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Matricaria L. (Anthemideae, Asteraceae) in Iran: a chemotaxonomic study based on flavonoids

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Abstract
Matricaria L. belongs to the tribe Anthemideae and the subtribe Matricineae (Asteraceae) and comprises 7 species of which 2 species grow wild in Iran. This study was aimed to characterize the Iranian materials of *Matricaria* using profiles of flavonoid spots and determination of skeletons of major flavonoids in each species. Twelve bulked population samples from *Matricaria aurea* and *M. recutita* were examined. Presence -absence data from two dimensional maps (2DM) of their flavonoid spots were processed using Cluster and PCA analyses. Differences at species level in flavonoid skeleton properties were investigated and a taxonomic review of close taxa was provided.
Key words: 2D-TLC, Asteraceae, Flavonoid skleton, Iran, *Matricaria*

Introduction

Matricaria L. is classified in subtribe Matricineae (Anthemideae (Cass.), Asteraceae (Dumortier)). This genus is a closely related taxon to *Tripleurospermum* Sch. Bip. and morphologically resembles to some Anthemidae's such as *Anthemis* L., *Microcephala* Pobed. and *Tanacetum* L.; a group of genera that have long been a matter of controversy, both taxonomically and nomenclaturally (Jeffrey, 1979; Xifreda, 1985; Applequist, 2002; Oberprieler and Vogt, 2006). *Matricaria* comprises seven species worldwide: *M. recutita* L. (type species of the genus), *M. aurea* (Loefl.) Sch. Bip., *M. matricarioides* (Less.) Porter ex Britton, *M. occidentalis* Greene, *M. macrotis* Rech. f., *M. tzvelevii* Pobed., and *M. songaria* Bunge (Bremer and Humphries, 1993). *Matricaria songarica* was later transferred to genus *Microcephala* (Bremer *et al.*, 1996). Furthermore, the recognized *Matricaria macrotis* based on the absence of receptacular scales (pales) on its heads was transferred to *Anthemis* under the legitimate name *A. macrotis* (Rech. f.) Oberpr. & Vogt (Oberprieler and Vogt, 2006). Sequencing the nr DNA internal transcribed spacer (ITS) region and some other morphological characters like indumentums, achene shape and anatomy support this transfer (Oberprieler and Vogt, 2006). Geographically, *M. matricarioides* and *M. occidentalis* mainly occur in North America and Western North America, respectively. The old world species of

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the genus grow as: *M. macrotis* (Turkey) *M. tzvelevii* (Crimea) and *M. songarica* (Kazakhstan, Mongolia and Sinkiang in China), *M. recutita* (Eurasia and Mediterranean) and *M. aurea* (Southwest-Central Asia). *M. macrotis* was considered as a basionym of Anthemis macrotis (Rech.f.) Oberpr. & Vogt (Oberprieler and Vogt, 2006). The two latter grow as sympatric species along Zagros mountain chain (Podlech *et al.*, 1986). *M. aurea* is distinguished from its co-generic traditionally well known medicinal species i.e., *M. recutita* by the absence of the white radial ligulate florets. The latter species has been confused with its closely related taxa, particularly *Microcephala lamellata* (Bunge) Pobed. and *Tripleurospermum* spp. Occasional taxonomic revisions show that more detailed understanding of taxa within Anthemideae is a requisite for a better classification.

Flavonoids are choice chemical characters in chemotaxonomic and biosystematic studies (Stace, 1989). Although principal chemical constituents of *Matricaria recutita* have already been reported (*e.g.* Mulinacci et al., 2000); it should be clarified whether all those already reported compounds have been well extracted, scored and analyzed in a given chemotaxonomic study. It would become most critical when comparing two chemotaxonomic studies respecting a given taxon or even a closely related taxa.

Chemical characterization of chamomile extracts have been studied for long. . Zekovic *et al*., (1994) used chromatographic methods for qualitative and quantitative analysis of non-volatile and volatile compounds of *Matricaria chamomilla* L. (synonym for *M. recutita*). In this study, apigenin (flavonoid) series, had been determined using HPTLC and HPLC (Zekovic et al., 1994). These variable chemical compounds have not been used for characterization of variation between natural populations so far (up to our knowledge), nor have been characterized for congeneric non-medicinal species in *Matricaria*.

This study was mainly aimed at (i) reassessment of the taxonomic status of *Matricaria* and its allies in Iran, (ii) comparison of the two Iranian species of *Matricaria* using their flavonoid skeleton properties, and (iii) the use of flavonoid two-dimensional maps of selected populations in Iran for a multivariate analysis and numerically classifying them.

Materials and Methods

Plant material

In this study, a total of twelve population samples including seven populations from *Matricaria recutita* and five from *M. aurea* were specifically collected and examined for flavonoid analysis (Table 1). A voucher specimen from each population was deposited in Herbarium of the University of Isfahan, Iran. For taxonomic purposes and geographical distributions, the *Matricaria* specimens of other herbaria including herbarium of the University of Tehran (HTU) and Research Institute of Forest and Rangelands, Iran (TARI) were examined. Taxonomic identifications were based on Tutin *et al.* (1964); Zohary (1966); Podlech *et al.* (1986) and Grierson (1975).

Methods

Flavonoid extraction and 2D-TLC: Total flavonoids were extracted following Gornall and Bohm (1980). A two-dimensional TLC map of total flavonoids for each population was performed using 20 x 20 cm glass plates coated with Polyamide DC6, 0.35 mm. Solvent systems were adopted from Wagner *et al.* (1996). Each TLC plate was run once in an aqueous solvent system (Water: 70, Ethanol: 20, n-Butanol: 10) and then in an organic solvent system (1, 2-diChloroEthan: 50, Methanol: 25, Butanone: 21, Water: 4). Plates were examined under UV_{254} nm before and after spraying by Diphenyl Boric Acid-2-Amino

Ethyl Ester (NP). Flavonoid spots were scored and entered in a data matrix for multivariate analysis using NTSYS-pc ver. 2.11 (Rohlf, 2000). Cluster analysis of specimens (a normal analysis) was performed using Dice similarity coefficient (Dice, 1945) including in SIMQUAL (NTSYS-pc software).

Flavonoid skeletons determination: Total flavonoids were extracted from the bulk samples and separation was performed using column chromatography (column of sephadex LH20, h: 38 cm, r: 1.5 cm). The solvent system used for column chromatography was 20, 40, 60, 80 and 100% methanol (100 ml each) and fractions were collected in 50 ml volumes. Fractions were concentrated, then examined for flavonoid composition and further purification using preparative TLCs. The UV absorption spectrum of each purified component was determined using Carl-Zeiss-Tech Specord-S10 spectrophotometer in wavelength range 200-500 nm. UV absorption spectra of methanol extracts and their shifts after addition of shift-reagents AlCl3/HCl and NaOAc/H3BO3 were recorded for each purified flavonoid constituent. All spectra were interpreted according to Markham (1982).

Table 1: Details of the *Matricaricaria* accessions used in this study

Species	Smaple Code	Locality	Alt. (m)
M. aurea			
	Au01	Khuzestan: Between Sarkhun and Katula, Do-ab	810
	Au02	Khuzestan: Dehdez	410
	Au03	Fars: Gachsaran to Shiraz, After Brim bridge	-
	Au04	Fars: 25 km to Kazeroon from Dalaki	900
	Au05	Fars: Around Takht-e Jamshid	1570
M. recutita			
	Re01	Khuzestan: Dehdez	410
	Re02	Khuzestan: 40 km to Izeh from Dehdez	610
	Re03	Khuzestan: 25 km to Izeh from Dehdez	900
	Re04	Khuzestan: 5 km from Izeh to Baghmalek	800
	Re05	Fars: Gachsaran to Shiraz, after Brim bridge	-
	Re06	Fars: 25 km to Kazeroon from Dalaki	900
	Re07	Fars: Around Ghaemieh Town	860

Results and Discussion

Taxonomy

Matricaria chamomilla (scentless mayweed), *M. recutita* (chamomile), and *M. maritima* (sea mayweed) were first described by Linnaeus (1753); although, scientific names for chamomile and scentless mayweed were later considered as synonyms to *M. suaveolens* and *M. inodora* respectively by the author (Linnaus 1753). Sea mayweed was also considered as *M. inodora* var. *maritima* (Hansen and Christensen, 2009). These changes caused the first taxonomic and nomenclatural confusions in this genus and its allies as well.

Using *Chamomilla* instead of *Matricaria* in Flora Europaea led to some taxonomic confusions and misidentifications on a number of herbarium specimens; e. g., a herbarium sheet can be determined as *M. chamomilla* based on Flora of Turkey and *Chamomilla recutita* using Flora Europea's key, interestingly both are a synonym to *Matricaria recutita*.

Treatment of genera *Matricaria*, *Tripleurospermum* and *Chamomilla* in Flora Europaea (Tutin *et al.*, 1964) were incorrect. In fact, descriptions of *Chamomilla* (and the four species under this name) in Tutin *et al.* (1964) belonging to the accepted name *Matricaria* L.; *Chamomilla* S. F. Gray, was treated as a synonym to *Matricaria* L. by Jeffrey (1979). The description of *Matricaria* L. in Tutin *et al.* (1964) coincided with that of *Tripleurospermum* Sch. Bip., while the name *Tripleurospermum* was considered as a synonym to *Matricaria*. These incorrect treatments caused some misidentifications when a number of *Tripleurospermum* specimens were identified as *Matricaria* spp. e. g., at HTU.

Despite two records from *M. aurea* from Northern Iran (Podlech *et al.*, 1986), the specimens were neither collected during our field trips, nor determined among the specimens collected from northern Iran at TARI and HTU. Since geographical distribution of the species is inconsistent with that report, it defied rather clear identification.

Tripleurospermum which is most confused with *Matricaria* differs in having two resin glands at the apex of the abaxial face of achenes and three prominent ribs on adaxial face. *Matricaria* differs from resembling genus *Microcephala* in which fruits are provided with scales, hairs, and a distinct crown-like pappus (Bremer *et al.*, 1996). However, marginal achenes of *Matricaria recutita* may sometimes be coronate, so that if only marginal achenes of *M. recutita* are used in determination, it could be incorrectly identified as *Microcephala lamellata*. Species of *Anthemis*, which are morphologically resembling *Matricaria* spp., differ by having chaffy bracts on the receptacle (which are absent in *Matricaria* spp.).

Recent reports of *M. discoidea* from Iran is uncertain; the taxonomic position of this species is stressed as being rather a member of *Achillea* clade (Oberprieler and Vogt, 2006) and may segregate it.

The two species of the genus *Matricaria* in Iran should be determined using two corresponding identification keys (Zohary, 1966; Podlech *et al.*, 1986). A modified brief key to genus *Matricaria* and its allies in tribe Anthemideae is as follow:

1- Achenes heteromorph, marginal achenes 3-winged, interior achenes 2-winged or with longitudinal middle veins..... *Chrisanthemum*
1- Achenes not heteromorph, not as above.
2- Receptacle bare
3- Achenes with two resin glands at the top of the abaxial face..... *Tripleurospermum*
3- Achenes without two resin glands at the top of the abaxial face.
4- Achenes distinctly coronate..... *Microcephala*
4- Achenes ecoronate, only achenes of marginal ligulate florets (if present) sometimes coronate..... *Matricaria*
2- Receptacle with chaffy bracts
5- Achenes compressed, laterally winged..... *Anacyclus*
5- Achenes not winged as above
6- Capituls with ligulate florets in margins, disk florets in center
7- Middle nerve of chaffy bracts excurrent..... *Anthemis*
7- Middle nerve of chaffy bracts non excurrent..... *Achillea*
6- Capituls without ligulate florets
8- Capituls in compound cymes..... *Handelia*
8- Capituls single in branches..... *Anthemis*

Chemodiversity

Patterns of flavonoid spots in *M. aurea* and *M. recutita* specimens are shown in Figure 1 (A-C). Co-migrating spots were considered identical for populations of the same species, but may not be identical between the two species (Stace, 1989). Therefore, patterns of flavonoid spots were recorded separately for each species. The Pattern of flavonoid spots in *M. recutita* was also found to be different for stems and capitula (Figure 1- B, C). Not all spots were present in all specimens. Spot data for each specimen are presented in tables 2, 3. Flavonoid spots of stems and capitula in *M. recutita* were not the same. Capitula spot profiles offered more data than stems which were used for subsequent cluster analysis of spot data in *M. recutita* using NTSYS-pc. Resulting dendrograms and PCA diagrams are presented in Figure 2 (A-D). Overall topology of both dendrograms (*M. aurea* and *M. recutita*; Figure 2- A, B) showed that specimens were well separated by the data matrix,

and the grouping of the specimens did not suffer chaining.

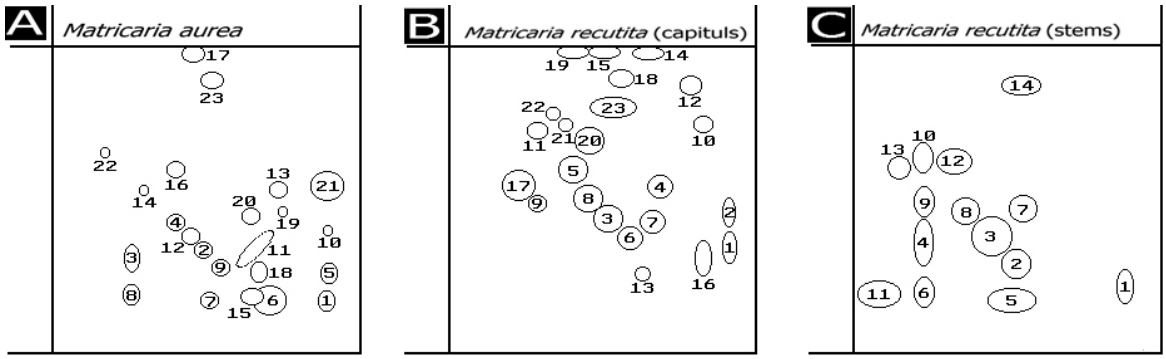

Figure 1: Flavonoid spots in 2D-TLC of *M. aurea* (A: all parts of plant) and *M. recutita* (B: capitula and C: stems) populations. Not all spots were present in all 2D-TLC chromatograms (See tables 2, 3). Spots are numbered according to an overall (combined) map.

Populations in this study were from two regions: West and South of Zagros (Table 1). Cluster analysis of flavonoid spot profiles separated populations of each species according to their geographical location. Re05, Re06, Re07 were clustered together; while Re01, Re02, Re03, Re04 made the second cluster which contained subclusters Re01+Re02 (Populations from Dehdez) and Re03+Re04 (Populations from Izeh). Populations belonging to *M. aurea* were also well clustered. The only misplaced population was Au02M which was an outlyer in a clade containing South Zagros Populations. Au02M was from West of Zagros (Dehdez) and could be interpreted as an outlayer because Au02H (same population, but only the capitula) was groped with other samples from West of Zagros.

Table 2: Flavonoid spots in populations of *M. aurea* (H: heads, M: all parts of plant). Spots 1-5 are yellow, spots 6-14 are orange, spots 15-17 are dark, and spots 18-23 are blue. Dark green spots were absent in spot profile of *M. aurea* populations.

	Spot color	Au01, H	Au02, H	Au01, M	Au02, M	Au03, M	Au04, M	Au05, M
1	Y1	1	1	1	1	0	0	0
2	Y2	1	1	1	1	1	1	1
3	Y3	1	1	1	1	1	1	1
4	Y4	1	1	1	0	1	1	1
5	Y5	0	0	1	0	0	0	0
6	O1	0	0	1	0	0	0	1
7	O2	1	1	1	0	1	1	1
8	O3	0	0	1	0	1	1	1
9	O4	1	0	1	0	1	1	1
10	O5	1	0	0	0	0	0	0
11	O6	1	1	0	0	0	1	1
12	O7	1	1	1	1	1	1	1
13	O8	1	0	1	0	0	0	2
14	O9	1	1	0	0	0	0	0
15	D1	0	0	0	1	1	1	0
16	D2	0	1	0	0	1	0	0
17	D3	0	1	0	1	0	1	1
18	B1	0	0	0	0	0	1	0
19	B2	0	0	0	0	1	0	0
20	B3	0	0	0	0	1	0	0
21	B4	0	0	1	0	0	0	1
22	B5	0	0	0	0	0	0	1
23	B6	1	1	1	1	1	1	1

Table 3: Flavonoid spots in populations of *M. recutita* (H: heads). Spots 1-5 were yellow, spots 6-12 were orange, spots 13-15 were dark, spots 16-19 were blue, and spots 20-23 were dark green, under UV 254nm.

	Spot color	Re01, H	Re02, H	Re03, H	Re04, H	Re05, H	Re06, H	Re07, H
1	Y1	0	1	1	1	0	0	1
2	Y2	0	0	0	0	0	0	1
3	Y3	1	1	1	1	1	1	1
4	Y4	1	1	0	1	1	1	0
5	Y5	1	1	1	1	1	1	1
6	O1	0	1	1	1	1	1	1
7	O2	1	1	1	1	1	1	1
8	O3	1	1	1	1	1	1	1
9	O4	0	1	1	0	0	0	0
10	O5	0	0	0	0	0	1	1
11	O6	0	0	0	1	0	0	0
12	O7	0	0	0	0	0	1	1
13	D1	0	0	0	0	1	0	0
14	D2	1	0	0	0	0	0	0
15	D3	1	1	1	0	1	1	1
16	B1	1	1	1	1	1	1	1
17	B2	0	1	1	1	0	0	0
18	B3	1	1	1	1	1	1	1
19	B4	0	0	0	0	0	2	0
20	G1	1	1	1	1	1	1	1
21	G2	0	1	0	0	0	0	0
22	G3	1	1	1	1	1	1	1
23	G4	1	1	1	1	1	1	1

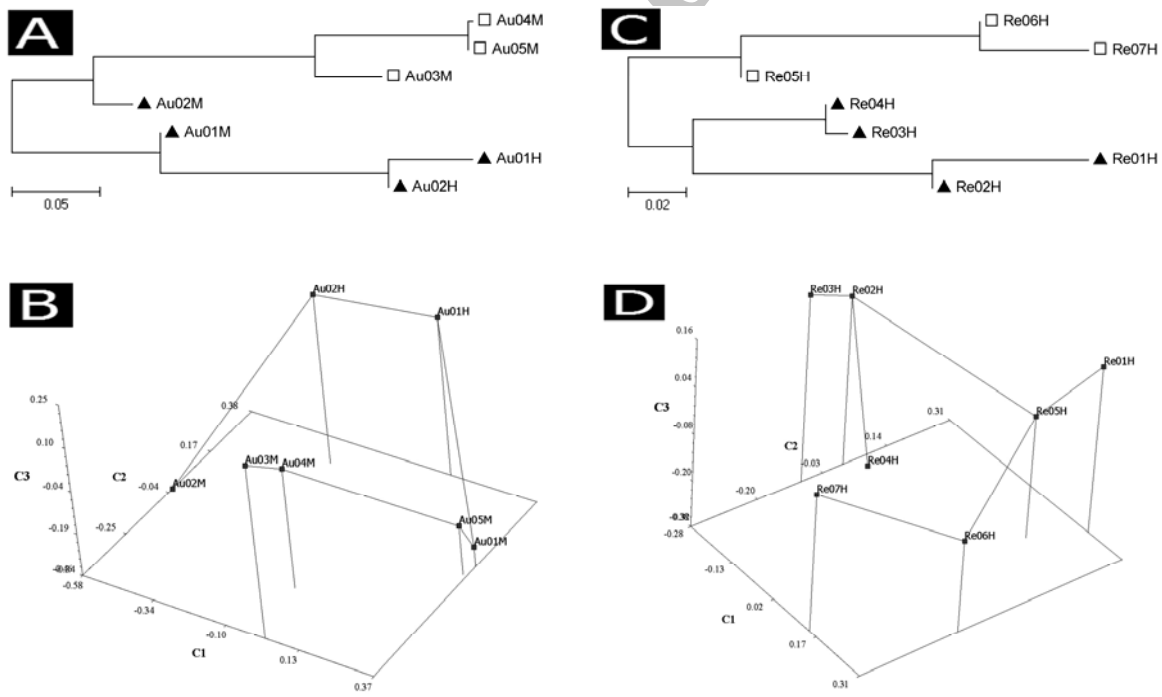

Figure 2: Resutls of multivariate analysis. A, C: Results (dendrograms) of cluster analyses of flavonoid spot profiles of *Matricaria aurea* (5 populations) and *M. recutita* (7 populations). Note that population of each species are analysed separately. Populations located in West of Zagros are black triangles; South of Zagros's are open squares. Scale bars under each dendrogram are relative distances. B, D: Results of Principal Coordinate Analysis (PCO) of flavonoid spot profiles of *M. aurea* and *M. recutita*. A Miminum lenght Spaning Tree is overimposed on each PCO graph which clarifies relationships between populations (see text).

A minimum length spanning tree is overimposed on PCA diagrams of *M. aurea* (Figure 2-B) and *M. recutita* (Figure 2-D). Au02M which was misplaced in cluster analysis is connected to Au02H and rest of West-Zagros populations. On the other hand, Re01H is connected to the rest of West-Zagros populations via Re05H (a South-Zagros Population). Population structure in accordance with geographical origin of samples in Zagros Mountain chain has been studied for grass species *Festuca arundinacea* using microsatellites (Sharifi-Tehrani *et al.*, 2009). Here, separation of *Matricaria* species populations across central Zagros region as revealed by flavonoids; supports for significance of Central Zagros region in effective separation of populations making genetic or chemical structure among them.

UV spectrophotometry

Most studies refered to Essential oil composition of *Matricaria* species of which *M. recutita* received more attention due to its importance as a known medicinal plant; however, *M. aurea* had also been studied for its oxygenated bisabolene compounds (Ahmed and Elela, 1999; Teixeira da Silva, 2004). We evaluated differences among *M. aurea* and *M. recutita* in flavonoid classes and partial details of the substitutions on the skeleton. Common structure of flavonoid skeleton is shown in Figure 3. UV spectrophotometry of purified flavonoids of each species, performed in order to compare flavonoid skeleton and substitutions properties of them in species level. Hydroxylation on carbon 3 (the heterocyclic ring) converts flavones to flavonols. This simple change required additional steps in flavonoids biosynthetic pathway and made the molecule physiologically more active.

M. recutita contained qualitatively more flavonoid compounds compared to *M. aurea*. To determine the class and structural properties of purified flavonoids, shift reagents were used. Those flavonoids with enough concentration to be detected and purified by column chromatography and TLC were considered.

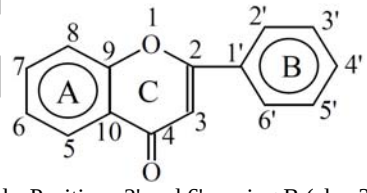

Figure 3: Common skeleton of flavonoids. Positions 2' and 6' on ring B (also 3' and 5') are identical (Markham, 1982).

Three flavonoid aglycons from *M. aurea* and nine from *M. recutita* were purified. Representative UV spectra of *M. aurea* and *M. recutita* are shown in Figure 4 and a summary of the properties of detected flavonoid constituents is presented in table 4. Three purified flavonoids extracted from *M. aurea* were of class flavones and shared the ortho-dihydroxyl system on ring B, which could be considered as a plesiomorphic chemical character shared by the two species. Two out of nine detected flavonoids in *M. recutita* belonged to class flavonols, one of which possessed two ortho-dihydroxyl systems on rings A and B.

Flavonoid skeleton 8 from *M. recutita* was a 3-hydroxy-flavone (apigenin) which was previously purified from capitula of *M. recutita* and characterized as a banzodiazepine receptor ligand with anxiolytic effects (Viola *et al.*, 1995).

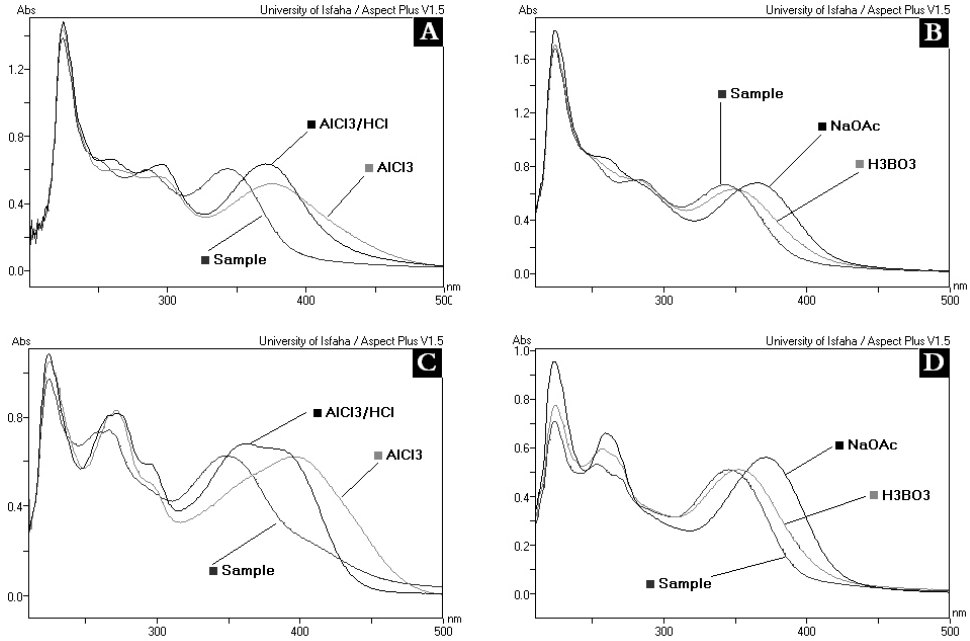

Figure 4: Representative spectra of UV absorption in 200-500 nm range. (A, B) UV spectra of one of the three flavones purified from *M. aurea*. Shifts to higher wavelengths in band (I) on spectrum (A) suggests 5-OH and 6-oxygenation. Shifts in band (I) on spectrum (B) suggests an ortho-di-hydroxyl system on ring B. (C, D) UV spectra of one of the nine flavonoids purified from M. recutita. Again, Shifts to higher wavelengths in band (I) on spectrum (C) suggests 5-OH and 6-oxygenation while shifts in band (I) on spectrum (D) suggests an ortho-di-hydroxyl system in positions 6, 7 or 7, 8 on ring A.

A qualitative comparison of flavonoids present in the two species showed that *M. aurea* may not be considered as a medicinal alternative for *M. recutita*; our results showed that it lacked (or had insufficient amount) physiologically active flavonoids: flavonols (Strack, 1997).

Conclusions

Matricaria recutita wasboth morphologically and chemically more complex than *M. aurea*, as revealed by flavonoid constituents. Heterogamous radiate capitula of *M. recutita* consisted of both white ligulate florets (rays) and pale-yellow central tubular disk florets. Capitula of *M. aurea* consisted of only disk florets. Disk florets were not the same in the two species; corolla tubes in disk florets were 4-lobed in *M. aurea*, while disk florets in *M. recutita* were 5-lobed.

Table 4: Flavonoid skletons from *M. aurea* and *M. recutita*, purified and determined in this study. Skeleton number corresponds to numbers in Figure 5

Skleton	Class	Skleton details	Species
1	Flavone	5-OH; oxygenation on carbon 6; ortho-dihydroxyl on ring B	*M. aurea*
2	Flavone	ortho-dihydroxyls on rings A and B	*M. aurea*
3	Flavone	ortho-dihydroxyl on ring B	*M. aurea*
4	Flavonol	5-OH; oxygenation on carbon 6; two ortho-dihydroxyls on rings A and B	*M. recutita*
5	Flavonol	5-OH; oxygenation on carbon 6; 7-OH	*M. recutita*
6	Flavone	5-OH; oxygenation on carbon 6	*M. recutita*
7	Flavone	ortho-dihydroxyl on ring A	*M. recutita*
8	Flavone	5-OH; ortho-dihydroxyl on ring A	*M. recutita*
9	Flavone	5-OH; ortho-dihydroxyl on ring A; oxygenation on carbon 6	*M. recutita*
10	Flavone	5-OH; prenyl group on carbon 6	*M. recutita*
11	Flavone	5-OH	*M. recutita*
12	Flavone	5-OH; two ortho-dihydroxyls on rings A and B	*M. recutita*

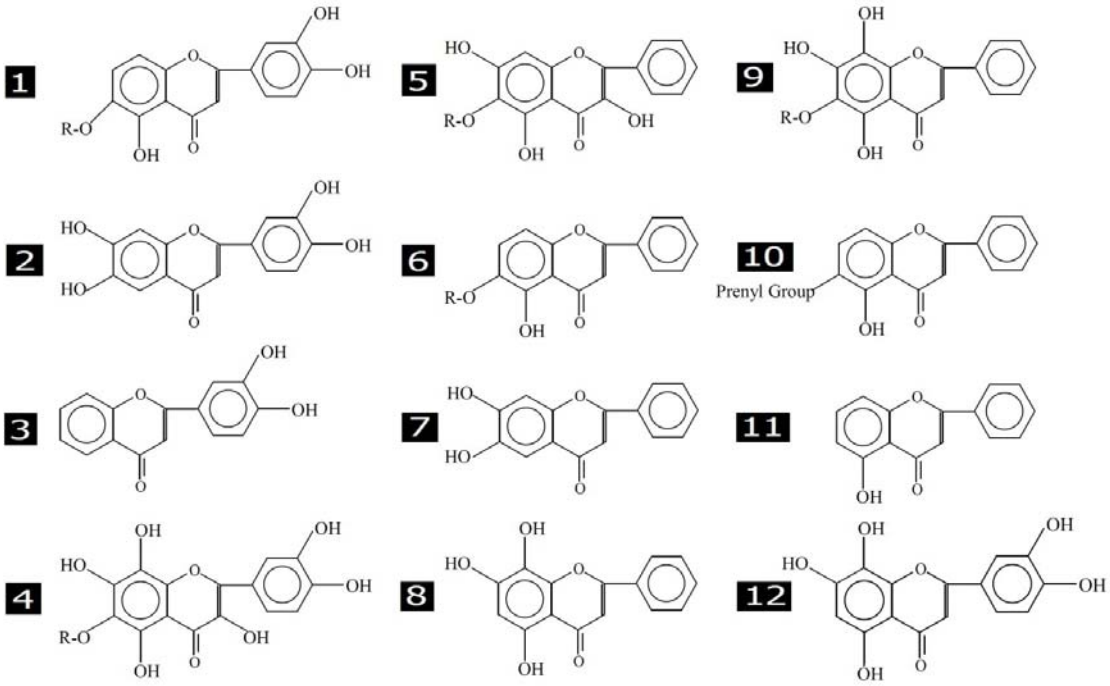

Figure 5: Flavonoid skletons from *M. aurea* and *M. recutita*, purified and determined in this study. Flavonoids 1-3 were separated from *M. aurea*; 4-12 from *M. recutita*. Skeleton numbers corespond numbers in Table 4.

From the biosynthetic aspects, flavones and flavonols were both derivatives of an intermediate class of flavonoids; namely flavanones which were directly resulted in flavones. Biosynthesis of flavonols from flavanones required construction of another extra intermediate class of flavonoids; namely flavanone-3-ols or (+)-Dihydroflavonols. Lack of ligulate florets in *M. aurea* in addition to lack of class flavonols could be interpreted as losses (synapomorphies).

Both discoid and radiate capitula are present in several close genera to *Matricaria*. However, it is unlikely that the ligulate flowers have evolved independently several times in those genera and species from ancestors without ligulate florets. This situation would be resolved by considering an ancestor with ligulate florets from which species with and without ligulate florets have been arisen via reversals in discoid (non-ligulate flower) capitula. It could be concluded that *M. recutita* is more primitive than *M. aurea* despite of being morphologically and phytochemically more complex. Taxonomic and nomenclatural problems within Anthmidae remain to be resloved by using different kinds of data from all genera in this tribe, through more detailed studies.

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جنس *Matricaria* L. (Anthemideae, Asteraceae) در ایران: مطالعه کموتاکسونومیک بر اساس فلاونوئیدها

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چکیده

جنس *Matricaria* L. متعلق به قبیله Anthemideae و زیر قبیله Matricineae (از تیره Asteraceae) است و شامل ۷ گونه است که دو گونه از آن به طور طبیعی در ایران می‌روید. این مطالعه به منظور توصیف نمونه‌های جمع‌آوری شده از این جنس در ایران با استفاده از پروفایل لکه‌های فلاونوئیدی و تعیین ویژگی‌های اسکلت فلاوئیدهای مطرح در هر یک از گونه‌های آن صورت گرفته است. ۱۲ نمونه جمعیتی بالک شده از دو گونه *M. aurea* و *M. recutita* مورد آزمایش قرار گرفتند. داده‌های حضور-غیاب حاصل از بررسی نقشه‌های دو بعدی لکه‌های فلاونوئیدی مربوط به همه نمونه‌ها ثبت و با استفاده از آنالیزهای خوشه‌بندی و اردیناسیون (PCA) مورد بررسی قرار گرفتند. در این مطالعه، ویژگی‌های مربوط به اسکلت‌های فلاونوئیدی در سطح گونه و تفاوت‌های آنها مورد بررسی قرار گرفته، مروری اجمالی بر موقعیت تاکسونومیک آرایه‌های نزدیک ارایه گردیده است.

واژه‌های کلیدی: اسکلت فلاونوئیدی، ایران، Asteraceae، کروماتوگرافی لایه نازک دو بعدی، *Matricaria*

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