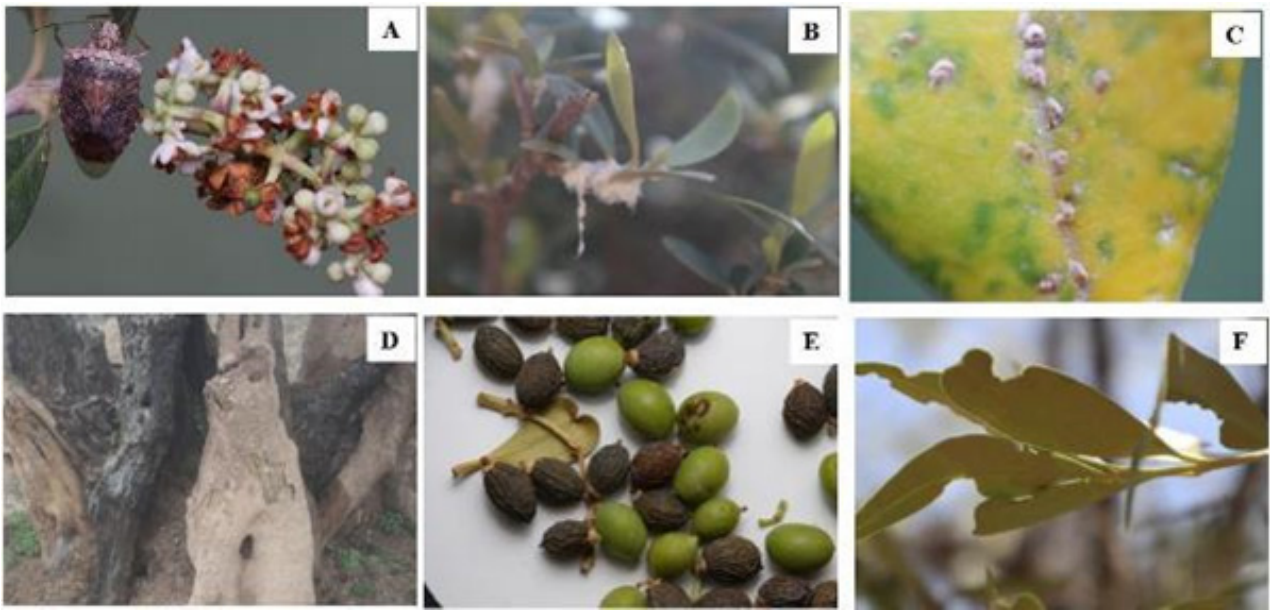


Figure 6. (A) *O. europaea* subsp. *cuspidata* sawn tree in western Hajar mountains; (B) sticks made from *Olea europaea* subsp. *cuspidata* wood (Photographs by Salim Al Rahbi, reproduced with permission).

Figure 7. Insect damage to wild olive trees: (A) southern green stink or shield bug (*Nesara viridula* L.) in the western Hajar mountains (Jabal Shams) (Photograph by Ali Al Raisi, reproduced with permission); (B) olive psyllid (*Euphyllura olivina* Costa) in the western Hajar mountains (Jabal Al Akhdar); (C) scale insect and mealybug in the Western Hajar mountains (Jabal Shams); (D) termite damage in Dhofar Mountains; (E) fruit fly damage; (F) grasshopper damage.



Cowie (1989) recorded thirty-three termite species in the Arabian Peninsula with eleven of these in the Dhofar and northern Oman mountains, with mountain regions providing the highest diversity of termites in the south-eastern Arabian Peninsula. Local people have recently noticed wild olive damage from termites in the Dhofar mountains, whilst in Jabal Qara the trees were damaged by termites (Figure 8) with many termite mounds present. Local people are protecting the wild olive trees from termites using pesticides and by painting the trunk to avoid attack from stem borers.

Figure 8. Termite damage to a wild olive tree (Photographs by Thuraiya Al Jabri).

Fire, whether caused by more frequent lightning or greater human activity, is a further threat to wild olive trees where they are associated with juniper woodlands in the western Hajar Mountains. Previously it was thought that human activities were not responsible for fire damage and that only small clusters of wild oli-

ve and juniper are affected (Gardner and Fisher, 1996). Greater fires have occurred subsequently, for example near Hayl Al-Juari in Jabal Shams in 2009 (Matwani, 2011) when fire guards were first posted and public access forbidden. Recently a massive fire of unknown cause occurred in Jabal Shams (Figure 9).

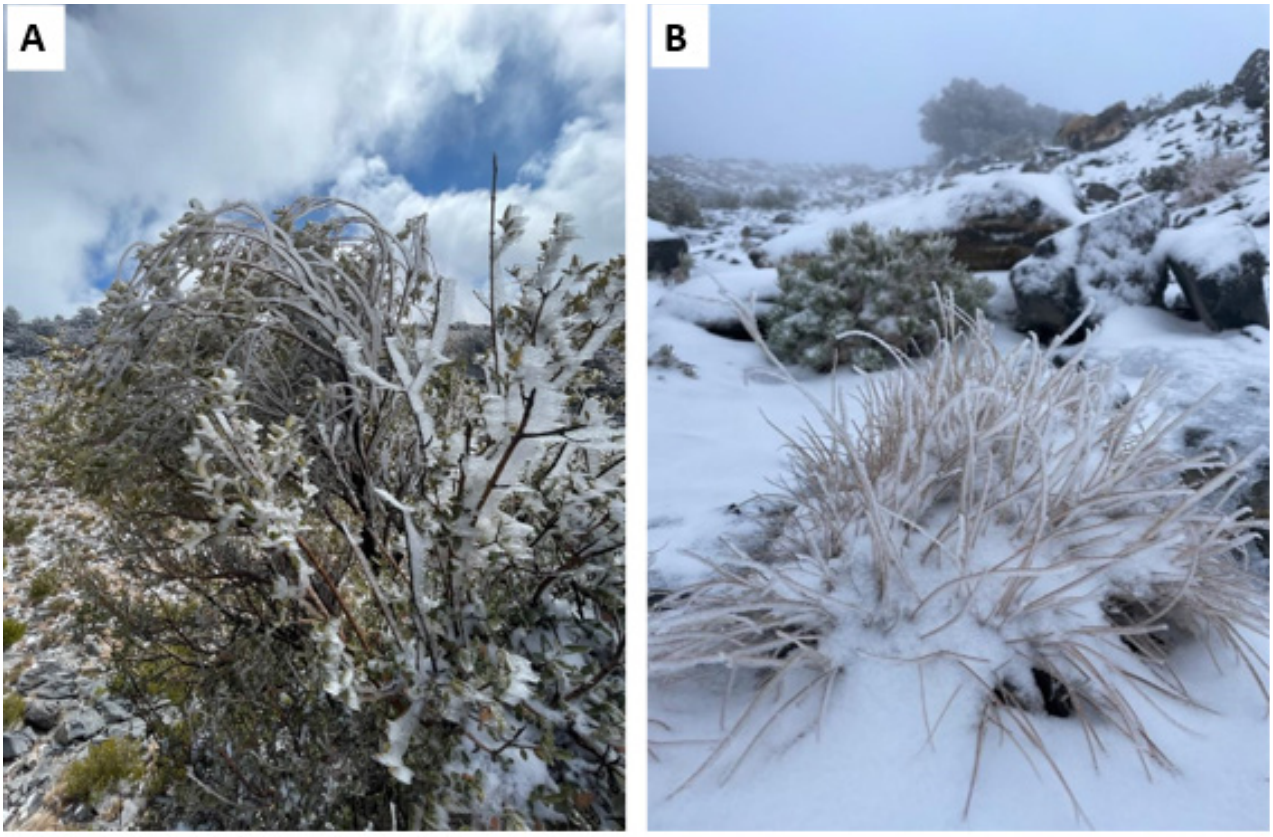
Hybridization with cultivated olive has the potential to damage the genetic resources of wild olive populations (Miller & Gross, 2011; Gaut et al., 2015; Gros-Balthazard et al., 2016). Pollen flow has been reported across 4 km in north-western Ethiopia between subpopulations of *Olea europaea* subsp. *cuspidata* (Kassa et al., 2017) and within a six-hectare plot of *O. europaea* subsp. *europaea* var. *sylvestris* in Spain (Beghé et al., 2017). Habib et al. (2021) studied the genetic differentiation of wild olive in the western Hajar Mountains of Oman and found no evidence of effective long-distance pollen or seed dispersal by birds and small mammals (Abiyu et al., 2015; Cuneo and Leishman, 2006), but they cautioned that the gene flow may change in the next generation. Introgression from the recently introduced cultivated olive to wild olive is therefore possible in Oman.

Climate change is a serious threat to biodiversity (Williams et al., 2008; Bellard et al., 2012) particularly in Oman which is vulnerable to damage from rising temperature, fluctuating preci pitation, and desertification (Ahmed & Choudri, 2012). Trends of warming by 0.79 °C per decade and 0.27 °C per decade for minimum and mean temperatures, respectively, and of precipitation declining by 9.42 mm per decade have been detected at Saiq meteorological station,

Figure 9. Fire damage to vegetation, Jabl Shams, June 2021. (A) *Juniperus seravschanica.* (B) *Olea europaea* subsp. *cuspidata* (Photograph by Salim Al Rahbi, reproduced with permission).

Jebel Akhdar, Oman (Al-Kalbani et al., 2015). Mountain habitats are highly sensitive to environmental stress (Victor 2008; Al Charaabi and Al-Yahyai 2013; Al-Kalbani et al. 2014; Patzelt 2015a, b). *Juniperus seravschanica* (MacLaren, 2016) in the western Hajar mountains and these have been damaged by foliar dieback with no new seedling regeneration (Al-Farsi et al., 2017), because regeneration by seedling establishment requires a continuous period of wet years (Gardner and Fisher, 1996). Wild olive is also under threat in the mountains of Oman and future conditions will be more severe with warming by as much as 4.5°C in Oman anticipated by 2100 under Representative Concentration Pathway 8.5 (MECA, 2019). Recently, the Western Hajar Mountains had an extreme snowstorm on January 2023 which affected the wild olive in Jabal Shams (Figure 10).

Figure 10. (**A**) wild olive tree covered by snow during the snowstorm in Jabal Shams at Western Hajar mountains. (**B**) (Photograph by Sultan Al Abri, reproduced with permission).



Conservation of Wild Olive (*Olea europaea subsp. cuspidata*) in Oman

The Oman plant red data book includes 261 species (Patzelt, 2015c). One hundred and fourteen of these are endemic or near endemic, with species of least concern such as wild olive excluded. Whilst classified as being of least concern on the National Red List wild olive is close to becoming near threatened (Ghazanfar, 2015). Recently, wild olive was assessed as Vulnerable in the United Arab Emirates National Red List of Vascular Plants Report (Allen et al., 2021). *In-situ* conservation is supported in Oman by a network of twenty-one registered nature reserves and lagoons operated by the Environ-

ment Authority (MECA, 2018) and four nature reserves were registered by royal decrees which operated by the Office for Conservation of the Environment. Among the twenty-five natural reserves and lagoons, only five of them have wild olives. These include Rustaq Wildlife Reserve, Wadi Sareen Nature Reserve, Jabal Qahwan Nature Reserve, and Al-Jabal Al-Akhdar Natural Landscape Reserve in the north of Oman; as well as Jabal Samhan Reserve in the Dhofar region of Southern Oman (Data from the Environment Authority and Office for Conservation of the Environment).

Collection and *ex situ* conservation of wild olive has also begun in Oman. The Oman Botanic Garden, in the capital Muscat, is one of largest botanic gardens in the Arabian Peninsula at 423 hectares. Its aim is to conserve and promote Oman's native flora with collections of live plants in the nursery, seeds in the seed bank, and preserved plants in the herbarium and so to provide a major well-documented collection of the Arabian flora.

The Oman Botanic Garden made 43 collection expeditions targeting wild olive across Oman between 2006 and 2020. Some 62% of samples (over half from the Western Hajar region) were collected as cuttings, 21% as seeds, and 17% as whole plants. Most collected seeds were propagated for replanting in the Oman Botanic Garden. In total, the Oman Botanic Garden holds 18 accessions of wild olive in living collections: 92 trees representing 12 accessions from the northern and southern mountains; a further five trees each representing a single accession (rescued from road developments by transplanting); and a single accession in the seed bank (from the western Hajar Mountains). The herbarium holds 10 voucher specimens from across Oman. The disparity between the number of expeditions and accessions conserved was due to early difficulties, since overcome, with seed germination and plant establishment from the samples collected. No recent natural regeneration of wild olive was detected during these collecting missions. This is similar to the situation with *Juniperus seravschanica* (Al-Farsi et al., 2017) and emphasises many threats to trees in the region's mountain habitats noted above.

Conclusion and Future Needs

Wild olives could be one of the crops of relative (CWR) in Oman because it is potentially used as rootstocks with cultivated olive in Jabal Akhdar. Globally, crop wild relative had conservation priority as it could presents a new source of genetic diversity (Castañeda-Álvarez et al., 2016). Today, wild olive is at some risk in Oman and the time for action to conserve it is now. The foundations for its *in situ* conservation have been laid in nature reserves and for its *ex situ* conservation in the Oman Botanic Garden. There is potential for genetic pollution from cultivated olive into wild olive cause by admixture their genetics. Studying the impact of gene flow from cultivated to wild olive is virgin and still no available study has been conducted yet. Now assessment the damages of wild olive in Oman will play an important role to protect this species and highlight the most damaged area in Oman. Research is now needed to understand the genetic diversity of wild olive across the regions of Oman and how that relates to the wider diversity in the Arabian Peninsula and beyond to support the development of a comprehensive,

prioritised plan to conserve Oman's wild olive genetic resources.

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