ANALYSIS OF SIMPLE HAIRED ASTRAGALUS SPECIES FROM IRAN FOR TOXIC NITRO COMPOUNDS

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Leaflets of 313 specimens including 240 simple haired *Astragalus* species in 38 sections were taken from the herbarium specimens of Research Institute of Forests and Rangelands (TARI). They were analyzed quantitatively for toxic aliphatic nitro compounds. The catabolites of nitro compounds, 3 - nitro - 1 - propanol and 3 - nitropropionic acid, are especially toxic to cattle and sheep. Nitro compounds were detected in 42 of 313 specimens or in 31 species.

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بررسی ترکیبات ازت‌دار سمّی در گونهای کرک ساده ایران

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برگچه‌های ۳۱۳ نمونه هرباریومی از گونهای کرک ساده ایران شامل ۲۴۰ گونه از ۳۸ بخش، به منظور تشخیص ترکیبات ازت‌دار آلیفاتیک سمّی مورد بررسی قرار گرفتند.

کاتابولیتهای (فروگوهره‌ها) ترکیبات ازت‌دار، ۳ - نیترو - ۱ - پروپانول و اسید ۳ - نیتروپروپیونیک برای احشام سمّی هستند. وجود این ترکیبات در ۴۲ آرایه، شامل ۳۱ گونه از گونهای ایران گزارش می‌شود.

Introduction

The principal poisons associated with *Astragalus* in terms of the number of species involved are aliphatic nitro compounds. More than 450 species and varieties of *Astragalus* synthesize these compounds (Williams 1981; Williams & Barneby 1977). The most potent of these compounds is miserotoxin, first isolated from *Astragalus miser* Dougl. var. *oblongifolius* (Rydb) Cornq. (Stermitz & al. 1969), which catabolizes to its toxic component 3 - nitro - 1 propanol (3 - NPOH) in the digestive tract of ruminans (Williams & al. 1970). Several species of *Astragalus* that synthesize miserotoxin have caused moderate to heavy losses of cattle and sheep on western rangelands (Cronin & al. 1981; Williams and James 1975). Other species of *Astragalus* synthesize karakin, hiptagin, cibarian and other compounds that catabolize to 3 - nitropropionic acid (3 - NPA) in the digestive tract of ruminants (James & al. 1980; Williams & James 1975; Williams & al. 1976). The oral toxic and lethal doses of 3 - NPA for ruminants are considerably higher than equivalent doses of 3 - NPOH (Williams 1982). Previous investigations indicated that these compounds are remarkably stable being preserved for up to 90 to 100 years in herbarium specimens of *Astragalus* (Williams & Parker 1974).

Analysis of *Astragalus* for these compounds from herbarium specimens identify the species that are nitro-bearing and therefore might be poisonous to livestock. Examination of the chemotaxonomic relationships among the nitro-bearing species suggests, that related species might be nitro-bearing even if specimens are not available for analysis (Williams 1981). Because *Astragalus* may be grazed by livestock or fed as fodder, these species require toxicological investigation to determine whether nitro compounds are present and whether they occur in toxic concentrations. The interception of poisonous or weedy species before introduction or extensive development can save time and money in needless research, alleviate future losses of livestock and costly control measures.

This paper identifies several nitro-bearing species of *Astragalus* from Iran.

Material and Methods

About 25 mg samples of leaves of 313 specimens including 240 species were

removed from herbarium specimens of *Astragalus* (simple hairs) at the Botonical Garden, Research Institute of Forests and Rangelands, (TARI). The leaflets were analyzed quantitatively for nitro compounds (Williams & Barneby 1977). In this method the intensity of the red color was determined visually. Ten mg of leaflet was placed in each of two test tubes and macerated to a powder with a glass stirring rod. One ml of 1 N HCl was added to each test tube and they were kept at room temperature with frequent stirring for 2 hours. One ml of 20% KOH was added to each test tube and they were kept at room remperature for 2 hours. One ml of glacial acetic acid followed by 1 ml of Griess - Ilosvay's reagent was added to one test tube. Two ml of glacial acetic acid was added to the blank. The intensity of the red color was determined visually after 3 minutes and rated on a scale of 1 to 4 in which the approximate quantities in mg NO2/g of plant (dry weight) were: 1 = 4 to 8; 2 = 9 to 13; 3 = 14 to 19; 4 = 20 to 25.

Results and Discussion

Nitro compounds were found in 42 specimens out of 313 specimens or in 31 species of *Astragalus* (12.92% of the species examined) (table 1). The highest levels of nitro compounds were found in *A. daenensis* Boiss, *A. biovulatus* Bunge, *A. vicarius* Lipsky and *A. schmalhausenii* Bunge.

The nitro-toxin concentration listed in table 1 should be considered as minimum concentration. Age may have lowered the nitro-toxin level in some species and may have lowered the nitro-toxin concentration below a detectable level in others (Williams 1981). Thus we removed our samples from the most recently acquired specimens that had leaves of good green color.

Nitro compounds were found in species from 16 out of 38 taxonomic sections of *Astragalus,* based on a scale of 1 to 4. These compounds were not found in sections *Acidodes* Bunge, *Ankylotus* Bunge, *Astragalus*, *Cremoceras* Bunge, *Eremophysa* Bunge, *Grammocalyx* Bunge, *Herpocaulos* Bunge, *Hespiduli* Podlech, *Hololeuce* Bunge, *Hymenostegis* Bunge, *Hypoglottedei* DC., *Laguropsis* Bunge, *Laxiflori* Agerger-Kirchhof, *Macrophyllium* Boiss., *Macrosemium* Bunge, *Microphysa* Bunge, *Plagiophaca* Maass. & Podl., *Platonychium* Bunge, *Platyglottis* Bunge, *Poterion* Bunge, *Rhacophorus* Bunge, *Stereothrix* Bunge, (table 1).

The numerical ranking assigned each nitro-containing species reflects only nitro-toxin concentration and though providing a basis for predictability, does not necessarily reflect absolute toxicity to ruminants (Williams & Barneby 1977). The concentration of nitro-toxin in *Astragalus* leaflets often indicates whether the toxic catabolite will be 3-NPOH or 3-NPA. This taxonomic character provides an estimate of the toxicity of the species to ruminants. Miserotoxin, which is catabolized in the digestive tract of ruminants to 3-NPOH, is primarily found in *Astragalus* species that synthesize nitro-toxins at levels T to 3 (Williams & Barneby 1977). T represents trace amount of nitro-toxins (1-3 mg No2/g of plant). We have not reported T scale species here. Nitro-toxins that are synthesized at levels 4 and 5 are catabolized to 3-NPA in the digestive tracts of ruminants. We did not find species with score of 5.

Williams (1981) has analyzed many species of *Astragalus*, including some species of *Astragalus* of Iran, collected from different herbaria of Europe, and reported some nitro-bearing species of *Astragalus.*

In this paper the occurrence of nitro-toxins in 12 out of 31 species is reported for the first time. These species are: *A. remotiflorus* Boiss., *A. crenatus* Schultes, *A. brachycalyx* Fischer, *A. angustiflorus* DC., *A. apricus* Bunge, *A. maymanensis* Podlech, *A. daenensis* Boiss., *A. campylotrichus* Bunge, *A. deickianus* Bornm., *A. elegans* Bunge, *A. kerkukiensis* Bornm., *A. magistratus* Maassoumi, Ghahreman & Mozaffarian.

In the species of *Astragalus* examined, the capacity to synthesize nitro compounds was a species characteristic. Nitro compounds were always detected in the same species, or subspecies or varieties of the species (Williams 1983). However, some are reverse results observed in nitro-toxin concentration of some specimens. These specimens belong to *A. meridionalis* Bunge, *A. crenatus* Schultes and *A. maymanensis* Podlech (table 1). As mentioned earlier, age may have lowered the nitrotoxin level in some species. This may be true in the cases of *A. meridionalis* Bunge and *A. crenatus* Schultes. However, in the case of *A. maymanensis* Podlech, that one specimen scored 1 and two specimens scored zeros a revision may be required.

Nitro-bearing sections as well as species may be chemotaxonomically related. The correct identification of the species is a

major problem. The genus *Astragalus* is a complex and is under continuous revisions. Analysis for nitro compounds can be used to correctly identify and classify nitro-bearing species as well as to resolve synonymy. The presence of nitro compounds tends to restrict a species within limited number of sections. Some sections are nitro-bearing and some others are nitro-free. Thus nitro-bearing species within otherwise nitro-free sections should be reexamined for proper identification and sectional classification.

Table 1. Nitro Concentration in the simple haired Astragalus species from Iran; the approximate concentration (mg No2/g dry weight) represented by the scores are: - =0; 1=4 to 8; 2=9 to 13; 3=14 to 19; 4=20 to 25.

Section	Specific epithet	Voucher specimens	NO2 scores
Alopecuroidei	*ajubensis* Bunge	Assadi & al. 4.6.1974	-
Alopecuroidei	*alopecias* Pallas	Assadi & Maassoumi 50860	-
Alopecuroidei	*alopecias* Pallas	Assadi & al. 35930	-
Alopecuroidei	*anacardius* Bunge	Maassoumi & al. 51972	-
Alopecuroidei	*anacardius* Bunge	Runemark & al. 30978	-
Alopecuroidei	*anacurdius* Bunge	Mozaffarian & al. 63564	1
Alopecuroidei	*ashuricus* Parsa	Maassoumi & al. 52095	-
Alopecuroidei	*echinops* Boiss.	Fattahi & al. 2398	-
Alopecuroidei	*hamadanus* Boiss.	Mozaffarian & al. 64438	-
Alopecuroidei	*hymenocalyx* Boiss.	Fattahi & al. 1011	-
Alopecuroidei	*jesseni* Bunge	Mozaffarian & al. 53918	-
Alopecuroidei	*kirindicus* Boiss.	Nowroozi & al. 2937	1
Alopecuroidei	*macrocephalus* Willd.	Wendelbo & al. 12087	-
Alopecuroidei	*macrocephalus* Willd. subsp. *finitimus* (Bunge) Chamberlain	Fattahi & al. 1038	-
Alopecuroidei	*maximus* Willd.	Runemark & al. 21939	-
Alopecuroidei	*megalotropis* C.A.Mey	Mozaffarian & al. 34519	1
Alopecuroidei	*melaleucus* Bunge	Mozaffarian & al. 64456	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Alopecuroidei	*meridionalis* Bunge	Wendelbo & al. 17539	-
Alopecuroidei	*ovalifoliolatus* Maassoumi & Ranjbar	Mozaffarin & al. 48079	-
Alopecuroidei	*ponticus* Pallas	Amin & al. 1751	-
Alopecuroidei	*schahrudensis* Bunge	Assadi & al. 50245	-
Alopecuroidei	*speciosus* Boiss. & Hohen.	Mozaffarian & al. 49212	-
Ankylotus	*ankylotus* Bunge	Fattahi & al. 164	-
Ankylotus	*ankylotus* Bunge	Mozaffarian & al. 63127	-
Ankylotus	*commixtus* Bunge	Assadi & al. 50865	-
Ankylotus	*stalinskyi* Sirj.	Maassoumi & al. 47559	-
Annulares	*annularis* Forsskal	Maassoumi & al. 51921	-
Annulares	*arpilobus* Boiss. subsp. *arpilobus*	Shahrud, 800 m, Rechiger	-
Annulares	*arpilobus* Boiss. subsp. *hauarensis* (Bioss.) Podlech	Rechinger 46309	-
Annulares	*arpilobus* Boiss. subsp. *hauarensis* (Boiss.)Podlech	Rechinger 7973	-
Annulares	*campylorrhynchus* F. & M.	Assadi & al. 41618	-
Annulares	*crenatus* Schultes	Maassoumi & al. 47572	2
Annulares	*crenatus* Schultes	Assadi & al. 50246	1
Annulares	*cruciatus* Link	Mozaffarian & al. 59173	-
Annulares	*eremophilus* Boiss. subsp. *eremophilus*	Mozaffarian & al. 44069	-
Annulares	*laricus* Boiss. & Hohen.	Dini & al. 15409	3
Annulares	*schimperi* Boiss.	Runemark & al. 27324	-
Anthylliodei	*ebenoides* Boiss. subsp. *ebenoides*	Siami & al. 5413	-
Anthylliodei	*ebenoides* Boiss. subsp. *ebenoides*	Nowroozi & al. 115	-
Anthylliodei	*eriostomus* Bornm.	Mozaffarian & al. 63794	-
Anthylliodei	*fuhsii* Freyn & Sint.	Mashhad Herbarium staff (s. n.) 27.3.70	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Anthylliodei	*raddei* Basilevsk	Assadi & al. 50171	-
Anthylliodei	*rubrolineatus* Sirj. & Rech. f.		-
Anthylliodei	*szovitsii* Fischer & C. A. Meyer	Foroughi & al. 6349	-
Anthylloidei	*brevipilus* Zarre	Pabot & al. 28723	-
Anthylloidei	*brevipilus* Zarre	Pabot & al. 28723	-
Anthylloidei	*ghashghaicus* Zarre & Tietz	Assadi & al. 31680	-
Anthylloidei	*khoshjailensis* Sirj. & Rech. f.	Mozaffarian & al. 48721	-
Anthylloidei	*megalocystis* Bunge	Wendelbo & al. 29502	-
Anthylloidei	*murinus* Boiss.	Assadi & al. 46094	2
Anthylloidei	*raswendicus* Hausskn. & Bornm.	Mozaffarian & al. 47960	1
Anthylloidei	*remotiflorus* Boiss. subsp. *melanogramma* (Boiss.) Zarre	Arak, 48332	2
Anthylloidei	*remotiflorus* Boiss. subsp. *melanogramma* (Boiss.) Zarre	Mozaffarian & al. 64002	2
Anthylloidei	*remotiflorus* Boiss. subsp. *remotiflorus*	Javidtash & al. 24	2
Anthylloidei	*submitis* Boiss. subsp. *submitis*	Babakhanlou & al. 15561	1
Anthylloidei	*tortuosus* DC.	Runemark & al. 29259	-
Astragalus	*basineri* Trautv.	Assadi & al. 36085	-
Astragalus	*caragana* Fischer & C. A. Meyer	Maassoumi & al. 56877	-
Astragalus	*caryolobus* Bunge	Mozaffarian & al. 59912	-
Astragalus	*orthocarpoides* Sirj. & Rech. f.	Mozaffarain & al. 67610	-
Astragalus	*retamocarpus* Boiss.	Dini & al. 15716	-
Astragalus	*sieversianus* Pallas	Vafaee & al. 275	-
Brachycalyx	*brachycalyx* Fischer	Assadi & al. 46052	1
Brachycalyx	*brachycalyx* Fischer	Zehzad & al. 8102	-
Brachycalyx	*eriostylus* Boiss.	Assadi & al. 46461	-
Bucerates	*hamosus* L.	Mozaffarian & al. 62464	2

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Campylanthus	*argyrostachys* Boiss.	Mozaffarian & al. 45769	1
Campylanthus	*campylanthus* Boiss.	Assadi & al. 1698	-
Campylanthus	*chalaranthus* Boiss.	Assadi & al. 46367	-
Campylanthus	*ecbatanus* Bunge	Hamzeh & al. 1513	-
Campylanthus	*sussianus* Boiss. subsp. *susianus*	Assadi & al. 46023	-
Caprini	*aegobromus* Boiss. & Hohen.	Maassoumi & al. 55116	-
Caprini	*aharicus* Maassoumi & Podlech	Maassoumi & al. 56967	-
Caprini	*angustiflorus* DC. subsp. *angustoflirus*	Mozaffarian & al. 62081	1
Caprini	*apricus* Bunge	Maassoumi & al. 57036	1
Caprini	*apricus* Bunge	Maassoumi & al. 57036	-
Caprini	*avicennus* Parsa	Assadi & al. 36734	-
Caprini	*basilicus* Poldlech & Maassoumi	Maassoumi & al. 64908	-
Caprini	*brachystachys* DC.	Freitag & al. 55925	-
Caprini	*chrysanthus* Boiss.	Assadi & al. 32875	-
Caprini	*citrinus* Bunge subsp. *barrowianus* (Aitch. & Baker) Podlech	Khorasan, 50757	-
Caprini	*curvipes* Trautv.	Assadi & al. 50443	-
Caprini	*esferayenicus* Podlech & Maassoumi	Mozaffarian, 48889	-
Caprini	*fabaceus* Bieb.	Maassoumi & al. 57042	-
Caprini	*flexus* Fischer	Freitag & al. 29094	-
Caprini	*gagnieui* Maassoumi & Podlech	Nowroozi & al. 1750	-
Caprini	*golestanicus* Maassoumi & Podlech	Maassoumi & al. 55087	-
Caprini	*ibicinus* Boiss. & Hausskn.	Wendelbo & al. 17750	-
Caprini	*indistinctus* Podlech & Maassoumi	Jahan-Beglou & al. 32231	-
Caprini	*indurescence* Gontsch.	Bonvan & al. 40884	-
Caprini	*ischredensis* Bunge	Assadi & al. 9962	-
Caprini	*jarmolenkoi* Gontsch.	Assadi & al. 50573	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Caprini	*johannis* Boiss.	Foroughi & al. 17493	-
Caprini	*kirpiczinikovii* Grossh.	Maassoumi & al. 56953	-
Caprini	*kopetdaghi* Boiss. var. *orientikopetdaghensis* Nikitin	Mozaffarian & al. 48555	-
Caprini	*lambinonii* Podlech	Maassomi & al. 59355	-
Caprini	*maassoumii* Podlech	Mozaffarian & al. 59874	-
Caprini	*maassoumii* Podlech	Nowroozi & al. 193	-
Caprini	*macropelmatus* Bunge subsp. *macropelmatus*	Wendelbo & al. 11452	-
Caprini	*macropelmatus* Bunge subsp. *pseudokurramensis* (Sirj. & Rech. f.) Podlech	Ayatholahi & al. 10861	-
Caprini	*managettae* Sirj. & Rech. f.	Riazi & al. 8882	-
Caprini	*maymanensis* Podlech	Assadi & al. 55854	1
Caprini	*maymanensis* Podlech	Assadi & al. 50740	-
Caprini	*maymanensis* Podlech	Assadi & al. 55854	-
Caprini	*monanthemus* Boiss.	Mozaffarian & al. 49202	-
Caprini	*multijugus* DC.	Mozaffarian & al. 47957	-
Caprini	*neo-mobayenii* Maassoumi	Assadi & al. 29874	-
Caprini	*nephtonensis* Freyn	Maassoumi & al. 47578	-
Caprini	*nurabadensis* Maassoumi & Poldlech	Mozaffarian & al. 45804	-
Caprini	*ovinus* Boiss.	Mozaffarian & al. 59849	-
Caprini	*ovinus* Boiss.	Mozaffarian & al.48347	-
Caprini	*pellitus* Bunge	Freitag & al. 13846	-
Caprini	*pellitus* Bunge	Freitag & al. 29008	-
Caprini	*pinetorum* Boiss. subsp. *pinetorum*	Maassoumi & al. 56915	-
Caprini	*pinetorum* Boiss. subsp. *alamutensis* Maassoumi & Poldlech	Assadi & al. 51206	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Caprini	*piranshahricus* Maassoumi & Podlech	Mozaffarian & al. 49017	-
Caprini	*pseudobrachystachys* Sirj. & Rech. f.	Assadi & al. 22861	-
Caprini	*pseudoibicinus* Maassuomi & Poldlech subsp. *kewlikoshensis* Maassoumi & Poldlech	Mozaffarian & al. 54351	-
Caprini	*pseudoindurascenus* Sirj. & Rech. f.	Mozaffarian & al. 48410	-
Caprini	*pseudovinus* Maassoumi & Podlech	Assadi & al. 36820	-
Caprini	*pseudovinus* Maassoumi & Podlech	Riazi & al. 6248	-
Caprini	*pseudozagrosicus* Maassoumi & Podlech	Mozaffarian & al. 54812	-
Caprini	*pseudozagrosicus* Maassoumi & Podlech	Mozaffarian & al. 54811	-
Caprini	*remotijugus* Boiss. & Hohen.	Mozaffarian & al. 63525	-
Caprini	*remotijugus* Boiss. & Hohen.	Amini & al. 6108	-
Caprini	*remotijugus* Boiss. & Hohen.	Assadi & al. 33363	-
Caprini	*renzianus* Podlech	Assadi & al. 35400	-
Caprini	*reticulato-venosus* Maassoumi & Podlech	Assadi & al. 35701	-
Caprini	*rubrocalycinus* Maassoumi & Podlech	Maassoumi & al. 56907	-
Caprini	*rubrocalycinus* Maassoumi & Podlech	Maassoumi & al. 64890	-
Caprini	*rufescens* Freyn & Bornm.	Assadi & al. 56259	-
Caprini	*savellanicus* Podlech	Assadi & al. 30765	-
Caprini	*subrosulariformis* Sirj. & Rech.f.	Ayatholahi & al. 12497	-
Caprini	*touranicus* Freitag & Poldlech	Assadi & al. 21181	-
Caprini	*urmiensis* Bunge	Wendelbo & al. 11915	-
Caprini	*vereskensis* Maassoumi & Poldlech	Maassoumi & al. 55023	-
Caprini	*vulcanicus* Bornm.	Assadi & al. 33134	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Chronopus	*bazmanicus* Poldlech	Assadi & al. 23109	-
Chronopus	*dactylocarpus* subsp. *acinaciferus* (Boiss.) ott.	Assadi & al. 21024	-
Chronopus	*dactylocarpus* subsp. *acinaciferus* (Boiss.) ott.	Foroughi & al. 15918	-
Chronopus	*dactylocarpus* subsp. *acinaciferus* (Boiss.) ott.	Freitag & al. 28291	-
Chronopus	*dactylocarpus* subsp. *acinaciferus* (Boiss.) ott.	Runemark & al. 22655	-
Chronopus	*dactylocarpus* subsp. *acinaciferus* (Boiss.) ott.	Wendelbo & al. 11529	-
Chronopus	*jesdianus* Boiss. & Buhse	Assadi & al. 23236	-
Chronopus	*jesdianus* Boiss. & Buhse	Assadi & al. 22664	-
Chronopus	*siebere* DC.	Runemark & al. 30984	-
Chronopus	*vanillae* Boiss.	Shirdelpur & al. 11606	1
Chronopus	*vanillae* Boiss.	Runemark & al. 19466	1
Eremophysa	*chiwensis* Bunge	Freitag & al. 29007	-
Eremophysa	*jarmalii* Poldlech	Rajamand & al. 32015	-
Eremophysa	*kahiricus* DC.	Assadi & al. 56023	-
Eremophysa	*litwinowii* Lipsky	Mozaffarian & al. 67665	-
Eremophysa	*maximowiczii* Trautv.	Foroughi & al. 6048	-
Eremophysa	*rassulovae* Podlech	Rajamand & al. 31775	-
Grammocalyx	*grammocalyx* Boiss. & Hohen.	Maassoumi & al. 55035	-
Grammocalyx	*grammocalyx* Boiss. & Hohen.	Assadi & al. 69653	-
Hemiphaca	*daenensis* Boiss.	Foraughi & al. 18019	4
Hemiphaca	*regestus* Maassoumi	Mozaffarian & al. 57697	-
Hemiphaca	*zerdanus* Boiss.	Assadi & al. 46167	1

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Herpocaulos	*vogelli* (Webb)Bornm. subsp. *fatimensis* (Chiovenda) Poldlech	Mozaffarian & al. 39103	-
Heterodontus	*campylotrichus* Bunge	Assadi & al. 50864	1
Heterodontus	*guttatus* Banks. & Soland.	Foroughi & al. 12350	-
Hispiduli	*bakaliensis* Bunge	Rechinger & al. 50582	-
Hymenostegis	*bounophilus* Boiss. & Hohen.	Wendelbo & al. 13336	-
Hymenostegis	*bounophilus* Boiss. & Hohen.	Assadi & al. 21183	-
Hymenostegis	*brunsianus* Bornm.	Assadi & al. 33142	-
Hymenostegis	*chrysostachys* Boiss.	Fattahi & al. 696	-
Hymenostegis	*chrysostachys* Boiss.	Runemmark & al. 29326	-
Hymenostegis	*cordatus* Bunge	Assadi & 68519	-
Hymenostegis	*dianant-nejadii* Ghahremani	Assadi & al. 20195	-
Hymenostegis	*glumaceus* Boiss.	Fattahi & al. 185	-
Hymenostegis	*glumaceus* Boiss.	Chehregani & al. 17856	-
Hymenostegis	*hirticalyx* Boiss. & Kotschy	Olfat & al. 444	-
Hymenostegis	*kohurdicus* Bunge	Foroughi & al. 12468	-
Hymenostegis	*lagopoides* Lam.	Kandovan, 16092	-
Hymenostegis	*lagopoides* Lam.	Youssefy & al. 1431	-
Hymenostegis	*lagopoides* Lam.	Foroughian & al. 15938	-
Hymenostegis	*manucehri* Sirj. & Rech. f.	Assadi & al. 51554	-
Hymenostegis	*mesopotamicus* Boiss.	Babakhanlou & al. 15011	-
Hymenostegis	*paralurges* Bunge	Fattahi & al. 1221	-
Hymenostegis	*paralurges* Bunge	E. Azarbayejan 7513	-
Hymenostegis	*persicus*(DC.) Fischer & C. A. Mayer	Tehran, 49098	-
Hymenostegis	*recognitus* Fischer	Mozaffarian & al. 34304	-
Hymenostegis	*rubriflorus* Bunge	Shahsavari & al. 69796	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Hymenostegis	*rubrostriatus* Bunge	Dini & al. 8677	-
Hymenostegis	*rubrostriatus* Bunge	Mozaffarian & al. 64430	-
Hymenostegis	*sciureus* Boiss. & Hohen.	Amin & al. 19325	-
Hymenostegis	*seidabadensis* Bunge	Maassoumi & al. 56949	-
Hymenostegis	*straussii* Bornm.	Mozaffarian & al. 47793	-
Hymenostegis	*woronowii* Bornm.	Assadi & al. 65722	-
Hypoglottidei	*articapillis* Bornm.	Assadi & al. 40899	-
Hypoglottidei	*brachypetalus* Trautv.	Wendelbo & al. 12655	-
Hypoglottidei	*cicer* L. [cultivated]	Vahabi & al. 5076	-
Hypoglottidei	*haematinus* Sirj. & Rech. f.	Assadi & al. 47620	-
Hypoglottidei	*nurensis* Boiss. & Buhse	Runemark & al. 20872	-
Hypoglottidei	*perpexus* Maassoumi	Nowroozi & al. 1611	-
Hypoglottidei	*pishchakensis* Maassoumi	Foroughi & al. 8955	-
Hypoglottidei	*pishchakensis* Maassoumi	Mozaffarian & al. 27388	-
Laxiflori	*dictyolobus* Bunge	Maassoumi & al. 56856	-
Laxiflori	*tawilicus* Townsend	Sabeti & al. 15795	-
Laxiflori	*tawilicus* Townsend	Foroughi & al. 1550	-
Macrophyllium	*oleifolius* DC.	Mozaffarian 68622	-
Macrosemium	*paradoxus* Bunge	Wendelbo & al. 19281	-
Malacothrix	*anserinaefolius* Boiss.	Babakhanlou & al. 23043	-
Malacothrix	*aspadanus* Bunge	Nowroozi & al. 305	-
Malacothrix	*babakhanloui* Maassoumi & Podlech	Mozaffarian & al. 59901	-
Malacothrix	*beckii* Bornm.	Assadi & al. 30655	-
Malacothrix	*belgheisicus* Maassoumi	Assadi & al. 60301	-
Malacothrix	*chahartaghensis* Maassoumi & Podlech	Nowroozi & al. 342	-
Malacothrix	*chrysotrichus* Boiss.	Fattahi & al. 724	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Malacothrix	*chrysotrichus* Boiss.	Zarre & al. 69622	-
Malacothrix	*deickianus* Bormm.	Maassoumi & al. 59381	1
Malacothrix	*deickianus* Bornm.	Maassoumi & al. 59381	-
Malacothrix	*elegans* Bunge	Maassoumi & al. 56977	1
Malacothrix	*entomophyllus* Boiss.	Maassoumi 47535	-
Malacothrix	*eriopodus* Boiss.	Tarighi & al. 1335	-
Malacothrix	*eriopodus* Boiss.	Amin & al. 15028	-
Malacothrix	*heterodoxus* Bunge	Assadi & al. 56148	-
Malacothrix	*heterodoxus* Bunge	Zehzad & al. 85049	-
Malacothrix	*holopsilus* Bunge	Nowroozi & al. 163	-
Malacothrix	*holopsilus* Bunge	Mozaffarian & al. 47983	-
Malacothrix	*holosemius* Bunge	Termeh & al. 10.6.86	-
Malacothrix	*iranicus* Bunge	Mozaffarian & al. 34182	-
Malacothrix	*kabristanicus* Grossh.	Maassoumi & al. 64894	-
Malacothrix	*laristanicus* Bornm. & Gauba	Foroughi & al. 10790	-
Malacothrix	*leushanensis* Maassoumi	Assadi & al. 60361	-
Malacothrix	*macrourus* Fischer & C. A. Meyer	Youssefy & al. 2681	-
Malacothrix	*mollis* Bieb.	Assadi & al. 33676	-
Malacothrix	*podocarpus* C. A. Meyer	Assadi & al. 36816	-
Malacothrix	*pulchellus* Boiss.	Nowroozi & al. 202	-
Malacothrix	*rawlinsianus* Aitch. & Baker	Assadi & al. 55580	-
Malacothrix	*rivashensis* Maassoumi	Freitag & al. 29026	-
Malacothrix	*rudimentus* Maassoumi	Javanshir 854	-
Malacothrix	*senilis* Bornm.	Maassoumi & al. 59419	-
Malacothrix	*spachianus* Boiss. & Buhse	Foroughi & al. 16216	-
Malacothrix	*spachianus* Boiss. & Buhse	Nowroozi & al. 5465	-
Malacothrix	*spachianus* Boiss. & Buhse	Foroughi & al. 17907	-

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Malacothrix	*suluklensis* Freyn & Sint.	Assadi & al. 50260	-
Malacothrix	*suluklensis* Freyn & Sint.	Assadi & al.50373	-
Malacothrix	*takhtadzhjani* Grossh.	Mianeh-Tabriz	-
Malacothrix	*tenuiscapus* Freyn & Bornm.	Assadi & al. 31241	-
Malacothrix	*typhaeformis* Maassoumi	Wendelbo & al. 11830	-
Microphysa	*ardahalius* Parsa	Zarre 69577	-
Microphysa	*callistachys* Boiss. & Buhse	Assadi & al. 55972	-
Microphysa	*cemerinus* G. Beck	Mozaffarian & al. 48108	-
Microphysa	*cephalanthus* DC.	Mozaffarian, 46995	-
Microphysa	*damavendicolus* Bornm. & Gauba subsp. *microphysopsis* Tietz	Pabot, 1935	-
Microphysa	*damavendicolus* subsp.*demavendicolus*	Assadi & al. 35202	-
Microphysa	*fragiferus* Bunge	Assadi & al. 31197	-
Microphysa	*lurorum* Bornm.	Runemark & al. 26127	-
Microphysa	*microphysa* Boiss.	Assadi & al. 46184	-
Microphysa	*microphysa* Boiss.	Mozaffarian 57728	-
Microphysa	*ptychophyllus* Boiss.	Mozaffarian 54539	-
Microphysa	*ptychophyllus* Boiss.	Mozaffarian 54421	-
Microphysa	*reuterianus* Boiss.	Assadi & al. 56443	-
Microphysa	*reuterianus* Boiss.	Pabot 6853	-
Oxyglottis	*oxyglottis* Bieb.	Karimi 15156	2
Oxyglottis	*oxyglottis* Bieb.	Bonwan 9920	2
Oxyglottis	*schmalhausenii* Bunge	Maassoumi 55146	4
Oxyglottis	*vicarius* Lipsky	Maassoumi 47570	4
Oxyglottis	*crispocarpus* Nabelek	Maassoumi 64771	3
Oxyglottis	*oxyglottis* Bieb.	Wendelbo & al. 19265	2
Oxyglottis	*oxyglottis* Bieb.	Freitag & al. 28838	1

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Plagiophaca	*coelicolor* Sirj. & Rech. f.	Assadi & al. 40908	-
Platonychium	*mesoleios* Boiss. & Hohen.	Assadi 25409	-
Platonychium	*verus* Oliv.	Assadi & al. 33585	-
Platyglottis	*bombycinus* Boiss.	Rechinger 46247	-
Platyglottis	*camptoceras* Bunge	Maassoumi 47538	-
Poterion	*anisacanthus* Boiss. subsp.*schurabicus* (Bunge) Tietz	Rajamand & al. 31944	-
Poterion	*baba-alliar* Parsa subsp. *baba-alliar*	Foroughi 3195	-
Poterion	*baba-alliar* Parsa subsp. *nudicarpus* (Sirj. & Rech. f.)Tietz	Runemark & al. 26014	-
Poterion	*calliphysa* Bunge subsp. *angustifolius* Tietz	Forougi 15955	-
Poterion	*calliphysa* Bunge subsp. *calliphysa*	Assadi & al. 56399	-
Poterion	*fasciculifolius* Boiss. subsp. *fasciculifolius*	Assadi & al. 41650	-
Poterion	*fasciculifolius* Boiss. subsp. *arbusculinus* (Bornm. & Gauba)Tietz	Foroughi 10761	-
Poterion	*fasciculifolius* Boiss. subsp. *arbusculinus* (Bornm. & Gauba) Tietz	Mozaffarian 49867	-
Poterion	*glucacanthus* Fischer	Tehran 25509	-
Poterion	*glucacanthus* Fischer	Runemark & al. 69582	-
Rhachophorus	*compactus* Lam.	Wendelbo & al. 12522	-
Rhacophorus	*stenolepis* Lam.	Maassoumi & al. 55128	-
Sesamei	*biovulatus* Bunge	Assadi 22826	4
Sesamei	*coronilla* Bunge	Runemark & al. 19506	2

Table 1. (Continued).

Section	Specific epithet	Voucher specimens	NO2 scores
Sesamei	*filicaulis* Kar. & Kir.	Pabot 28596	-
Sesamei	*filicaulis* Kar. & Kir.	Pabot 28597	-
Sesamei	*kerkukiensis* Bornm.	Wendelbo & al. 17753	1
Sesamei	*persepolitanus* Boiss.	Rechinger 50747	-
Sesamei	*tribuloides* Delile	Runemark & al. 19438	-
Sesamei	*tribuloides* Delile	Assadi 22825	-
Sesamei	*tribuloides* Delile	Foroughian & al. 15324	-
Sesamei	*tribuloides* Delile	Pabot 8098	-
Sesamei	*tribuloides* Delile	Bonvan 9961	-
Sesamei	*tribuloides* Delile	Runemark & al. 19497	-
Stereothrix	*capito* Boiss.	Runemark & al. 21777	-
Stereothrix	*ledinghamii* Barneby	Mozaffarian 54517	-
Stereothrix	*sphaeranthus* Boiss. & Hausskn.	Riazi, 10230	-
Theiochrus	*siliquosus* Boiss. subsp. *siliquosus*	Assadi & al. 50371	2
Theiochrus	*siliquosus* Boiss. subsp. *siliquosus*	Maassoumi & al. 59230	2
Theiochrus	*siliquosus* Boiss. subsp. *stramineus* (Boiss. & Kotschy)Podlech	Runemark & al. 26526	2
Theiochrus	*siliquosus* Boiss. subsp. *siliquosus*	Assadi & al. 50901	2
Theiochrus	*siliquosus* Boiss. subsp. *siliquosus*	Mozaffarian & al. 47981	2
Tricholobus	*magistratus* Maassoumi	Assadi & al. 35244	1
Tricholobus	*tricholobus* DC. subsp. tricholobus	Assadi & al. 35275	-
Tricholobus	*tricholobus* DC. subsp. tricholobus	Forghandust 36218	-
Tricholobus	*tricholobus* DC. subsp. *hohenackeri* (Boiss.) Tietz	Assadi & al. 65970	-

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