

A REVIEW OF *ASTRAGALUS ERIOCEPHALUS* WILD. SYNONYM *ASTRACANTHA ERIOCEPHALE* (WILD.) PODLECH AN INVASIVE SPECIES FOR RANGELANDS

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Abstract

This review summarizes the extensive published literature on Astragalus eriocephalus, which is native to Turkey, Iran and Iraq, by firstly providing an overview of its general description, biology, population ecology, utility and management. We then critically review the ecological literature examining the biotic and abiotic interactions that drive the population and community dynamics of this species followed by information on its invasive status and management. We highlight critical research questions that remain unresolved in the Eastern Anatolian Region in Turkey within the context of an invasive species.

Key words: biology, ecology, utilization, management

1. INTRODUCTION

The genus *Astragalus* (Family Fabaceae and subfamily Faboideae) has been known to contain a number of groups based on molecular and morphological studies that have required division into at least five genera (Frodin 2004). The current number of recognized species belonging to *Astragalus* genus is about 3200 in the World (Frodin 2004). The species of *Astragalus* consists mostly of thorny herbal and small shrubs, their distribution ranges extend from cool to tropical regions. The distribution of *Astragalus* species on the continents can be summarized as: 1500 species in Asia, 500 species in North America, 150 species in South America (150 species), 120 species in Europe and does not known for Africa (Podlech 2008). Generally, the genus is native to and has higher diversity in the Northern Hemisphere, and its common name changes as milk vetch, locoweed and goat's-thorn (Anon., 2013).

Astragalus species is used for different objectives, for example, igniter for fire, tannin, gums, fodder, bee forage, traditional medicine, qi, human nourishment, strengthened and pustule (Wang et al., 2014). *Astragalus* species also has the ability to fix nitrogen and thereby increase soil fertility. The spread of these species can have both beneficial and negative economic impacts on human enterprises such as agriculture, livestock production, erosion control and touristic activities, and as well as ecosystem and biodiversity (Arevalo et al., 2010).

2. GENERAL DESCRIPTION

As is in Turkey, the common name given to *Astragalus eriocephalus* in minor Asia (mainly in Turkey, Iraq and Iran) is given and this species is native to this geography. The species is described as a spreading dwarf shrub, mostly 20-30cm high, bark fissured, grey-brown, and often hairy towards apex, glabrous with age, with prominent lenticels. Leaves are 1.5-3 cm long, leaflets are 5-8mm, elliptic, mucronate, surfaces are simple villous, 4-7 paired, stipules are spinescent usually 6-8 mm long, triangular lanceolata. It has 4-15 sessile flowers. Bracts are 5-9 mm lanceolata to linear, white hairy at apex. Calyx is 9-14 mm, tubular, glabrescent, teeth are 4-8 mm and setaceous. Corolla is pink and 10-14 mm long (Davis 1970).

Astragalus eriocephalus are distributed on the area where cool climatic conditions prevail in the world. The species moved from the old world to the new world and probably the gene centre of the *Astragalus eriocephalus* is the joining areas of the eastern part of Turkey, the western part of Iran and

the southern part of Iraq (Davis 1970). *Astragalus eriocephalus* is common in relatively dry and disturbed habitats throughout the cool season region of the Turkey and the relative areas in the minor Asia (Davis 1970).

3. BIOLOGY

Astragalus eriocephalus is a dwarf shrub up to 30cm high, much branched and densely spiny. Its crown size can be grown 30 cm in diameter and can live for 10 years. The older bark is dark brown or black and rough. Plants have a deep taproot with nodules, which contain symbiotic nitrogen fixing bacteria. In the winter, its leaflets senesce but leafstalk with thorn holds on the plants. The leaflets alternate with four to seven pairs of pinnate, each with 8 to 14 pairs of narrow leaflets of 1.5 to 3 mm in length. The small twigs are dark brown or black with spines of 1 to 30 mm in length at the leaf tips (Davis 1970).

Inflorescence spherical, dense, many flowered, long pedicellate flowering begin in early summer and continue for 2 or 3 months. the colour of the flowers ranges from cream to pink and they are fragrant. The fruit is a green pod, turning black or dark brown at maturity, thick, indehiscent, cylindrical, 1-3 cm long and 0.5-1 cm in diameter. Each pod contains 3 to 8 seeds. Biotic factors can markedly depress the reproductive capacity by severely reducing the proportion of fertile seeds (Pigott et al., 1992; Garcia and Mejia 2000); although pollen limitation may not also be a factor in seed, species of *Astragalus* are known to have cross-pollination.

As do many leguminous seeds, *A. eriocephalus* seeds have a hard seed coat that acts as a barrier for the uptake of water and diffusion of oxygen into the embryo (Fenner and Thompson 2005). Hence, this species has a physical dormancy mechanism that can be broken using fire, high temperature, light, abrasion and ingestion by animals under natural condition (Rolston 1978; Bewley and Black 1994). For this reason, *A. eriocephalus* may most probably have a large dormant seed in the seed bank of the rangelands. The seeds can also easily be dispersed by animals because the seed heads are consumed by sheep especially during dry season (Personal Observation Koc and Erkovan) and passed through their digestive system without being digested which aids dispersal of the seeds (Tran and Cavanagh 1984).

Once the aerial portions are killed by fire, this species does not regenerate from the basal shoots because of the lack of dormant bud on basal tissue, thus the plant usually propagate from seed.

The plant seed have hard seed coat that acts as a barrier for the uptake of water and diffusion of oxygen into the embryo (Fenner and Thompson 2005), and also have physical dormancy mechanism that can be broken using low temperature, light, abrasion and ingestion by animals under natural conditions (Rolston 1978; Bewley and Black 1994). After seed dormancy is broken, germination may begin at -1⁰C and germination does not require light (Gokkus et al., 1987).

4. ECOLOGY

A. eriocephalus is well adapted to semi-arid and arid climatic conditions on the north hemisphere where the annual temperature ranges from 5 to 25°C (Davis, 1970). The species tolerates severe frost and grows well in the areas receiving between 300 and 400 mm of annual total precipitation. The plant grows best on sunny sites with well-drained loam or sandy soils and degraded area up to 2500 m elevation. However, the best growing occurs usually on heavy, calcareous clay soils on the rangelands in dry areas with the elevation ranging between 1500 and 2500 m (Davis 1970), but the plant cannot be adapted to wet soil and shade sites (Vasquez et al., 2010). The species can grow at a soil pH range of 6.5–8.0, but the best adaptation occurs at neutral soils. Since the species is well adapted to dry environment, it is expected that the occupation of the species increase in line with elevated CO₂ content especially on sunny areas (Vasquez et al., 2010).

Nitrogen fixation ability of the species through symbiotic relation with *Rhizobium* allows them to grow on nitrogen poor soils. After senescing of the nodule due to aging or dying of the root or whole plant, plant available nitrogen transfers to rhizosphere, (Erkovan et al., 2008), thus, associated grasses

or other species generally produce more biomass compared to the other plants. There is no information about the amount of transferred nitrogen from *A. eriocephalus* to rhizosphere. On the other hand, as far as we are concerned, the species do not have a seriously allelopathic effect on other species. These two properties give specific talents to the species with respect to environmental conservation especially on the area under erosion threat.

Although there is some information about the biology of some *Astragalus* species, it is limited for *A. eriocephalus*, especially seed dispersal and viability, germination behaviour etc. Nonetheless, we personally observed that seeds of the species are dispersed by ant, mouse, birds, sheep and goats in the Eastern Anatolian Region of Turkey, however, there is no scientific information on hard seed percentage, germination rate, effect of digestive system of vertebrates on the seed viability.

A. eriocephalus is thought to be an aggressive competitor on overgrazed rangelands and other disturbed areas in the Eastern Anatolian Region of Turkey since the plant leaf are hardly consumed by livestock and its invasion on disturbed areas are expected results because of the fact that the plant has competition advantage due to using symbiotic nitrogen.

If plant crown are damaged by burning or cutting, plant always die because there are no adventive bud on the roots. *A. eriocephalus* is a typical sun (heliophyt) plant and the plant lost its vigour under the shade effects of neighbouring plants, thus, *A. eriocephalus* abundance decreases quickly on exclosed or fertilized (especially N) rangelands in the region (Koc et al., 1994).

5. UTILIZATION

There is no serious information about the chemical content of *A. eriocephalus* but there is knowledge on the other species of *Astragalus* genus, because *Astragalus* genus is considered as an invasive species. On the other hand, about all species of the genus, except *A. cicer*, contain several poisonous contents. Both green and dried plant parts contain poisonous content, but poisonous compounds content is higher in the spring, thus, the plants cause disorders when they are over consumed by ruminants (Gokkus et al., 2001).

Astragalus genus is used in the production of many commercial products, as is other Fabaceae species. For example, they are used for charcoal, tannin, gums, scents, fodder, twigs, bee forage, medicine and human nourishment (Shu et al., 2010). In addition, the genus has beneficial effect in native semi-arid habitats owing to carbon storage, nitrogen fixation, habitat and feed for wildlife, improving the soil properties.

In the medicine, roots of some species of the genus are used as gum tragacanth, antiperspirant, diuretic, tonic drug for diabetes treatment, mellitus, nephritis, leukaemia and cancer (Bedir et al., 1998a, b; Rezaee et al., 2006). The root, leaves and seeds of *Astragalus* spp. are rich in bioactive secondary metabolites (Bedir et al., 1998a, b; Benchadi et al., 2013). The main content of *Astragalus* species include polysaccharides, saponins, flavonoids, amino acids and trace elements. The polysaccharides found in *Astragalus* spp. have been considered to play a significantly role in immune modulatory actions. Polysaccharides A, B, and C are found as glucans, and D is found as hetero polysaccharide in the genus (Bedir et al., 1998a, b; Rezaee et al., 2006; McKenna et al., 2002). Especially, *Astragalus* root contains triterpenoid saponins, azukisaponin and astragaloside (He and Findlay 1991; Benchadi et al., 2013). The genus also contains flavonoids such as calycosin, ononin, narcissin, nicotiflorin, kaempferol and trihydroxyflavone (Lin et al., 2000; Benchadi et al., 2013). Moreover, the genus contains a volatile oil, amino acids (Bedir et al., 1998a, b; Rezaee et al., 2006; Mills and Bone 2000), minerals such as calcium, potassium, magnesium, sodium, manganese, zinc, iron, copper, cobalt, rubidium, molybdenum, chromium, vanadium, tin, silver and traces of tantalum, hafnium, europium and thorium. In addition, it contains organic compounds choline, betaine, gluconic acid and beta sitosterol and aromatic compounds essential oil, linoleic acid, alpha amino butyric acid, bitter compounds and asparagine (McKenna et al., 2002).

Astragalus species is used as medicinal herbs in the treatment of ulcer, cough, bronchitis, hypertension, diabetes and venomous bites of scorpion (Benchadi et al., 2013; Bedir et al., 1998a, b).

Their root stimulates immune systems, increases the stem cells, and can inhibit membrane lipid peroxidation and protein oxidation (Wang et al., 1996; Jiao et al., 1999; Toda et al., 1999). Some *Astragalus* species support immune modulation, adjunctive cancer treatment, antiviral activity, cardiovascular disease, genitourinary and renal disorders nephritis and male infertility (Chu et al., 1994; Hong et al., 1992; Luo et al., 1995; Mills and Bone 2000).

Because of the fact that climatic conditions restrict the growth of grasses and other herbaceous plants in the arid and semi-arid regions, the pods and leaves of *A. eriocephalus* provide an alternative feed for sheep and goats during summer and winter period. The plant has also been used as alternative feed source for animals after shredding and soaking of roots and crown collected from natural areas during winter at the Eastern Anatolia in the ancient times. There is no record on the feeding value of the plant, but it is claimed that feeding value is always better than cereal straws, however, the material is not used purely in the animal diets, because about all *Astragalus* species cause poisoning in ruminants having high percentage in the diets due to toxic content (Reece and Moser, 1985; Gokkus et al., 2001).

The plant plays a key role in the erosion control on degraded rangelands in arid and semi-arid regions, because the plant does not object to overgrazing due to morphological features. The plant has a cushion life form and this life form gives the plant a unique role in protecting its covered surface against erosion. Root system, deep and intense taproot and nitrogen fixing capability give the plant the advantage to adapt to degraded nutrient poor environments (Venterink 2011).

In addition to above-mentioned using area, aerial parts of the plant are also used for igniting stove or other fire materials after dried in the eastern part of Turkey. On the other hand, *Astragalus* genus has a long flowering period. While several herbaceous plants enter summer dormancy due to lack of moisture and warm temperature, this genus still produce nectar. This properties gives them a significant role in honey production in the Central and Eastern Anatolian Regions, especially in Siirt and Bitlis provinces which are famous for *Astragalus*' honey in Turkey. On the other hand, the genus provides a habitat for a lot of insects, especially Lepidoptera (Anon., 2014), that are essential for ecosystem function.

6. MANAGEMENT IMPLICATION

Although *A. eriocephalus* are used for different goals such as medicine, industry, fire igniter and etc., we regard the plant only from a natural resource management perspective. The plant is noted in many semi-arid parts of Turkey as an invasive dwarf shrub species and it covers large areas especially in the Eastern Anatolia and the Central Anatolia. In the past, the plant was considered totally as an invasive plant from the range management perspective. Nowadays, this consideration is not realistic especially with respect to environmental conservation, because the plant have crucial role in erosion control and wildlife protection. In reality, the plant drastically causes a carrying capacity on the rangelands, thus the plant control can be considered on the area as having high grazing potential especially on the flat areas with deep soil profile, but the plant coverage needs to be totally conserved or even increased on the area with slope and shallow soil profile. This is essential for both soil conservation and wild life because rangelands provide different benefit beyond grazing with respect to ecosystem stability.

The plant control can be made by different methods such as mechanical, cultural, biological, and chemical on the area having high grazing potential. Mechanical control techniques either remove the entire plant or physically damage shoots, roots, or root crowns of plants to the point where they can no longer survive. Mechanical control methods include hand pulling, hoeing, tilling, mowing, grubbing, chaining, cutting, and bulldozing. These techniques can be expensive, and they disrupt the soil, creating disturbed sites prone to invasion. *Astragalus eriocephalus* is generally destroyed manually by digging out the roots and seedlings, and fire burning the stems to ground level (Gokkus 1987). Mechanical top removal results in only big plant suppression of *Astragalus eriocephalus*, and gives the species competitive advantage. However, root plowing or root plowing fallowed by raking temporarily reduced its density (Personal observation by Koc and Erkovan). On the other hand, dormant season fire can be an effective and cheapest tool to control *Astragalus* spp. on the rangelands, because dormant season fires do not have a harmful effect on the grasses of highland steppe

rangelands (Erkovan et al., 2015). Chemical control is not suggested for *Astragalus* spp. control, because besides environmental pollution, herbicides used for *Astragalus* spp. control will also suppress other leguminous plants that are essential to meet the animal nutritional needs during the dormant season and to improve the soil fertility. Biological control might not be suggested for *Astragalus* spp. control because biological control agents can spread to untargeted areas.

In conclusion, *A. eriocephalus* and other thorny species of the genus are undesired plants on the areas with high grazing potential without erosion risk, but it is essential to save its coverage area with erosion risk. This is necessary to save the ecosystem stability on highland steppes.

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