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Economic and ecological importance of *Alkanna Orientalis* Var. orientalis (L.) Boiss.

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Abstract

In this research, the economic and ecological use value of *Alkanna orientalis* was determined. The biodiversity functions and services of the species were analysed economically by classifying the data obtained from the literature analysis. In the regulation functions, which is one of these functions, pollination value and seed dispersal, use in traditional medicine within production functions, pharmacological researches and use as raw materials have been revealed as important ecological services. Among the habitat functions, nursery services came to the fore front but among the information functions, the use value whose purpose is education and scientific research has come to the fore front. This shows that the species has a high ecological and economic use value.

Key words: *Alkanna orientalis, ecological value, economic value, biodiversity services, biodiversity functions*

1. Introduction

Alkanna orientalis (L.) Boiss. var. orientalis (*A. orientalis*) is a important member of the Boraginaceae family (Davis et al 1988). *A. orientalis* is a perennial herbaceous plant. It is a widely found species that grows globally in S. Greece, Syria, Lebanon, Palestine, Sinai, Transcaucasia, N. Iran, and Turkey. The general distribution areas of the species in Turkey are northwest, southwest, and continental Anatolia (Figure 1) (Bizimbitkiler 2013; TÜBİVES, 2021). Among the habitats of the *A orientalis* which can live at an altitude of 0-2450 meters above sea level, there are rocky areas, steppes and volcanic slopes. It is an the Irano-Turanian phytogeographic region elements (Akçin 2004; TÜBİVES, 2021).

In the researches, it is seen that *A orientalis* created a food source in many pollinators due to its flamboyant flowers, as well as many uses such as medicine, excretory, cosmetics, traditional medicine, dye industry (Moustafa and Mansour, 2020; Yaman et al., 2019). Because of these usage areas *A orientalis* is an important plant species both ecologically and economically. However, it is striking that the studies on the species are mostly focused on secondary metabolites and to their biochemical cotents, while the studies on the ecological and economic importance of the species are quite limited. This situation is considered as an important gap for species protection. We should provide and reveal a sufficient information about the habitat, ecosystem characteristics, ecological and economic characteristics of species in order to take effective measures for species protection and to apply conservation measures successfully. From this point of view, in this study, the ecological characteristics of the species were evaluated in terms of ecosystem services and its economic and ecological importance was determined. In addition, the economically prominent service functions have been inclined and a

significant contribution has been made to the literature by determining the usage areas and usage patterns of the species.

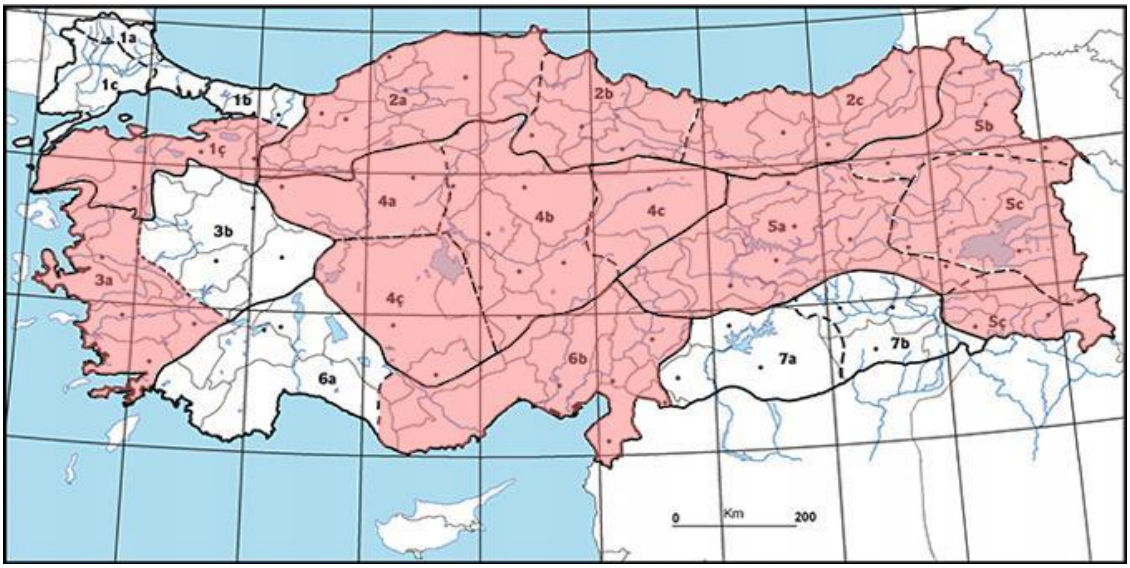

Figure 1. *Alkanna orientalis* (L.) Boiss. var. Geographical distribution of *A orientalis* on the Grit map; 1ç) South Marmara Division, (2a) West Black Sea Division, (2b) Central Black Sea Division, (2c) East Black Sea Division, (3a) Main Aegean Division, (4a) Upper Sakarya Division, (4b) Middle Redriver Division, (4c) Upper Redriver Division, (4ç) Konya Division, (5a) Upper Fırat Division, (5b) Erzurum-Kars Division, (5c) Upper Murat-Van Division, (5ç) Hakkari Division, (6b) Adana Division (Bizimbitkiler 2013).

2. Material and Method

In the study, primary data obtained from literature researches were used. By systematically investigating these primary data in depth, the data about the ecological characteristics and usage areas of the species were obtained. It was determined whether the species has biological diversity services and functions in the ecosystem by using these data systematically in the research. It has been determined which services come to the fore economically within the identified biodiversity services regulation, habitat, production and information functions. (Figure 2). The regulatory functions are functions that emerge as a result of ecosystem capacities that regulate basic ecological processes and life support systems. These include some functions which the regulation of atmospheric gases, climate regulation, nutrient cycling, water supply and waste control, soil formation, biological control, pollination, seed dispersal, etc. (de Groot et al., 2002; de Groot et al., 2006). The habitat functions are produced by biological diversity through creating a suitable space and environment for both the system itself and humans. Functions such as reproduction and shelter are evaluated in this group (Nunnes et al ., 2003; de Groot et al., 2002). The production functions are related to processes and resources derived from biodiversity. The food substance or nutrient of biological resources is raw material, genetic resource, medicinal resource or use for ornamental purposes. The fact that biological species are the raw materials of genetic engineering and biotechnology and the use of many plants in drug production is extremely significant in terms of demonstrating the necessity of sustainable use of biological diversity. The information function, on the other hand, is a function that does not include a physical effect or output from any biological source, unlike contribution to human happiness and well-being in a spiritual, cultural, historical and individual sense (Nunnes et al., 2003; de Groot et al., 2002; de Groot et al., 2006). *A orientalis* has been evaluated in terms of these biodiversity service and functions. In this way, the ecological and economic service functions of the species and the importance of these functions for ecosystem services have been demonstrated.

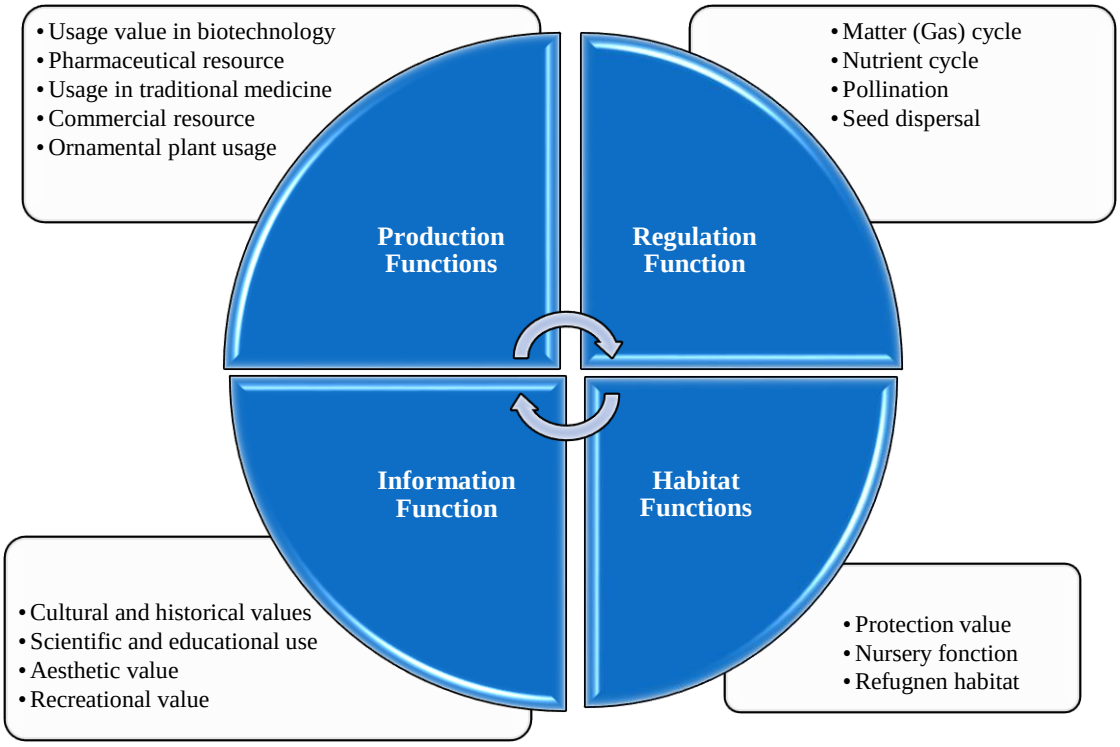

Figure 2. *A orientalis*' economic service cycle (Adapted from de Groot et al., 2002)

3. Results and Discussion

3.1. Habitat and ecological characteristics of *Alkanna orientalis*

A. orientalis generally spreads on cliffs, steppes and volcanic slopes (Karaca 2008; Akçin et al., 2004). *A. orientalis* has specific pattern of growth where it grows in scattered patches of different size separated by rocky boulders and the population of its is also limited by habitat size (Moustafa and Mansour, 2020). It can also be said that *A. orientalis* shares the same habitat with species such as *Asyneuma limonifolium, Rosularia libanotica, Minuartia hirsuta, Umbilicus erectus and Anthemis cretica* (Karaca, 2008). These species are extremely important in terms of nursery function. The flowering period of the species is between April and August (Karaca 2008; Moustafa and Mansour,2020; TÜBİVES, 2021).

Table 1. Habitat and ecological characteristics of *Alkanna orientalis* (Moustafa and Mansour, 2020; TÜBİVES, 2021).

Features	Identifiers
Famlie	Boraginaceae
Species	*Alkanna orientalis*
Lifetime	Perennial
Structure	Herbaceous
Habitat	Cliffs, steppe, volcanic slopes
Flowering period	April-August
Blooming:	4-8
Altitude	0-2450
Endemic status	Not endemic
Element	Iran-Turan
Threat factors	Climate change, overgrazing, collection, anthropogenic activities etc.
Population	Wide distribution and clump formation in the active population
Local name	Havaciva herb

In recent studies, it has been observed that the active population of the species has decreased due to climate change in the last 10 years (Moustafa and Mansour, 2020). Moisture is the most decisive factor distribution, life form of the plant ,and controlling plant productivity. In general, the total amount of precipitation falling on an ecosystem does not always clearly explain the required moisture for plants. Precipitation type, its soil deposits, its annual variation, its topography ,its intensity, and its plant physiognomy affect the availability of moisture that precipitation provides to plants (Moustafa and Mansour, 2020). In particular, soil moisture, soil texture and the amount of organic matter in the soil is important in the vegetative development of the plant (Moustafa, 2002; Moustafa and Mansour, 2020). At the same time, these ecological factors control the dominance of the species in the location and the reproduction conditions. Additionally, *A. orientalis* is not a completely edible plant due to the dense thorny hairs on the leaves, however animals graze suitable parts of Alkanna due to its early flowering behaviour (Moustafa and Mansour, 2020)**.** In this context, the populations of the species are constantly threatened by climate change on the one hand, and overgrazing and human activities on the other.

3.2. Pollination, Seed Dispersal and Formation on *Alkanna orientalis*

Since the flowers of A orientalis produce abundant nectar, *Anthophora pauperata* is regarded as the main pollinator of *A. orientalis* (Gilbert et al. 1996). Characters were considered to be important for the pollinator behaviour such as nectar availability, seed production, flower phenology, namely flower size and structure,and numbers of flowers open (Moustafa, 2002; Moustafa and Mansour, 2020). Willmer et al. (1994) reported that males of *A. pauperata* patrol a cluster of *A. orientalis* plants in a particular area. He found that females only come out of their nests, which reach the top in the early morning and afternoon. *A. orientalis* flowers secrete approximately 6 µl of nectar containing approximately 35% sucrose. As can be seen, the nectar-producing potential of the flowers of the species is fairly high (Willmer et al., 1994; Moustafa and Mansour, 2020)

According to the research by Gilbert et al 1996, the number of visits made by *A. pauperata* to *A. orientalis* per day changes depending on the geographical region. While the number of visits is lower in flat areas, this rate is higher in high areas. For example, the average number of visits was 1.1 (+/- 0,3) in the valley in the same study but in the mountains, this ratio was determined as 22,2 (+/- 0,7). Likewise, the rate of seeds formed as a result of these visits is 12.6% and 28.3%, respectively. *A. pauperata* bees are obliged to forage from this plant (Wolff et al., 1997). The proportion of seeds set was positively correlated to the mean number of visiting. In addition, it was determined that there is a linear relationship between the average size of flowers in a plant and mean nectar volume (Gilbert et al1996; Wolff et al., 1997).

Each flower can set a maximum of four seeds. *A. orientalis* seeds are germinating in constant moisture condition with temperatures of about +20°C. (Moustafa and Mansour, 2020). The seeds of these plant have a very strong dormancy even with different treatments applied. One could reach only 35% as a maximum percent of germinated seeds at consistent soil moisture content (Moustafa and Mansour,2020). It is the only plant blooms in late March and early April. Solitary bee Anthophora bees emerge at about the same time, and are the only pollinator of these flower. After May, they share visitation to these flowers with other visitors (Moustafa and Mansour,2020). As other plants begin to bloom, the bee diverts attention from A. orientalis and shares its nectar source with flying flies and bombyliids (Gilbert et al. 1996; Wolff et al., 1997). These insects are probably less effective as pollinators (Gilbert et al. 1996).

Table 2. Seed distribution, seed formation and pollination status of *Alkanna orientalis* (Gilbert et al.1996; Wolff et al., 1997; Willmer et al. (1994; Moustafa and Mansour, 2020).

Features	Identifiers
Pollinator	*Anthophora pauperata* (main pollinator), hoverflies and bombyliids (less effective)
Average number of visits of pollinators	In the valley 1.1 (+/- 0,3), In the mountains 22,2 (+/- 0,7)
Product used	Nectar
Nectar amount per flower	6 µl
Number of flowers	4-8
Germination condition of seeds	Germinating in constant moisture condition with temperatures of about +20°C.
Amount of seeds formed per flower	4 Seed

3.3. Use of *Alkanna orientalis* in traditional medicine

Plant medicines have important roles in the treatment of diseases all over the world. The fact that these plants have few side effects, are natural and have therapeutic efficacy attracts people. (Esfahani et al., 2012). In this context, *A orientalis* is one of the most important medicinal plants belongs to the family Boraginaceae, and it is widely used in various ways for therapeutic purposes among the people (Table 2). As it can be seen in table 2, the plant is known to be used in folk medicine for the treatment of ulcus cruris and for wound healing (Papageorgiou, 2008). In same way, This species is widely used in the treatment of rheumatoid arthritis and other inflammatory diseases in Iran (Esfahani et al., 2012).

Ointment obtained from the roots of the species is used in the treatment of diseases such as tinea barbae, wound healing, ambustion, scar, rheumatoid arthritis, in burn treatment, ulcus cruris. Aerial parts of species are used in the treatment of festering sore and ambustion. Leaves are used in the treatment of asthma, bronchitis, stomach ache and ophthalmia (Table 2). In addition, several pharmaceutical preparations containing quinones from *A orientalis* have been reported (Papageorgiou, 1999; Esfahani et al., 2012).

Table 3. Use of *Alkanna orientalis* in Traditional Medicine.

Species	Plant part used	Preparation	Way of Consumption	Threatment
Alkanna orientalis	Roots	Burnt, Cooked with butter	External, every morning put on head	Tinea barbae
		Crushed. cooked with butter, added beeswax	External	Wound healing, ambustion, scar, rheumatoid atrid, in burn treatment, ulcus cruris
	Aerial parts	Cooked with butter	External	Festering sore, ambustion
		Boiled	External with pulp for one day	Ophthalmia
	Leaves	Decoction	Internal, before breakfast	Asthma, bronchitis, stomach ache
		Crushed	External for one day	Ophthalmia

3.4. Phytochemical aspect of *Alkanna oriantalis*

A. oriantalis is widely known for its medicinal and pharmaceutical properties, depending on the chemical constituents of its plant parts. The most important part of the plant is the bark of the root which is containing dying substances. In biochemical studies, it has been determined that these substances are the major compounds of naphthoquinones, which are aromatic diketones belonging to widely known Alkannins and Shikonin. (Zannou and Koca, 2020; Abel Elglil et al., 2019; Moustafa and Mansour, 2020; Wafaa et al., 2007). These compounds are containing double ring structure that conveys the intense red pigments (Wafaa et al .,2007). Alkannins, shikonin and its derivatives have been used for dyeing purposes in areas such as textile, food and cosmetics for many years (Yaman et al., 2020). Another site, *Alkanna orientalis* is known to contain pyrrolizidine alkaloids (Bull et al, 1968; Hammouda et al.,1992). Pyrrolizidine alkaloids (PA) are mostly natural toxins. PAs is the best known natural toxin for all living things. *A. orientalis* is known to contain pyrrolizidine alkaloids (Bull et al, 1968; Hammouda et al.,1992). *A. orientalis* is known to contain pyrrolizidine alkaloids (Bull et al, 1968). Pyrolizidine alkaloids are alkaloids that are naturally produced by plants as a defense mechanism against herbivores and are basically in the chemical structure of pyrrolizidine. These derivatives were different among species and within the same species grown in different regions and altitudes (Moustafa, & Mansour, 2020).

It has been determined that these substances have various biological activities such as a powerful wound healing, antimicrobial, anti-inflammatory, antithrombotic, cytotoxic, antioxidant, enzyme inhibitor in medicine and pharmacology (Han et. al., 2019; Xu et al., 2019; Yaman et al., 2019; Yaman et al., 2020; Esfahani et al., 2012).). In the latest studies, it has been shown to have anti-tumor properties and these compounds are actively used in anticancer treatments in many countries (Yeh et al. 2015; Petrosyan et al., 2015; Han et al., 2019; Xu et al., 2019). According to by Lev and Amar (2000), *A. orientalis* produces an antimicrobial agent called sarothrin against *Staphylococcus aureus* and *Mycobacterium smegmatis*, and the leaf and flower extract of *A orientalis* inhibited the growth of *Staphylococcus aureus.*

Table 4. Phytochemical Aspect of *Alkanna oriantalis* (Yeh et al. 2015; Petrosyan et al., 2015; Han et al., 2019; Xu et al., 2019; Lev and Amar, 2000).

Plant part used	Extract		Effect
The Bark of the Root	Naphthoquinones	Alkannins	Antimicrobial, anti-inflammatory, antithrombotic, cytotoxic, antioxidant, enzyme inhibitor
		Shikonin	Anti-Tumor
The Leaf and Flower	Sarothrin		Inhibited the growth of Staphylococcus aureus, antimicrobial
	Pirolizidin alkaloidleri (PA),	Pirolizidinin	Natural toxin produced as a defence mechanism against herbivores

3.5. Use as Dyestuff Raw Material of *Alkanna orientalis*

Due to the increasing environmental awareness, the use of natural dyes in the textile industry is increasing day by day (Onal et al., 2017; Kamat and Alat, 1990; Glover,1995). Especially, natural dyes are preferred because they are non- allergic and non-toxic (Moiz et al., 2010)

The dyeing extract of the plant is generally obtained from the parts of the plant such as leaves, root, bark, flowers, and seed. Especially in the bark, the rate of dyestuff is quite high and the bark is mostly preferred for dyeing, but removal of the bark from the plant can threaten the life of the plant (Onal et

al., 2017). Therefore, leaves, flowers and seeds are widely used for the extraction of the dyestuff from the plant. The leaves of the plant provide abundant and easy availability source for dyeing industry (Raja, 2008). It is also economical.

Extracts obtained from the roots of *Alkanna orientalis* are also used as dyestuffs (Oztav, 2009). The root of the species is concentrated in alkannin acetate, and giving naphthalene its red colour (Tawfiket al., 2007; Onal et al., 2017). Alkannin acetate can be form different colours by chemical reactions. *A. orientalis* extract has been used in dyeing of fabric and when wool yarns are treated with calcium carbonate, the colour becomes smokey; when iron sulphate is used, the colour becomes light green. Also, copper sulphate turns the colour to green, when mediator substances are not used, the colour of yarns becomes dark brown (Ozgokçe, and Yilmaz, 2003).

3.6. Distribution of Economic Value Functions and Services in Ecological Terms of *Alkanna orientalis*

As a result of the research, *A. orientalis* draws attention in terms of some biological diversity functions and services (Figure 2). Especially the Production function draws attention with its common usage areas. Pharmaceutical resource (seconder metabolite etc.), usage in traditional medicine (the treatment for wounds and burns etc.), Usage as a raw material source (use in dyestuff, cosmetic, textile etc.). The usage services as nutrient source value (being food source for pollinator) and commercial resource (its use in textiles as a root dye) are the most important biodiversity services of the species.

Seed dispersal, seed formation and pollination services as regulatory functions of the species are quite interesting. With the nectar it carries in its flowers, it creates a food source for pollinators and contributes to the reproduction and geographical distribution of this species in these pollinators. This is an indicator of an ecologically important symbiotic relationship. In addition, studies have shown that the species accumulates Ni. This showed that there is a potential for use in phytoremediation studies, especially for Ni (Demir et al 2021). Phytoremediation service flow, which is included in the regulation function, is also economically important in terms of low cost and high benefit. Nursery function as a habitat function, refugnium habitat function constitutes important biodiversity services. Although factors such as climate change and overgrazing threaten the population of the species, no protection measures are applied. As information function, their use for science and education purposes, aesthetic and historical and cultural values are important services. *Alkanna orientalis* is a basic material especially in scientific research, various projects and education. In addition, the habitats in which it grows naturally are aesthetically important due to its flamboyant flowers and have a recreational value.

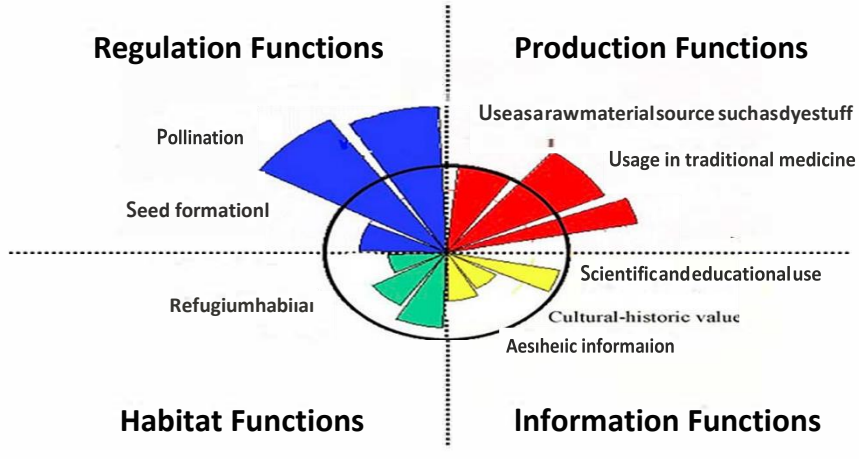

Figure 2. Distribution of *Alkanna orientalis'* biodiversity services and functions.

4. Conclusion

The results of the research revealed that *A. orientalis* is an important plant species in terms of ecological and economic services and functions. The ecological contribution of the species with its regulation, production, habitat and information functions is also an indicator of its economic contribution. In regulation functions pollination, seed formation and dispersal constitute the most important services. The continuity of the species and its pollinator in the habitat is possible with this biodiversity service. Clarifying this biodiversity service function will play an important role in developing management strategies for the protection and conservation of natural habitats and embryological research to increase reproductive capacities. The use value in traditional medicine, which is included in the production function, is another service with ecological and economic importance. It will be possible to evaluate the species with original use and used for therapeutic purposes and to determine the active substances in these plants in order to reach more qualified results with pharmacological studies. Evaluation of the results obtained with the aim of supporting the local economy will bring vitality to the economically weak region. Expanding the production of plants with positive results and offering them for consumption will create an important source of economic income for the local people. Likewise, the therapeutic efficacy and fewer side effects of these strains make them a good alternative source for synthetic drugs. Therefore, there is a great need to design studies that provide some data on the pharmacological and therapeutic effects of these traditional drugs. *A. orientalis* is an extremely important plant species in this respect, and more research is needed, especially focusing on the ecological and economic value of the species.

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