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INULA L. TURKUMIGA MANSUB TURLARNING GIS VA STATISTIK TAHLILLARI

G.Z. Ermatova, N.M. Naraliyeva, G.A. Ibrohimova

Maqolada turli ekologik mintaqalarda tarqalgan Inula L. turkumi vakillarining GIS va statistik tahlili bayon qilingan. Inula grandis Schrenk ex Fisch. & C.A.Mey., Inula rhizocephala Schrenk ex Fisch. & C.A.Mey., Inula helenium L., Inula macrolepis Bunge., Inula glauca C.Winkl., Inula rhizocephaliformis Kamelin & Turak. turlarining tabiiy yashash muhitlari, ekologik moslashuvlari va ularning tarqalish qonuniyatlari o‘rganilgan. Tadqiqot davomida O‘zbekiston Milliy Gerbariysi (TASH)da saqlanayotgan Inula L. gerbariy namunalaridan georeferens ma’lumotlari tahlil qilinib Markaziy Osiyoning 37 ta ekomintaqasi asosida Inula L. turlarining xaritasi shakllantirilgan.

Kalit so‘zlar: *ekomintaqa, Inula L. endemik, balandlik diapazoni, ildizbosh andiz, GIS tahlil*.

В статье приведены результаты ГИС-анализа и статистического исследования представителей рода Inula L. в различных экологических регионах. Рассмотрены естественные местообитания, экологические адаптации и закономерности распространения таких видов, как Inula grandis Schrenk ex Fisch. & C.A.Mey., Inula rhizocephala Schrenk ex Fisch. & C.A.Mey., Inula helenium L., Inula macrolepis Bunge., Inula glauca C.Winkl. и Inula rhizocephaliformis Kamelin & Turak. На основе анализа геопривязанных данных гербарных образцов, хранящихся в Национальном гербарии Узбекистана (TASH), смоделировано распределение видов рода Inula L. в пределах 37 экорегионов Центральной Азии.

Ключевые слова: *экорегионы, род Inula L., эндемичные виды, высотное распределение, морфология корневища, ГИС-анализ*.

Kirish

Qoqidoshlar (Asteraceae) oilasi O‘zbekiston florasida muhim o‘rin egallaydi. Ushbu oilaga mansub ko‘plab turkumlar dorivor xususiyatlari va manzarali o‘simlik ekanligi bilan ahamiyat kasb etadi. Ular orasida *Inula* L. – bo‘ydor andiz turkumi yirik va e’tiborga loyiq vakillardan biri hisoblanadi. *Inula* L. turkumiga dunyo bo‘yicha 78 ta tur kirib, ularning asosiy tarqalish hududlari Yevropa, Osiyo va Afrikadir [1].

O‘zbekiston florasida *Inula* L. turkumining 9 turi – *I. helenium L., I. grandis, I. salicina, I. glauca, I. caspica, I. britannica, I. macrolepis, I. multicaulis, I. rhizocephala* tarqalgan [2, 3].

Floristik manbalarga asosan, hozirda *Inula* ning 3 turi – *I. salicina* L., *I. caspica* Blum. va *I.britannica* L. lar morfologik, anatomik, genetik tuzilishlaridan kelib chiqib, Asteraceae oilasi *Pentanema* Kass. turkumiga qo‘shib yuborilgan [4, 5, 6, 7].

So‘nggi yillarda asl vatani Xitoy va Yaponiya bo‘lgan *Inula japonica* va *Inula linariifolia* O‘zbekistonda iqlimlashtirilgan [1]. O‘zbekistonning janubiy qismida tarqalgan *Inula grandis* turi bir guruh botanik olimlar – A.V.Mahmudov, O.S.Abduraimov, A.I.Allamurotov, V.Mahmudov, B.J.Mavlonov, O.T.Mamatqosimov (2024) tomonidan o‘rganilgan. O‘simlikning yer osti biomassasi resurslarini o‘rganish bo‘yicha olib borilgan tadqiqotlarda mazkur tur uchun eng qulay ekologik sharoit (d.s. 1300–1500 m.) o‘t-buta-archa jamoasi ekanligi aniqlangan [7].

Shuningdek, Qozog‘istonda *Inula* L. turkumiga mansub o‘simliklarning tarqalishi turli balandlik mintaqalariga bog‘liq holda o‘rganilgan. Mazkur tadqiqotlarga ko‘ra, *Inula helenium* L. Shimoliy Tyanshanning bargli o‘rmonlari uchun xarakterli tur bo‘lib, asosan d.s.1000-1700 m. balandlik oralig‘ida tarqalgan. O‘simlikning ahamiyatli jihati shundaki, ushbu tur tog‘ o‘simliklari tarkibidagi muhim ekologik komponentlardan biri sifatida e’tirof etiladi. Baland tog‘ hududlariga xos yana bir tur – *Inula rhizocephala* esa asosan 3700-4000 m balandlikda uchrab, yuqori tog‘li ekotizimlarga moslashgan. Ushbu tur ekstremal sharoitlarga chidamliligi va o‘ziga xos morfologik belgilari bilan ajralib turadi [8].

Bundan tashqari, Tojikistonning Hisor tizmasi janubiy qismida olib borilgan tadqiqotlar natijasida

I. macrophylla, I. rhizocephala asosan d.s.1800-2300 m. balandlik oralig‘ida tarqalganligi aniqlangan [9].

Hayotiy shakllariga ko‘ra *Inula* turlarining aksariyati ko‘p yillik o‘tlar bo‘lib, ular orasida *Inula hissarica* Markaziy Osiyo va O‘zbekiston uchun endemik tur sifatida alohida ajralib turadi [2; 3]. Shuningdek, ayrim turlari xalq taboboti va farmakologiyada keng qo‘llaniladi.

Inula helenium (mahalliy nomi – Katta andiz yoki Qora andiz) va *Inula grandis* (Yirikbargli andiz yoki Sariq andiz) o‘zining shifobaxsh xususiyatlari bilan mashhur. Bu turlarning shifobaxsh xususiyatlarini MDH miqyosida bir qancha olimlar – A.A.Sorokina (2010), A.V.Yanitskaya, I.V.Zemlyanskaya (2012), A.M.Gurev, L.G.Sosnina (2014), I.Sh.Yanturin, A.A.Amineva (2013), V.N.Bubenchikova, A.V.Azarova (2014), S.I.Korinyak (2016), V.V.Chumakova, V.F.Chumakov (2017), J.M.Dergachyova (2018) o‘rgangan. Bundan tashqari, J.Boymurodov (2017) *I. macrophylla, I. rhizocephala*dan ajratib olingan polifenollardan yo‘g‘on ichak saratonini davolashda foydalanish uchun tavsiyalar bergan [9]. O.Baitulin (2005) tomonidan *Inula helenium* turining fitotsenozdagi ahamiyati, N.M.Nayda (2014), Y.Y.Xabaltuyev (2006) tomonidan esa turning biomorfologiyasi bo‘yicha tadqiqot ishlari amalga oshirilgan [10].

O‘zbekiston florasida mavjud dorivor o‘simliklardan xalq xo‘jaligida foydalanish bo‘yicha ham bir qancha tadqiqotlar olib borilgan. Jumladan, H.X.Xolmatov, Z.H.Habibov (1976) baland bo‘yli andiz ildizpoyasining tarkibida efir moylari, saponinlar, smola, shilimshiq va achchiq moddalar, izoalantolaktonlar, fitomilan va boshqa atsetilen birikmalari, inulin va psevdoinulin uchrashi to‘g‘risida ma’lumotlarni keltirgan. Botanik olimlardan P.Q.Zokirov, R.I.Toshmuhamedov va A.T.Qobulov (1983), Q.Hojimatov, M.Olloyorov (1988), I.To‘xtasinov (1992), A.I.Qosimov (1994), O‘.P.Pratov, M.N.Maxsumov (2006), K.Sh. Tojiboyev, N.Y.Beshko, V.A.Popov (2016), A.Sattorov (2016), A.Y.Ibragimov (2016) N.Y.Kuchkarov (2021) Z.I.Sanoyev (2023) va boshqalarning tadqiqotlarida ham baland bo‘yli andizning areali, kimyoviy tarkibi, tabobatda va zamonaviy tibbiyotda ishlatilishi, introduksiyasi, bioekologiyasi bo‘yicha ishlar amalga oshirilgan.

Ma’lumki, hozirgi kunda *Inula* ning ayrim turlaridan (*Inula helenium, Inula grandis*) tabobatda va zamonaviy tibbiyotda keng foydalaniladi. Ilmiy manbalarda Qora andiz (*Inula helenium* L.)ning areali Sirdaryo qirg‘oqlari, Pomir-Oloy, Hisor, Ko‘hitang, Bobotog‘, Zarafshon, Turkiston, Chotqol, Ugom, Piskom va Farg‘ona tog‘ tizmalariga to‘g‘ri kelishi qayd etilgan [3, 11]. Qora andizdan tayyorlangan dorivor preparat balg‘am ko‘chiruvchi dori sifatida hamda me’da va ichak kasalliklarini davolashda foydalaniladi. O‘simlikning tarkibida uchraydigan efir moylari (1–3%) antiseptik xususiyatga ega bo‘lib, gijja haydovchi va yallig‘lanishga qarshi shifobaxsh xususiyatlarga ega [12, 13, 14, 15].

Inula grandis (Sariq andiz) Markaziy Osiyoda keng tarqalgan dorivor o‘simlik hisoblanadi. O‘zbekistonda bu turning tarqalish hududlari Surxon-Sherobod vodiysi, Hisor, Ko‘hitang, Bobotog‘, Nurota, Zarafshon, Turkiston, Chotqol, Qurama, Ugom, Piskom va Farg‘ona tog‘ tizmalariga to‘g‘ri keladi [3].

Sariq andiz ildizining tarkibida 13%–27% gacha inulin bor. Bundan tashqari, ildizidan 80% gacha spirt olish mumkin. Oshqozon va o‘n ikki barmoqli ichak yaralarini, gastritni, duodenitni, periduodenitni, surunkali ich qotishni qaynatma bilan davolashda klinik tadqiqotlar ijobiy natijalar ko‘rsatgan, ayniqsa, oshqozon saratonini davolashda sezilarli natijalar olingan [12;13;14;15].

Ekologik mintaqalar turlarning tarqalishida muhim rol o‘ynaydigan omillardan biridir. Tadqiqotlarimizdan ko‘zda tutilgan maqsad dorivor va manzarali o‘simliklarni o‘z ichiga olgan *Inula* L. turkumi *Inula grandis*, *Inula rhizocephala*, *Inula helenium*, *Inula macrolepis*, *Inula glauca*, *Inula rhizocephaliformis* turlari populyatsiyalarining Markaziy Osiyo ekomintaqalarida o‘sishini tahlil qilishdan iborat.

Material va metodlar

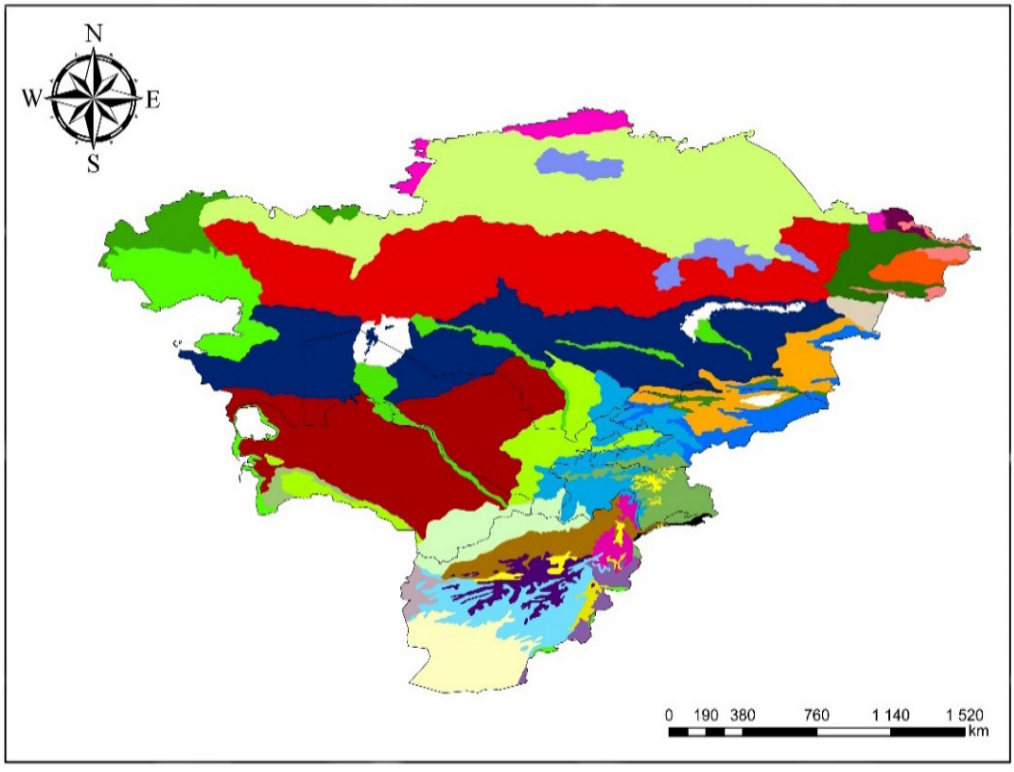
2022–2024-yillarda Markaziy Osiyo hududida tarqalgan *Inula* L. turkumiga mansub o‘simliklarning ekologik mintaqalarda taqsimlanishi GIS texnologiyalari va statistik tahlil usullari yordamida o‘rganildi. O‘zbekiston Milliy Gerbariysi (TASH)da saqlanayotgan 120 ta *Inula* L. gerbariy namunalaridan georeferens ma’lumotlari olindi. Shuningdek, Surxon-Sherobod botanik-geografik hududidagi o‘simliklar qoplamini o‘rganish uchun 2022–2023-yillarda olib borilgan dala tadqiqotlari davomida to‘plangan *Inula* L. turlariga oid georeferens ma’lumotlari, MW (Moscow University Herbarium) [16], Plantarium [6], Plants of the World Online [5], INaturalist [17], GBIF (Global Biodiversity Information Facility) onlayn bazasidan ma’lumotlar olingan [18]. Turlarning Markaziy Osiyo hududida tarqalishini aniqlash uchun ArcGIS 10.8.2 dasturiy ta’minotidan foydalangan holda jahon quruqlik ekomintaqalari xaritasidan mamlakatning quruqlik ekologik hududlari chiqarildi. Bu ma’lumotlarning statistik tahlili R dasturi (version 4.3.1) va

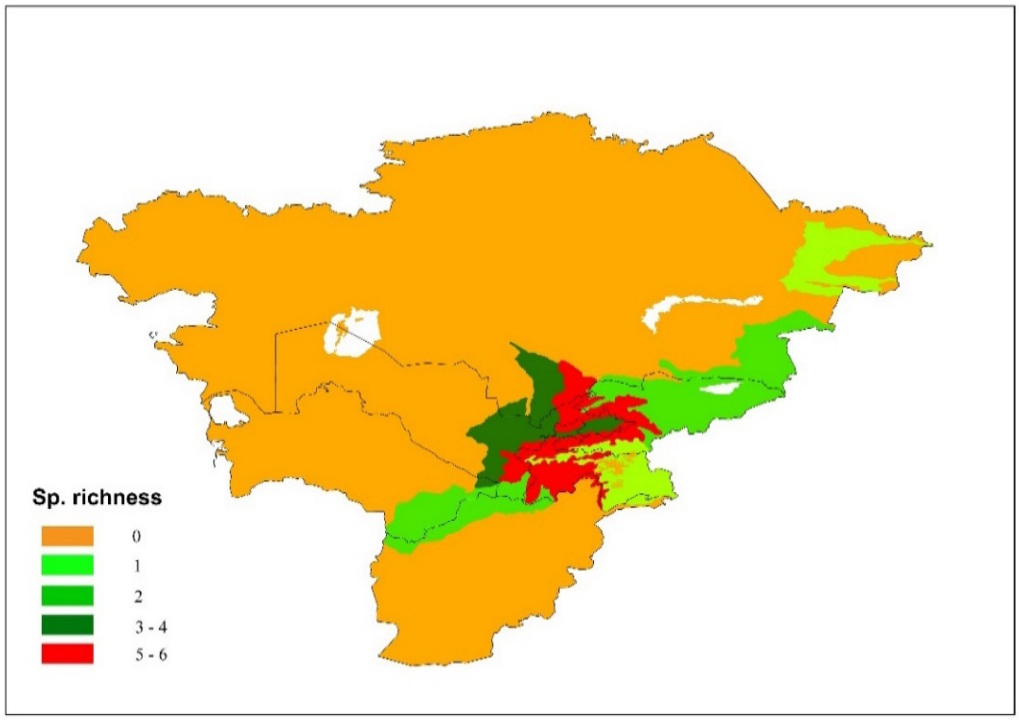
OriginPro-2022 dasturi (v.9.9.0.225-SR1)da amalga oshirildi. Bu Markaziy Osiyoning o‘ziga xos geografik sharoitida turlarning tarqalishini tahlil qilish imkonini berdi. Bundan tashqari, turlarning kengroq tarqalish diapazoni haqida tushunchaga ega bo‘lish uchun Markaziy Osiyoning ekomintaqalari (ecoregion)laridan foydalanildi. Markaziy Osiyoning ekoregionlari o‘ziga xos botanik xususiyatlari va geografik omillarini hisobga olgan holda turlarning Markaziy Osiyo ichida tarqalish qonuniyatlarini batafsilroq tahlil qilish imkonini beruvchi tasniflash tizimini taqdim etadi. Ushbu metodologiya birlamchi dala ma’lumotlarini ham, biologik xilmaxillik to‘g‘risidagi ommaviy ma’lumotlarni ham birlashtirishga imkon berdi. Olingan natijalar *Inula* L. turlarning o‘rganilayotgan hududda tarqalishining ishonchli tahlilini ta’minladi.

Natijalar va ularning muhokamasi

Tadqiqotimizda Markaziy Osiyo va O‘zbekiston hududida tarqalgan *Inula* L. turkumining 6 ta – *Inula grandis*, *Inula rhizocephala*, *Inula helenium*, *Inula macrolepis*, *Inula glauca*, *Inula rhizocephaliformis* turiga oid 297 ta namuna georeferens ma’lumotlaridan foydalanib, Markaziy Osiyoning 37 ta ekomintaqasiga asoslangan *Inula* L. turlarining xaritasi shakllantirildi (1-, 2-rasmlar).

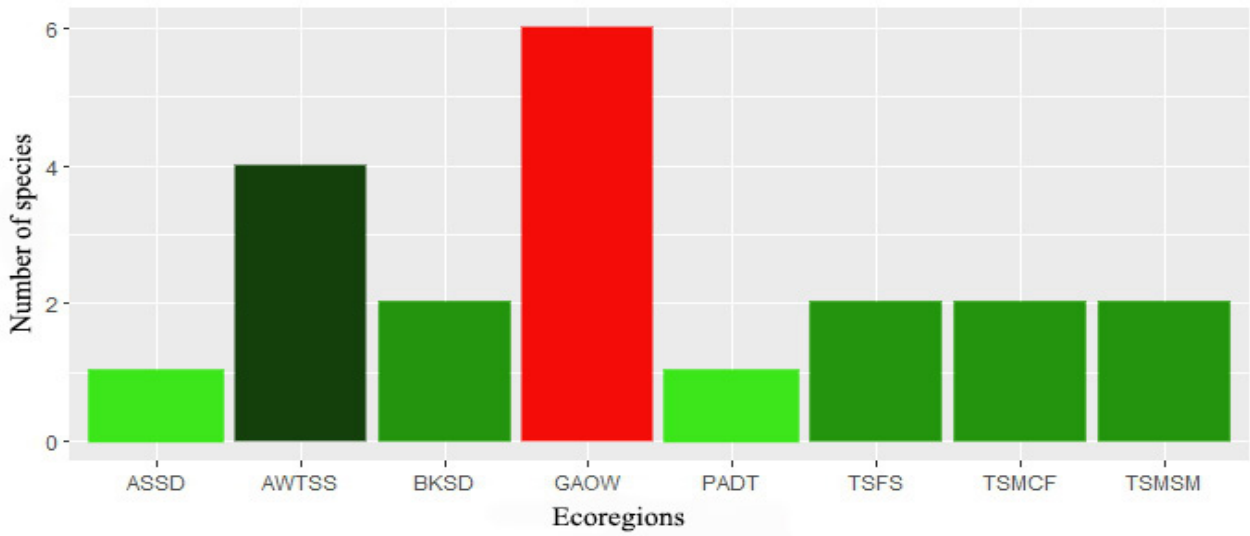
AMSD	Afghan Mountains semi-desert	RI	Rock and Ice	KDSD	Kopet Dag semi-desert
*AWTSS	Alai-Western Tian Shan steppe	EAMCF	East Afghan montane conifer forests	KDWFS	Kopet Dag woodlands and forest steppe
AAMT	Altai alpine meadow and tundra	EVS	Emin Valley steppe	NHASM	Northwestern Himalayan alpine shrub and meadows
AMFFS	Altai montane forest and forest steppe	GHAM	Ghorat-Hazarajat alpine meadow	*PADT	Pamir alpine desert and tundra
*ASSD	Altai steppe and semi-desert	*GAOW	Gissaro-Alai open woodlands	PXW	Paropamisus xeric woodlands
*BKSD	Badghyz and Karabil semi-desert	HKAM	Hindu Kush alpine meadow	PS	Pontic steppe
EAMCF	East Afghan montane conifer forests	JBSD	Junggar Basin semi-desert	RNPSD	Registan-North Pakistan sandy desert
CLD	Caspian lowland desert	KWTPAS	Karakoram-West Tibetan Plateau alpine steppe	SRAM	Sulaiman Range alpine meadows
CAMXW	Central Afghan Mountains xeric woodlands	KFS	Kazakh forest steppe	*TSFAS	Tian Shan foothill arid steppe
CASD	Central Asian southern desert	CAND	Central Asian northern desert	*TSMCF	Tian Shan montane conifer forests
CARW	Central Asian riparian woodlands	KS	Kazakh steppe	*TSMSM	Tian Shan montane steppe and meadows
CAND	Central Asian northern desert	KUS	Kazakh upland steppe	WHSCF	Western Himalayan subalpine conifer forests
CPDB	Central Persian desert basins				





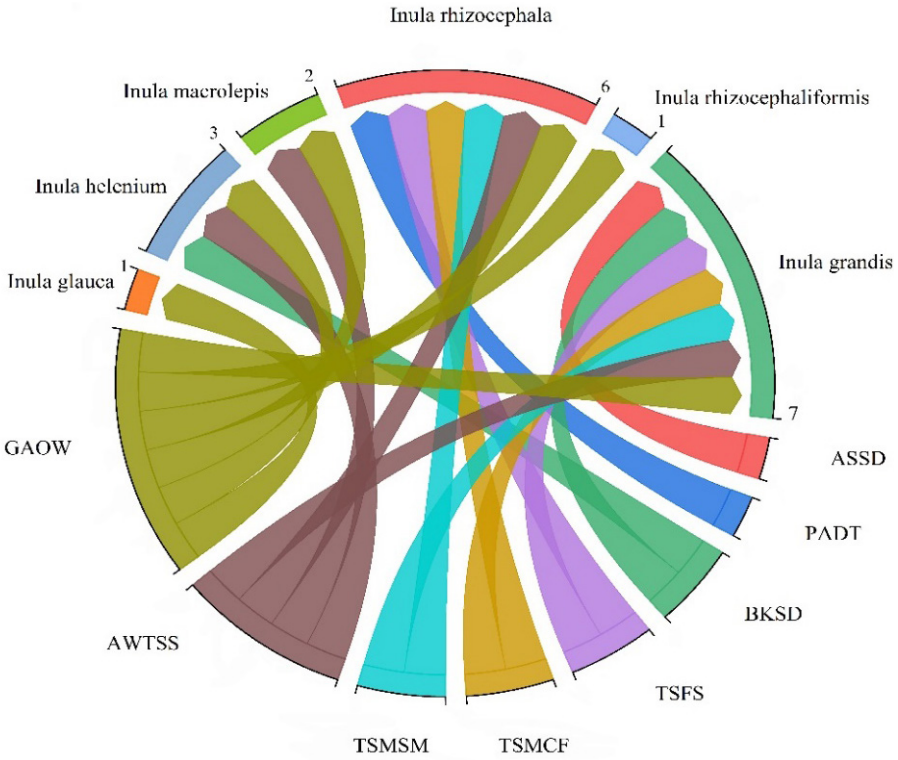
1-rasm. Markaziy Osiyo ekomintaqalarida *Inula* L. turlarining tarqalishi.

Tadqiqot davomida Hisor-Oloy ochiq o‘rmonzorlari ekomintaqasi (Gissaro-Alai open woodlands – GAOW) da *Inula* L. turkumining 6 ta turi uchrashi aniqlandi. Oloy-G‘arbiy Tyan-Shan yaylovlari (Alai-Western Tian Shan steppe – AWTSS)da 4 ta tur aniqlandi. Badxiz va Qorabil yarim cho‘li (Badghyz and Karabil semi-desert – BKSD), Tyan-Shan tog‘ etagidagi qurg‘oqchil yaylov (Tian Shan foothill arid steppe – TSFAS), Tyan-Shan tog‘ yaylovlari va o‘tloqlari (Tian Shan montane steppe and meadows – TSMSM), Tyan-Shan tog‘ining ignabargli o‘rmonlari (Tian Shan montane conifer forests – TSMCF) ekomintaqalarida 2 tadan tur uchrashi aniqlandi. Pomir tog‘ cho‘llari va tundra (Pamir alpine desert and tundra – PADT) va Oltoy yaylovi va yarim cho‘li (Altai steppe and semi-desert – ASSD) ekomintaqalarida esa 1 ta tur uchrashi aniqlandi.



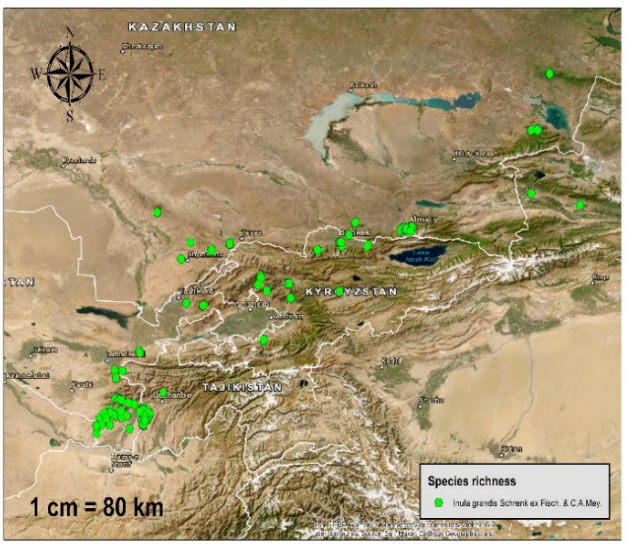
2-rasm. *Inula* L. turkumi turlarining har bir ekomintaqada tarqalishi.

Ekomintaqalarga asoslangan xaritadagi turlarning tarqalishini o‘rganib, Markaziy Osiyoning 8 ta ekomintaqasida turli balandlik diapazonlarida *Inula* L. turlari o‘sishini aniqladik. *Inula grandis* Schrenk ex Fisch. & C.A.Mey. 7 ta, *Inula rhizocephala* Schrenk ex Fisch. & C.A.Mey. 6 ta, *Inula helenium* L. 3 ta, *Inula macrolepis* Bunge 2 ta, *Inula glauca* C.Winkl. va *Inula rhizocephaliformis* Kamelin & Turak. 1 ta ekomintaqada uchrashi aniqlandi (3-rasm).



3-rasm. Markaziy Osiyo ekomintaqalariga *Inula* L. turkum turlarining tarqalish nisbati.

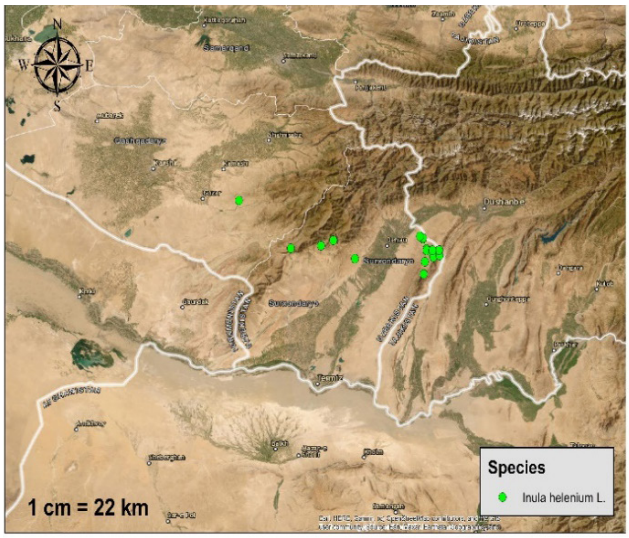
Yuqorida keltirilgan ma’lumotlar asosida har bir *Inula* L. turi tarqalishining fazoviy xaritasi shakllantirildi (4-rasm). O‘zbekiston Milliy Gerbariysi (TASH) dagi gerbariy namunalari asosida to‘plangan ma’lumotlar bazasi hamda dala tadqiqotlari natijasida olingan ma’lumotlar umumlashtirildi.



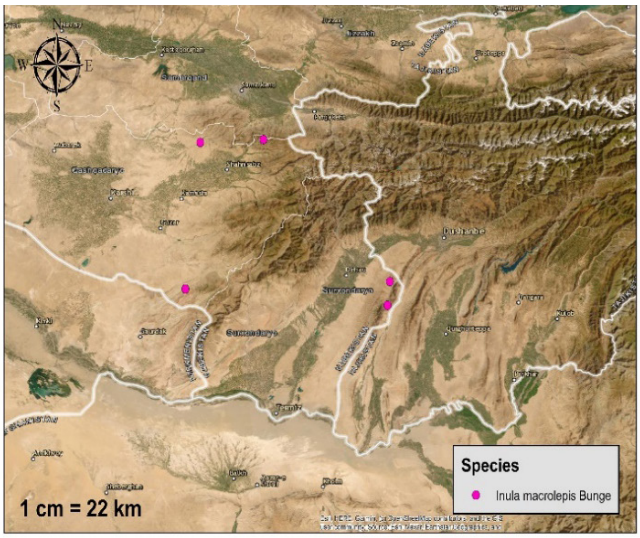
Inula grandis Schrenk ex Fisch. & C.A.Mey.



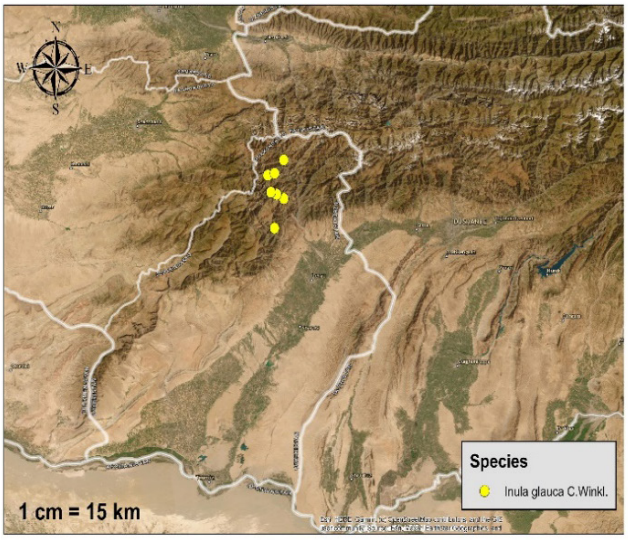
Inula rhizocephala Schrenk ex Fisch. & C.A.Mey.



Inula helenium L.



Inula macrolepis Bunge



Inula glauca C.Winkl.



Inula rhizocephaliformis Kamelin & Turak.

Bu gerbariy ma'lumotlari hozirgi kunda dala tadqiqotlaridan yig'ilgan namunalar bilan boyitilmoqda. O'tgan yillar mobaynida ba'zi turlar terilgan joylari o'zlashtirilishi natijasida dala yoki katta ekin maydonlariga aylantirilgan. Shu sababli ba'zi turlar uchramasligi mumkin.

Xulosa

Hozirgi vaqtda O'zbekiston florasida Asteraceae oilasi muhim ahamiyatga ega. Buning sababi – ko'plab dorivorlik xususiyati bo'lgan turkumlarni o'z ichiga olishidir. *Inula* L. shunday turkumlardan biri bo'lib, bu oilaning eng katta turkumlaridan biridir. *Inula grandis* Schrenk ex Fisch. & C.A.Mey. va *Inula helenium* L. turlari dorivorligi sababli bu turkumning tarqalishini o'rganish alohida ahamiyat kasb etadi. Bu turkumning Markaziy Osiyo ekomintaqalarida tarqalishi turlarning muayyan atrof-muhit sharoitlariga moslashishini ko'rsatadi. Hozirgi kunda iqlimning o'zgarib borishi ularning tarqalishiga va xilmaxilligiga ta'sir qiladi. Tadqiqot davomida o'rganilgan turlarning Hisor-Oloy ochiq o'rmonzorlari, Tyan-Shan tog' tizmasi yaylovlari va o'tloqlarida, Badxiz va Qorabil yarim cho'l hududlari, Pomir-Oloy tog' tizmasida tarqalishi aniqlandi. Turlar bu hududlarda 500 metrdan 2000 metrgacha bo'lgan hududlarda o'sadi. *Inula* L. turkumiga mansub turlar O'zbekistonning turli balandlik zonalarida keng tarqalgan bo'lib, ularning ekologik moslashuvchanligi va morfologik o'ziga xosliklarini o'rganish fan uchun muhim ahamiyatga ega.

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GIS AND STATISTICAL ANALYSIS OF SPECIES BELONGING TO THE *INULA* L. GENUS

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The Asteraceae family is of great importance in the flora of Uzbekistan. There are 78 species belonging to the genus *Inula* L., which are mainly distributed in Europe, Asia, and Africa. In Uzbekistan, there are 9 species of the *Inula genus, I. helenium L., I. grandis, I. salicina, I. glauca, I. caspica, I. britannica, I. macrolepis, I. multicaulis, I. rhizocephala.* In recent years, *Inula japonica* and *Inula linariifolia*, which are native to China and Japan, have been acclimatized in Uzbekistan. *Inula hissarica* R.Nabiev is an endemic species to Uzbekistan and Central Asia.

The distribution areas of these species in Uzbekistan are the Surkhan-Sherabad valley, the banks of the Syrdarya River, and the Pamir-Aloy, Hisar, Kokhitang, Bobotog, Nurota, Zarafshan, Turkestan, Chatkal, Kurama, Ugam, Piskom, and Fergana mountain ranges. Ecological regions are one of the factors that play an important role in the distribution of species. Therefore, the goal of our research is to analyze the growth of populations of the *Inula* L. genus, which includes medicinal and ornamental plants: *Inula grandis, Inula rhizocephala, Inula helenium, Inula macrolepis, Inula glauca, Inula rhizocephaliformis*, in the ecoregions of Central Asia. In 2022-2023, field research was conducted to study the distribution of Inula L. plants in the Surkhan-Sherabad botanical-geographical region. The study used 120 herbarium specimens from the National Herbarium of Uzbekistan (NHU) and georeferenced data from international databases (MW, Plantarium, Plants of the World Online, iNaturalist, GBIF). To determine the distribution of species in Central Asia, a map of the country's ecological regions was created using ArcGIS 10.8.2. Statistical analysis of the data was performed using R software and OriginPro-2022. In addition, Central Asian ecoregions were analyzed to understand the broader distribution range of the species.

Our study shows that using georeferenced data from 297 specimens of 6 species of Inula L. distributed in Central Asia and Uzbekistan, the following results were obtained: 6 species of Inula L. in the Hissaro-Alai open woodlands (GAOW) ecoregion, 4 species in the Alai-Western Tian Shan steppe (AWTSS), 2 species each in the Badghyz and Karabil semi-desert (BKSD), Tian Shan foothill arid steppe (TSFAS), Tian Shan montane steppe and meadows (TSMSM), and Tian Shan montane conifer forests (TSMCF) ecoregions. species, and 1 species was found in the Pamir alpine desert and tundra (PADT) and Altai steppe and semi-desert (ASSD) ecoregions. Species belonging to the Inula L. genus were found to be distributed in the open woodlands of Hissar-Alai, pastures and meadows of the Tien Shan mountain range, in the semi-desert regions of Badkhiz and Karabil, and in the Pamir-Alai mountain ranges at altitudes from 500 to 2000 meters.

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